**DIURINAL ACTIVITY PATTERNS AND FEEDING HABITS OF GRIVET MONKEY (*Chlorocebus aethiop aethiops)* IN WONDO GENET COLLEGE OF FORESTRY AND NATURAL RESOURCE, SOUTHERN ETHIOPIA**

**Chalachew Alemneh****1;** **Zerihun Girma2**

1Department of wildlife and ecotourism management, Wolkite University, Wolkite, Ethiopia. **Email**:alemnehc899@gmail.com

**Phone No**:+25192829177

2Department of Wildlife and Protected Area Management, Hawassa University, Hawassa, Ethiopia. **Email**: zeru75@yahoo.com.

**Phone No;**+251922127083

**ABSTRACT**

*The Grivet monkey (Chlorocebus aethiop aethiops) is an old-world primate Monkey species distributed on the east of the White Nile in Sudan to Ethiopia, Eritrea, and Djibouti*. *The study on activity patterns and feeding habits of Grivet Monkeys in and around Wondo Genet College of Forestry and Natural Resource was carried out from February 2021 to August 2022 during both the wet and dry season. Instantaneous scan sampling method was used at 15-min intervals for up to 10 minutes duration.* *During each scan, individuals were recorded as performing one of the following activities: feeding, moving, resting, grooming, playing, and others. Descriptive statistics and inferential statistics such as One-way ANOVA, Kruskal Wallis test, and Mann-Whitney U-test were used to analyze data.On average, the greatest proportion of the activity time budget of the grivet monkey was devoted to feeding (29.5±0.6%), followed by resting (27±0.8%), moving (26±0.2%), grooming (9±0.2%), playing (5.5±0.6%) and the least time spent on other social activities (3±0.2%). They feed 42 food sources grouped into 41 plant species and one insect. On average, the forb of leaf 32±3.2% comprised the highest percent proportion of their diet, whereas, roots (0.3±0.2%) and insects (0.5±0.4%) comprised the least. Psidium guava was the top preferred plant species and Callistemon linearis was the least preferred plant species by the grivet monkey. Due to the existence of low quality of food in human dominated area, Grivet monkey most of their time spent on feeding activity. Therefore, concerned body and regional governments need to take action to stop deforestation of the natural forests and sustainable management must be needed for the top preferred plant species.*

**Keywords/ Phrase:** Activity, Behavior, Proximate analysis, Time budget.

## INTRODUCTION

Primates are charismatic mammals found in many parts of the world’s tropical forests (Fashing et al., 2012). In Ethiopia, there exist more than 13 species of primates excluding *Homoe sapiens* (Bekele &Yalden, 2013). Activity budgets of primates are commonly related to strategies of energy gained and other factors of a predator or human pressure; season, distribution, social structure, availability, and quality of food resources (Yazezew et al.,2020). Due to the exponential growth of human populations, some wild animals live in habitats that are changed to some extent by anthropogenic activities (Tilman et al.*,* 2017). In a human-dominated landscape, primate species had been sharing food resources with local people (Kifle &Bekele, 2021).

For instance, in 1977, 13% of the Wondo Genet Catchment was under natural forest, but in 2000 it was reduced to 2%, vegetation cover decreased from 36% to 24% and the area for cultivation and settlement had increased from 55% in 1977 to 65% in 2000. The day-to-day forest has severely declined and reduced from a 16% catchment land base to 2.8% within the past three decades alone, due to the expansion of agricultural activity, commercial farms, and logging (Kebede et al., 2013). As a result, wildlife species are forced to occupy modified habitats, which are small habitat patches surrounded by human-dominated landscapes (Girma et al*.,* 2012).

Understanding the feeding ecology of animals in human-dominated habitats will contribute to understanding how changing environments shape primate ecology and evolution (Jarvey *et al.,* 2018; Kifle and Bekele, 2021) and their capacity to coexist in the long term with their human neighbors

The Grivet monkey *(Chlorocebus aethiops aethiops*) is an old-world monkey and has long white tufts of hair around the side of the face with long hind limbs (Groves, 2005; Yibalu, 2019; Butynski & De Jong, 2022). They are highly distributed in Ethiopia, Sudan, Eritrea, Djibouti, and Senegal (Yibalu, 2019; Butynski & De Jong, 2022). Its opportunity omnivores and) and extremely adaptable in both rural and urban environments (Butynski & De Jong, 2022).

Activity patterns and feeding habits of grivets were only studied in the natural forests (Yibelu, 2019) and studies in a human-modified landscape are scant. All authors studied the feeding preferences of plants without justifying why they prefer a particular item over another using proximate analysis (Yitayihet al., 2021). So, the aim is to investigate the daily activity patterns, diet composition and preferences of grivet monkeys in the study area and to fill the above-mentioned gaps in and around the Wondo Genet College of Forestry and Natural Resources.

# 2. MATERIALS AND METHODOLOGY

## 2.1 Description of Study Area

The study area was conducted in Wondo Genet College of Forestry and Natural Resources (WGCFNR) in Sidama National Region State in the southern part of Ethiopia. It is located about 264 km south of the capital, Addis Ababa, and 24 km east of Hawassa town, the capital of the region (WGWA, 2009). The study area is geographically situated between 38036’30’’ and 380 39’30’’E longitudes and 705’30’’ and706’30’’ N latitudes (Figure -**1**). The altitudinal elevation of the area ranges from 1778 to 2670masl (Girma et al., 2017). Wondo Genet College of Forestry and Natural Resources has humid montane climates (Zerihun et al., 2012). The mean annual temperature varies between 17 and 19 0c and the mean annual rainfall is about 1200 mm( Kebede et al., 2013).

The vegetation type of Wondo Genet College of Forestry and Natural Resource is moist evergreen afromontane forests (Kebede et al., 2013). The forest is home to diverse large wild mammals such as the olive baboon (*Papio anubis*), grivet monkey (*Cercopithecus aethiops*), Menelik bushbuck (*Tragelaphus scriptus meneliki*), common duiker (*Sylivica pragrmmia*), serval cat (*Leptailurus serval*), civet (*Civettictis civetta*) and colobus monkey (*Colobus gureza*) (Zerihun et al., 2012). The Forest is also home to 137 bird species, out of those 1 is endemic; Yellow-fronted parrot (*Poicephalus flavifrons)* and 6 are near-endemic.

