Feeding habits and preferences of southern gelada (*Theropithecus gelada obscurus*, Heuglin 1863) in Abune Yoesf Zigit Community Conservation Area, northern Ethiopia

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**ABSTRACT**

*The feeding habits and preferences of gelada has been studied in different parts of Ethiopia. However, still the diet composition and preferences of the species is poorly understood because of diet composition and preference variations among its ranges. Therefore, this study*is aimed at investigating*the diet composition and preferences of southern gelada in remote unexplored Abune Yosef Zigit Community Conservation Area. Diet composition was assessed by instantaneous scan sampling within a 10-minute interval lasting for 5-minutes and feeding preferences by systematic random sampling. The data was collected for two seasons: the dry season (February 2021 to April 2021) and the wet season (June 2021 to August 2021). Sorenson's similarity index was used to compute diet similarity during both seasons. The result revealed that a mean total of 22 plants, 3 insect species and unidentified tubers were consumed by southern gelada. An average of 55.11% forbs, 41.71% graminoids, 1.61% insects and 1.59% unidentified tubers were consumed by southern gelada. The top two preferred fodder species were Festuca richardii (12.55%) and Rumex nepalensis (10.80%). Southern gelada feeding preference is significantly influenced by plant availability and utilization frequency (P≤0.05). Festuca rechardii is the most desired diet for gelada, and plantation should be supported to increase its availability.*

***Keywords/phrases:****Diet composition, Feeding, preference, southern gelada, utilization.*

**1.****INTRODUCTION**

Geladas are brown and grey-colored old-world primates endemic to Ethiopia. They are commonly distinguished by red hourglass-shaped, bald patches of skin on their chests; they are named after it as bleeding-heart primate (Bergman & Beehner, 2013). There are three sub-species of gelada, namely; *Theropithecus gelada gelada* (northern gelada), *Theropithecus gelada obscure* (southern gelada) and *Theropithecus gelada arsi* (arsi gelada) *Theropithecus gelada gelada* occurs in Gondar and Tigray provinces (Bergman & Beehner, 2013; Gippoliti et al., 2020; Girmay & Tesfay, 2021), whereas *Theropithecus gelada obscure* inhabits Wollo and Showa provinces (Abie et al., 2017; Abate and Girma, 2023). *Theropithecus gelada*arsi occurs in Arsi province, west of Bale Mountains National Park (Abu, 2018; Amera, 2019). Geladas mostly prefer afro-alpine grasslands, adjacent rocky gorges and cliffs at altitudes between 1,800 and 4,400m a.s.l. (Bergman & Beehner, 2013; Gippoliti *et al.,* 2020; Girmay & Tesfay, 2021; Teressa *et al*., 2021). The current habitats of geladas consist of montane grasslands with no tall trees and are characterized as wet and cool, but they may differ in geographic features, vegetation types and composition, and climatic conditions (Hunter, 2001).

Geladas spent time feeding on graminoids, forb leaves, forb roots, corms, unidentified food items and others. During the dry season, when grasses are dried, they prefer to eat food items like forb roots, rhizomes and bulbs (Kifle *et al*., 2013), while during the wet season, the feeding habit is covered nearly entirely by grass, which long grass blades, short grass blades and grassroots are consumed (Abie *et al.*, 2017). The Abune Yosef massif is placed on the very extreme northeastern edge of the Ethiopian highlands and defines the upper Tekeze River. Abune Yosef massif is home to diverse wild flora and fauna, including southern gelada.

Gelada population studies have been conducted in several parts of Ethiopia (Beehner *et al*., 2007; Kiflie *et al*., 2013; Girmay & Dati, 2020). However, there is no evidence of gelada’s feeding behavior at Abune Yosef Zigit Community Conservation Area. Inadequate data on the dietary diversity of geladas makes it difficult not only to identify the type of plant species consumed but also to determine seasonal variations in diet requirements. The dietary preference of geladas varies with seasonal variations (Fashing *et al*., 2014). The nutritional diversity and preferences vary greatly between sites and seasons, which urges feeding ecology studies in all localities the species inhabit. Lack of dietary data concerning different ecological zonation across seasons was also a subject of the study. Consequently, dietary data is a fundamental task in identifying the type of plant species consumed in relation to the seasonal variations. This allows wildlife managers and policymakers to decide what type of plant species they prefer and for what purpose; it makes it easy to manage and conserve geladas in the community conservation area or elsewhere. This will also lead biologists to conclude why gelada has a different dietary system over a different ecological distribution. Therefore, the aim of the study is to investigate the dietary composition and preferences of southern gelada (*Theropithecus gelada obscurus*) in Abune Yosef Zigit Community Conservation Area.

**2.****MATERIALS AND METHODS**

***2.1.******Description of the study area***

Abune Yosef Zigit Community Conservation Area (AYZCCA) is found in Amhara Regional State, in the northeast direction of the ancient holy town of Lalibela in the North Wollo zone, Lasta district (Saavendra, 2009). It is situated between 12°04'45" and 12°10'11" latitude and 39°08'24" and 39°16'45" longitude, with an altitude ranging from 3505 to 4284 meters asl. ([Figure 1](https://mc.manuscriptcentral.com/ecologyandevolution?DOWNLOAD=TRUE&PARAMS=xik_2wW45XMpu3ouXafAvf3aNYfo2Bc6fjKc52eXWm7MRRDDBEnmeWPguknHj2b33yajEw7Daz6tQc5AZvgpPHHwH1WtEg6fXXx7PoA1SjhnK1q1sd15DfFpoHbG67nR5J8EGZ5onxwzExroXLg6dwPshwJ9cEwJrwMGmhudpHJrkK4KZx3mKmZn5XMDr6cbZMC6nhfQfj65tN9weKWWweJMvLHzYtR5uW2kcGJyGC1rhztTLwnqRwJWCPzGWXB5TJYj56eV92n#_Ref139617175)). The Community Conservation Area is found at 730 km north of Addis Ababa, and about 48 km north of the historical Lalibela town. The entire area of the community conservation area is 80.59 km2(ACTPO, 2014; AZACCA, 2018). However, gelada's potential habitat in the region of AYZCCA is almost 13.09 km2 (own survey).

