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Review on Activity Patterns, Population Ecology and Conservation Status of gelada baboon *(Theropithicus gelada,* Ruppell 1835*)* in Ethiopia

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Abstract
Ethiopia is one of the few countries in the world which possess unique and characteristic fauna and flora with a high level of endemism. *Theropithecus* gelada are among the chrstimatic endemic mammals of Ethiopia known to inhabit Ethiopian highlands. The habitat of gelada baboon is characterized by cooler, less arid and vicinity to cliffs for sleeping and the use of several different types of relatively treeless and montane grass lands for foraging. Lower elevation area is not comfortable to gelada because the digestibility of grass is to low due to high temperature and low rainfall. Higher elevation is more comfortable because the grassland is green throughout the year and palatable due to high rainfall and lower temperature. The diet of gelada is highly dominated by grass with other food types, such as underground items, accounting for a considerable proportion of the diet. The diet preference of the geladas varies based on season. Root and rhizomes accounts higher proportion of gelada diet during the dry season due to grass is less digestible during the dry season. Grass comprises higher proportion of gelada diet during the wet season grass account. Animal prey was much less important food source of gelada populations. Time is limited for most baboon population. Ecological factor such as food availability and distribution are among the most important determinate factor that affects the activity pattern of gelada baboon. *Theropithecus gelada* faced different pressures on its present and future existence; some of threats are fire wood collection, agricultural land expansion, hunting for mane and also climate change higher impact on the food availability and accelerate abortion rate on gelada population. The current conservation status of gelada baboons as a whole are not considered to be threatened at the moment, but need conservation effort.

Keywords: conservation status, Ethiopia, gelada baboon, population ecology

Introduction
Primates are large, charismatic mammals found in many of the world's tropical forests (Fashing *et al*. 2012) [18]. Africa harbors a great diversity of primates most of which are endemic to the content. There are 175 species and sub species of primates listed in Africa. Primates represent one of the best studied groups of mammals in East Africa. However, still their biogeography, abundance and conservation status was remaining poorly understood.

The past geological history, unique topographical structure and the wide ranging of climate have made Ethiopia diverse in biological resource (Bekele & Yalden, 2013) [8] and a variety of other fauna and flora with a high level of endemism. According to Bekele & Yalden (2013) [8], Ethiopia possesses more than 320 species of mammals of which 41 are endemic to the country. Among the mammals of the country about 30 (10.5%) are species and sub species of non- human primates (Groves, 2005) [21]. There are about 13 species of primates occur in Ethiopia (Bekele &Yalden, 2013) [8]. Among the species of primates that found in the country, three are endemic to Ethiopian highland such as, gelada baboon (*Theropithecus gelada*), Blue monkey (*Cercopithecus mitis boutourlinii*) a sub-species of *Cercopithecus mitis* and Bale monkey (*Chlorocebus djamdjamensis*) (Gippoliti, 2010) [20].

Ethiopia is fortunate to have an endemic Cerceopithecine species, gelada baboon (*Theropithecus gelada*). Currently, gelada baboons are found only in a few areas throughout the northern Ethiopia highlands However, there is also a small population of gelada baboons living in the southeastern Ethiopia between Arsi and Bale (Gippoliti, 2010) [20]. The information on the status analysis on global scale shows that primates are the most threatened groups of mammals (Schipper, 2008) [35]. Like other groups primates' gelada baboon (*Theropithecus gelada*) is threated by anthropogenic activities like habitat distraction, agricultural expansion, inappropriate investment (Abi & Bekele, 2016) [1]. Due to lack of clarity concerned to the ecological information and conservation status of *Theropithecus gelada* affect the conservation effort of gelada population and there habitat. Therefore, the objective of this review paper is to reveal the most important ecological information and the current conservation status of gelada baboon in Ethiopia.