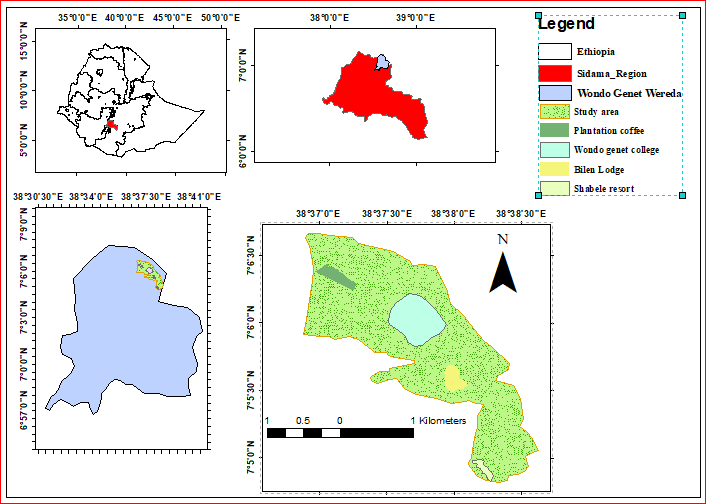


Figure 1.Location map of the study area (Source using QGIS , 2022).

## 2.2. Methods

### 2.2.1 Preliminary survey;

A preliminary survey was conducted during the last week of January 2022 for seven days. During this period the distribution of Grivet monkeys in the area was assessed as well as groups of Grivet monkeys for behavioral studies were identified. In addition, information about the habitats, weather conditions, accessibility, fauna, flora, and topography of the study area was gathered.

### 2.2.2 Data collection

### 2.2.3 Activity pattern

Data collection was conducted between February 2022 to September 2022 including both wet and dry seasons. The daily data collection (scanning) period was divided into three sessions: morning (07:00–9:30 h), mid-day (12:00–14:00 h), and afternoon (15:00–17:30 h) when the animals were most active and had good visibility (Mamo & Wube, 2019). The activity recorded for each individual was the first activity that lasts for ≥5sec once grivets come into view (Ibrahim et al., 2017). For each activity, the instantaneous scan sampling method was used (Altman, 1974) at 15-min intervals for up to 10 minutes duration for 7 hours. The total months of observation were 4 months (2 months for the dry; February –March and 2 months for the wet season; June-July). For each month 15 days were sampled (during the entire study period (Yazezew et al., 2020).

The five individual activities of each group were observed as; male-female adults, sub-adult male-female, juveniles and infants excluded from scan sampling (Ibrahim et al., 2017; Kifle and Bekele, 2021). Identification of age and sex was carried out using morphological characteristics such as body size, external genitalia (Ejigu & Bekele, 2010). During scan sampling, individuals' observations were recorded as performing one of the following behavioral activities: feeding, moving, resting, playing, aggression, grooming, sexual activity, and others such as drinking, vocalization and defecation (Mekonnen et al.*,* 2010; Abie et al., 2017).

### 2.2.4 Feeding habits

Instantaneous scan sampling was used to observe. Grivet feeding at 15-minute intervals for up to 10 min duration (Altman, 1974). During scans, the type of food item and species name (Mekonnen et al., 2010; Ibrahim et al*.*, 2017) were recorded on a standardized data sheet. Feeding data from the first 3 random individuals (adults male-female and juveniles but not from infants) were collected (Kifle & Bekele, 2021) in order of occurrence from left to right that avoids possible biases toward eye-catching activities, recording the first feeding activity they engage in that last ≥3s (Fashing et al., 2014). The food item was categorized as grasses (buds), herbs (leaves, flowers, roots), shrubs (flowers, stems, fruits, or leaves), trees (fruits, leaf, seeds, or gums), invertebrates (ants), as well as crops (fruits, seed, or others) (Kifle &Bekele, 2021). During scan sampling, foraging activities on different food items available within the garbage, especially fruits (banana, avocado, and mango) and others (Ejigu & Bekele, 2010) were recorded. The feeding behavior of the Grivet monkey was investigated using binoculars (Nikon 10×506.5) and with the naked eye, depending on the distance between the Grivet feeding place and the observer (Abie et al., 2017). All plant species consumed by the Grivet monkey were identified by taking parts of plants and merging them on the bag and went to the taxonomic identification of herbarium in the Wondo Genet College.

Proximate analysis is the analysis of foods and feeding stuff for nitrogen (protein); crude fiber and ash (mineral salts); together with soluble carbohydrates (Olaleru, 2017). The proximate analysis was carried out at WGCFNR and the College of Agriculture laboratories at Hawassa University. All samples were stored in paper bags labeled with the date, food type name, and name of a plant, and maintained in a dry place with a silica desiccant until phytochemical analyses were performed. Appropriate samples representing the level of preference (high, medium, low, or avoided) of grivet consumption throughout the study seasons were included in the proximate analysis. Only wet season data was used to test the forage quality of grivet monkeys and the seasonal variation was not tested (Derebe & Girma, 2020).

## 2.3 Data Analysis

The data were analyzed using SPSS software for Windows Version 20. Descriptive statistics such as tables, percentages, figures, graphs, and charts were used to analyze data. Microsoft Excel 2010 was used for data summarization and to elaborate results into tables and figures ( (Derebe and Girma, 2020). One-way ANOVA, Kruskal Wallis test and Mann Whitney U-test (Mekonnen et al., 2010) were used.

According to Derebe and Girma (2020) feeding preference index was calculated by the following equations;

-------------------------------eq (1)

\*100--eq(2)

--------------------------------eq(3)

Sorenson's similarity (Ss) index between the plant species consumed by a monkey during the wet and dry seasons was calculated by the following formula (Derebe & Girma, 2020); Where = Sorenson's similarity, *s*= number of species consumed in both seasons, *b* = number of species unique to wet season *c* = number of species unique to dry season. Sorenson's similarity index (Ss’) has been categorized as low (0-25%), moderate (26-50%), high (51-75%) and extremely high (75-100%) (Ratliff, 1993).

