ACTIVITY PATTERNS, FEEDING AND RANGING ECOLOGY OF COLOBUS MONKEY (*Colobus guereza*) IN CORE AND TRANSITION ZONE OF KAFFA BIOSPHERE RESERVE, SAYLEM DISTRICT, SOUTHWESTERN ETHIOPIA

MSc. THESIS

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MSc. Thesis

Submitted to the Department of Natural Resources Management, College of Agriculture and Veterinary Medicine, Jimma University in Partial Fulfillment of the Requirements for the MSc. Degree in Natural Resources Management (Wildlife and Ecotourism Management)

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DEDICATION

This thesis is wholeheartedly dedicated to my beloved parents who have been my source of inspiration and gave me strength when I thought of giving up, who continually provide their moral, spiritual, emotional and financial support.

STATEMENT OF AUTHOR

I, hereby confirm that this thesis is my original work and has not been presented for a degree in any other University and that all sources of material used in this thesis have been duly acknowledged.

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BIOGRAPHICAL SKETCH

Temesgen Tafesse was born in Saylem Woreda Kaffa Zone South Nation Nationalities and People Region on June 10/ 1990. He attended his primary education and junior secondary education at Saylem Primary School from 1996 to 2004 and his secondary educations at Masha Senior Secondary School from 2004 to 2006.

He joined Wolayita Agricultural Technical Vocational Educational Training College in 2006, and graduated with a Diploma in natural resource management on July 25, 2009. After graduation, he was serving in Saylem Woreda as a position of Development Agent for 4 years; he joined Mizan-Tepi University as an advanced standing student and graduated with BSc degree in Natural resource management in December 2016.

After graduation, he had been working in Saylem Woreda as Agriculture and Natural Resource Management office as a watershed design expert for one year. Then he joined Jimma University College of Agriculture and Veterinary Medicine School of Graduate Studies for the degree of Masters of Science in natural resources management specialization of wildlife and ecotourism management in 2017.

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ABBREVIATION AND ACRONYMS

^{0}C	Degree Celsius
GMS	Geisha Meteorological Station
GPS:	Geographical Positioning System
IUCN:	International Union for Conservation of Nature
LC:	Least concerned
NABU:	Nature and Biodiversity Union
MAB:	Man and Biosphere
Masl:	Meter above Sea Level
MM:	Millie Meter
SNNPR	South Nation Nationalities and Peoples Region
UNESCO	United Nations Educational, Scientific and Cultural Organization

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ACTIVITY PATTERNS, FEEDING AND RANGING ECOLOGY OF COLOBUS MONKEY (Colobus guereza) IN CORE AND TRANSITION ZONE OF KAFFA BIOSPHERE RESERVE, SAYLEM DISTRICT, SOUTH WESTERN ETHIOPIA

ABSTRACT

Understanding of activity pattern, ranging and feeding ecology of primates is essential for caring its behavioral ecology and evaluating the suitability of habitats for the species. Colobus monkey (Colobus guereza) is currently listed as Data Deficient on the IUCN Red list and thus it does not get more conservation attention. With the current increasing habitat loss and degradation across its geographic range, data on the current activity pattern, feeding and ranging ecology are essential to design a management plan as well as it helps to evaluate the UNESCO program under the Man and Biosphere Reserve's objective with respect to colobus monkey conservation. This study, therefore aims at providing data on the activity patterns, day range length, home range size and diets of two different Colobus guereza groups (Group I and Group II) in transitional and core zone of Kaffa biosphere reserve, Saylem District, SNNPR, southwestern Ethiopia. The activity time budget, feeding ecology and ranging behavior were studied in two groups for five minutes with 15 minute interval scan sampling for the 6 month study period. Ranging data were derived from by calculating daily movements and estimating home range. To see the variation of the two-habitat types vegetation studies were carried out by using systematic random sampling. On each transect, five rectangular plots of dimensions 20m by 25m (500m^2) were systematically established at 100m interval throughout the home range of the two groups. The overall activity time budgets (n=11861) of the two groups of C. guereza were, (37.67% and 47.60%) of their time spent in resting, (29.7% and 12.52%) moving, (16.2% and 21.79%) feeding, (4.55% and 4.75%) playing, (5.70% and 8.13%) grooming (2.96% and 2.10%) aggression, (0.87% and 1.23%) sexual activities and (2.35% and 1.88%) of their of time spent on other activities in Group I and Group II, respectively. During the course of the study in total they foraged 16 different plant species belonged to 13 families. The individuals of Group I consumed 15 different plant species, while individuals of Group II consumed 12 plant species. The most frequently consumed plant species in Group I were Ilex mitis (21.79 %), Prunus africana (21.56%) and Macaranga capensis (13.32%). In the case of Group II, Prunus africana contributed for (25.07%) Macaranga capensis (16.65%) and Syzigium guineans (15.5%) were mostly consumed species. Colobus guereza in the study area had shown strong preference on young leaves and fruits (47.85% and 30.88%) in Group I and (43.73% and 30.74%) in Group II respectively. Home range size was 63.3 ha for Group I and 67.2 ha for Group II. The average day range length was 558.77m and 495.00m for Group I and Group II. Even though there are some behavioural activity variation in the two groups of Colobus generally, transition zone of Kaffa Biosphere can serve as an equivalent habitat for colobus conservation by planting some preferred diet plants in the area.

Key words: biosphere reserve, Group I, Group II, Guereza, Kaffa, Saylem District

1. INTRODUCTION

1.1 Background and Justification

Habitat loss and degradation are the main causes of loss of species in different parts of the world. Habitat degradation is one of the most common outcomes of human-induced habitat loss in tropical forest ecosystems. A number of forest-dwelling animals, including primates, are severely affected by the degradation of their habitat (Isabirye-Basuta and Lwanga, 2008). The existing evidence suggested that habitat degradation influences the lives of primates in many arenas, including impacting their home range sizes, dietary compositions, daily path lengths, gastrointestinal parasite loads and opportunities for dispersal (Boyle *et al.*, 2012). Hence, identifying and developing alternative management strategies, including forest ecosystem services that sustain and fulfil human life and provide conservation is increasingly important.

The UNESCO program under the Man and Biosphere (MAB) in the creation of biosphere reserve was believed to be a promising management technique for better resource utilization of human and wild animal's as well as their coexistence. A biosphere reserve is a protected area in which multiple use of land is permitted by dividing it into three zones (Core, Buffer and Transitional zones), each for a particular activity (UNESCO, 2017). This system is meant for preserving biodiversity, ecosystem and landscape resources without evacuating inhabitants. So the traditional lifestyle and traditional resources of the local people are also maintained.