Gelada Baboons
Gelada baboon (*Theropithecus gelada)* was discovered by a German naturalist called Ruppel in 1835 in a few areas of the northern Ethiopian highlands. *Theropithecus gelada* is a large primate which is endemic to the highland Ethiopia. Geladas are large primates with dark brown to buff coarse pelage with dark brown faces and lighter, pale eyelids (Simons, 2007). Female have shortage pelage than male (Puff &Nemomissa, 2005) [31]. Adult Males are larger than adult female and marked sexual dimorphism is characteristics of the species, with adult females around two-third the size of adult males. Adult females weight an average around 11 kg while, adult males weight 18.5 kg Head and body length of the adult female and male range

between 50 and 75 cm and the tail is between 30 and 50 cm, respectively. Male gelada have larger canine teeth than female (Hughes *et al*, 2008) [22]. Gelada baboons differ from other baboons by the bright patch of skin on its chest. In addition, its fingers are short and strong, allowing them to be used efficiently for digging of food source from the ground. Most characteristics of gelada are the hairless hourglass-shaped pink or red area of the skin located on the chest.

Habitat

The habitat is characterized by their vicinity to cliffs for sleeping and the use of several different types of relatively treeless and montane grass lands for foraging; habitats that are usually intermixed with bushes, trees, and dens thickets .The habitat of gelada is generally cooler and less arid and thus less effect of food scarcity even during the dry season. Areas that have higher elevation are more comfortable for gelada because the grass lands stay green for a longer period of time due to high rainfall and low temperature (Puff & Nemomissa, 2005) [31]. This helps gelada baboons to have accesses of a well digestible grass for a better time span throughout the year. On the other hand, areas at very high altitude, the protein content of grass and other food sources declines, which make it difficult for geladas to meet the food requirements (Dunbar 1998) [17]. In addition, geladas face difficulty to cope with grasses at lower elevations, because the digestibility of grasses is too low **Social Organization**

Primates exhibit a wide diversity of social system compared to other mammals (Ren *et al*, 2010) [32]. Ecological and social factors promoted the development of flexible social system in gelada and related taxa. The dominant social systems in gelada are depends on anti- predator behaviour, mate choice and access to food resource. In gelada baboons one- male unit (OMU) is the primary level of origination, comprising a reproductive leader male, 1-12 adult females with their dependent offspring, and possibly one or more follower males. Another primary social group is all- male group, contains 2-15 young adult and sub adult males isolated from their natal unit (Dunbar, 1993) [16].

There are many factors that affect the group size of gelada such as disease, parasite risk (Altizer *et al.* 2003) [2] resource availability and competition and foraging patch size (Johnson *et al*, 2002) [23].

Grooming and calls have an important role to maintain group cohesion and stable relationships in gelada (Sueur *et al.* 2011) [37]. In addition, grooming has its own purpose like, hygiene, to crate strong social bond between them (Schino *et al.* 2009) [34], to remove ectoparasites and lowering the risk of disease (Nunn & Altizer 2006) [30], to reduce tension. Most of a time grooming in gelada concentrated among materially related individual especially within mother- offspring. Nevertheless, grooming also occurs among non- related individuals of gelada.

Reproduction and mating system

According to Anderson & Bielert (1994) [4], reproduction among male and female gelada have some variation in time of reaching sexual maturity. The male gelada reaches sexual maturity at the age of six and the female one reaches at the year of four**.** During estrus the female gelada show different characteristics like chest color change, pink hourglass shaped skin patches on the chest that change in appearance throughout their estrus cycle. In addition, the skin in the anogenital region becomes swollen with bright pink or red and releases a pheromone with aliphatic acid, which enhances her attractiveness to the male (Bergman *et al*, 2009) [11]. This has its own advantage for the male to know if the female is ready to mate (Savin *et al*, 2008) [33].

Gelada baboons do not have specific mating season, though it has been noted that the birth rate is higher during the rainy season. The mating system of gelada population is based on the system of only male unit (OMU); polygamous mating system. In the OMU system the male gelada in the group have the capacity to monopolize several females. The Dominate male try to protect females from other males (Dunbar, 1993) [16]. Grooming always occurs before copulation and copulation in gelada occurs during the morning hours. During estrus the female gelada copulate 2-5 times per day. The gestation period of gelada is about six months. Although single infant is the most common, twins also occur infrequently (Bergman & Kitchen 2009) [11].