Proximate analysis; According to AOAC (1995), the percentage values of all the proximate analyses were calculated by the following Equations 1(7);

Determination of Moisture content

%M ………………………………………………… equ1 (Method 930.04)

Where; %*M* = percentage of Moisture, *W*bd = wt of sample + dish before drying, *W*ad = wt of sample + dish after drying, *W*s = Wt of sample taken.

Determination of Dry Matter

Percentage of dry matter, = 100- the percentage of Moisture…………...eq2 (Method 2001.2)

Determination of Ash

…….. ………………………………………. equ3 (Method 942.05);

Where; *W*a = Weigh ignited crucible + sample, *W*t = Weight oven-dry crucible, *W*0 = (Weight oven-dry crucible + sample),

Organic matter determination

Percentage of Organic matter(%OM) =100-%Ash………………………equ4 (Method967.05)

Determination of Crude Protein

………………………………………equ5 (AOAC, 1990)

Where V = Volume of HCl required to reach the endpoint. Protein factor= 6.25.W = Weight of sample used (g). The 6.25 factor was used to estimate crude protein in the samples by multiplying the amount ofnitrogen because many plants and animal proteins are known to contain on average 16% nitrogen (Mijanur *&* Rakhimov, 2019).

Detergent Fiber Determination of Neutral

------------------ (Method 2002.04)

Where; %NDF = percentage of Neutral detergent fiber

Determination of Acid detergent fiber

-----------------------equ7(method973.18)

Where; %ADF= Percentage of Acid detergent fiber.

# 3. RESULTS

# 3.1. Activity Budget

The total direct observation time with the grivets encountered was 210 hours out of 420-hour samples. Hourly, the greatest proportion of the activity time budget of the grivet monkey was devoted to feeding 61.5h, followed by resting 56.3h, moving 54.8h, grooming 18.8h, playing 12h and others 6.6h. Statistically, there was a significant difference between the frequency of time budgets for each different activity feeding, resting, moving, grooming, playing and other social activities (mating, calling, courtship, defecation and aggregation) (F=185.355, df=5, p=0.000≤0.05).

Grivet monkeys spent most of their time feeding and resting during the dry season 32%, and 30% than the wet season 27%, and 24% respectively. However, more time was spent moving, grooming, playing and other behavior 27%, 10%, 8%, and 4% in the wet season than dry season 25%, 8%, 3% and 2% respectively (Fig-2). There was a significant difference in feeding (U=283.500, P=0.014), resting (U=229.500, P=0.001) and playing (U=162.500, P=0.000) were statistically different between seasons. However, the time allocated for moving (U=393.500, P=0.403), grooming (U=425.000, P=0.711) and other behaviors like; mating, suckling aggregations and calling (U=330.500, P=0.076) did not show a significant variation among season.

**Figure 2**. Time budget proportion allocated for dominant behavior displayed in both seasons.

In the **figure-3** bellow depicts the trend of each activity during the day. Feeding activity was high in the morning and drooped towards noon during the entire season. Resting was high in the noon from 11-12:00 a.m., to 13-13:30 p.m. and declined towards the evening lowest from 16-17:00 p.m. The percentage of moving activity was highest in the morning peaking 8-9:00 a.m. and then declined towards noon starting from 11-12:00 a.m. to 13-13:30 p.m. During the dry season, grooming activity was low in the morning from 7-8:00 a.m. to 9-9:30 a.m., but peaked towards noon and evening. During the wet season, playing was low in the morning starting from 7:00 a.m. to 9:30a.m and increased towards noon and evening (from 12:00 a.m. to 17:30 p.m.), which were nearly consistent throughout the season. Other activities (mating, suckling, defecation, and calling) were almost fairly uniform throughout the day during the entire season. Thus, feeding (F=7.275, df=2, P=0.002), resting (F=7.128, df=2, P=0.002), and moving (F=3.239, df=2, P=0.049) were significant differences in grivet monkeys' daily time sessions during the complete seasons (p≤0.05). Grooming (F= 2.708, df=2, P= 0.078), playing (F= 0.504, df=2, P= 0.608), and other (F= 0.785, df=2, P=0.463) activities, on the other hand, did not differ significantly between daily time sessions.

**Figure 3.** Dominant behaviour diurnal activity pattern of grivet during the both seasons

The adult male and sub-adult males devote much of their time to resting 77.55h, 76.3h and less time playing 8.3h and 7.25h others respectively. However, adult females and sub-adult females spent more time feeding 71.4h, 64.65h and less time on other infrequent activities 6.5h, 6.25h (occasional activities like; mating, suckling and calling) respectively during the overall study period. The juvenile spent relatively more time feeding 72.5h compared to other individuals and the least time on the other activities 4.7h (**table-1**). There was a significant variation in the time allocated among age-sex categories on the feeding (H=21.354, Df=4,P=0.000), resting (H=53.635, Df=4,P=0.000), moving (H=13.989, Df=4,P=0.007), grooming (H=38.384, Df=4, P=0.000)and playing (H=76.867, Df=4, P=0.000), except for other minor social activities (H=8.488, Df=4, P=0.75≥0.05).

**Table 1.** Time allocated for dominant behaviors displayed among different age-sex categories.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Age-sex | Mean of activity (hours) | | | | | |
| Feeding | Resting | Moving | Grooming | Playing | Others |
| Adult male | 48.2 | 77.55 | 46.2 | 19.85 | 8.3 | 9.9 |
| Sub-adult male | 51.55 | 76.3 | 46.25 | 16.3 | 12.35 | 7.25 |
| Adult female | 71.4 | 48.9 | 54.9 | 21.45 | 6.85 | 6.5 |
| Sub-adult female | 64.65 | 45.6 | 61.45 | 25 | 7.05 | 6.25 |
| Juvenile | 72.5 | 29.8 | 61.75 | 12.5 | 28.75 | 4.7 |
| M±SE | 61.7±5.1 | 55.6±9.3 | 54.1±3.4 | 19.02±2.1 | 12.7±4.1 | 6.9±0.8 |

*Others (mating, suckling, calling and aggregation), M± SE = Mean standard error*

## 3.2. Feeding habits

### 3.2.1 Diet composition

A total of 1598 individual behavioral observations on the various feeding food type were recorded throughout the entire season (dry N= 660; wet N=938). They feed on 42 food items grouped into 41 plant species (27 wild plants, 14 crop foods) and 1 insect .