The community conservation area boundary is shared by the North Wollo (Lasta and Gidan districts) and Wag-Himra (Gazgibla district) zones of the Amhara National Regional State.  Abune Yosef Zigit Community Conservation Area is the seventh highest mountain in Ethiopia and Rim Gedel reaches up to 4284m a.s.l. (Kassa, 2018). It is characterized by three highest peaks: the Rim Gedel or Abune Yosef peak; 4,284m, the Big Zigit (4,080m) and the Small Zigit (4,035m) (Saavedra, 2009).  The average rainfall is about 790mm (Gebrehiwot et al., 2018), with a mean temperature of 15.3°C (Saavedra, 2009).

Abune Yosef Mountain has a high diversity of mammals, 43 species of mammals, including Ethiopian endemics such as the endangered Ethiopian Wolf (*Canis simensis*) and gelada (*Theropithecus gelada*) (Saavedra, 2009). Out of 221 bird species identified in the area (Lepage, 2006), six of them are endemic, including Yellow-fronted parrot (*Poicephalus flavifrons*) (Saavedra, 2009).

The main ecosystem types that characterize AYZCCA are afro-alpine (Friis *et al.,* 2011). The Afro-alpine ecosystem (> 3,500m) is covered with *Alchemilla, Potentilla, Helychrisum, Senecio, Carex, Poa, Festuca, Agrostis* species and the endemic giant Lobelia*(Lobelia rhynchopetalum).* In the north direction, it is dominated by grasslands (with *Poa, Agrostis, Carex, Festuca spp.*), most of them with short grasses due to heavy overgrazing. Very steep slopes and a high degree of humidity with long grasses exist only in some areas. Moderately steep and highlands of the Aremgarem is the place where the Giant lobelias (*Lobelia rhynchopetalum)* are more abundant, with densities ranging from 800 to 2500 plants per hectare (ACTPO, 2014; AZACCA, 2018).

***2.2.******Methods***

2.2.1. Preliminary survey

A reconnaissance survey was conducted for one week in February 2021 to get basic information about the study area, including gelada population size, distribution and habitat types. Based on the information collected during the survey, accessibility of the area/topography, study blocks, vegetation, fauna and gelada population occupancy in the area were recognized. The organizational arrangement of the base camp and logistic support, hiring and giving training to assistant/data collectors and purchasing field equipment were also carried out during this period.

* + 1. Sampling design

Dietary data were collected through instantaneous scan sampling from two groups of gelada (Abie *et al.,* 2017) and direct observation was used to record feeding ecology (Yihune & Bekele, 2012). The study units were distinguished from others by unique body marks/scars on the bodies of a few members of the individuals of each unit, as well as their sleeping locations (Moges, 2015). The criteria for the selection of these target groups (one from Kechin Gedel and one from Gimew Kitel) were based on group size, body marks (like colour, special features) and geographic location (easily accessible compared to others). The study unit was differentiated from others by its unique body marks at Kechin Gedel (injured/slightly cutoff hairs in the mane of the group leader adult male gelada) and relatively small group size at Gimew Kitel at their resting site.

Following Yazezew *et al*. (2011), 2.62km2 area was sampled (20% of the total area) from a total area of 13.09km2 to assess feeding preferences/vegetation survey. Transects were laid 250m away from the edge of AYZCCA following the slope of the ground, using a systematic random sampling techniques (Worku & Girma, 2020). According to the author Di-Fiore (2004), the daily foraging distance of gelada ranges from 1–2 km, but geladas will move up to 2.3 km per day, especially during the dry season, to secure their food sources in the study area (reconnaissance survey). Depending on the accessibility of the study area, the length of the transect varied between 0.4 km and 0.8 km. To avoid redundancy, spaces of around 200-500 m were left between consecutive transects (Jatani *et al*., 2019).

The first point was selected randomly; a total of six transects were established systematically with 400m intervals and 20 plots were laid within 200m intervals. The transect lines were also demarcated by painting on stagnant stones and other natural markings such as old aged giant lobelia stems, streams and basalt-erected rocks. Forage species were surveyed during both the dry and the wet seasons in each of the 20 m x 1m plots established along the line transects (Figure 2).

### Data Collections

Dietary data collections were carried out from February 2021 to April 2021 for the dry season and June 2021 to August 2021 for the wet season. The types of food items such as graminoid (grass blades, grassroots and sedge), forb leaves, forb roots, succulent fruit, tree/shrub fruit, underground forb tubers and other items (unidentified foods) were recorded (Fashing *et al.,* 2007; Abie *et al.,* 2017; Amera, 2019). During the study time, food items were recorded at every 10-minute interval between early morning hours (7:30-10:00 a.m.) and late afternoon hours (3:00-5:30 p.m.) and scans lasted for 5 minutes, following Di-Fiore (2004) and Amera (2019). Within a total of 6 months, 8 days in each month, 4 scans per hour, a total of 960 scans were recorded.

As described by Moges (2015), geladas were followed by walking gently and flowing individuals of target groups from a distance of around 10- 20m. The observer moved in the opposite direction of the wind to minimize individual disturbances and being scant by the animals (Yazezew *et al*., 2011). To collect data on dietary composition and preferences, two individuals were deployed per group of gelada: one expert and one researcher. As geladas were observed feeding, the type of food items were recorded on standardized datasheets, named by their local name, pressed and taken to the National Herbarium housed at Addis Ababa University for taxonomic identification (Kifle *et al*., 2013). All insects, spider webs and foreign substances attached to the food item specimens were thoroughly removed before placing them in the collecting bag (Seshagirirao *et al*., 2016).

The types of food items such as grass blades, forb leaves, forb roots, grassroots, grass corm, underground forb tubers and other items (unidentified foods) were recorded (Fashing *et al.,* 2007). Graminoids comprise grasses and sedges identified as blades, seeds and roots. Forbs are any seed-bearing plant that does not belong to grasses without a woody stem and dies down to the ground after flowering. Dietary preference data in terms of occurrences were obtained from 20 plots and frequency of utilization was computed from the percentage of diet composition (Fashing *et al.,* 2007; Amera, 2019). Forbs consisted of a wide variety of non-graminoid herbs (Fashing *et al*., 2014). Rhizomes were the creeping rootstalks and corms of the swollen storage organs of the graminoid (Fashing *et al*., 2014). Insects as gelada food sources were identified using a field guidebook and the researchers’ prior knowledge.

