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## Feeding Ecology of Colobus Monkey (*Colobus Guereza*, Ruppell 1835) in Bonga Forest South West Ethiopia

Belaynew Asmamaw<sup>1\*</sup>, Melkamu Adamu<sup>1</sup>, Yosef Mamo<sup>2</sup>

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### ABSTRACT

A study on the feeding ecology of the colobus monkey (*Colobus guereza*) was conducted in Bonga forest, Ethiopia. The aim of this study was to investigate the feeding habits and diet composition of *Colobus guereza*. Scan sampling method was used throughout the study to record the feeding activities. The Data was collected during dry season and wet season. In order to analyse the data Chi-square and mann-U-tests were used by using SPSS version 23 software. According to the result of this study, a total of 13 tree plant species were known to be consumed by colobus monkey at the study site. Out of these, the top three are; *Milletia ferruginea* (33.3%), *Sapium ellipticum* (24.95%) and *Olea welwitschii* (23.7%) were commonly consumed in both seasons. Moreover, seasonal variation in the study area occurred when Guereza consume different plant parts. During the dry season, colobus monkey preferred more of leaves and flowers, while they preferred leaves and fruits during wet season. Statistically, there was a significant difference in feeding records of plant parts consumed by colobus monkey across seasons ( $P=0.003<0.05$ ). In conclusion, colobus monkey is more abundant in the Bonga forest area due to the diversity and intactness of habitats that meet the needs of the species. Therefore, future research would be conducted on the feeding ecology of guerezas in different parts of southern region in particular and Ethiopia in general to conserve this species and its living ecosystem.

### INTRODUCTION

Primates are medium to large-sized, charismatic mammals found in many tropical forests around the world (Fashing *et al.*, 2012). The Colobine monkeys are found in Africa and Asia (Fashing, 2006). African colobines are classified into three genera: *colobus* (Black and white colobus), *procolobus* (Olive colobus), and *pilio Colobus* (Red colobus) and 15 species (Grooves, 2001; Groves, 2007). The genus *Colobus* comprises involves five species: *Colobus guereza*, *Colobus satanas*, *Colobus polykomos*, *Colobus vellerosus*, and *Colobus angolensis* (Kingdon, 2015). *Colobus guereza* is the most widely distributed species in East and West Africa; including Ethiopia (Kingdon *et al.*, 2008). Eight sub-species of *Colobus guereza* have been identified in Africa, of which, Omo River Guereza (*C. g. guereza*) and Djaffa Mountains Guereza (*C. g. gallarum*) are endemic to Ethiopian highlands (Zinner *et al.*, 2019). So, *C. g. guereza* found in West of the Great Rift Valley and *C. g. gallarum* found in East of the Great Rift Valley of Ethiopia. *Colobus guereza* sub-species are distinguished from one another based on morphological characteristics (Fashing & Oates, 2013). *Colobus guereza* is a heavy bodied animal with a long tail. The head and body length is 45 to 72 cm and the tail length is 52 to 100 cm. Guerezas are slightly sexually dimorphic in that the males are heavier than females (Kingdon, 2015) and *Colobus guereza* is a heavy bodied animal with a long tail.

Colobus monkeys consume a large amount of leaves, primarily young leaves, mature leaves, and a small proportion of leaf buds, blossoms, flowers, petioles, and