### 3.2.2 Seasonal variation of diet composition

During the dry season, grivet consumed 38 plant species, while 18 plant species were consumed during the wet season. Fruit was the most (26±2.5%) and insect (0.5±0.4%) was the least frequently consumed for the diet of grivet monkey during the entire seasons. There were significant seasonal differences in time allocated for feeding leaves (U=0, P=0.000), fruits(U=21.5, P= 0.031), roots (U=30, P=0.030), stems (U=5, P=0.000), seeds(U=0, P=0.000), and buds(U=24.5, P=0.051). However, there were no significantly seasonal differences in the time allocated for feeding flowers (U=50, P=1.000), insects (U = 5, P = 0.510), barks (U = 15, P = 0.071) and unidentified food items (U=33.5, P=0.187). During the wet season, the most frequently consumed plants by the grivets from the wild plant was *Oxalis corniculata* (16.3%), while *Croton macrostachyus* (11.0%) *was* the most consumed during the dry seasons (**Table -2**). Based on the result of Sorenson′s similarity index (Ss); the plant species consumed by the grivet monkeys, were highly shared in the entire seasons (Ss=0.717).

Table 2. List of plant species consumption by Grivet monkey during dry and wet season

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Family** | **Species name** | **Edible Parts** | **Dry season** | | **Wet season** | | **Mean** | |
|  |  |  | Ff | % | Ff | % | Ff | % |
| Euphorbiaceae | *Croton macrostachyus* | Seed | 72 | 11 | --- | --- | 36 | 4.5 |
| Boraginaceae | *Cordia africana* | Fruit | 12 | 1.8 | --- | --- | 6 | 0.7 |
| Fabaceae | *Acacia seiberiana* | Flower | 16 | 2.4 | --- | --- | 8 | 1.0 |
| Fabaceae | *Albezia gummifera* | Flower | 4 | 0.6 | --- | --- | 2 | 0.2 |
| Moraceae | *Ficus sur* | Fruit | 3 | 0.4 | --- | --- | 1.5 | 0.2 |
| Cannabaceae | Celtis Africana | Fruit | 14 | 2.1 | --- | --- | 7 | 0.9 |
| Proteaceae | *Grevillea robusta* | Flower | 2 | 0.3 | 10 | 1.1 | 6 | 0.7 |
| Salicaceae | *Dovyalis abyssinica* | Fruit | 4 | 0.6 | --- | --- | 1 | 0.1 |
| Asteraceae | *Bidens Pilosa* | Leaf | --- | --- | 4 | 0.4 | 2 | 0.2 |
| Verbenaceae | *Lantana viburnoides* | Fruit | 12 | 1.8 | 56 | 6 | 34 | 4.1 |
| Rosaceae | *Eriobotrya japonica* | Flower | --- | --- | 4 | 0.4 | 2 | 0.2 |
| Apocynaceae | *Catheranthus roseus* | Flower | --- | --- | 10 | 1.1 | 5 | 0.6 |
| Arecaceae | *Phoenix reclinate* | Fruit | --- | --- | 16 | 1.7 | 8 | 1.0 |
| Myrtaceae | *Callistemon linearis* | Flower | 1 | 0.1 | --- | --- | 0.5 | 0.1 |
| Annonaceae | *Annona glabra* | Fruit | 8 | 1.2 | --- | --- | 4 | 0.6 |
| Moraceae | *Ficus vasta* | Fruit | 10 | 1.5 | --- | --- | 5 | 0.6 |
| Rosaceae | *Rubus steudneri* | Fruit, | 5 | 0.8 | --- | --- | 2.5 | 0.3 |
| Fabaceae | *Leucaena leucocephabe* | Leaf | 11 | 1.7 | --- | --- | 5.5 | 0.7 |
| Solanaceae | *Physialis peruviana* | Fruit | 1 | 0.1 | --- | --- | 0.5 | 0.1 |
| Dioscoreaceae | *Dioscorea bulbifera* | Root | 2 | 0.3 | --- | --- | 1 | 0.1 |
| Araceae | *Colocasia esculenta* | Leaf | 3 | 0.4 | --- | --- | 1.5 | 0.2 |
| Nyctaginaceae | *Bougainvillea glabra* | Flower | 5 | 0.7 | --- | --- | 2.5 | 0.3 |
| Solanaceae | *Solanum incanum* | Flower | 17 | 2.6 | --- | --- | 8.5 | 1.1 |
| Fabaceae | *Cajanuse cajan* | Fruit | 4 | 0.6 | -- | --- | 2 | 0.2 |
| Nyctaginaceae | *Mirabilis longiflora* | Flower | 2 | 0.2 | 6 | 0.6 | 4 | 0.5 |
| Convolvulaceae | *Dichondra micrantha* | Y leaf | 42 | 6.3 | 112 | 12 | 77 | 9.6 |
| Fabaceae | *Desmodium intortum* | Y leaf | 57 | 8.6 | 102 | 10.9 | 79 | 9.9 |
| Poaceae | *Cenchrus clandestinus* | Buds | 40 | 6.1 | 22 | 2.3 | 31 | 3.9 |
| Oxalidaceae | *Oxalis corniculata* | Leaf | 19 | 2.9 | 152 | 16.3 | 85 | 11 |
| Lauraceae | *Persea Americana* | Fruit | 41 | 6.2 | 82 | 8.8 | 61 | 7.6 |
| Poaceae | *Saccharum officinarum* | Stem | 26 | 3.9 | --- | --- | 13 | 1.6 |
| Anacardiaceae | *Mangifera indica* | Fruit | 12 | 1.8 | 56 | 6 | 34 | 4.2 |
| Solanaceae | *Solanum tuberssum* | Fruit | 16 | 2.4 | --- | --- | 8 | 1.0 |
| Musaceae | *Musax paradisiac* | Fruit | 4 | 0.6 | 14 | 1.5 | 9 | 1.1 |
| Rubiaceae | *Coffee Arabica* | Fruit | 5 | 0.8 | --- | --- | 2.5 | 0.3 |
| Poaceae | *Zea mays* | Seed | 18 | 2.7 | --- | --- | 9 | 1.1 |
| Myrtaceae | *Psidium guava* | Fruit | 34 | 5.1 | 28 | 3 | 31 | 3.9 |
| Solanaceae | *Solanum lycopersicum* | Fruit | 6 | 1 | 2 | 0.2 | 4 | 0.5 |
| Amaryllidaceae | *Allium cepa* | Fruit | 4 | 0.6 | 16 | 1.7 | 10 | 1.2 |
| Brassicaceae | *Brassica oleracea* | M leaf | 7 | 1.1 | 18 | 1.9 | 12 | 1.6 |
| Amaranthaceae | *Beta vulgaris* | Fruit | 1 | 0.1 | --- | --- | 0.5 | 0.1 |
| Apiaceae | *Daucus carota* | Fruit | 2 | 0.3 | --- | --- | 1 | 0.1 |
| Insect (Formicidae) | *Lepisiota canescens* | --- | 2 | 0.3 | 8 | 0.8 | 5 | 0.6 |

