

Feeding and Ranging ecology of *Colobus guereza gallarum* in Bale Mountains National Park, Southeast Ethiopia

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Abstract

Colobus guereza gallarum is one of the subspecies *Colobus* monkeys (*Colobus guereza*) that restricted to east of the rift valley occupying the highland ecosystems in south eastern Ethiopia. The study of feeding and ranging ecology of *Colobus guereza gallarum* was conducted in Bale Mountains National Park, Southeast Ethiopia from February to June 2016. Data were collected using focal animal sampling technique for 10 minutes with 5 minutes interval. When the monkeys are observed feeding, plant parts and species eaten were recorded and marked and identified later. During the observation of focal animals in each troop, locations of troops were recorded using GPS every 10 min until the follow was concluded. Ranging data was carried out by calculating daily movements and estimating home range. To study the habitat characteristics of *Colobus guereza gallarum*, we established three 50×40m quadrats in randomly selected locations within the home range of the focal groups to provide vegetation composition in the study area. The major feeding consumption of *Colobus guereza gallarum* was leaves (82%) followed by fruits (14%) and shoots (2%), of the overall diet of 8 plant species during the study period. Barks and flowers were the least consumed food items which account 1% each during the observation time. *Colobus guereza gallarum* is characterized by a daily range length of 243m. However, no significant difference between the range lengths during the wet and dry seasons ($X^2=0.205$, $df=1$, $p=0.651$). A total of 18 plant species were mainly characterizing the home range of *Colobus guereza gallarum* focal groups in the study area. *Colobus guereza gallarum* were mainly seen in habitats characterized by forests composed of tall trees. Therefore, special attention should be given to conserve the food plants and animals which reside in it.

Keywords: *Colobus guereza gallarum*; Feeding; Leaves; Home range

Introduction

In order to help conserve a threatened species conservationists need much more information on their habitat requirements. A lot of this information is behavioural such as diet choice, social systems, breeding behaviour and home range [1]. By studying the species activity and behaviour these applied questions can begin to be answered [2].

Home ranges are defined as 'the area traversed by the individual in its normal activities of food gathering, mating, and caring for young'. Animal movements leading to these home ranges are determined by many social, ecological and environmental factors [3,4]. Therefore any changes in these factors may produce observable changes in home range size, which could be used as an indicator for habitat quality [5].

Primate abundances are determined by the availability of food [6]. Of primates, the *Colobus* monkeys (*Colobus guereza*) are a large glossy black monkey with a white mantle and a tail tuft. It is found in diverse regions of equatorial Africa including Ethiopian highlands [7]. *Colobus* monkeys are diurnal primates, with trichromatic vision allowing them to see more shades of colors than other primates. This is good for spotting ripe and unripe fruit, but also young darker colored leaves. As such they spend a large part of their day foraging for food in high to low light conditions [8]. *Colobus* monkeys are folivores-frugivores having a diet mainly of leaves, but buds and fruits can also be included [5]. Either way, although a lot of observations of *colobus*

foraging may be of leaf eating, some population's diets come from multiple sources [9].

The subspecies classification of *Colobus guereza* is not well resolved. However, *Colobus guereza gallarum* is one of the subspecies *Colobus guereza*. It restricted to east of the rift valley occupying the highland ecosystems in south eastern Ethiopia [10]. As other subspecies, *Colobus guereza gallarum* have an ecologically diverse diet for the range of their species, their ability to survive in a small forest patch is most likely attributable to their ability to survive on whatever is available [11]. Overall, the feeding behavior of primate appears complex and is not yet fully understood. Feeding ecology, range ecology and habitat use is crucial to assess the habitat requirements of the species [12]. Identifying the feeding requirement of the species contributes for conservation mechanism of the species in the park [13]. Therefore, our study examined the feeding habit and home range of *Colobus guereza gallarum* in Bale Mountains National Park.