Feeding Ecology

Theropithecus gelada populations living in different habitat appear to differ in their feeding habits. For example, the diet of Arsi gelada population comprises considerable amount of fruit but, gelada in Simen Mountain National park their diet highly depends on grass rarely fruit rarely which have been used as a food source. Among primates gelada baboon are an excellent digger and the only primate which has a specialized graminivorous diet (Mau *et al*, 2009) [28].

Varies studies elsewhere in Ethiopia have reported that grasses comprise more than 80% of the gelada diet (W/Georiges & Bekele 2015; Kassahun Abi *et al*, 2017) [39]. The diet preference of the geladas varies based on season. They change their diets in response to changes in available resources (Batron &Whiten, 1993) [6]. During the dry season root and leaves are taken in larger proportions as food source (Abi *et al*, 2017) [24]. During the wet season they predominantly feed on grass species due to availability of abundant grasses. However, during the dry season geladas have been observed to feed on insects such as locusts, but accounts about 0.05% (Cherkos W/ Georiges and Bekele, 2015) [39]. This study also showed that during the excess of food gelada baboons do not usually plan for captures insect. Gelada also feed upon cultivated crops leading to conflict with the local human communities (Yihun *et al*, 2009) [41]

Distribution and Population Status

The distribution of gelada population on the Ethiopian plateau is associated with the availability of easily digested montane grasses. Gelada baboons occur in the highland of Ethiopia particularly in the northern and south eastern Ethiopia. Gelada baboons occur between altitude of 1800 and 4400 m asl. The highest population of gelada occurs in Simien Mountain National Park (Beehner *et al*, 2008) [7]. Simien Mountain National park is the only place in which gelada is officially protected. The second largest population of gelada baboon is found in Guassa Community Conservation Area (Moges, 2015) [29]. Gelada population is limited to the highly grassland cliff in the deep gorges in the central plateau, of South wollo in Azwa and Arego patches of valley forest and associated grasslands North Wollo specifically, in Mount Abune Yosef community conservation in Gondar area in Delanta escarpment and the meta population of gelada also occurs in Wonchit valley in

Amhara regional state between North Shoa and South Wollo .The southern isolated population of gelada baboon is distributed over forest area like Indato, eastern Arsi.

There are two sub-species of gelada baboons that occur in Ethiopia. These are: *Theropithecus gelada and Theropithecus gelada obscure*. The former occur in northern highland and the latter is found southern parts of Ethiopia (Gippoliti, 2010) [20]. The differences between in *T.g. gelada* and *T.g. obscures* are minimal; there are a few visible differences. The *T.g. obscurus* the darker coloured dorsal fur and flesh coloured face (Belay & Shotake, 1998) [10]. This sub species inhabits the north-western area of the Great Rift Valley in Showa (Menz, Debre lebanos and Muger areas), and in the Wollo and Gojjam Provinces. However, *Theropithecus gelada* has lighter fur appearance. This subspecies inhabits in the northern highlands particularly in the Gondar area. There is also a Meta population of gelada baboon distributed in the southeastern part of the rift valley in the Arsi province near to Bale Mountain National Park. Some pilot survey showed that the Arsi gelada populations can be regard as yet another distinct subspecies, *T. gelada senex* (Gippoliti, 2010) [20]. Arsi gelada population lives in a lower- elevation habitat ranging from 1,800 to 2, 300 m. asl.

The population size of gelada in different parts of Ethiopia is surveyed and their number per area unit was estimated. According to Beehner *et al.* (2008) [7], in Simein Mountain National Park the population size of gelada baboon about 4620. In Guassa Community Conservation Area 1502 individual gelada were recorded (Moges, 2015) [29]. The population at Borena Sayint National Park, Azwa and Arego forest patch, Arsi Indato forest and Wonchti valley were estimated to be 914, 338, 529 and 1525 individual gelada were recorded respectively. The global population estimated of gelada baboon ranges from 50,000 to 60,000 individuals (Beehner *et al*, 2008) [7].