Ff= Frequency of feeding

### 3.2.3 Diet preferences

On average*,* *Psidium guava*, *Desmodium intortum* and *Persea Americana* were the top three preferred plant species and *Coffee arabica*, *Bidens pilosa* and *Callistemon linearis* were the least preferred plant species by the grivet monkey. During the dry season, *Psidium guava (FPI=* 17), *Dichondra micrantha* (FPI= 15.75) *and Solanum lycopersicum* (FPI=12) were the most preferred, whereas *Coffee arabica* (FPI=0.6), *Physialis peruviana* (FPI=1) and *Grevillea robusta* (FPI=0.75) were the least preferred plant species (**Table-3**). On the other side*, Persea Americana* (FPI=14.7), *Desmodium intortum* (FPI=11.5) and *Oxalis corniculata* (FPI=16.3) were the top preferred and *Bidens Pilosa (*FPI=0.4*), Eriobotrya japonica* (FPI=1) and *Grevillea robusta* (FPI=2.75) were the least preferred plant species during the wet season.

**Table 3.** Average (mean) feeding preference indices (FPI) of plant species consumed by Grivet monkey based on frequency of usage and occurrence at Wondo Genet College of Forestry and Natural Resource, Ethiopa.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Scientific name of plants** | **Average (Mean)** | | | |
| **Frequency of occurrence** | **Frequency of usage** | **Feeding preference Index** | **Rank** |
| **Highly preferred** |  |  |  |  |
| *Psidium guava* | 0.3 | 4 | 13.33 | 1 |
| *Desmodium intortum* | 0.75 | 9.9 | 13.2 | 2 |
| *Persea americana* | 0.6 | 7.6 | 12.67 | 3 |
| *Dichondra micrantha* | 0.75 | 9.6 | 12.8 | 4 |
| **Medium preferred** |  |  |  |  |
| *Lantana viburnoides* | 0.8 | 4.1 | 5.25 | 11 |
| *Eriobotrya japonica* | 0.2 | 1.0 | 5 | 12 |
| *Leucaena leucocephabe* | 0.15 | 0.7 | 4.6 | 13 |
| *Musax paradisiac* | 0.25 | 1.1 | 4.4 | 14 |
| **Low preferred** |  |  |  |  |
| *Dovyalis abyssinica* | 0.2 | 0.1 | 0.5 | 23 |
| *Coffee Arabica* | 0.65 | 0.3 | 0.46 | 24 |
| *Bidens Pilosa* | 0.5 | 0.2 | 0.4 | 25 |
| *Callistemon linearis* | 0.3 | 0.1 | 0.33 | 26 |

#### 3.2.3.1 Proximate analysis

*Dovyalis abyssinica (*76.9%) and *Musax paradisiac* (74.6%) had the highest moisture content, whereas *Eriobotrya japonica* (52.21%) *and Coffee arabica* (32.4%) had the lowest moisture content (**Table-4**)*. Desmodium intortum* (18.71%) *and Psidium guava* (24.82%) had the highest crude protein content, while *Callistemon linearis* (6.13%) *and Dovyalis abyssinica* (6.75%) had the least. *Musa paradisiac (*48.86%) *and Dovyalis abyssinica (*44.55%) had the highest NDF content and *Psidium guava* (23.28%) and *lantana viburnoides* (25.31%) had the least. *Musax paradisiac* (46.68%) and *Dovyalis abyssinica* (52.59%) had the highest and *Psidium guava* (30.8%) and *Leucaena leucocephabe* (33.02%) had the least ADF content.

**Table 4.** Proximate analysis of some food items consumed by grivet monkeys.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **List of food** | **%M** | **%DM** | **%Ash** | **%ODM** | **%CP** | **%NDF** | **%ADF** | **FPI** |
| **Highly preferred** |  |  |  |  |  |  |  |  |
| *Psidium guava* | 70.3 | 29.7 | 3.96 | 96.04 | 24.82 | 23.28 | 30.8 | 1 |
| *Desmodium intortum* | 54.2 | 45.8 | 8.21 | 91.79 | 18.71 | 29.79 | 39.7 | 2 |
| *Persea americana* | 71.2 | 28.8 | 14.26 | 85.74 | 16.99 | 34.74 | 42.72 | 3 |
| *Dichondra micrantha* | 55.4 | 44.6 | 13.76 | 86.23 | 17.77 | 34.54 | 43.52 | 4 |
| **Medium preference** |  |  |  |  |  |  |  |  |
| *lantana viburnoides* | 54.8 | 45.2 | 4.86 | 95.14 | 9.16 | 25.31 | 34.95 | 11 |
| *Eriobotrya japonica* | 52.21 | 47.79 | 6.15 | 93.85 | 6.81 | 35.01 | 37.82 | 12 |
| *Leucaena leucocephabe* | 57.2 | 42.8 | 12.51 | 87.49 | 8.25 | 32.42 | 33.02 | 13 |
| *Musax paradisiac* | 74.6 | 25.4 | 7.89 | 92.1 | 7.56 | 48.86 | 52.59 | 14 |
| **Low preference** |  |  |  |  |  |  |  |  |
| *Dovyalis abyssinica* | 76.9 | 23.1 | 11.45 | 88.55 | 6.75 | 44.55 | 48.68 | 23 |
| *Coffee arabica* | 32.4 | 27.6 | 6.33 | 93.66 | 7.32 | 30.48 | 41.26 | 24 |
| *Bidens Pilosa* | 68.02 | 42 | 12.57 | 87.43 | 12.85 | 29.76 | 37.86 | 25 |
| *Callistemon linearis* | 66.9 | 33.1 | 4.25 | 95.75 | 6.13 | 37.28 | 43.38 | 26 |