### Data Analysis

Microsoft Office Excel (V. 19) and R software (V. 4.2.2) were used to organize and analyze feeding ecology data. Mann-Whitney U tests were used to compare seasonal variations in diet composition, utilization, occurrences of diet and preference indices.

Following Kifle (2018), diet compositions were evaluated by determining the proportion of different food items consumed by geladas. The percentage of each species consumed was calculated by dividing the frequency of feeding on a single species by the total feeding record of the total species. The diet composition was calculated as follows:

Where n is the number of feeding records for item Y and N is the sum of the number of feeding records for each diet item.

The food preference indices (FPI) for each plant species consumed by gelada were calculated and ranked to determine the most preferred plants. As described by Derebe & Girma (2020), the feeding preference indexes (FPI) of gelada for each plant species were calculated by:

A multiple comparisons test was used to test the relationships between the utilization, availability and feeding preference index of consumption of different food items by southern gelada.

Sorenson's similarity (Ss’) index between the plant species consumed by southern gelada during the dry and wet seasons was calculated following (Kent & Coker, 1992; Kifle, 2018; Derebe & Girma, 2020);

where, a is the number of species consumed in both seasons, b is the number of species unique to the wet season c is the number of species unique to the dry season.

According to Ratliff (1993), Sorenson's similarity index (Ss’) is categorized as low (0-25%), moderate (26-50%), high (51-75%) and full (75-100%).

**3.****RESULTS & DISCUSSIONS**

***3.1.******Diet Composition***

A total of 761 feeding records were recorded; more feeding records were observed during the dry season (N=408) than during the wet season (N=353). Southern gelada fed a total of 25 food items; 22 plant species (six species of graminoids and 16 spp. of herbs), and three insect species, excluding unidentified tubers. Forbs accounted for the highest percentage (55.11%) of the diet composition of southern gelada followed by grasses (41.71%) and the least was unidentified tubers (1.59%). This finding is in line with Hunter (2001) at Sankaber, Fashing *et al*. (2014) at GCCA and Abu *et al*. (2017) at Indetu (Arsi), who discovered that geladas ate more forbs and graminoids. Similarly, Kifle & Bekele (2021) found that gelada ate more graminoids and forbs, while grass portions accounted for 79.6% of the diet of southern gelada in Kosheme, BSNP, while herbs represented 5.2%. This might be because local communities aggressively harvested the grasses as a source of revenue and livestock grazing is more common at Abune Yosef than in other areas. However, a small number of grasses found in cliffy places are so dry that they have a low water content, which might reduce their palatability, while grasses are scarce; they feed on forb leaves, roots, rhizomes and corms (Abu, 2018).

*Festuca simensis* (19.52 %), had the largest percentage and *Helichrysum citrispinum* (0.13%) contributed the least percentage of diet composition in the diet of southern gelada ([Table 1](https://mc.manuscriptcentral.com/ecologyandevolution?DOWNLOAD=TRUE&PARAMS=xik_2wW45XMpu3ouXafAvf3aNYfo2Bc6fjKc52eXWm7MRRDDBEnmeWPguknHj2b33yajEw7Daz6tQc5AZvgpPHHwH1WtEg6fXXx7PoA1SjhnK1q1sd15DfFpoHbG67nR5J8EGZ5onxwzExroXLg6dwPshwJ9cEwJrwMGmhudpHJrkK4KZx3mKmZn5XMDr6cbZMC6nhfQfj65tN9weKWWweJMvLHzYtR5uW2kcGJyGC1rhztTLwnqRwJWCPzGWXB5TJYj56eV92n#_Ref139618672)). In contrast, gelada consumed more than 56 plant species at Guassa Community Conservation Area (GCCA) (Fashing, 2014), 74 plant species and 3 animal species at Borena Sayint National Park (BSNP) (Kifle, 2018), 61 plant species in Arsi (Amera, 2019) and 41 plant species at Abo Gedam Church, west of Debre Birhan (Shewa) (Yazezw *et al*., 2020). All these studies reported that geladas consumed much more plants than geladas at Abune Yosef. However, Tesfaye *et al*. (2013) at Jibat Forest and Fashing *et al*. (2014) at GCCA reported that the diets of primates are often less diverse in disturbed habitats than in intact habitats. The lower proportion of the diet composition of southern gelada at Abune Yosef could be because the area had fewer plant species (i.e., only graminoids and forbs); particularly all areas were covered by an afro-alpine habitat type (>3500m a.s.l.), which is unsuitable for tree and shrub growth (Gebrehiwot *et al*., 2019). On the other side, although Abune Yosef has a steep slope and is accessible to humans, there is massive human and livestock disturbance, including intensive grazing and grass harvesting for sale and home consumption. This might also enhance food source rivalry between livestock and gelada; gelada could be forced to concentrate on a limited proportion of feed items.

Roots of both graminoids and forbs and forb rhizomes accounted for 48.84% of the diets of southern gelada, with *Trifolium acaule* accounting for the largest 8.76% root sources. The band dislodged stones and licked larvae of ants contributed 1.61% of the total diet of southern gelada.