water-plants; they have also been reported to consume bark and wood, seeds, and soil on occasion (Fashing *et al.*, 2007). Colobus monkeys exhibit seasonal diet variation based on food availability (Matsuda *et al.*, 2020). *Colobus guereza* and its subspecies *C. g. guereza* are folivorous monkeys that eat the most nutritive and easily digestible items, such as young leaves and leaf buds, though they also eat other plant parts and arthropods to supplement their diet (Chapman *et al.*, 2002; Hanya & Chapman, 2013; Kibaja, 2014). A variety of ecological and behavioral factors influence colobus monkey's activities and ranging patterns, including food availability (distribution and quality of food), availability of water sources, predation, rain fall pattern, habitat conversation, competition, group size reproduction situation, and resting or sleeping site selection (Zhou *et al.*, 2011; Wijten *et al.*, 2012; Smith *et al.*, 2013; Zhou *et al.*, 2013). Colobus monkeys consume a large amount of leaves, primarily young leaves, mature leaves, and a small proportion of leaf buds, blossoms, flowers, petioles, and water-plants; they have also been reported to consume bark and wood, seeds, and soil on occasion (Fashing *et al.*, 2007). According to the Nature and Biodiversity Union (NABU, 2017) reports, the *Colobus guereza* and its sub-species; *C. g. guereza* is found in Bonga Forest Area. Bonga Forest Area (BFA) is a forest in Ethiopia's highlands that has been designated as one of the country's national forest priority areas (Vreugdenhil *et al.*, 2012). It is home to a variety of wild animal species, which play an important role in gene flow between coffee trees and adjacent forest trees,

<sup>1</sup> Belaynew Asmamaw Lege, Gambella University, Ethiopia

<sup>2</sup> Department of Biology, Hawassa University, Ethiopia

\* Corresponding author's e-mail: [yosefdubale16@gmail.com](mailto:yosefdubale16@gmail.com)

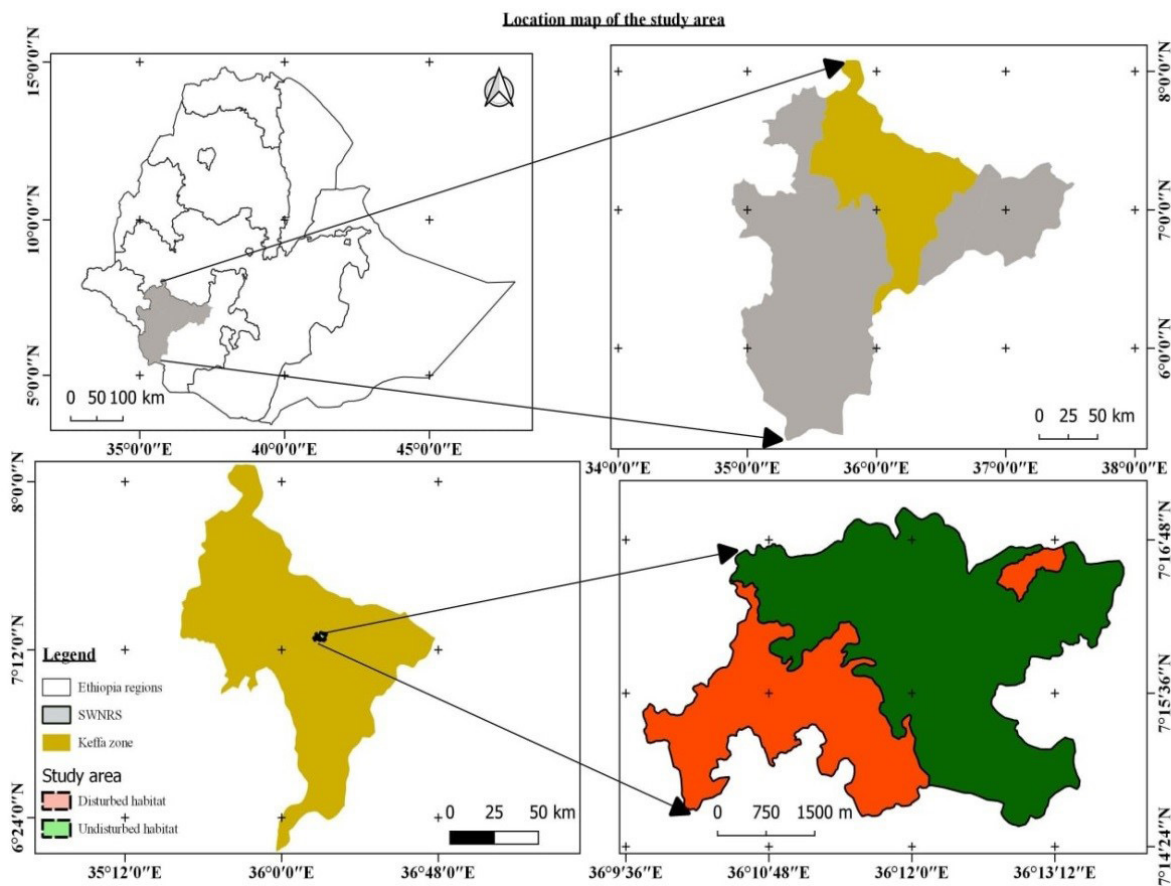
particularly primates (Aga Esyas, 2005). The major causes of species reduction and extinction globally are habitat loss, shrinkage, and fragmentation (Stabach *et al.*, 2016). The loss of habitat causes a temporal and spatial scale of variation in primate ecological patterns, including feeding ecology (Onderdonk & Chapman, 2000; Fashing *et al.*, 2007). The main causes of forest resource shrinkage in Ethiopia, including the Bonga forest, are agricultural expansion, overgrazing, settlement, fuel wood gathering, wood extraction, and timber production (Sisay Nune, 2008; Getahun Yakob & Anteneh Fekadu, 2016; Tulu Tolla *et al.*, 2017; Fikadu Yirga *et al.*, 2019). Previously, in another study area in Ethiopia, the feeding ecology of the *Colobus guereza* and its sub-species were studied. Also, under biodiversity assessment at the Kaffa biosphere reserve, the assessment of primate community composition around the BFA is well understood (NABU, 2017). However, there was no information in the BFA about feeding ecology of primate species, particularly *Colobus guereza*. Therefore, the current study aimed to address the feeding activity patterns and diet composition