*% M = percent moisture, % DM = percent dry matter, % Ash = percent ash, % ODM = percent organic dry matter, % CP = percent crude protein, % NDF = percent nitrogen detergent fiber, % ADF = percent acid detergent fiber, FPI = feeding preference index.*

**4. DISCUSSION**

**4.1. Activity Patterns**

Feeding was the most predominated diurnal activity of the grivet (29.5%) (Ejigu & Bekele, 2010; Mekonnen et al., 2010; Chapman et al., 2016; Yibelu, 2019). This may be animal consume greater amounts of lower-quality food; they increase feeding time to survive (Fiore & Rodman, 2001). Grivet monkeys are social animals that spend less time grooming, playing and other social activities (mating, defecation, calling and suckling). Social animals have spent less time on social activities (playing and grooming), because they are active in feeding, moving and resting (Li et al., 2020). This is in line with the report of (Mekonnen et al., 2010; Yibelu, 2019; Yitayih et al.*,* 2022).

Feeding, resting and playing were significantly different between the dry and wet seasons. Feeding and resting were displayed with the maximum value recorded during the dry season then the wet season. The significant variation of activity patterns in the wet and dry seasons is due to the existence of several factors such as; food availability, weather condition and ignore from predators (Abie et al., 2017). The existence of several factors such as resource dispersion and low food quality force grivets to spend more time feeding during the dry season (Fiore & Rodman, 2001). The resting activity was commonly affected by temperature (Bireda and Yihune, 2020). During the dry season, primate animal increases their resting time and decrease their moving time due to temperature factors (Li et al., 2020). Grivet also displays playing behavior more frequently during the wet season than during the dry season. This may increase the body heat during the cold time.

Daily time session was a significant effect on feeding, resting and moving activities. The feeding and moving activity were high in the morning and dropped at noon whereas, resting was high in the noon and declined towards evening at the lowest peak around 16-17:00 (Yitayih et al., 2022). More feeding in the morning may be due to the fewer disturbances of human factors during this time and replace the loosed energy during the night time. Moving might be most probably due to the search for food and temperature factors. Moving lowest in the middle may be due to the increase of atmospheric temperature at midday and to save energy expenditure, so the grivet monkey had restricted its movement at this time (Mark, 2012). Increasing temperature makes increasing energy loss through evaporative water loss and rate of respiration so animals need to rest to reduce loss of energy (Bireda & Yihune, 2020).

The proportions of all activity budgets were significantly different among the age-sex categories except for other activities. The adult male spent more of their time resting compared to adult females and young. This might be because when animals get older, they become less active and need to rest more time to save energy (Ejigu & Bekele, 2010). Adult females, sub adult females and a juvenile spent more time feeding than adult males and sub-adult males. This may be because the adult female and sub adult females require satisfying extra energy demand for natal care giving. Females spent most time grooming. This may be associated with childcare responsibilities such as an attempt to remove insect pests from the body.

**4.2. Diet Composition**

Leaves were the major food items to be consumed by the grivet monkeys during both wet and dry seasons. Because leaves have higher protein and higher energy contents (Tesfaye et al., 2021). This is in line with the report of Menbere & Balakrishnan (2016) on Heller’s Vervet Monkey at Arba Minch Forest, Ethiopia. The most plant parts (leaves) that were consumed by the grivet monkey were *Bidens Pilosa, Leucaena leucocephabe, Dichondra micrantha, Desmodium intortum* and *Oxalis corniculata.* In Wondo Genet, the leaf was available in both seasons due to the advantage of bimodal rainfall and other food items were less available in both seasons (Kebede et al., 2013). The least time was spent feeding on roots and insects. They feed insects from tree canopies and grounds and often try to catch moving insects, especially *Lepisiota canescens*.

There were significant seasonal differences for feeding on leaves, fruit, root, stem, seed, and bud. During the dry season, grivet monkeys spend more time feeding on fruit, root, stem and seed than in the wet season. This may be due to the seasonal fluctuation and availability of plants and temperature variation between seasons (Yitayih et al., 2022; McFarland et al., 2014). The fruit contributed the largest percentage of the diet for the grivet monkey during the dry season than the wet season (Yibelu, 2019; Dessalegn, 2019; Yitayih et al*.,* 2022). Increasing the consumption of root, and seed during the dry season was only available for both *Dioscorea bulbifera* (root) and *Croton macrostachyus* (seed) during this time. Additionally, the bud of *Cenchrus clandestinus* and stem of *Saccharum officinarum* was available during both seasons but spends more time during the dry season. This is may be associated with less quality of food existence during the dry season (Abie et al., 2017). During the wet season, grivet spent most time feeding on the leave. The greener part of the plant leave has more nutritious due to the high moisture content and ease of digestibility (low fever content) (Derebe & Girma, 2020).

The feeding preference of the grivet monkeys might be pushed by the nutritional quality especially high crude protein and moisture content and frequency of occurrence of the plant species and frequency of consumption. Lowe’s monkeys seasonally adjust their diet on plant parts, probably according to nutrient content and availability (Bempah et al.*,* 2021). *Psidium guava* was the first preferred plant species by the grivet monkey consumption. *Psidium guava* was highly preferred due to the existence of high nutritional quality (moisture content of 70.3% and crude protein of 24.82% with relatively low ADF of 30.8%). Even though it had relatively fewer occurrences and it has been the most preferred food item by the grivet monkey. *Psidium* guava fruits have high moisture and crude fiber contents and are rich in macronutrients (Gurusamy et al*.,* 2020). The variation might be the availability of plant species in the study place and the soil composition variation of plant growth. In the study habitat, *Psidium guava* was moderately available in both seasons. *Callistemon* *linearis* and *Bidens pilosa* were the lowest preferred plant species by the grivet monkey consumption. *Callistemon* *linearis* had relatively moderate moisture content, a low crude protein with moderate ADF values, and less frequency of occurrence. *Bidens pilosa* was least preferred becauseofits less availability and less crude protein content (Kuo et al., 2021).