Activity Patterns

Time is very limited for most baboon population. Thus, baboon population are faced with the challenge of allocating the limited time to different activities like resting, feeding, socializing, moving (Dunbar, 1998) [17]. The amount of time spent for different activities like foraging which related to the quality of the food or the energy content of the food relative to the costs of obtaining the food plus the cost of all other activities (resting, moving or socializing). Food quality and at the same time quantity are the most determinants factor of primates daily activity pattern. So, factors that influence the availability of food have a strong bearing on time allocation profiles in different baboon species.

According to Boyle (2008) [14], the activity pattern of primates can be determined by habitat types in which they are living. The habitat component such as food, water, cover, and other environmental factors influence the time allocation of baboon species.

Gelada baboon *(Theropithecus gelada*) is among the chrstimatic endemic mammals of Ethiopia known to inhabit Ethiopian highlands. Like other baboon species gelada baboon also allocate it's time for different activities. There are different factors such as seasons and climatic conditions which influence the daily activity pattern of Gelada baboons throughout Ethiopian highlands (Kefile *et al*. 2013) [25] the different studies conducted in Ethiopia showed that the percent time budget for feeding was higher in dry season than wet season (Abi *et al*, 2017) [24] this is due to in Ethiopia the quality and availability of food resource during the dry season is a cause for a seasonal variation on feeding time allocation of gelada baboon.

Season also have effect on the moving time allocation. Gelada are forced to move long distance during the dry season to satisfy their nutritional requirements. Social activities of gelada baboons have an important role to maintain group cohesion and stable relationship (Sueur *et al.* 2011) [37]. During the wet season gelada baboon devote more time for social activities in different part of Ethiopia (Abi *et al*, 2017) [24]

Threats and Conservation Status

In Ethiopia over the past few decades mammal and other fauna species has become increasingly threatened the root causes are; domestic animal encroachment and expansion of agriculture (Mamo *et al*, 2012) [27] unsustainable use of natural resource, deforestation, illegal forest fire, land degradation (Amare, 2015) [3], weak law enforcement; human wildlife conflict, and lack of alternative livelihood activities for the community, poaching, expansion of invasive plant in forest reserve and in protected area (Chane & Tesfaye, 2015) [15].

Gelada baboon faced different threats in different parts of Ethiopia. The finding of Abi &Bekele (2016) [1], showed that in Debre libanos North Shewa zone, the population of gelada faced different pressures on its present and future existence; some of threats in the area are habitat destruction, fire wood collection commercial timber production, livestock grazing, expansion of agricultural land and unsuitable investment. Likewise, Yihune *et al.* (2009) [41], reported that increasingly, geladas come into contact with humans in Simien Mountain National Park as local farmers expand their cultivation and livestock grazing to steep hillsides once occupied only by wildlife; these activities affected the long term existence gelada baboon in the park. Similarly, habitat degradation was also a serious problem in guassa community conservation area (Mogese, 2015) [29]. Gelada have been accused by local community due to crop raiding behaviour that often provokes retaliatory killing by farmers (Abi & Bekele, 2016) [1]. Gelada baboon is hunted for its mane in most of its localities (Tefera, 2011) [38]. Currently climate changes highly affect the distribution and availability of food for primate population. Gelada baboon is a graminivorous primate and whose ecology is unusually sensitive to ambient temperature. Grass constitutes the highest portion of the gelada diet composition (Kifle *et al*, 2013; & Abi *et al*, 2017) [29, 24]. However, at the present time the grassland habitat in Ethiopian highland is shrink in size and quality over time due to the grass species are highly sensitive to ambient temperature, precipitation and grazing pressure. Climate change also affects the birth rate of gelada population. The unexpected weather change is a major cause to have high abortion rate in gelada population due to cold stress.

Fig 1: Livestock grazing inside the Semen Mountain National Park

The confusion and lack of clarity with regard to the correct the accurate taxonomic arrangement of gelada populations could negatively affect conservation strategies (Gippoliti, 2010) [20]. The current conservation status of gelada baboons as a whole are not considered to be threatened at the moment, but need conservation effort. The current problem that faced on gelada populations continue in this way would raise serious question over the species geographic distribution and future long term survival (Dunbar, 1998) [17]

Conflicts of Interest

The authors declare no conflicts of interest with respect to the authorship, and/or publication of this review article.

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