of colobus monkey in the BFA for better conservation of species with their natural behavior. This study could be used as an input for the planning to sustainable management of this unique forest area and the wildlife, particularly colobus monkey in this protected forest area.

## METHODS AND MATERIALS

### Description of the Study Area

The study was carried out in the Bonga national forest priority area, which is located in the Kaffa Zone, South West National Regional State (SWNRS) of Ethiopia (Figure-1). This is part of the Kaffa biosphere reserve's southern boundary (NABU, 2017). The BFA stretches across the boundaries of five woreda: Gimbo, Menjiwo, Tello, Decha, and Chena. On the other hand, the study forest site is only found in two neighboring districts, namely "Gimbo and Decha," which are located at 7°14'24"- 7°16'48" North latitude and 36°9'36"- 36°13'12" East longitude (Figure-1). It is approximately 12 and 470 kilometers far from Bonga town and Addis Ababa, respectively (KZEFCCO, 2021).



**Figure 1:** Location map of the study site with habitat types  
 Source: Google earth; Ethio- region and zone, 2021; using QGIS version 3.8

The study area has a jagged and mountainous topography, ridges and valleys, and a gentle and flat landscape towards the Gojeb River (Abayneh Deraro *et al.*, 2003). The average annual temperature ranges from 15.1°C to 22.5°C (Ayele Kebede, 2011; EMSA, 2019). The warmest months are February, March, and April, while the peak rainy months

June, July and August are the wettest months. The annual rainfall in the study area ranges from 1401-2000 mm. As a result, the area has received the most rainfall distribution in Ethiopia (Ayele Kebede, 2011). Bonga Forest is a type of Ethiopian vegetation known as moist evergreen montane forests. It provides shelter, food, and breeding

areas for a variety of wild animals, including avifauna in and around the forest. At least 48 mammalian species from 14 families and 100 bird species have been identified (Taye Bekele, 2003). Wild mammals found in and around the Bonga forest area are Lion, Leopard, hyena, Buffalo, Anubis baboon, Colobus monkey, Grivet monkey, Black faced vervet monkey, De Brazza monkey, Ethiopia lesser Galago, Ethiopian hare, Bouturlini Blue Monke, Common Bushbuck, Aardvark, Warthog and Forest Pig (NABU, 2017).