**5. CONCLUSION**

Grivet monkey in and around the WGCNF spends most of their daily time feeding compared to other activities like moving, resting, grooming, playing, and social activities. Some diurnal activity (feeding, resting and playing) patterns showed seasonal differences. Feeding, resting and moving activities were varied among the daily time sessions.

The study concludes that grivet monkeys are opportunistic feeders in their diet choices. It consumes more diversified food items in a human-dominated landscape such as; fruit, leaf, flower, seed, stems, roots, buds, barks and insect. Leaves contributed the highest percentage to the diet of grivet monkeys. The leaf of *Desmodium intortum* contributed to the major plant food for the diet of grivet monkeys throughout the year. They feed on different parts of plants and human foods with different extents of preference. When the scarcity of food occurred, grivet feeds on less preferable food. *Psidium guava*, *Desmodium intortum* and *Persea americana* were the top three preferred plant species for the diet of grivet monkeys. Finally, the grivet monkey in the modified landscape has a great advantage to feed alternative source of food like natural food, as well as crops.

# ACKNOWLEDGEMENT

We would like to thank the Wondo Genet College of Forestry and Natural Resource, and Hawassa College of Agricultural for permitting me to use the laboratory. Also we would like to acknowledgment the wolkite university for supporting of finance to the data collection.We are also great thank full to Tizazu Animaw for sharing of knowledge and skill during laboratory work.

**CONFLICT OF INTERESTS**

We have no any conflict of interest regarding to this paper.

**AUTHOR CONTRIBUTION**

**Chalachew Alemneh**: Conceptualization (equal); Data curation (lead); Formal analysis (lead); Funding acquisition (lead); Investigation (equal); Methodology (supporting); Project administration (equal); Resources (lead); Software (supporting); Supervision (supporting); Validation (supporting); Visualization (equal); Writing-original draft (equal); Writing-review & editing (supporting).

**Zerihun Girma**: Conceptualization (lead); Data curation (supporting); Formal analysis (equal); Funding acquisition (supporting); Investigation (equal); Methodology (lead); Project administration (equal); Resources (supporting); Software (lead); Supervision (lead); Validation (equal); Visualization (equal); Writing-original draft (equal); Writing-review & editing (lead).

**DATA AVAILABILITY STATEMENT**

I will here confirm that the data that support the findings of this study up on after publication of the manuscript. specifically, the data that support the findings will be available in Grivet Monkey diet analysis file name at Zenodo data repository following the date of publication.

**ORCID**

**Chalachew Alemneh;** [https://orcid.org/0009-0000-0452-693X](https://orcid.org/0009-0000-0452-693X" \t "https://mail.google.com/mail/u/0/" \l "inbox/_blank)

# **REFERENCES**

Abie, K., Bekele, A., & Mekonen, A. (2017). Daily activity, feeding ecology and habitat association of Gelada baboon (Theropithecus gelada) around Debre-Libanos, Northwest Shewa Zone, Ethiopia. *International Journal of Biodiversity and Conservation*, *9*(6), 232-238.

Altman, J. 1974. Observational study of behavior: sampling method. 49: 227–267.

Association of Official Analytical Chemists (AOAC) (1990). Official Methods of Analysis (15th Edition), Washington DC, USA, 83p.

Association of Official Analytical Chemists (AOAC) (1995). Official methods of analysis (16th ed.). 685p.

Bekele, A., & Yalden, D. (2013). The mammals of Ethiopia and Eritrea. 2013. Addis Ababa University Press, Addis Ababa, Ethiopia. pp. 391.

Bempah, G., Changhu, Lu., &Yoonjung, Y. (2021). Anthropogenic Food Utilization and Seasonal Difference in Diet of Cercopithecus lowei at a Community Protected Forest in Ghana. Diversity, 13(12 ), 610.

Bireda. M., & Yihune, M. (2020). Foraging ecology and diurnal activity patterns of klipspringer (Oreotragus oreotragus) in Yetefet Woyenat Forest, East Gojjam, and Ethiopia. *International Journal of Zoology*, 2(3),530.

Butynski, T.M., & De Jong, Y.A. (2022). Chlorocebus aethiops. The IUCN Red List of Threatened Specie: https://dx.doi.org/10.2305/IUCN.UK.

Chapman, C. A., Twinomugisha, D., Teichroeb, J. A., Valenta, K., Sengupta, R., Sarkar, D., & Rothman, J. M. (2016). How do primates survive among humans? Mechanisms employed by vervet monkeys at Lake Nabugabo, Uganda. *Ethnoprimatology: Primate conservation in the 21st century*, 77-94.

Derebe, Y., & Girma, Z. (2020). Diet composition and preferences of Bohor reedbuck (Redunca redunca) in the compound of Alage College, Central Rift Valley of Ethiopia. *Ecology and Evolution*, *10*(23), 13370-13381.

Dessalegn, D. (2019). Biology of Grivets (Chlorocebus aethiops). July.

Ejigu, D., & Bekele, A. (2010). Population structure, feeding ecology and human-grivet monkeys conflict at Bahir Dar University main campus, Bahir Dar. *Ethiopian J Biol Sci*, *9*(1), 35-47.

Fashing, P. J., Nguyen, N., Venkataraman, V. V., & Kerby, J. T. (2014). Gelada feeding ecology in an intact ecosystem at Guassa, Ethiopia: variability over time and implications for theropith and hominin dietary evolution. *American Journal of Physical Anthropology*, *155*(1), 1-16.

Fashing, P.J., Nguyen, N. Luteshi, P. Opondo, W. Cash, J.F., and Cords, M. (2012). Evaluating the suitability of planted forests for African forest monkeys: a case study from Kakamega Forest, Kenya. *American Journal of Primatology,* 74(1), 77-90.