The Kaffa biosphere reserve is one of the largest and most accessible of the four UNESCO-recognized biosphere reserves in Ethiopia's western highlands. The Kaffa biosphere reserve is possibly home to six primate species of five different genera (NABU, 2017). Among these, it is common to find Black-and-white colobus in the three zones of the biosphere reserve.

Black-and-white colobus *(Colobus guereza)* are an arboreal Old World primate taxon inhabiting the deciduous and evergreen forests of several African countries (Fashing and Oates, 2013). It is known as a monkey that spend more time in resting and feeding rather than moving as a strategy for energy conservation (Oates, 1977a; Dasilva, 1992; Wijtten *et al.*, 2012). Currently the species is listed as Data Deficient on the IUCN Red list and thus it does not get conservation attention (IUCN, 2012). The behavior and ecology of guerezas are highly influenced by forest fragmentation, habitat modification and other forms of human disturbance to their natural habitats. Therefore, studying the activity pattern, feeding and ranging ecology are important for evaluation of the habitat types.

Activity patterns and time budgets of Colobus monkeys are commonly associated with strategies of energy conservation (Oates, 1977b; Dasilva, 1992) and are affected by predator; human pressure; social structure, season, distribution, availability and quality of food resources (Clutton-Brock, 1975; Kinnaird and O'Brien, 2000). Increased resting levels among Colobus monkeys have also been linked to vegetation quality (Marsh, 1981). Travel and feeding activity might also be influenced by the availability of food sources.

Leaves and fruits are the main food items of the *C. guereza* but the diet is quite variable as would be expected in a species with such a wide distribution and range of habitat types (Fashing, 2001b). While the species has historically been believed to be exclusively leaf-eaters, they are not obligated folivorous (Oates, 1994; Fashing, 2001b). The proportions of these types of food relative to one another varies by study site and seasons, often with leaves, making up more than half to most of the diet, but with fruit sometimes predominating (Harris and Chapman, 2007). Often, while a number of species of plant are exploited, only several make up the majority of the diet at a specific site (Harris and Chapman, 2007).

Home range is variable with study site, with full home range estimates ranging from just over 0.01 km^2 to 1 km^2. Most estimates at the lower end of this range, usually under 0.2 km^2 (Fashing, 2001a). In addition, there are core areas within the home range, which are significantly smaller than the overall home range (Harris and Chapman, 2007). Several studies showed that, single-group day range averages were between 252 and 734 m ranging as small as 62 m in a day to over 1360m (Bocian, 1997; Fashing 2001a).

In different parts of Ethiopia, limited researches have been conducted on the activity patterns, feeding and ranging ecology of Colobus monkeys (Dereje, 2018; Petros *et al*, 2018). So far, no study has been conducted on activity patterns, ranging and feeding ecology of *C. guereza* residing in the core and transitional zones of the biosphere reserve. Therefore, this study was aimed at investigating the activity patterns, ranging and feeding ecology of colobus monkeys in the core and transitional zone of the Kaffa Biosphere Reserve of Saylem District.

1.2 Statement of the problem

The taxonomic status of many of East African primates is still under debate and the geographical distribution and conservation status of many of the primate taxa remain poorly understood (De Jong and Butynski, 2012). Even though the most other subspecies of colobus monkeys have been a subject of study for decades (Oates, 1977a; Bocian, 1997; Von Hippel, 1998; Von Hippel *et al.*, 2000; Fashing, 2001a; 2001b; 2002; Chapman *et al.*, 2007) little is known about the behavioral flexibility of colobus in natural and fragmented habitats as well as only limited number of researches have been conducted on the behavior and ecology of colobus monkeys in some parts of Ethiopia (Dunbar, 1987; Jensz and Finley, 2011; Dereje, 2018). They lack of adequate information regarding the behavioral ecology of the monkeys could negatively affect its conservation strategies and can cause future extinction of the species. Thus, understanding of the basic quantitative natural history of primate species is essential for effective conservation endeavor. Nevertheless, there is no data in particular on activity patterns, feeding, and ranging behavior of the guerezas that compares different zones of the Kaffa biosphere reserve (NABU, 2017). Historically the forest area covered a large area of land, but currently it is being shrunk into inaccessible corridor due to anthropogenic factors. As a result, the size of transition zones is increasing from time to time. This undoubtedly forces the wildlife population, including colobus monkeys to decline in size or congregate within the remaining fragment of the forest.

Thus, examining activity pattern, ranging and feeding ecology is an integral part of primate field studies including guerezas for two reasons. Firstly, Knowledge on the diurnal activity pattern, time budget and ranging behavior of the animal can serve as an important tool in developing the species conservation strategies (Kivai *et al*., 2007). Secondly, examining the feeding ecology provide information on the individual food species is necessary for the primate's survival and also insight its level of dietary specialization (Addisu *et al*., 2010). Although the Colobus monkeys have been studied, the issues related to activity pattern, feeding and ranging ecology in some parts of the countries, the parameters to be dealt in this issue, will provide information and facilitate conservation initiatives for better protection of the animal and its habitat in the Kaffa biosphere reserve Saylem District.

1.3 The objectives of study

1.3.1 General objective of study

The general objective of this study was to investigate the activity patterns, ranging and feeding ecology of *Colobus guereza* in core and transitional zones of Kaffa biosphere reserve, Saylem District, Southwestern Ethiopia.

1.3.2 Specific objectives

The specific objectives of this study are to:

- Compare the activity patterns and time budgets of *Colobus guereza* in core and transitional zone habitats of the Kaffa biosphere reserve.

- Examine seasonal diet items and food preference of *Colobus guereza* in core and transitional zone habitats of the Kaffa biosphere reserve.

- Examine the home range size and day range length of Colobus monkeys in core and transitional zone habitats of the Kaffa biosphere reserve.

- Compare the vegetation composition in the home ranges of *Colobus guereza* in core and transitional zone habitats of the Kaffa biosphere reserve.

1.4 Research question

1. What are the major daily activities of *C. guereza* and how much time devoted to each activity in each zone?

2. Which diet item is most preferred in which season by *Colobus guereza* in core and transitional zone habitats of Kaffa biosphere reserve?

3. What is the daily range length and home range size of *Colobus guereza* in core and transitional zone habitats of Kaffa biosphere reserve?

4. What is the vegetation composition in the home ranges of *Colobus guereza* in core and transitional zone habitats of the Kaffa biosphere reserve?