A total of 19 and 17 species of food items were consumed during the dry season and the wet season, respectively. Mann–Whitney rank test revealed that there was no significant variation between the frequency of diet composition of plants by southern gelada (U = 156.00, N1 = 19, N2 = 17, P = 0.862) across seasons ([Table 1](https://mc.manuscriptcentral.com/ecologyandevolution?DOWNLOAD=TRUE&PARAMS=xik_2wW45XMpu3ouXafAvf3aNYfo2Bc6fjKc52eXWm7MRRDDBEnmeWPguknHj2b33yajEw7Daz6tQc5AZvgpPHHwH1WtEg6fXXx7PoA1SjhnK1q1sd15DfFpoHbG67nR5J8EGZ5onxwzExroXLg6dwPshwJ9cEwJrwMGmhudpHJrkK4KZx3mKmZn5XMDr6cbZMC6nhfQfj65tN9weKWWweJMvLHzYtR5uW2kcGJyGC1rhztTLwnqRwJWCPzGWXB5TJYj56eV92n#_Ref139618672)). Forbs were the most consumed food item during both dry (54.42%) and wet (57.04%) seasons. The highest percentages of diet composition of southern gelada comprised *Festuca simensis*(20.80 %),while *Helichrysum citripinum*(0.25%) constituted the least percentage. Southern gelada consumed underground roots regularly throughout time, much more during the dry season (65.93%) than during the wet season (22.09%). Similarly other studies reported that, unlike during the wet season, roots are consumed in a higher proportion during the dry season when above-ground biomass is reduced (Hunter, 2001; Ayalew, 2009; Fashing *et* *al*., 2014). This study is also consistent with that of Yazezew *et* *al*. (2020), who discovered that geladas at Abo Gedam Church, west of Debre Birhan, ate more tubers, leaves and roots of forbs, grass roots and animal prey like termites and ants during the dry season than during the wet season. During the dry season, the largest proportion of forbs in the diet of gelada might be associated with a variety of factors. Initially, local communities harvested grass species as an alternative source of revenue (selling) and intensive animal grazing was more popular during the dry season than the wet season. Secondly, forb leaves could be reduced during the dry season due to limited rainfall availability and the plant might mature and die out, whereas they feed roots more intensively during the dry season than the wet. Finally, forb species were more diverse than grass species in the study area.

Sorenson's similarity index of species consumed by southern gelada did not demonstrate notable similarities in the dietary species, during both seasons. There was a low diet overlap (Ss = 0.3462) of food items consumed between seasons which indicates that 34.62% of the food species were commonly shared by southern gelada in the entire season. From the overall 25 food species of southern gelada in the area, nine species were common during both the dry and the wet seasons, whespan style="font-family:'Times New Roman'">reas the other species of plants were consumed exclusively ([Table 2](https://mc.manuscriptcentral.com/ecologyandevolution?DOWNLOAD=TRUE&PARAMS=xik_2wW45XMpu3ouXafAvf3aNYfo2Bc6fjKc52eXWm7MRRDDBEnmeWPguknHj2b33yajEw7Daz6tQc5AZvgpPHHwH1WtEg6fXXx7PoA1SjhnK1q1sd15DfFpoHbG67nR5J8EGZ5onxwzExroXLg6dwPshwJ9cEwJrwMGmhudpHJrkK4KZx3mKmZn5XMDr6cbZMC6nhfQfj65tN9weKWWweJMvLHzYtR5uW2kcGJyGC1rhztTLwnqRwJWCPzGWXB5TJYj56eV92n#_Ref139618994)). The lower dietary overlap among the dry and wet seasons could be due to significant variations in availability of plant consumed, especially grass species among seasons.

***Feeding Preference***

The selection of forage species by southern gelada during the entire season is presented in ([Table 3](https://mc.manuscriptcentral.com/ecologyandevolution?DOWNLOAD=TRUE&PARAMS=xik_2wW45XMpu3ouXafAvf3aNYfo2Bc6fjKc52eXWm7MRRDDBEnmeWPguknHj2b33yajEw7Daz6tQc5AZvgpPHHwH1WtEg6fXXx7PoA1SjhnK1q1sd15DfFpoHbG67nR5J8EGZ5onxwzExroXLg6dwPshwJ9cEwJrwMGmhudpHJrkK4KZx3mKmZn5XMDr6cbZMC6nhfQfj65tN9weKWWweJMvLHzYtR5uW2kcGJyGC1rhztTLwnqRwJWCPzGWXB5TJYj56eV92n#_Ref139619327)). *Festuca richardii* (12.55%),was the most preferred, while and *Festuca abyssinica* (1.14%) was the least preferred forage species by southern gelada. According to Fashing *et al*. (2014), geladas in GCCA preferred *Festuca grass spp*. and *Trifolium spp*., which is consistent with the current finding. On the other hand, Arsi gelada prefers *Digitaria abyssinica* as a diet since it is soft and simple to digest (Moges, 2019). Because of its high protein and non-detergent fiber content, *Eremurus robustus*was the mostpreferred plant species in GCCA (Moges, 2015). Itwas probably a preferred diet in Abune Yosef because it was the only grass species that could produce both roots and blades, which might have reduced energy wasted in searching for new food items and made it easier to grasp. Forbs provided 55.84%, 63.72%, and 69.4% of the total percentage of utilization, availability, and a percentage preference ratio of southern gelada, respectively. Graminoids contributed 44.16% of the percentage of utilization, 36.28% of availability and 30.53% of the percentage preference ratio ([Table 3](https://mc.manuscriptcentral.com/ecologyandevolution?DOWNLOAD=TRUE&PARAMS=xik_2wW45XMpu3ouXafAvf3aNYfo2Bc6fjKc52eXWm7MRRDDBEnmeWPguknHj2b33yajEw7Daz6tQc5AZvgpPHHwH1WtEg6fXXx7PoA1SjhnK1q1sd15DfFpoHbG67nR5J8EGZ5onxwzExroXLg6dwPshwJ9cEwJrwMGmhudpHJrkK4KZx3mKmZn5XMDr6cbZMC6nhfQfj65tN9weKWWweJMvLHzYtR5uW2kcGJyGC1rhztTLwnqRwJWCPzGWXB5TJYj56eV92n#_Ref139619327)).