Fiore, A. D., & Rodman, P. S. (2001). Time allocation patterns of lowland woolly monkeys (Lagothrix lagotricha poeppigii) in a neotropical terra firma forest. *International Journal of Primatology,* 22, 449-480.

Girma, Z., Mamo, Y., Mengesha, G., Verma, A., & Asfaw, T. (2017). Seasonal abundance and habitat use of bird species in and around Wondo Genet Forest, south‐central Ethiopia. *Ecology and Evolution*, *7*(10), 3397-3405.

Groves, C. P. (2005). Order primates. Mammal species of the world. 111–184.

Gurusamy, K., Santhi, V. P., Indhumathi, K., & Parthiban, S. (2020). Study on proximate and nutritional parameters of guava (Psidium guajava L.) varieties grown in sodic soil. *Journal of Pharmacognosy and Phytochemistry*, 9(4), 3020-3023.

Ibrahim, H., Bekele, A., & Yazezew, D. (2017). Population structure and feeding ecology of Guereza (Colobus guereza) in Borena-Sayint National Park, northern Ethiopia. *International Journal of Biodiversity and Conservation*, *9*(11), 323-333.

Jarvey, J.C., Low, B.S. Pappano, D.J. Bergman, T.J., and J.C.Beehner. 2018. Graminivory and fallback foods: annual diet profile of geladas (Theropithecus gelada) living in the Simien Mountains National Park, Ethiopia. *International Journal of Primatology* 39(1): 105-126.

Kebede, M., Kanninen, M., Yirdaw, E., & Lemenih, M. (2013). Vegetation structural characteristics and topographic factors in the remnant moist Afromontane forest of Wondo Genet, south central Ethiopia. *Journal of forestry research*, 24, 419-430.

Kifle, Z., & Bekele, A. (2021). Feeding ecology and diet of the southern geladas (Theropithecus gelada obscurus) in human‐modified landscape, Wollo, Ethiopia. *Ecology and Evolution,* 11(16), 11373-11386.

Kuo, T.F., G.Yang, T.Y. Chen, Y.C. Wu, H. Tran Nguyen Minh, L.S. Chen, W.C. Chen, M.G. Huang, Y.C. Liang and W.C.Yang. (2021). Bidens pilosa: Nutritional value and benefits for metabolic syndrome. *Food Frontiers,* 2 (1): 32-45.

Li, Y., Ma, G., Zhou, Q., & Huang, Z. (2020). Seasonal variation in activity budget of assamese macaques in limestone forest of southwest Guangxi, China. *Folia Primatologica*, *91*(5), 495-511.

Mamo, M., & Wube, T. (2019). Variability in group size and daily activity budget of family groups of the gelada baboon (Theropithecus gelada) at Guassa Community Conservation Area, Central Ethiopia. *Journal of Ecology and Environment*, *43*(1), 1-8.

Mark, Ch. B. (2012). Activity time budget of the blue monkey (cercopithecus mitis) during the dry season period. a case study of the north nandi forest in nandi county. Bsc. Thesis. University of Eldoret. 37p.

McFarland, R., Barrett, L., Boner, R., Freeman, N. J., & Henzi, S. P. (2014). Behavioral flexibility of vervet monkeys in response to climatic and social variability. *American journal of physical anthropology,* 154(3), 357-364.

Mekonnen, A., Bekele, A., Fashing, P. J., Hemson, G., & Atickem, A. (2010). Diet, activity patterns, and ranging ecology of the Bale monkey (Chlorocebus djamdjamensis) in Odobullu Forest, Ethiopia. *International Journal of Primatology*, *31*, 339-362.

Menbere, I. P., & Balakrishnan, M. (2016). The effect of habitat on density, feeding behaviour and activity of heller’s vervet monkey (chlorocebus pygerythrus arenarius): A case study in arba minch forest, Ethiopia. *International Journal of Natural Resource Ecology and Management*, *1*, 71-78.

Mijanur Rahman, K. M., & Rakhimov, I. I. (2019). Activity patterns and feeding ecology of the semi-aquatic Varanus flavescens (Reptilia: Varanidae). *Russian Journal of Herpetology*, *26*(2).

Olaleru, F. (2017). Seasonality and nutrient composition of the plant diets of mona monkeys (Cercopithecus mona) in University of Lagos, Nigeria. *Zoologist (The)*, *15*, 13-21.

Ratliff, R. D. (1993). trend assessment by similarity--a demonstration. *Rangeland Ecology & Management/Journal of Range Management Archives*, *46*(2), 139-141.

Tesfaye, D., Fashing, P. J., Meshesha, A. A., Bekele, A., & Stenseth, N. C. (2021). Feeding ecology of the Omo River guereza (Colobus guereza guereza) in habitats with varying levels of fragmentation and disturbance in the southern Ethiopian Highlands. *International Journal of Primatology*, *42*, 64-88.

Tilman, D., Clark, M., Williams, D. R., Kimmel, K., Polasky, S., & Packer, C. (2017). Future threats to biodiversity and pathways to their prevention. *Nature,* 546(7656), 73-81.

Yazezew, D., Bekele, A., & Ibrahim, H. (2020). Activity budget and feeding ecology of Geladas (Theropithecus gelada obscurus) around Abogedam Church west of Debre Berhan Town, Ethiopia. *The Scientific World Journal*, *2020*.

Yibelu, Y. (2019).Population size, diurnal activity budget, and human-grivet monkeys (chlorocebus aethiops) conflict in zegie peninsula, bahir dar, Ethiopia (doctoral dissertation).31p

Yitayih, Y., Asmare, E., & Mola, M. (2022). Diurnal activity budget and feeding activity of grivet monkeys (Chlorocebus aethiops) in Zegie Peninsula, Northern Ethiopia.

Yitayih, Y., Ejigu, D., & Mola, M. (2021). Population size and human-grivet monkeys (Chlorocebus aethiops) conflict in Zegie peninsula, Bahir Dar, Ethiopia. *BMC Zoology,* 6(1), 1-9.

Zerihun Girma, Z., Mamo, Y., & Ersado, M. (2012). Species composition, distribution and relative abundance of large mammals in and around Wondo Genet Forest Patch, Southern Ethiopia. *Asian Journal of Applied Sciences*, *5*(8), 538-551.