Methodology

Study area

The study was conducted in the Bale Mountains National Park in the Oromiya administrative regional state between February to June, 2017. BMNP lies within five woredas of Bale Zone, Dinsho in the North, Adaba to the West, Goba to the northeast, Mena-Angetu to the South and Barbare to the East [14]. Human population before the establishment of BMNP, human population density and its impacts on

the biodiversity of the area was not that much significant. However, from time to time, the impact has been increasing dramatically especially starting from the year 1970. In 1998, there was an estimated human population of just 2,500 and 10,500 head of livestock in the area [15]. However, in 2011, the number of inhabitants surrounding the Park with in the five weredas is now reaching to 280,596 [14].

The Bale Mountains harbor unique and diverse fauna and flora. The area contains species that are Ethiopian endemics, but there are also species that are found only within the Bale Mountains themselves [15]. The variety of species and high rate of endemics is due to the wide variety of habitats and to the isolation of the Ethiopian highlands from other similar highlands in Eastern Africa by the surrounding hot dry lowlands [14].

For this study, Dinsho woreda was selected. The administrative town of the woreda is Dinsho, which located 400km far from Addis Ababa; the capital city of Ethiopia. The woreda is located in the coordinates of 7°10' -7°10' 02'' N Latitude and 39°55' -39°55' 02'' E Longitude. The Rainfall distribution pattern of the woreda is characterized by eight month rainy season from late March to October. In general the area receives annually 600-1000 mm rainfall in the lower altitude areas and 1000-1400 mm in the higher altitude areas. It has a mid-sub-tropical highland climate with annual mean and maximum temperature of 2 and 20°C, respectively [15,16].

Method of data collection

Foraging behaviour: The feeding habits of *Colobus guereza gallarum* in the study area was collected using focal animal sampling (Altmann, 1974). The feeding behaviour of focal animals was recorded for the duration of ten minutes with five minutes interval. When the monkeys are observed feeding, plant parts such as: young leaves, mature leaves, bark, flower, fruit and shoots, and species eaten were recorded and marked and identified later. Focal animals were selected on a rotating basis, according to age/sex class [17]. The records of focal animals lost from sight before ten minute observation period were terminated and the feeding data were discarded.

Feeding behavior of *Colobus guereza gallarum* were analyzed by computing the percentage of foraging time devoted to a specific plants species and the parts consumed. The percentage of foraging time devoted to a specific plant item were calculated as the total time spent eating that item divided by the total amount of continuous observation time that monkeys were seen to feed [18]. The specific highly consumed plant species by *Colobus guereza gallarum* were identified from flora study in Addis Ababa University. Diet selection of the study group was determined from the relative proportion of the feeding time on different food items and species in their diet. The feeding habits of *Colobus guereza gallarum* were compared between seasons to distinguish variations of feeding in different seasons.

The definition of different food items:

- **Leaves:** A green plant part that grows in various shapes from the stems or branches of a plant such as mature and young leaves.
- **Fruits:** The fleshy edible part of plant that contain seeds.
- **Barks:** The rough outer covering of the woody stems of trees such as bud, young branch.
- **Flower:** The colored part of plant that contains leafy shoot with modified leaves, petals, etc.
- **Shoot:** A newly grown aerial part of a plant, e.g. a leaf bud or branch, young branch.

Ranging ecology and habitat characteristics: Movement data was collected studying each troop of *C. g. gallarum* and following for continuous periods at regular intervals of 10 minutes. This study was carried out in combination with feeding and behavioral study of the troops.

During the observation of focal animals in each troop, location of troops were recorded using GPS every 10 min until the follow was concluded, either by the monkeys' entering an evening sleeping tree or the researchers no longer being able to be located [19]. Points with inaccurate GPS position records were excluded from ranging data.

Analysis of ranging data was carried out by calculating daily (short distance) movements and estimating home range. Daily travel routes involve going from a sleeping tree in the morning, through a series of feeding trees throughout the day, to a different sleeping tree in the afternoon [20]. Based on this, daily travel distance by were estimated by summing the distance travelled between the first trees in which they were encountered and all subsequent food and sleeping trees that day [21]. Moreover, movement data was also compared between the dry and wet seasons from the daily records in different periods.

To study the habitat characteristics of the focal troops, sample quadrates were made on the habitats where focal animals dwell. For vegetation description of the study sites, four 50×40 quadrates in each site were established. In each quadrant, the type and number of plant species were recorded. The quantity of plant species for trees, linnas and herbs were calculated.