The mean feeding Preference indices were analyzed using the linear regression, and the regression function showed that FPI had a positive relationship with FU and a negative relationship with FO, and both of them were statistically significant (P <0.001). The regression function showed that the 77.53% variation in the feeding preference of southern gelada is explained by the availability and utilization frequency of a given plant species, which was statistically significant (p < 0.001). The Pearson correlation function revealed that FU and FO (r = 0.787) had a strong, positive relationship that was statistically significant (P= 0.001) ([Table 4](https://mc.manuscriptcentral.com/ecologyandevolution?DOWNLOAD=TRUE&PARAMS=xik_2wW45XMpu3ouXafAvf3aNYfo2Bc6fjKc52eXWm7MRRDDBEnmeWPguknHj2b33yajEw7Daz6tQc5AZvgpPHHwH1WtEg6fXXx7PoA1SjhnK1q1sd15DfFpoHbG67nR5J8EGZ5onxwzExroXLg6dwPshwJ9cEwJrwMGmhudpHJrkK4KZx3mKmZn5XMDr6cbZMC6nhfQfj65tN9weKWWweJMvLHzYtR5uW2kcGJyGC1rhztTLwnqRwJWCPzGWXB5TJYj56eV92n#_Ref139619391)). The Mann–Whitney rank test confirmed that there was no significant variation between the dry and wet season in the frequency of utilization (U = 55.00, N1 = 10, N2 = 12, P = 0.742), occurrences (U = 59.50, N1 = 10, N2 = 12, P = 0.974) and feeding preference indices (U = 50.00, N1 = 10, N2 = 12, P = 0.510).

During the dry season, *Rumex nepalensis* has been the most preferred forage species of southern gelada, with a percentage selection ratio of 18.99 %. While, *Festuca abyssinica*, was the least preferred forage species. In terms of feeding utilization and availability, *Festuca simensis* consistently rated first both in percentages of utilization (26.1%) and availability/occurrence (21.54%) ([Table 5](https://mc.manuscriptcentral.com/ecologyandevolution?DOWNLOAD=TRUE&PARAMS=xik_2wW45XMpu3ouXafAvf3aNYfo2Bc6fjKc52eXWm7MRRDDBEnmeWPguknHj2b33yajEw7Daz6tQc5AZvgpPHHwH1WtEg6fXXx7PoA1SjhnK1q1sd15DfFpoHbG67nR5J8EGZ5onxwzExroXLg6dwPshwJ9cEwJrwMGmhudpHJrkK4KZx3mKmZn5XMDr6cbZMC6nhfQfj65tN9weKWWweJMvLHzYtR5uW2kcGJyGC1rhztTLwnqRwJWCPzGWXB5TJYj56eV92n#_Ref139621851)). The regression function showed that the 79.07% variation in the feeding presence of southern gelada is explained by the availability and utilization frequency of a given plant species, which was statistically significant (p < 0.001). The correlation function showed that FU and FO (r = 0.759) had a strong relationship and was statistically significant (p < 0.011) ([Table 4](https://mc.manuscriptcentral.com/ecologyandevolution?DOWNLOAD=TRUE&PARAMS=xik_2wW45XMpu3ouXafAvf3aNYfo2Bc6fjKc52eXWm7MRRDDBEnmeWPguknHj2b33yajEw7Daz6tQc5AZvgpPHHwH1WtEg6fXXx7PoA1SjhnK1q1sd15DfFpoHbG67nR5J8EGZ5onxwzExroXLg6dwPshwJ9cEwJrwMGmhudpHJrkK4KZx3mKmZn5XMDr6cbZMC6nhfQfj65tN9weKWWweJMvLHzYtR5uW2kcGJyGC1rhztTLwnqRwJWCPzGWXB5TJYj56eV92n#_Ref139619391)).

During the wet season, *Thymus schimperi*(13.78%) was the most preferred forage species, while *Bidens macroptera* (1.79%) had a lower percentage preference ratio ([Table 5](https://mc.manuscriptcentral.com/ecologyandevolution?DOWNLOAD=TRUE&PARAMS=xik_2wW45XMpu3ouXafAvf3aNYfo2Bc6fjKc52eXWm7MRRDDBEnmeWPguknHj2b33yajEw7Daz6tQc5AZvgpPHHwH1WtEg6fXXx7PoA1SjhnK1q1sd15DfFpoHbG67nR5J8EGZ5onxwzExroXLg6dwPshwJ9cEwJrwMGmhudpHJrkK4KZx3mKmZn5XMDr6cbZMC6nhfQfj65tN9weKWWweJMvLHzYtR5uW2kcGJyGC1rhztTLwnqRwJWCPzGWXB5TJYj56eV92n#_Ref139621851)). The regression function showed that the 90.27% variation is in the feeding presences of southern gelada is explained by the availability and utilization frequency of a given plant species, which was statistically significant (p >0.05). Correlation function of FU and FO had a weak (r = 0.348) relationship, and was statistically insignificant (p >0.05). This result showed that southern gelada has not consumed all the plants that are found in the area ([Table 4](https://mc.manuscriptcentral.com/ecologyandevolution?DOWNLOAD=TRUE&PARAMS=xik_2wW45XMpu3ouXafAvf3aNYfo2Bc6fjKc52eXWm7MRRDDBEnmeWPguknHj2b33yajEw7Daz6tQc5AZvgpPHHwH1WtEg6fXXx7PoA1SjhnK1q1sd15DfFpoHbG67nR5J8EGZ5onxwzExroXLg6dwPshwJ9cEwJrwMGmhudpHJrkK4KZx3mKmZn5XMDr6cbZMC6nhfQfj65tN9weKWWweJMvLHzYtR5uW2kcGJyGC1rhztTLwnqRwJWCPzGWXB5TJYj56eV92n#_Ref139619391)).

**4.****CONCLUSION AND RECOMMENDATIONS**

Southern gelada favor cliffy areas for resting at night and open *Festuca*-dominated grassland for foraging at Abune Yosef Zigit Community Conservation Locations. They consume more plant species and spent more time looking for food remnants during the dry season than during the wet season. Furthermore, southern gelada ate grass blades, grass roots, forb leaves, forb rhizomes, forb roots, forb stems and forb flowers, forb fruits and forb young shoots. Graminoids and forbs were the most prevalent forage species consumed by southern gelada, with forb flowers and fruits consumed by just a few plant species. It indicates that gelada is an opportunistic graminivore rather than an obligatory graminivore. *Festuca richardii*and*Rumex nepalnesis* were the most preferred forage species of southern gelada in the area, while *Bidens macroptera* was the least preferred. Thus, *Festuca richardii*and*Rumex nepalnesis*were suggested to have more nutritive value than other diet items. As a result, *Festuca richardii* and *Rumex nepalnesis* were proposed to have a higher nutritional value than other food items.