2. LITERTURE REVIEW

2.1 Description and taxonomy of Colobus monkeys

Black and white Colobus monkey belongs to order primate; Suborder *Haplorrhini*; Infraorder: *Simiiformes*; Family: *Cercopithecidae*; Genus: *Colobus*; and Species: *Colobus guereza* (Grooves, 2005). Known simply as the guereza, the eastern black-and-white colobus, or the Abyssinian black-and-white colobus, is one of the old world primates.

The *Colobus guereza* got their name from the highly reduced or absence of the thumbs from its limbs. They are named after the Greek word kolobos, which means mutilated. Although their thumbs are reduced, the other phalanges are very long. The hind limbs in colobines are longer than the forelimbs, and they have long tails (Davies and Oates, 1994). The guereza is a large, sturdy colobus monkey with a black and white coat. Glossy black fur covers much of the body, but contrasts with short, white hair surrounding the face, and a U-shaped, cape-like mantle of long white hair that extends down the shoulders and across the lower back. The tail is either a white or yellow Color from tip to base with a large white tuft at the end of the tail (Kim, 2002). The face is gray and has no fur. At birth, the hair of infant guereza is completely white, in striking contrast with the predominately black fur of the adult guereza

2.2. Distribution and biology of colobus monkeys

The primate order is one of the most diverse and successful group of mammals with more than 630 taxa currently described (Mittermeier *et al.*, 2009; Rowe and Myers, 2011). Over the course of their evolutionary history, non-human primates display a great diversity of behavioral and morphological traits. Nonhuman primates have been documented in every continent colonized by placental mammals with the exception of Antarctica (Rowe and Myers, 2011). A number of primate societies have been subject to observational studies for many decades. These studies have focused on the behavior, ecology and social organization of primates in their natural environment and have transformed our understanding of their social systems and evolution (Rodrigues, 2012).

The black and white colobus monkey (*Colobus guereza*) is one of the five recognized species in the genus *Colobus* which inhabits a wide range of forest types in tropical Africa from Ethiopia to Nigeria (Dunbar and Dunbar, 1974). The species are folivorous and often, though not always, exhibits a preference for young leaves (Fashing, 2001b). According to Kingdon *et al.* (2008), the species, contains eight subspecies, of which, two are endemic to Ethiopia: *C.g guereza* and *C.g gallarum*.

The Ommo River Colobus monkey (*Colobus guereza* Ruppell, 1835) is found in the highlands west of the Great Rift Valley down to the reaches of the Awash River, the Omo River and in the Blue Nile gorge. The Djaffa Mountains Colobus monkey (*C.g gallarum*, Newmann 1902) is found east of the Great Rift Valley in Ethiopia (Groves, 2007; Jensz and Finley, 2011). The subspecies status is based on differences in morphological features. In *C. g guereza,* mantle hair is relatively long, covering about 20% of the tail. The tail is much longer than head-body length (HB) and proximal part of the tail is gray while the distal part is silvery white. Whereas, in *C. g gallarum*, the proximal part of the tail is black with scattered gray hairs increasing distally and the distal part is white and bushy. Both of the subspecies occur at altitudes ranging from 400-3300 masl (Yalden *et al.,* 1977).

2.3 Activity patterns of colobus monkeys

Identifying how animals divide their activities throughout the day offers clear perception into their interaction with the environment and their strategies for maximizing energetic and reproductive success (Defler, 1995). Studies on the activity budgets of species in fragments in comparison to larger forest blocks can give an indication of habitat quality such as food availability, density and distribution at least in the short term (Zanette *et al.,* 2000; Wong and Sicotte, 2007).

Activity budgets of guerezas are directly related to metabolism and energy needs those changes over the course of the seasons or in relation to reproductive stage (Halle and Stenseth, 2012). The availability and spatial patterning of food resources affect the activity and ranging patterns of many primates (Olupot *et al.*, 1997; Wijtten *et al.,* 2012; Smith *et al.*, 2013).

Colobus monkeys in forests spend more time resting and feeding than moving or engaging in social activities. This variation in activity pattern can also be due to energy conservation strategies (Wijtten *et al.,* 2012). As a consequence of energy conservation, colobus monkeys tend to move short distances and spend much time resting while feeding on the abundant food available (Fashing, 2001; Wijtten *et al.,* 2012). Difference in activity might be due to variations in habitats, from coastal forests to mountain forests (Fashing *et al.,* 2007). For example the studies in the Ethiopia Sidama Zone, Gidabo forest revealed that the percentage of time spent for different diurnal activity patterns in *C. g gallarum* indicated that more time (55.77%) was devoted to resting; this was followed by feeding (22.64%). Moving, grooming and social play activities took relatively less time compared to resting and feeding (Mohammed and Desalegn, 2017).

2.4 Feeding ecology and resource availability

Colobus monkeys are forest-dependent and live in groups of highly variable size, often forming mixed-species associations with other primates (Clutton-Brock, 1975; Oates, 1977). Guerezas extremely depend on leaves and their special adaptation to exploit the foliage attributed to life in the gallery and dry forests (Oates, 1977; Bocian, 1997). However, descriptions of the diets of frugivorous primates traditionally contrasted the relative importance of different food items by the time spent feeding on them (Felton *et al.*, 2008).

Members of the subfamily reveal various anatomical structures that can be considered as adaptations for ingesting leaves (Xiang *et al.*, 2007). Several studies reported that colobus monkey feed primarily on young leaves of different plant species (Oates 1977; Bocian, 1997; Oates, 1994). From these plant species that contributed to the overall diet of the study species, the top three plant species, namely *prunes africana, Celtis africana and Ficus vasta* accounted for more than 50% of their plant diet (Mohammed and Desalegn, 217).

2.5 Ranging ecology of colobus monkeys

Information about species' home-range size, ranging and activity patterns is vital for understanding its behavioral ecology, habitat requirements, and vulnerability to extinction (Singleton and van Schaik, 2001; Nkurunungi and Stanford, 2006). Researchers observe animal ranging behavior and habitat use to investigate the interaction between ecological influences and individual patterns of behavior (Zhou *et al.*, 2014). Ranging patterns are thought to be influenced by a variety of ecological and behavioural factors, including food availability, distribution and quality (Clutton-Brock, 1975; Zhang, 1995; Olupot *et al.*, 1997), rainfall patterns (Isbell, 1983; Olupot *et al.*, 1997), distribution of water (Scholz and

Kappeler, 2004), group size (Waser, 1977; Van Schaik *et al.*, 1983), reproductive situation (Rasmussen, 1979; Overdorff, 1993), location of sleeping site (Zhou *et al.*, 2011), intergroup relationships and social interaction (Isbell, 1983), forest structure (Fan and Jiang, 2008), and parasite avoidance (Nunn and Dokey, 2006). Of these factors, primate ranging patterns are influenced primarily by the availability, distribution and quality of food (Zhou *et al.*, 2011).