## MATERIAL AND METHODS

### Sampling Method

#### Preliminary Survey and Study Site Selection

A reconnaissance survey was conducted for one week just before to the period of actual data collection and sampling design proposed to obtain information regarding accessibility, climatic condition, topography, vegetation types, fauna, and, in particular, the distribution of guerezas in the area. This time period allowed the observer to become intimately familiar with the current situation of the forest environment, as well as to know the current status of the species and how close the observer could approach them. The habitat types were identified and stratified using stratified random sampling method during this time period. According to preliminary observation, the area's forest habitat types and topography were diverse; the study site was stratified into disturbed and undisturbed forests using a method developed by Zerihun Girma *et al.* (2018). In addition, GPS coordinate points from each habitat types were collected, which aided in the digitization of habitat stratification and area calculation using Quantum Geographic Information System (QGIS version 3.8) software. Furthermore, the exact location was determined using GPS (Garmin-64H) to collect the coordinate sample points in different habitat types.

#### Field Data Collection

Data was collected during dry season (March to June) and wet season (July to October, 2021). Data was gathered using the primary data collection method, which was direct field observation. Two observation sessions (morning and afternoon) were used to collect data for scanning feeding activity patterns of colobus monkeys. In addition, the frequency of observation was three times per hour in each observation session to follow the feeding activities. Using repeated standard observation and the focal animal sampling method, the feeding habit, food items, and seasonal dietary variations of guerezas were identified (Fashing, 2001a). Data such as the name of the plant species, the forms and parts consumed by the animal, the time spent foraging, and the number of observation times when they consume the plant types or parts were recorded (Fashing, 2001a). The scanning activity was limited to two focal groups of guereza: one from disturbed forest habitat and one from undisturbed forest habitat (Addisu Mekonen *et al.*, 2010a; Addisu

Mekonen *et al.*, 2017). The group size was selected ranges from 3-13 members (on average 8 members). However, the sizes of the individuals in the selected groups did not remain constant across observations. Only one individual focal animal was selected on each age group to follow the feeding activity patterns. The focal animal was selected opportunistically at random from the group. Furthermore, if the focal animal lost before the end of the observation period, another focal animal was selected and its behavioural feeding activity was recorded (Fashing *et al.*, 2007; Abraham Eustace *et al.*, 2015). Care was taken to avoid sampling the same individuals more than once in the same scanning. Individual guerezas activities, time spent, and number of observation times was recorded by approaching the animals and observing them with aided eyesight and Binocular (Nikon 10x50 Aculon A211) according to the distance of the encountered animal from the observer to identify the specific types of activities they performed.

#### Data Analysis

Data collected during the survey were analyzed by using the Statistical Package for Social Sciences (SPSS version 23) software. The Chi-square test used to compare the proportion of time that the different group members and individuals performed consuming plant parts and plant types in wet and dry seasons. The non-parametric test (Mann Whitney U-test) was used to compare the mean ranks of plant type consumed by colobus monkeys between seasons. The feeding behavior of *Colobus guereza* was analyzed by computing the percentage of foraging time devoted to a specific plants species and the parts consumed. Dietary composition was measured by calculating the proportion of various dietary items and plant species consumed by focal groups based on the total amount of feeding time spent (Felton *et al.*, 2008b; Addisu Mekonen *et al.*, 2010a).