Data Analysis

SPSS software was used to analyze diurnal activity pattern and social behavior of the target animal. Chi-square test, percentage and mean were used to compare the proportion of time that the different group members and individuals performed consuming plant parts and home range in wet and dry seasons.

Result

Feeding ecology

The dietary strategy of *Colobus guereza gallarum* indicated that they depend leaves, fruits, barks, flowers and shoots for their diet. The major feeding consumption observed was leaves which accounted for 205, 82%, of the overall diet during the study period. Fruits and shoots were the next most often consumed food items accounting 14% and 2%. Barks and flowers were the least consumed food items during the observation time (Figure 1).

During the dry season, *Colobus guereza gallarum* consumed more leaves, barks, and shoots. But, during the wet season they consumed more fruits and flowers. The feeding items of *Colobus guereza gallarum* in the wet and dry seasons is provided in Figure 2.

The identified plants species and the parts of the plants consumed by *Colobus guereza gallarum* in the area are described in Table 1. The frequently consumed plant species throughout the study period were *Schefflera volkensii*, *Brucea antidysenterica*, *Galiniera saxifrage*, *Dombeya torrid*, *Myrsine melanophloeos*, *Rubus steudneri Schweinf*, *Hygenea abyssinica* and *Urera hypselodendron*. Fruits were consumed mostly from *Brucea antidysenterica*, *Rubus steudneri Schweinf* and *Schefflera volkensii* whereas leaves were consumed from all other remaining plant species.

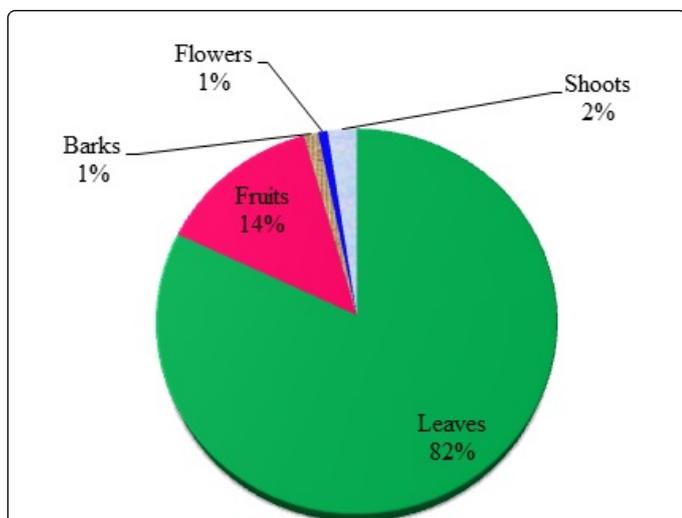


Figure 1: Plant parts preferred by *Colobus guereza gallarum* and their percentage frequency of consumption.

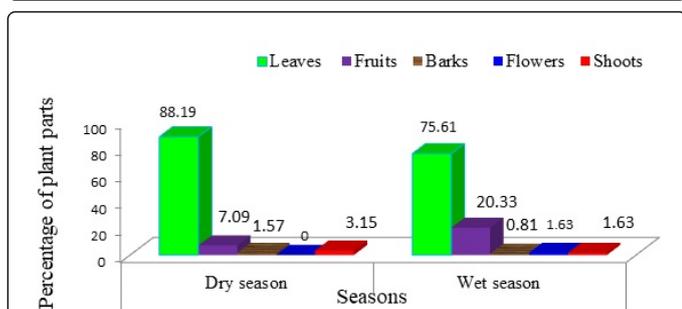


Figure 2: Feeding plant part items of *Colobus guereza gallarum* in the wet and dry seasons.