Home range size within a species tends to increase with increasing group size and a similar relationship between group biomass and range size (Dunbar, 1988). Folivorous species such as guerezas tend to have smaller home ranges and travel shorter distances each day than frugivorous primates (Zhou *et al.*, 2014). The relatively poor quality yet increased ubiquity of the forage consumed by folivorous may account for these trends (Chapman, 2000). Moreover, primates can regulate their ranging behavior in response to seasonal changes in food availability as some primates reduce the length of daily travel when high-quality food is scarce (Bartlett, 1999), while others show the opposite response, travelling further in search of high-quality food (Bocian, 1997).

2.6 Habitat use and preference of colobus monkey

The guereza is mainly found in forests and savannah woodlands within, and to the north, of the moist forests of central Africa, often spreading into highland or mountain forests (Oates *et al.*, 1994). Other habitat types include primary, secondary, riparian, gallery, and upland forest, and moist lowland, medium-altitude and highland forests, rainforests, swamp forests and wooded grasslands (Oates 1977b; Dunbar 1987; Oates 1994; Fashing 2001; Harris and Chapman 2007). This species also inhabits disturbed, secondary, or colonizing forests, and prefers degraded forests to old growth when both are available (Thomas, 1991; Lwanga, 2006). In addition, they can be found in high forests in mountainous areas, including altitudes up to 3300 m as well as areas under human use, such as eucalyptus plantations (Gron, 2009). The guerezas desire to occupy the lower part of the trees if their area does not overlap with that of any other group of monkeys. When trees are not densely spaced, guereza feed and travel on the ground (Kim, 2002).

2.7 Threats to Colobus monkeys

Africa contains a number of the world's biodiversity hotspots, including; the Western African Forests and the Eastern Arc and Coastal Forests of Tanzania and Kenya, (the latter is listed as the 8^{th} hottest hot spot in the world) all vital habitats of colobus monkeys (Myers *et al.*, 2000). In addition to ongoing deforestation; hunting, diseases and climate change are major threats to colobus monkey populations in these forests (McGoogan *et al.*, 2007). Particularly in East African tropical forests, rapid human population growth has had a drastic effect. These forests are increasingly used for bush meat, fuel wood, poles, timber and charcoal production and are labeled for growing crops and exotic trees. This has led to widespread forest fragmentation. Colobus monkeys being highly arboreal are especially vulnerable to these threats, as they require leaves, fruits and seeds for survival (Anderson *et al.,* 2007)

In order to conserve primates in the future, conservation practice involving participation of the local people is mandatory (Wallis and Lonsdorf, 2009). Natural forest is threatened by agricultural expansion, and grazing has a significant negative impact in the area as it accelerates habitat degradation and competition of wildlife with livestock (Mohammed and Desalegn, 2017).

In Ethiopia colobus monkey has no direct danger of local people because local community does not consider the species as crop pests, but it is indirectly in danger by the local people through deforestation and disturbance of their home range. This attitude has a positive impact for long term conservation of the colobus monkeys in the area (Mohammed and Desalegn, 2017). Consideration about the local people's attitude towards wildlife and particular aspects helping people's tolerance about conservation need to be studied as part of the process of developing modification strategies (Hill, 2004).

3. MATERIALS AND METHODS

3.1 Description of the study area

The Kaffa biosphere reserve is situated in South Nation Nationalities and People's Region Southwestern Ethiopia. It is located in the coordinates of 7°22' - 8°3' N, Latitude and 35°9'-36°3' E, Longitude and covers a total area of 760,144ha which located 460 km far from the capital Addis Ababa Ethiopia. The Kaffa biosphere reserve is one of the 701 biosphere networks in the global and attained the status in March, 2011 (NABU, 2017). The biosphere reserve stretches across the boundaries of 10 Districts in the zone. For this study, Saylem District was selected. The administrative town of the Saylem District is Yadota, located 160km far from Bonga; the office Kaffa biosphere reserve (Figure 1). The Rainfall distribution pattern of the District is characterized by eight month wet season from late April to November. The mean annual rainfall of the study area was 2115.1mm. The temperature ranged from a low mean monthly minimum of 11.69°c in February to a highest mean monthly maximum of 23.52°c in November (GMS, 2019)

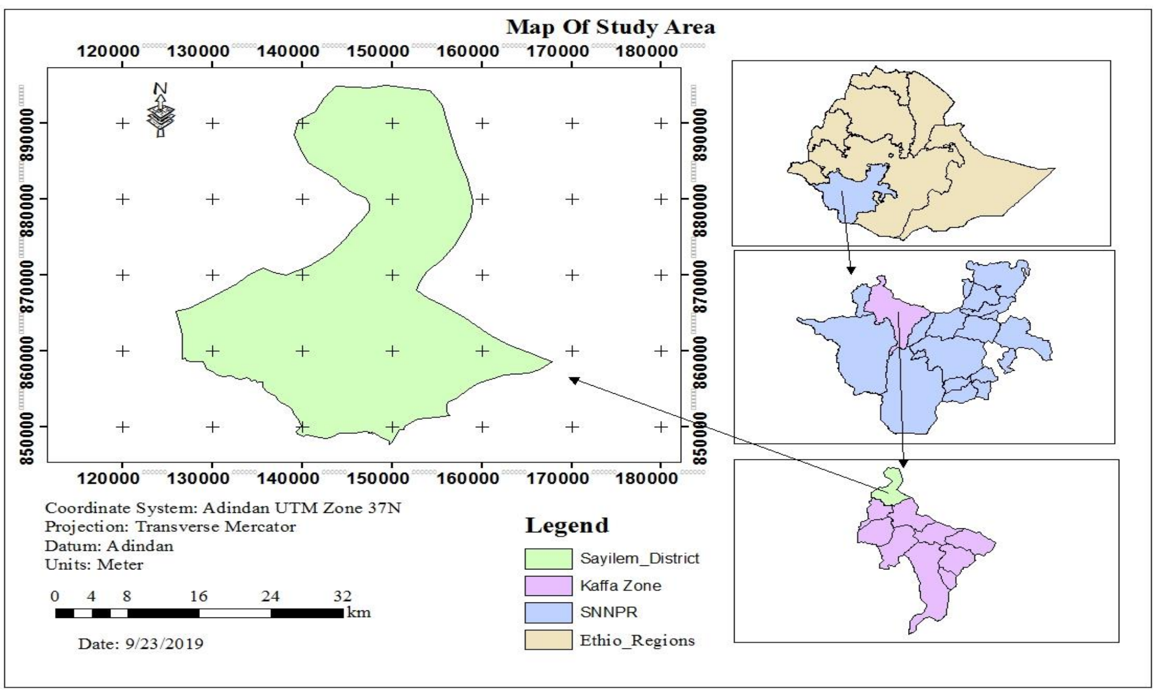


Figure 1: Map of the study area

3.2 Materials

Materials used for this study were binoculars, a digital photograph camera, tape meter, Garmin Global Positioning System (GPS) 72, compass, papers, bag, data collection sheets, flagging and a plant press.