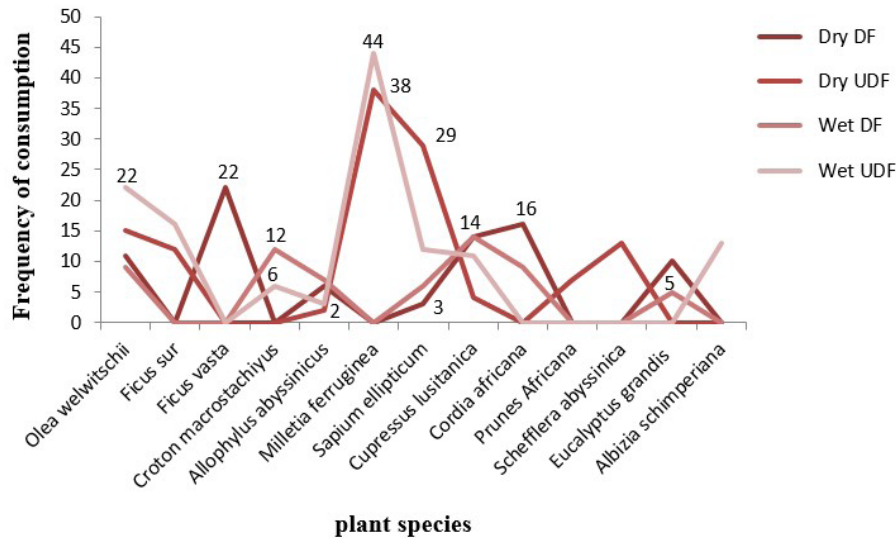
## RESULTS AND DISCUSSION

A total of 528 feeding frequency activities were recorded from the guereza scan sampling during both seasons. According to the feeding activity recorded result, *Colobus guereza* consumed a total of 13 tree plant species belonging to nine families at the study forest site (Table-1). Based on feeding frequency observation illustrated in (figure-2), four plant species were frequently consumed on both habitats during the dry season. Such as *Olea welwitschii*, *Sapium ellipticum*, *Cupressus lusitanica*, and *Allophylus abyssinicus*.

Whereas, four species; *Olea welwitschii*, *Croton macrostachyus*, *Cupressus lusitanica* and *Sapium ellipticum* were consumed by colobus monkey on both habitat types during wet season. During dry season, *Ficus vasta* (22) was the most frequently consumed plant species by colobus monkey, followed by *Cordia africana* (16), while *Sapium ellipticum* (3) was the least frequently consumed on disturbed forest. Also, *Milletia ferruginea* (38) was the highest consumed food type by colobus monkey followed by *Sapium ellipticum* (29) in

undisturbed forest while, *Allophylus abyssinicus* (2) was the least consumed (Fig-5). *Cupressus lusitanica* (14) was the most frequently consumed plant type on disturbed forest during the wet season, followed by *Croton macrostachyus* (12), and *Eucalyptus grandis* (5) was the least frequently consumed. On undisturbed habitat, *Milletia ferruginea* (44)

was the most frequently selected plant species, followed by *Olea welwitschii* (22) and *Croton macrostachyus* (6) was the least selected species during wet season. There was no statistically significant difference in feeding records of plant types consumed by Colobus monkeys between habitats (Chi-square,  $\chi^2=0.000$ ,  $df=12$ ,  $P=1.000>0.05$ ).



**Figure 2:** Feeding time spent of Colobus monkey on each plant types on both habitat types. ‘DF’=Disturbed Forest; ‘UDF’=Undisturbed Forest

As shown in table-1. *Milletia ferruginea* (30%) was the most commonly consumed food item during the dry season, followed by *Sapium ellipticum* (26.6%). Also, *Milletia ferruginea* (36.6%) was the most commonly consumed food item during the wet season, followed by *Olea welwitschii* (25.8%). On the other hand, *Prunes Africana* (5.8%) and *Eucalyptus grandis* (4.1%) were the least consumed food

items during the dry and wet seasons, respectively. Based on feeding records, there was no statistically significant difference in the rank of dietary contribution of plant species consumed by the Colobus monkey across seasons (Mann-Whitney U test;  $U=23.500$ ,  $Z=-0.128$ ,  $P=0.898>0.05$ ).