No.	Scientific Name	Family Name	Parts consumed
1	<i>Schefflera volkensii</i> (Engl.) Harms	Araliaceae	Leaves, fruits
2	<i>Brucea antidysenterica</i> JF. Mill.	Simaroubaceae	Fruits
3	<i>Galiniera saxifraga</i> (Hochst.) Bridson	Rubiaceae	Leaves, fruits
4	<i>Urera hypselodendron</i> (A. Rich.) Wedd.	Urticaceae	Leaves
5	<i>Dombeya torrida</i> (J. F. Gmel.) P. Bamps	Sterculiaceae	Leaves
6	<i>Myrsine melanophloeos</i> (L.) R. Br.	Myrsinaceae	Leaves
7	<i>Rubus steudneri</i> Schweinf.	Rosaceae	Leaves, fruits
8	<i>Hyganea abyssinica</i>		Leaves

Table 1: List of dominant plant species consumed and their parts used by *Colobus guereza gallarum*.

Ranging ecology

The ranging ecology of *Colobus guereza gallarum* in the study area is characterized by a daily range length of 243m. No major difference was observed in the daily range length of guereza in both season wet and dry seasons (Table 2). The Chi-square test indicated no significant difference between the range lengths during the wet and dry seasons ($X^2=0.205$, $df=1$, $p=0.651$).

Monthly records	Range length during the wet and dry seasons	
	Wet season	Dry season
1	248m	256m
2	245m	270m
3	204m	232m
4	260m	237m
Mean	239m	248.7m

Table 2: Range length of *Colobus guereza gallarum* in the wet and dry seasons.

Colobus guereza gallarum were tied to habitats that have trees and are present in forests of Bale Mountains National Park. A total of 18 plant species were mainly characterizing the home range of focal groups in the study area (Table 3).

No.	Scientific Name	Family Name
1	<i>Discopodium eremanthum</i> Chiov.	Solanaceae
2	<i>Conyza hypoleuca</i> A. Rich.	Asteraceae
3	<i>Hypericum revolutum</i> Vahl	Hypericaceae
4	<i>Schefflera volkensii</i> (Engl.) Harms	Araliaceae
5	<i>Brucea antidysenterica</i> JF. Mill.	Simaroubaceae
6	<i>Crotalaria agatitlora</i> Schweinf	Fabaceae
7	<i>Galiniera saxifraga</i> (Hochst.) Bridson	Rubiaceae
8	<i>Urera hypselodendron</i> (A. Rich.) Wedd.	Urticaceae
9	<i>Asparagus racemosus</i> Willd.	Asparagaceae
10	<i>Dombeya torrida</i> (J. F. Gmel.) P. Bamps	Sterculiaceae
11	<i>Conyza spinosa</i> Sch. Bip. ex Olivo & Hiern	Asteraceae
12	<i>Myrsine melanophloeos</i> (L.) R. Br.	Myrsinaceae
13	<i>Rhamnus prinoides</i> L 'Herit.	Rhamnaceae
14	<i>Polystichum magnificum</i> F. Ballard	Dryopteridaceae
15	<i>Solanum adoense</i> Hochst. ex A. Rich.	Solanaceae

16	<i>Rubus steudneri</i> Schweinf.	Rosaceae
17	<i>Diospyros abyssinica</i>	
18	<i>Hygenea abyssinica</i>	

Table 3: Description of the habitat characteristics for focal troops of *Colobus guereza gallarum* in Bale Mountains National Park.

Discussion

Assessment of the quantity and quality of the most and the least eaten plant species is important to make the bulk of the diet of herbivore (Ego, 2003). The highest selection ratio for the plant parts suggests that a preference for the food items that the plant species provided while low selection ratio indicates not preferred [22,23].

According to present study, the dietary preference of *Colobus guereza gallarum* in the study area included leaves, fruits, barks, flowers and shoots. *Colobus guereza gallarum* in the study area rely less on fruits than leaves and the majority of their food source of was leaves (82.00%) followed by fruits 13.60%. This coincides with the other studies on which leaves and fruit make the main foods of the *guereza* species [24,25]. All species of colobus are leaf-eating primates. Food items selected vary by site. Their natural diet consists of predominately leaf material followed by fruits [26]. They also suggested that wild colobus is engaged on leaves due to its high protein and fiber contents. Other foods consumed include bark and flowers as agreed to [18,27,28]. Some authors noted that colobus monkey look for swamp plants, bark and drink water from mud puddles to ingest ample levels of minerals lacking in their primary food components [22,28].