3.3 Preliminary surveys

Reconnaissance surveys were made during the initial phase of the study in December 1 to December 25, 2018. During the reconnaissance survey, habitat types were identified based on the dominant vegetation cover and forest management types. Two Kebeles were purposively identified from transitional and core zone of the biosphere reserve from the total of 21 rural Kebeles found in the three zones of the biosphere reserve in Saylem District. The Shuunit Kebele was selected from the transitional zone of the biosphere due to the availability of larger farm activities and the level of deforestation in the area and Shonkora Kebele was selected from the core zone of the biosphere due the presence of dense natural forest (Table 1). The distance between the two Kebeles is around 19km. This distance was measured by using arc map view (GIS version 10.3).

Table 1: Description of habitat types in Kaffa Biosphere reserve

Habitat types	Descriptions
Core Zone	The core zone is absolutely undisturbed. It contain two suitable habitat types (primary forest and riparian forest) for numerous plant and animal species, including higher order predators and may contain centers of endemism
Transition zone	Is the outermost part of a biosphere reserve which contain five habitat types (farm land, grazing land, fragmented forest, plantation forest and bamboo forest) the activities in this zone include settlements, crop lands, managed forests and area for intensive recreation and other economic uses characteristic of the region.

To determine the distribution of the study subject in the study area and two sites were selected based on the availability of natural forest in order to compare variation among the different forest management types. Then two groups of colobus monkeys were selected for this study from several groups of Colobus monkeys found in transitional and core zone of the biosphere reserve. Group I from the transitional zone of the biosphere and the other Group II from the core zone of the biosphere for scan sampling to record activity, diet and ranging patterns.

Accordingly, the selected groups were identified from other groups by the total number of individuals, the sex ratio of individuals and unique natural marking of dominant individuals of group members. Group I consisted of seven individuals (one adult male, two adult females, one sub-adult male, one sub-adult female and two juveniles) at the start of this study, increased to eight individuals after one infant was born in February, 2019. Group II had nine individuals (two adult males, three adult females and one sub-adult male, one sub adult female and two juveniles) at the start of this study, also adding three infants (born in January and April, 2019) which increased the group size to twelve.

The study groups were habituated to human observer for a month by following the groups throughout the day. Both groups of guerezas were shy and elusive during the start of habituation period and flee from observers and hide themselves especially in the upper canopy of the tallest trees of *eucalyptus* and S*chefflera abissinica.* Hence, it was not possible to see colobus monkeys at a distance greater than 50 m. After being habituated, colobus monkeys were approached up to 5 m animal observer distance whereby they perform their natural behavior ignoring human presence in their vicinity.

3.4 Data collection and sampling methods

Data were collected for six consecutive months (January, 2019 to June, 2019) in two phases. The dry season data were collected from January to March, 2019 and the wet season data were collected from April to June, 2019. Direct observation method was used for activity pattern recording and parts of the plant were recorded by using binoculars and their location points using GPS. Sampling methods for activity pattern of *Colobus guereza* groups was done through field observation using scan sampling (Altman, 1974) for five consecutive days for each group per month.

3.4.1 Activity pattern

The scan sampling method was used to collect behavioral data on multiple group members (Altman, 1974). Activity data were collected from each of the two study groups (Group I and

II) for 10 consecutive days (five days for each group) per month in dry and wet seasons to minimize seasonality effects. During activity scan sampling, the activities of monkeys were recorded for 5 minutes at 15 minute intervals to combat observers fatigue from 07:00-17:30 h (Fashing, 2001a; Wong and Sicotte, 2007).

The activity recorded for each visible individual was the first activity that lasted for 5 seconds. Data was collected for the first 1-5 visible adults, sub-adults or juveniles (ignoring infants). The group was scanned each time from left to right to avoid possible biases towards eye-catch activities like grooming, fighting or mating (Fashing, 2001a).

The identity of the scanned individuals was recorded and assigned to one of the following age/sex classes: adult male, adult female, sub-adult male, sub-adult female, juvenile male or juvenile female. An individual scan was recorded when guerezas performed one of the following behavioral records on the standardized data sheet: feeding, moving, resting, playing, aggression, grooming, sexual activity and others (Fashing, 2001a).

Feeding was recorded when monkeys were manipulating, masticating, or ingesting a particular food item. Moving was recorded when monkeys changed spatial position, included walking, jumping, or running. Resting was recorded when monkeys were inactive, either sitting or lying down. Playing included chasing, hitting, and other vigorous activities involving exaggerated movements and gestures by a monkey interacting with others in a non-aggressive manner. Aggression was recorded when the monkey is chased, bit, grabbed, displaced, threatened another monkey, or vocalize in an aggressive context. Grooming was recorded when a monkey used its hands to explore or to clean its body or the body of another monkey. Sexual activities were recorded when an individual engaged in copulatory behavior. Others activities were recorded when the monkey performs activities such as vocalizing or defecating that did not fit into the main categories (Addisu *et al.*, 2010).

Activity time budget was calculated by dividing the proportion of the number of behavioral records for each activity category by the total number of activity records in each day. Then it was summed within each month to construct monthly proportions of time budgets. The grand mean proportion of the monthly budget provides the overall time budgets, as well as the overall time budgets during the entire study period (Di Fiore and Rodman, 2001).