**Table 1:** Plant species consumed by Colobus monkey and frequencies of feeding records during both dry and wet seasons

Plant species	Dry season			Wet season		
	Frequency	Percentage	Rank	Frequency	Percentage	Rank
<i>Milletia ferruginea</i>	38	30	1 <sup>st</sup>	44	36.6	1 <sup>st</sup>
<i>Sapium ellipticum</i>	32	26.6	2 <sup>nd</sup>	28	23.3	3 <sup>rd</sup>
<i>Olea welwitschii</i>	26	21.6	3 <sup>rd</sup>	31	25.8	2 <sup>nd</sup>
<i>Ficus vasta</i>	22	18.3	4 <sup>th</sup>	-	-	-
<i>Cupressus lusitanica</i>	18	15	5 <sup>th</sup>	25	20.8	4 <sup>th</sup>
<i>Croton macrostachyus</i>	-	-	-	18	15	5 <sup>th</sup>
<i>Cordia africana</i>	16	13.3	6 <sup>th</sup>	9	7.5	8 <sup>th</sup>
<i>Schefflera abyssinica</i>	13	10.8	7 <sup>th</sup>	-	-	-
<i>Ficus sure</i>	12	10	8 <sup>th</sup>	16	13.3	6 <sup>th</sup>
<i>Albizia schimperiana</i>	-	-	-	13	10.8	7 <sup>th</sup>
<i>Eucalyptus grandis</i>	10	8.3	9 <sup>th</sup>	5	4.1	9 <sup>th</sup>
<i>Allophylus abyssinicus</i>	10	8.3	9 <sup>th</sup>	-	-	-
<i>Prunes Africana</i>	7	5.8	10 <sup>th</sup>	-	-	-

(-); indicates no recorded, when the Colobus monkey consumed the plant species as food type

Colobus monkeys were observed consuming seven tree plant species as a common diet during both seasons, including *Milletia ferruginea*, *Sapium ellipticum*, *Olea welwitschii*,

*Cupressus lusitanica*, *Cordia africana*, *Ficus sure*, and *Eucalyptus grandis* (Table-2). Of these, *Milletia ferruginea* (Baker) was the most consumed (33.3%) followed by *Sapium ellipticum*

(Jumping-seed tree) which had constituted 24.95%. On the other hand, *Eucalyptus grandis* (Grand eucalyptus) were

**Table 2:** The types of common trees consumed by *Colobus guereza* during both dry and wet seasons

No	Plant scientific name	English name	Percentage (%)
1	<i>Milletia ferruginea</i>	Baker	33.3
2	<i>Sapium ellipticum</i>	Jumping-seed tree	24.95
3	<i>Olea welwitschii</i>	Olive	23.7
4	<i>Cupressus lusitanica</i>	Cypress	17.9
5	<i>Cordia africana</i>	Large-leaved Cordia	10.4
6	<i>Ficus sure</i>	Cape fig	11.65
7	<i>Eucalyptus grandis</i>	Grand eucalyptus	6.2

The plant parts consumed as a diet by the study species, as well as the frequency of feeding time scans for each plant part during feeding activity, are illustrated below (Table-3). During the dry season, the colobus monkey's diet was primarily made up of leaves followed by flowers. During the wet season, colobus

monkeys favored leaves followed by fruits. During both seasons, stems/woods/barks were the least consumed food item from other plant parts. The feeding records of plant parts consumed by *Colobus* monkeys differed statistically across seasons (Chi-square,  $\chi^2=16.00$ ,  $df=4$ ,  $P=0.003<0.05$ ).

**Table 3:** Overall food items selection of *Colobus* monkey as diet during both dry and wet seasons

Plant Parts	Dry season		Wet season	
	FSP	DSI=FSP/TSP	FSP	DSI=FSP/TSP
Leaves	84	0.7	97	0.80
Flowers	49	0.40	37	0.30
Fruits	28	0.23	41	0.34
Stems	14	0.11	6	0.05

Where; DSI=Diet Selection Index, FSP=Frequency Scanning Period per plant part, TSP=Total Scanning Period (120 for each season)