*Festuca richardii* was the most preferred forage species of southern gelada in the area. However, it was widely harvested by local populations as a source of income and for animal grazing. As a result, local inhabitants should be encouraged to diversify their animal feed sources to reduce their dependency on and intensity of grazing in the area. *Festuca rechardii* plantation should be supported if necessary to increase its availability in the area because it is the most desired diet for southern gelada.

**CONFLIC T OF INTERE S TS**

We, the authors, declare that we have no conflicts of interest with the research, writing, and/or publishing of this paper.

**AUTHOR CONTRIBUTION**

The authors confirmed contribution to the paper as follows: Setie Ewnetu; conceptualization and design of the study, data collecting, analysis and interpretation, and writing of the draft manuscript: Zerihun Girma; intense supervision, draft manuscript production, and follow up of this paper's development. We evaluated the findings and approved the final paper version.

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**DATA AVAILABILITY STATEMENT**

The data that support the findings of this study will be archived at Zenodo data repository after acceptance of the manuscript. The data is uploaded as supplementary material in the manuscript submission system.

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List of figures

Figure 1. Location map of Abune Yosef Zigit Community Conservation Area.

Figure 2. Sampling plots for the vegetation survey (feeding preferences).

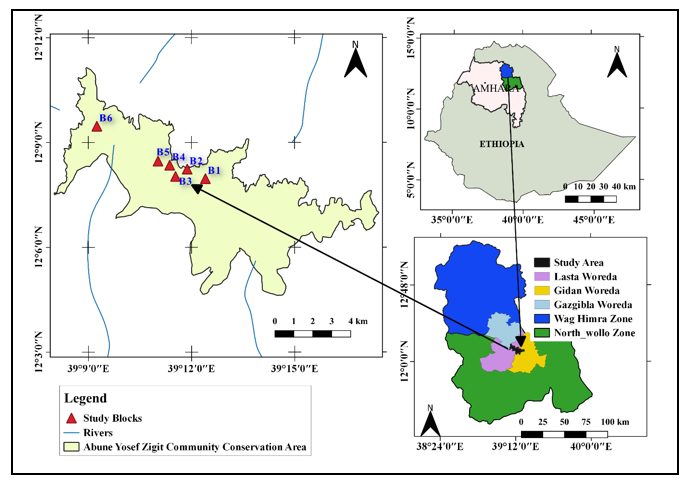


Figure 1. Location map of Abune Yosef Zigit Community Conservation Area (Ewnetu, 2022)

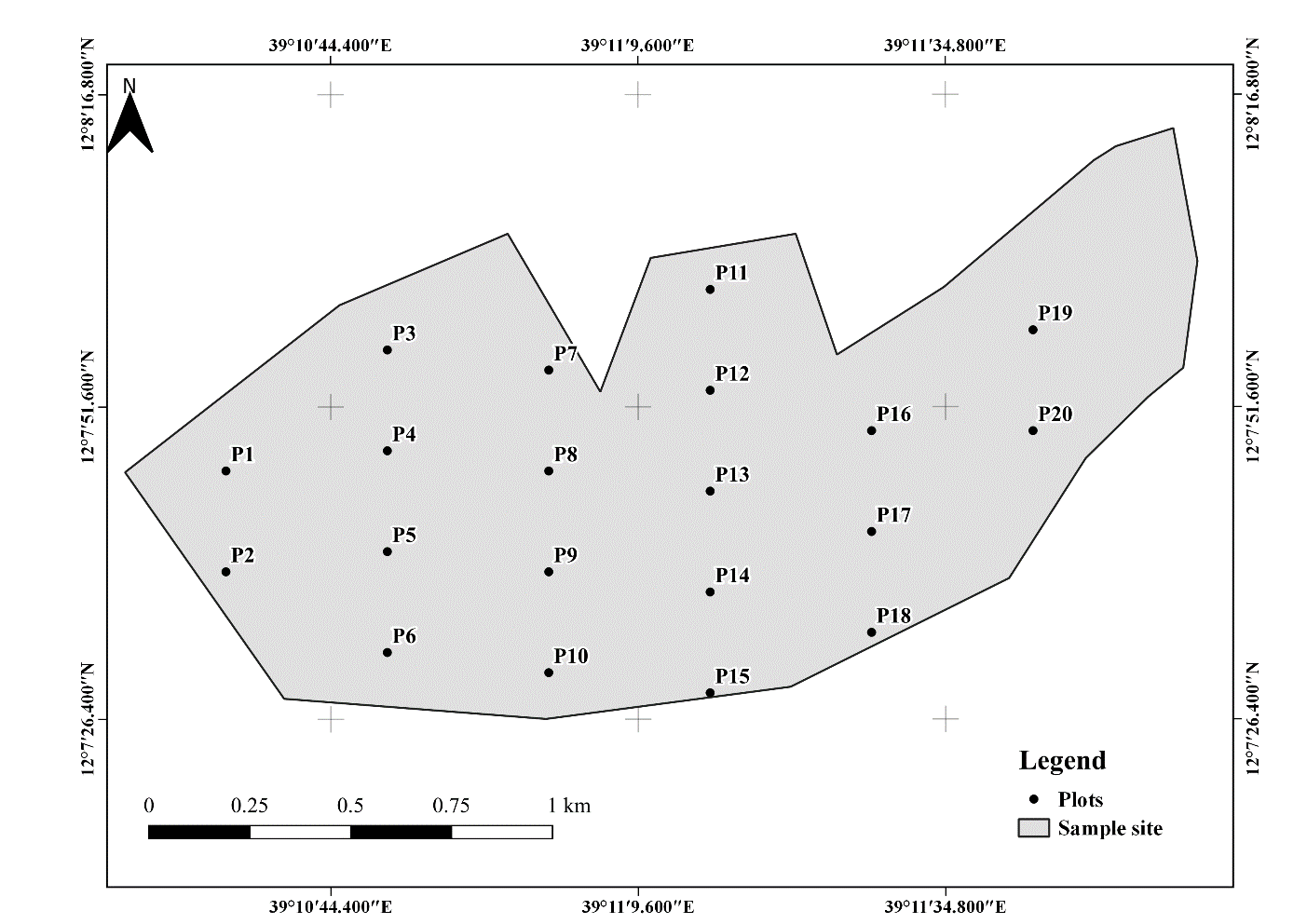


Figure 2. Sampling plots for the vegetation survey (feeding preferences) (Ewnetu, 2022).