Colobus guereza gallarum consumed more leaves, barks, and shoots during the dry season. But, they consumed more fruits and flowers during the wet season. There was significant variation in parts of plant consumed by colobus monkey during the wet and dry seasons. Likewise, Jensz and Finley [7] noted that colobus monkeys are most of the time prefer and engaged on leaves that are less vulnerable to seasonal fluctuations. Fruits are frequently consumed by colobus monkey when unripe [25,27]. The type of food and plant species was different seasonally, most plants in the study area shaded their leaves during dry season and the study animal changed their foraging seasonally and the most predominant food type was young leaf and followed by unripe fruits. Food availability and preference might be the major reason for seasonal variation in food items consumed [25].

In total the *Colobus guereza gallarum* foraged for 8 plant species throughout the study period. The number [26] of plant species identified as being consumed by *Colobus guereza gallarum* was less comparable to the findings of Shumet and Yihune [25] collection of foraging behaviour studies of colobus monkeys at Fenot Selam Forest, Ethiopia (11 plant species). But, the difference in the number of plant species reported as consumed by *Colobus guereza gallarum* in the study area and the former might be due to the duration of study periods, the subspecies of *Colobus guereza* and the availability of foraging plants.

In the study area, *Colobus guereza gallarum* travelled an average distance of 200 meters and above during both the wet and dry seasons. This coincides with the daily distance travel of other *Colobus* studies that varies with single-group day range averages were between 252 and 734m [29]. Colobine day-range lengths are similarly linked to the availability of food resources [19]. Quite a number of studies on

colobus monkey troops have shown that they travel from 307 to 1068 meters per day on average [29]. Studies on black and-white colobus monkeys have shown they can travel from 26 to 141 meters per hour [28]. In the present study we did not do whole day observations so we cannot say daily path length per troop without extrapolating.

The *Colobus* display considerable variation in home-range size and ranging patterns among genera, species, and populations, although ranges are generally <100 ha [30]. Home range is variable with full home range estimates ranging from just over 0.01 km² to 1 km² with most estimates at the lower end of this range, usually under around 0.2 km² [29,31]. The average range length of *Colobus guereza gallarum* was 239m and 248.7m during the wet and dry seasons, respectively. But, there was no significant difference between the range lengths during the wet and dry seasons. The greater range length records in dry season of this study might be the animal moved long distance to search food sources as compare to wet season. Ehlers idea also agrees with the issue that *Colobus* day-range lengths are similarly linked to the availability of food resources [19]. Habitat loss causes temporal and spatial variation in primates feeding ecology, home range size and activity pattern [9,28]. Primates living in fragmented habitats have smaller home range due to limited resource availability [32,33], travel greater daily distances, and spend more time traveling and less time resting [34,35] which all affects its fitness.

Guerezas are tied to habitats that have trees and are present in forests. They are found in highland or mountain forests [36]. The present study also agreed to this habitat association and distribution. This preference is likely attributable to high species diversity of food trees in some secondary growth forests and may also be explainable in terms of milder chemical defenses in secondary growth species [27,28]. Moreover, the present study revealed that *Colobus guereza gallarum* were seen in habitats characterized by forests composed of tall trees [37-39].

Generally *Colobus guereza gallarum* have preferred leaves, fruits, barks, flowers and shoots for their diet in the study area. However, leaves were the most often consumed food items of the overall diet during the study period followed by fruits and shoots. But, barks and flowers were the least consumed food items of *Colobus guereza gallarum*. Besides these, food items have been eaten by this animal according to their availability during dry and wet season. Even, the dry and wet season range length had no major difference, it depend up on the availability of food sources. Moreover, the present study provides relevant and base line information for conservation organizations and other concerned bodies about the basic information on its feeding and range ecology [40,41]. Therefore, the survival of the species depends comprehensively on planning and implementing on the conservation and management of their food plants and habitat. For that reason, special attention should be given to conserve the plant and animals which reside in it. Further studies should be conducted to analyze the fecal of *Colobus guereza gallarum* and different aspects of it in the study area.

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