3.4.2 Feeding ecology

During the activity scan sampling, when the colobus monkey was observed feeding, the type of food item it consumed was recorded as young leaves, mature leaves, roots, stems, flowers, fruits, seeds, shoots, barks, unknown plant parts or animal prey. The type of species consumed were also recorded (Fashing, 2001b; Fairgrieve and Muhumuza, 2003; Di Fiore, 2004). The shoots are the newly grown aerial parts of plants including buds. Plant species in this study area were identified with nature and the biodiversity union (NABU, 2017) and for further study experiment method was used such as different pictures, taxonomic books.

Dietary records were evaluated by calculating the proportion of different food items and species consumed by the monkeys. The daily food items and type of species consumed by the groups were summed within each month to construct monthly proportion of food items and food types consumed. The monthly proportion of each food item was calculated as the total number of monthly individual scans for each food item divided by the total number of individual scans for all food item individual scans spent for the groups. The relative proportion of plant species used as food for colobus monkeys were calculated from the monthly percentage contribution of different species (Fashing, 2001b; Di Fiore, 2004).

Dietary preference for different food species of the study group was also calculated as the proportion of total feeding time spent during the study period feeding on a certain species *i* divided by the density of that species *i* in the study groups' home range (Fashing, 2001b; Xiang *et al.*, 2007; Ryan *et al.*, 2013).

$$\mathrm{SR} = \frac{\text{Percentage of time spent feeding on species i}}{\text{stem density of species i}}$$

Where SR=selection ratio

3.4.3 Ranging ecology

At the time of each activity scan sampling, the location of the geographic center of the group in both habitat types was recorded by using GPS. The distance travelled each day with the group was determined based on the shortest point-to-point movements of the group center between consecutive locations during full-day follows (from 07:00 to 17:30 hours) (Dereje, 2018).

Each day range was drawn on a GIS-system and generated maps by connecting the consecutive GPS location records and the total distances traveled per day. The home ranges were calculated by constructing a polygon around the outermost GPS locations used by colobus monkeys during both wet and dry seasons. The seasonal and overall home range areas used during the course of the study period were calculated by GIS Arc View 10.3. Then mean day range lengths were calculated by averaging the wet and dry season day range lengths of the colobus monkeys for both groups. Arc Map software programs were used to calculate the home range size of the colobus monkeys were inhibited in both transitional zone and core zones by minimum convex polygon (MCP) method (Addisu *et al.,* 2017; Derje, 2010).

3.4.4 Vegetation composition

To classify the habitat management types in the biosphere reserve, vegetation studies were carried out by using systematic random sampling in each study site, Group I and Group II. Four sets of 500 m transect were laid systematically in the north-south direction that was 250m apart. Within a particular transect, five rectangular plots of dimensions 20m by 25m ($500m^2$) were also systematically established at 100m interval (Wiafe, 2014). Red ribbons were tied at the corners of the plot and if the greater part of a border tree fell within the plot the tree was enumerated, and if the greater part fell outside the plot then the tree was excluded. Moving in a clockwise direction within a plot, all vegetation, including herbs, climber, shrubs and trees were recorded. Trees with girth at breast height (1.30m from the ground) equal to or greater than 31cm (>31cm, gbh), were identified, measured and recorded. The girth at breast height of each sampled tree was measured over bark with the linear tape. However, there were some reasons to deviate sometimes from this standard “breast height” and execute the girth/diameter measurements at another position on the sample tree.

These were as follows:

1. Sample trees with buttresses: the stem diameter was measured approximately 30 cm above the buttress.

2. Sample trees with aerial or stilt roots: the stem diameter was measured at 1.3m above the beginning of the stem.

3. Forked trees were regarded as two sample trees if the fork was below 1.3m. Consequently, forked trees were regarded as one tree if the fork is above 1.3m.

The girth values (gbh) were converted to diameter at breast height (dbh) values by using the formula:

D = $\boldsymbol{\frac{C}{\pi}}$ Where D represents diameter; C represents girth and $\pi = 3.142$. To examine plant species diversity over the study period, the Shannon-Weaver index of diversity (H′) was calculated (Krebs, 1989). Evenness was calculated to determine whether the plant species were evenly distributed or not in the study group’s home ranges. Potential scores range from '0' (least even) to '1' (most even).

The formula for computing diversity was used is:

$$\mathbf{H'} = -\sum_{i=1}^{s} pilnpi$$

Where, H' is Shannon-Weaver index of diversity, **s** is the number of species and *pi* is the proportion of the total number of individuals represented by the i^{th} species.

Evenness was calculated by using the evenness index formula:

$$\mathbf{J} = \frac{\mathbf{H'}}{\mathbf{H}\ \text{maximum}}$$

Where, H' is Shannon-Weaver index of diversity and H maximum is a maximum diversity index.

$$\text{Density} = \frac{\text{Total number of species}}{\text{Unit area in hectar}}$$

$$\text{Basal area} = \frac{\pi D^2}{4}$$

Where D=the diameter at the breast height and $\boldsymbol{\pi} = 3.14$

$$\text{Relative density} = \frac{\text{Number aparticular species}}{\text{Number of all enumerated species}}$$

$$\text{Relative dominance} = \frac{\sum \text{basal area for all trees of a particular species}}{\sum \text{basal area for all species pooled}}$$

3.5 Data analysis

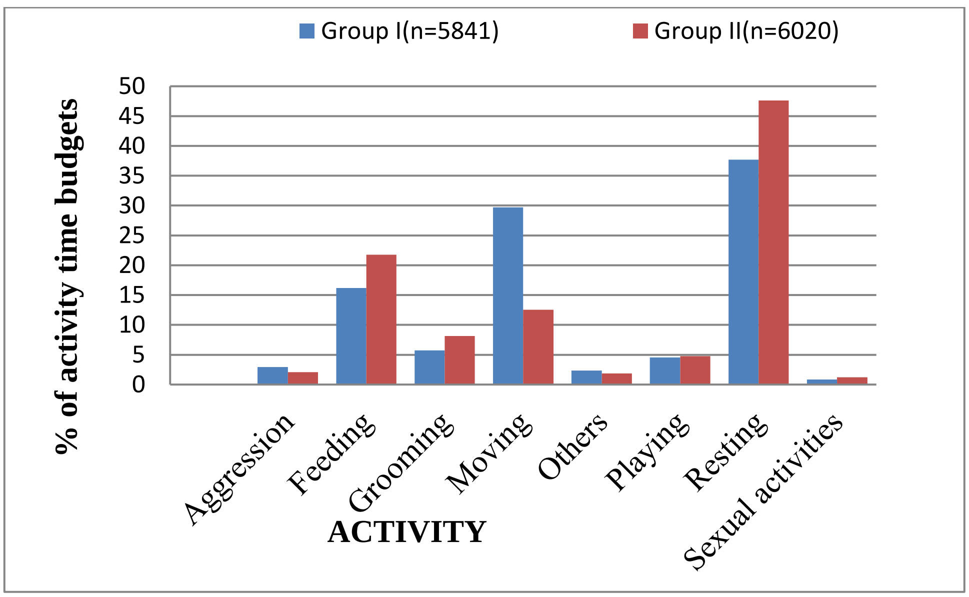
All statistical data were analyzed using R 3.5.2 Programing language software. Percentage and mean were used to compare the proportion of time budgets that the different groups performed, consumed plant parts and home ranges in wet and dry seasons. Statistical tests used were two-tailed with 95% confidence intervals. The chi - square test was used to compare statically significance between the groups and seasons.