Table 1. Diet composition of southern gelada during the dry season and the wet season.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Family | Scientific Name | Local Name (Amharic) | Edible Parts | Type | Frequency (%) | | |
| Dry | Wet | Mean |
| Aizoaceae | *Delosperma abyssinica* | Yelam tut | RT | F | 7.11 | 8.21 | 7.66 |
| Asphodelaceae | *Kniphofia foliosa* | Ashendye | RT, ST | F | 2.23 | 5.95 | 4.09 |
| Asteraceae | *Haplocarpha schimperi* | Getin | RH | F | 6.62 | 3.68 | 5.15 |
| Asteraceae | *Carduus schimperi* | Dendero | RT | F | 3.92 | 0 | 1.96 |
| Asteraceae | *Echinops macrochaetus* | Kushele | FR | F | 0.49 | 0 | 0.25 |
| Asteraceae | *Helichrysum citrispinum* | Tonchi | FL | F | 0.25 | 0 | 0.13 |
| Asteraceae | *Bidens macroptera* | Adey Abeba | LV, FL | F | 0 | 1.89 | 0.71 |
| Asteraceae | *Senecioschultzii* | Koilo | FL | F | 0 | 1.13 | 0.57 |
| Campanulaceae | *Lobelia rhynchopetalum* | Jibera | YS, ST | F | 10.29 | 3.12 | 6.71 |
| Cypreae | *Cyperus bulbosus* | Yezenejoro-Kolo | GB | G | 0 | 5.95 | 2.98 |
| Fabaceae | *Trifolium acaule* | Chemekote | RT | F | 8.33 | 8.78 | 8.56 |
| Formicidae | *Pogonomyrmex barbatus* | Kunchach | LR | I | 1.23 | 0 | 0.62 |
| Lamiaceae | *Thymus schimperi* | Tosign | L | F | 3.92 | 12.46 | 8.19 |
| Lamiaceae | *Salvia tiliifolia* | Yezenjoro Zekakibe | LV | F | 0 | 3.12 | 1.56 |
| Lepidoptera | *--------* | Caterpillar | I | I | 0 | 0.85 | 0.43 |
| Poaceae | *Festuca simensis* | Guassa/lisha | GB | G | 18.63 | 20.40 | 19.52 |
| Poaceae | *Festuca richardii* | Key sar | GB, GR | G | 13.24 | 14.16 | 13.70 |
| Poaceae | *Pennisetum mezianum* | Kirtan | GB, GR | G | 5.64 | 0 | 2.82 |
| Poaceae | *Festuca macrophylla* | Chima | GB | G | 3.43 | 0 | 1.72 |
| Poaceae | *Festuca abyssinica* | Kundo chima | GR | G | 1.96 | 0 | 0.98 |
| Polygonaceae | *Rumex nepalensis* | Tult | RT | F | 5.15 | 5.48 | 5.32 |
| Polygonaceae | *Rumex abyssinicus* | Mekmeko | RT, ST | F | 3.43 | 0 | 4.17 |
| Scrophulariaceae | *Hebenstretia angolensis* | Wetet matebia | LV | F | 0 | 1.98 | 0.99 |
| Termitidae | *Macrotermes carbonarius* | Kiremt Agba | I | I | 0 | 1.13 | 0.57 |
| Utricaceae | *Utrica simensis* | Sama | RT | F | 2.70 | 0 | 1.35 |
| ------- | ------- | Others | UT | UT | 1.47 | 1.70 | 1.59 |

*Grasses = G, Forbs = F, Insects = I, Grass Blades= GB, Grass Roots= GR, Forb Flowers=FL, Forb Fruits= FR, Forb Roots= RT, Forb Rhizomes= RH, Forb Leaves= LV, Forb Stems= ST, Forb Young Shoots= YS, Unidentified Tubers = UT*

Table 2. Common diets of southern gelada during the dry and the wet season

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| No | Family | Scientific name | Amharic Name | Season | Items |
| 1 | Aizoaceae | *Delosperma abyssinica* | Yelam Tut | Both | Forb |
| 2 | Asphodelaceae | *Kniphofia foliosa* | Ashendye | Both | Forb |
| 3 | Asteraceae | *Haplocarpha schimperi* | Getin | Both | Forb |
| 4 | Campanulaceae | *Lobelia rhynchopetalum* | Jibera | Both | Forb |
| 5 | Fabaceae | *Trifolium acaule* | Chemekote | Both | Forb |
| 6 | Lamiaceae | *Thymus schimperi* | Tosign | Both | Forb |
| 7 | Poaceae | *Festuca richardii* | Key sar | Both | Grass |
| 8 | Poaceae | *Festuca simensis* | Guassa/lisha | Both | Grass |
| 9 | Polygonaceae | *Rumex nepalensis* | Tult | Both | Forb |

*Grasses = G, Forbs = F, Insects = I, Grass Blades= GB, Grass Roots= GR, Forb Flowers=FL, Forb Fruits= FR, Forb Roots= RT, Forb Rhizomes= RH, Forb Leaves= LV, Forb Stems= ST, Forb Young Shoots= YS, Unidentified Tubers = UT*