According to the current study, the types of food items and plant species consumed by the study animal were varied. The guerezas were only seen feeding on certain tree species in this study. They were observed feeding on thirteen different kinds of tree plant species in different seasons (Table-1). Their diet primarily consisted of the leaves, fruits, flowers, and occasionally, the stems/wood/barks of the tree plant species. Guerezas have adapted to digest a diverse group of plant species due to their large and multi chambered stomach (Gron, 2009; Arkive, 2011), and they have demonstrated dietary flexibility (Fashing, 2001b; Matsuda *et al.*, 2020). *Milletia ferruginea*, *Sapium ellipticum*, and *Olea welwitschii* were the most dominant tree plant species observed to be highly utilized by the study animal during both seasons in the study area. This could be due to the high abundances of those plant species and their selection by the guerezas in the study area. This finding is consistent with the findings of Dereje Tesfaye *et al.* (2021) on the Feeding Ecology of the Omo River Guereza in Habitats with Varying Levels of Fragmentation and Disturbance in the Southern Ethiopian Highlands; *Milletia ferruginea* was the most selected plant species by *Colobus* monkey, whereas the least frequently consumed plants were *Eucalyptus grandis* and *Ficus sure*. This is due to the abundance of these species, and the probability of selection by the *Colobus* monkey may be reduced. This finding was supported by

Mohammed Hussein and Dessalegn Ejigu (2017)'s study; *Ficus sure* was the least frequently consumed species. Odwyer (2011) states that the proportion of their time spent foraging for various food items is specified in the feeding activity pattern of the *Colobus guereza*. As a result of the high proportion of time spent foraging for leaves, the most common food items of *Colobus* monkeys in the current study area were leaves. This contradicts Fashing (2001a) findings, which show that guerezas in Kakamega, Kenya, rely heavily on tree fruits. However, the present finding is similar to those Fentahun Shumet & Mesele Yihune, 2017; Hussein Ibrahim *et al.*, 2017; Mohammed Hussein & Dessalegn Ejigu, 2017; Dereje Yazezew, 2018. The reason why *Colobus* monkeys consumed more leaves, because they were higher in protein to fiber ratios, less toxic, more digestible, and less susceptible to seasonal fluctuations than other plant parts (Kaplin & Moermond, 2000; Chapman *et al.*, 2002; Fashing *et al.*, 2007; Harris & Chapman, 2007). Guereza displayed seasonal variation in the study area by eating different plant parts. This implies that plant parts consumed by *colobus* monkeys differed significantly by season ( $P\leq 0.05$ ). As a result of the scarcity of young leaves during the dry season and the availability of young leaves with matured leaves during the wet season, they consume more leaf parts during the wet season than the dry season. This is consistent with finding of Hussein Ibrahim *et al.* (2017), who revealed that

they consumed more young leaves during the wet season than the dry season. In the current study, they also spent more time feeding on fruits during the wet season than the dry season due to the abundance of fruits with the highest abundance of leaves and the lowest abundance of flowers. This contradicts the findings of (Fashing, 2001b; Hussein Ibrahim *et al.*, 2017). This could be due to ecological differences with vegetation cover between the areas. According to Hussein Ibrahim *et al.* (2017), barks/steams were the least consumed food items by guereza in the study site during the wet season compared to the dry season. This is because they can get more moisture from the leaves than the barks during this season, but during the dry season, they want to search high moisture content from the barks due to a shortage of rain distribution.

## CONCLUSION

The current study adds to our understanding of the feeding ecology pattern of the *Colobus guereza*. Guereza forage and live in the tall trees where they can easily find food, so they rarely come down to the ground in Bonga Forest. Due to adequate resource requirements such as food, water, cover, and space for long-term survival, they were mostly found in dense forest habitat rather than disturbed habitat. Primates changed their foraging habit due to seasonal variation. As a result, assessing dietary variation in relation to seasonal status is critical for evaluating primate foraging strategies. Colobus monkeys foraged on 13 different tree plant species in the study area. Because it was abundant and preferred, *Milletia ferruginea* was the most frequently consumed species by guereza due to its abundance and probability of selection as a diet, which accounting for 33.3% of total feeding scanning time frequency. They foraged primarily on leaves, which were the most commonly consumed plant food item, and this helps guerezas maximize their energy. In general, understanding primate dietary patterns and their implications for habitat utilization may be useful for understanding the habitat requirements needed to sustain viable populations. Lastly, the current study focused on the diet composition of *Colobus guereza* only. However, the nutritional contents of the plant species or portions chosen by the species have not been examined. As a result, more research should be conducted into the nutritional preferences of *Colobus guereza* is advised.

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