4. RESULTS AND DISCUSSION

4.1. Activity patterns

A total of 11861 individual behavioral observations were recorded from 2760 instantaneous group scans during 690 hours in 60 total observation days (30 days for each of transitional (Group I) and core zone of the biosphere reserve (Group II)). From the total behavioral observations, 5841 and 6020 were recorded in Group I and Group II respectively.

Based on the combined study *Colobus guereza* in Group I spent 37.67% of their time budgets in resting, 29.70% moving, and 16.20% in feeding. The corresponding values for Group II were: 47.60%, 12.52%, and 21.79% for each corresponding behavioral category. Time spent while socializing by Group I accounted 5.7% grooming, 4.55% playing, 2.96% aggression, and 0.87% sexual activities. Other activities took 2.35% of its time, which included defecating, urinating and vocalizing, they are not categorized under main categories. Group II spent of its time for 8.13% grooming, 4.75% playing, 2.10% aggression, and 1.23% sexual activities and 1.88% other activities (Figure 2).



N=number of observations

Figure 2: Percentage of overall activity time budgets for *Colobus guereza* in Group I and II (n=11861)

The chi - square test showed that there was a significant difference in time spent between the two groups while feeding, moving, and resting ($x^2 = 8$, $P < 0.01$). Much time in resting might be needed to assist food digestion, as Colobus monkeys feed on cellulose-rich food materials requiring long gut passage times. The unique foregut anatomy of Colobus monkeys allows for fatty acid fermentation, which is believed to be an adaptation for reducing leaf toxin levels prior to absorption (Oates, 1977).

An increase in resting might be explained by the induced demand to reduce toxin levels (Dasilva, 1992). The feeding time variation might suggest that the availability of fruits during the dry season allowed them to take more time when foraging as it is their primary choice. The presence of ample resource would reduce the time spent for searching it. According to Wijtten *et al.* (2012) activity time budgets are commonly associated with energy conservation strategies and affected by a variety of variables. The present study showed that guerezas in the transitional zone of the biosphere (Group I) moved for more time compared with core zone dweller guerezas (Group II). The probable reason might be associated with food availability, vegetation distribution and human impact as human activities were allowed in the transition zone of the biosphere, the also more heterogeneous than core zone, for this reason the movement pattern of guerezas might have showed differently. The result of this study is similarly linked to the finding of Kaplin, (2001) who reported that the availability of preferred food items are impacted on the movement pattern of the guerezas.

The activity time budgets resulting from group scans generally are comparable with those of guerezas and other species of the black and white Colobus monkeys studied in other areas of Ethiopia and other African countries (Bocian, 1997; Dereje, 2018; Wong and Sicotte, 2007; Wijtten *et al.*, 2012; Shumet and Yihune, 2017). However, there are extreme values of time spent on resting that range from 32% (Fashing *et al.*, 2007) to 76.4 % (Shumet and Yihune, 2017) and feeding range 12%-42%.

Seasonal variation was observed on the activity time budgets between the groups in dry and wet season of this study period. Individuals in Group I, on average spent more time in resting 39.88% and moving 30.58% during the dry season than during the wet season (Table 2). They also spent more time in social activities, like aggression 3.0% and playing 4.90% during the dry season than during the wet season. However, they spent less time in activities such as feeding 14.83% and sexual activities 0.22% during the dry season than the wet season (Table 2). While individuals in Group II on average spent more time in feeding 22.14%, resting 49.70% and playing 5.90% during the dry season than the wet season. This group took less time in moving 11.12%, aggression 1.8%, grooming 7.38%, sexual activities 0.92% and other activities 1.05% during the dry season than during the wet season (Table 2).

Table 2: seasonal activity time budgets of *Colobus guereza* in Group I and Group II

		Activities in %							
Group	Season	Aggression	Feeding	Grooming	Moving	Others	Playing	Resting	Sexual Activity
I (n=2871)	Dry	3.00	14.83	4.60	30.58	1.99	4.90	39.88	0.22
II (n=3050)	Dry	1.80	22.14	7.38	11.12	1.05	5.90	49.70	0.92
I (n=2970)	Wet	2.92	17.50	6.80	28.82	2.70	4.25	35.52	0.92
II (n=2970)	Wet	2.42	21.45	8.89	13.98	2.73	3.60	45.40	1.55