Table 3. Mean feeding preference indices of southern gelada during the entire season.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| No | Plant Spp. | FU% | Rank | FO % | Rank | FPI | FPI% | Rank |
| 1 | *Festuca richardii* | 15.93 | 2 | 9.10 | 5 | 1.75 | 12.55 | 1 |
| 2 | *Rumex nepalnesis* | 6.18 | 8 | 4.10 | 9 | 1.51 | 10.80 | 2 |
| 3 | *Thymus schimperi* | 9.16 | 4 | 6.15 | 6 | 1.49 | 10.67 | 3 |
| 4 | *Festuca simensis* | 24.05 | 1 | 17.82 | 1 | 1.35 | 9.68 | 4 |
| 5 | *Delosperma abyssinica* | 7.49 | 6 | 5.64 | 7 | 1.33 | 9.52 | 5 |
| 6 | *Utrica simensis* | 1.70 | 10 | 1.54 | 12 | 1.10 | 7.90 | 6 |
| 7 | *Trifolium acaule* | 9.95 | 3 | 9.87 | 4 | 1.01 | 7.23 | 7 |
| 8 | *Cyperus bulbosus* | 3.20 | 9 | 3.21 | 10 | 1.00 | 7.16 | 8 |
| 9 | *Kniphofia foliosa* | 3.20 | 9 | 3.21 | 10 | 1.00 | 7.16 | 8 |
| 10 | *Salvia tiliifolia* | 1.68 | 11 | 1.92 | 11 | 0.87 | 6.26 | 9 |
| 11 | *Haplocarpha schimperi* | 7.32 | 7 | 12.05 | 3 | 0.61 | 4.35 | 10 |
| 12 | *Lobelia rhynchopetalum* | 8.14 | 5 | 14.74 | 2 | 0.55 | 3.96 | 11 |
| 13 | *Bidens macroptera* | 1.02 | 12 | 4.49 | 8 | 0.23 | 1.62 | 12 |
| 14 | *Festuca abyssinica* | 0.98 | 13 | 6.15 | 6 | 0.16 | 1.14 | 13 |

*Frequency of Usage = FU, Frequency of Occurrence = FO, Feeding Preference Indices = FPI*

Table 4. Relationships between FU, FO and FPI

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Correlations** | | | | | | | | | |
|  | | **Dry Season** | | | **Wet Season** | | **Entire Season** | | |
| FU | FO | | FU | FO | FU | | FO |
| FU | Pearson Correlation | | 1 | 0.759\* | | 1 | 0.348 | 1 | | 0.787 |
| P-value | |  | 0.011 | |  | 0.268 |  | | 0.001\*\* |
| FO | Pearson Correlation | | 0.759\* | 1 | | 0.348 | 1 | 0.787 | | 1 |
| P-value | | 0.011 |  | | 0.268 |  | 0.001\*\* | |  |
|  | **Regression Function** | | | | | | | | | |
| Season | | **Co-efficient** | | | | | | | **R2 (adj.)** | |
| FU | | | FO | | | |  | |
| Dry Season | | 0.857 | | | -1.073 | | | | 79.24 | |
| 0.001\*\* | | | 0.001\*\* | | | |  | |
| Wet Season | | 0.742 | | | -0.809 | | | | 90.27 | |
| 0.001\*\* | | | 0.001\*\* | | | |  | |
| Entire Season | | 0.774 | | | -0.789 | | | | 77.53 | |
| 0.001\*\* | | | 0.001\*\* | | | |  | |

*\*\*. Correlation is significant at 0.01,*

*\*. correlation significant at 0.05*

*(Frequency of Usage/Utilization = FU, Frequency of Occurrence/Availability = FO, Feeding Preference Indices = FPI).*

Table 5. Feeding preference indices of plant species consumed by southern gelada based on consumption and availability during the dry and the wet season

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **No** | **Scientific Name** | **Dry season** | | | | | | | **Wet season** | | | | | | | |
| FU | Rank | FO | Rank | FPI | FPI% | Rank | FU | Rank | FO | Rank | FPI | FPI% | Rank |
| 1 | *Rumex nepalnesis* | 6.45 | 6 | 3.08 | 9 | 2.1 | 18.99 | 1 | 5.88 | 7 | 5.13 | 7 | 1.15 | 9.09 | 5 |
| 2 | *Festuca richardii* | 16.59 | 2 | 9.23 | 6 | 1.8 | 16.28 | 2 | 15.19 | 2 | 8.97 | 3 | 1.69 | 13.43 | 3 |
| 3 | *Festuca simensis* | 26.1 | 1 | 21.54 | 1 | 1.21 | 10.97 | 3 | 21.89 | 1 | 14.10 | 1 | 1.55 | 12.31 | 4 |
| 4 | *Utrica simensis* | 3.38 | 9 | 3.08 | 9 | 1.1 | 9.96 | 4 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| 5 | *Thymus schimperi* | 4.91 | 8 | 4.62 | 8 | 1.06 | 9.64 | 5 | 13.37 | 3 | 7.69 | 4 | 1.74 | 13.78 | 1 |
| 6 | *Delosperma abyssinica* | 6.14 | 7 | 6.15 | 7 | 1 | 9.04 | 6 | 8.81 | 5 | 5.13 | 7 | 1.72 | 13.62 | 2 |
| 7 | *Trifolium acaule* | 10.44 | 5 | 10.77 | 5 | 0.97 | 8.78 | 7 | 9.42 | 4 | 8.97 | 3 | 1.05 | 8.33 | 6 |
| 8 | *Lobelia rhynchopetalum* | 12.89 | 3 | 15.38 | 2 | 0.84 | 7.59 | 8 | 3.35 | 9 | 14.10 | 1 | 0.24 | 1.88 | 10 |
| 9 | *Haplocarpha schimperi* | 10.65 | 4 | 13.85 | 3 | 0.77 | 6.97 | 9 | 3.95 | 8 | 10.26 | 2 | 0.38 | 3.05 | 9 |
| 10 | *Festuca abyssinica* | 2.46 | 10 | 12.31 | 4 | 0.2 | 1.81 | 10 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| 11 | *Kniphofia foliosa* | ---- | ---- | ---- | ---- | ---- | ---- | ---- | 6.38 | 6 | 7.23 | 5 | 1 | 7.9 | 7 |
| 12 | *Cyperus bulbosus* | ---- | ---- | ---- | ---- | ---- | ---- | ---- | 6.38 | 6 | 6.41 | 6 | 1 | 7.9 | 7 |
| 13 | *Salvia tiliifolia* | ---- | ---- | ---- | ---- | ---- | ---- | ---- | 3.35 | 9 | 3.85 | 8 | 0.87 | 6.9 | 8 |
| 14 | *Bidens macroptera* | ---- | ---- | ---- | ---- | ---- | ---- | ---- | 2.03 | 10 | 8.97 | 3 | 0.23 | 1.79 | 11 |

*Frequency of Usage= FU, Frequency of Occurrences= FO, Feeding preference indices= FPI*