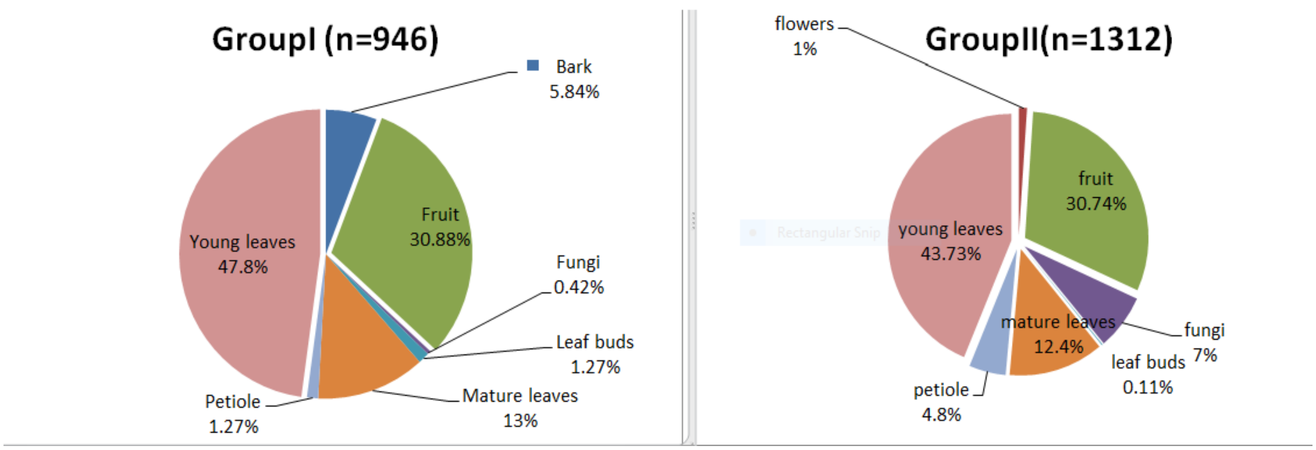
N= number of observations

The value of the chi - square test showed a significant difference in time spent of moving between the groups in dry and wet seasons (x^2=6.1, P < 0.05). This difference might be associated with the availability and seasonal fluctuation of dietary species in their home ranges. The result of this study is similarly linked to findings of Smith *et al.* (2013) who reported movement pattern of guerezas were similarly linked to the availability of food resources. Group II spent more of their time on feeding than Group I in dry and wet season during the study period. The probable reason could be the presence of ample food items in their home range. Food abundance and distribution has great influence on primates feeding behavior (Clutton -Brock, 1975). The time budget for playing, took greater time during the dry season. This might be related to the sunlight that can induce them to perform social activities like playing.

4.2 Feeding ecology

The two guereza groups inhabited different habitat types. The home range of Group I is dominated by human use forest composed of plantation forest, bamboo forest and partly surrounded by farm lands while individuals in Group II range through two habitat types: primary forest and riparian forest. A total of 2258 feeding behavioral observations were recorded from a 15 minute interval instantaneous scan sampling of the two combined study groups of guerezas, 946 for Group I and 1312 for Group II collected for the 6 months.

The guerezas in Group I depended on young leaves, mature leaves, fruits, fungi, petiole, leaf bud and barks for their diet. The feeding consumptions observed in Group I were young leaves which accounted for 47.85%, followed by fruits and matured leaves which accounted 30.88% and 12.45% of the overall feeding records respectively (n=946 feeding records). They took less time on feeding, bark 5.84%, leaf bud 1.27%, petiole 1.27% and fungi 0.42%, (Figure 3). The most frequently consumed food items by Group II were young leaves, which accounted for 43.73% of the overall feeding observation (n=1312 feeding records) during the study period. Fruits 30.74% and matured leaves 12.43% were the second and the third most often consumed food items. Leaf buds, flowers, petiole and fungi constituted 0.11%, 1.05%, 4.81% and 7.12% of the feeding records respectively (Figure 3).



N=Number of observations

Figure 3: Percentage of feeding records to feed upon different food items by the *Colobus guereza* (n=2258)

The value of the Chi - square test showed that no significant differences in feeding records of fruit, young leaves and mature leaves (x^2=7.5, P > 0.05) between the two guereza groups.

However, there were significant differences between the two groups on feeding records bark, fungi, flowers, leaf buds and petioles (x^2=10.1, P < 0.05).

According to the present study, the dietary preference of *Colobus guereza* in the study area relies less on fruits than young leaves and the majority of their food source was young leaves (47.85% and 43.73%) followed by fruits (30.88% and 30.74) overall feeding records (n=2258) for each study group (Group I and Group II) respectively. The reason for this young leaves are easier to digest and less toxic compared with other parts plants (Usongo and Amubode, 2001). The result of this study is in line with the finding of Petros *et al.* (2018); Mohamed and Desalegn, (2017) who reported on which leaves and fruits make the main diets of the guereza species.

All species of *Colobus guereza* are leaf-eating primates, but their food items preference varies by site. Their natural diet consists of predominately leaf material followed by fruits (Lessiak, 2014). Fleshy fruits are usually consumed by guereza when unripe, with consumption being reduced as they fully ripen because ripe fruit contains high proportions of simple sugars that can lower for stomach pH in Colobus monkeys, leading to acidosis or even death (Danish *et al.*, 2006).

In this study the value of the chi square test showed a significant difference between the two groups in the consumption of food items such as petiole, leaf buds, fungi, barks and flowers (p < 0.05). This difference might be associated with the nutrient content of preferred food items which found in their home range. As reported by Eustace *et al.* (2015) and Fashing, (2007) *Colobus guereza* depends on leaves due to its high protein and fiber contents.

Seasonal variation was observed on the percentage of time spent on feeding observation of different food items in both groups. Group I took more time on feeding fruits, bark, petiole and leaf bud at an average of 35.03%, 11.68%, 2.55% and 2.34% respectively, during dry season. While young leaves and mature leaves were relatively consumed less time during the dry season than wet season in Group I. Group II took more time on consuming young leaves 52.60%, fungi 11.4% and flowers 1.63%, leaf bud 0.23%, during the dry season than wet season and took less time of fruit, matured leaves and petioles during the dry season than the wet season (Table 3).

Table 3: Seasonal percentage of feeding records to feed upon different food items by the *Colobus guereza*

Group	Season	Bark	Flowers	Fruits	Fungi	LB	ML	Petiole	YL
		Food items							
I (N=471)	Dry	11.68	0.00	35.03	0.00	2.34	7.86	2.55	40.55
II (N=675)	Dry	0.00	1.63	24.74	11.40	0.23	4.75	4.60	52.60
I (N=475)	Wet	0.00	0.00	26.74	0.84	0.21	17.05	0.00	55.16
II (N=637)	Wet	0.00	0.47	36.74	2.83	0.00	20.10	5.02	34.85

YL=Young leaves, ML=Mature leaves, N=Number observation

The present study showed little variation between food items consumed by both study groups in dry and wet seasons. *Colobus guereza* in Group I consumed more leaf buds, barks, fruits and petioles during the dry season. But, they consumed more young leaves, mature leaves and fungi during the wet season. *Colobus guereza* in Group II consumed more flowers, fungi and young leaves during the dry season than wet season. Unlike Group I fruits and petioles were consumed more during the wet season than dry season by Group II.

Likewise, Jensz and Finley (2011) noted that *Colobus guereza* most of the time prefer and engage on leaves that are less vulnerable to seasonal fluctuations. Fruits are frequently consumed by Colobus monkeys when unripe (Shumet and Yihune, 2017; Eustace *et al.*, 2015). The value of the Chi- square test showed significant difference in consumption of mature leaves by the two groups between the seasons (x^2=4.5, $P < 0.05$). This might be associated with the fluctuation of the preferred food items between dry and wet seasons. In dry season most of the preferable plant species bear fruit in the present study area and consumed by guerezas because fruits are with less toxicity and higher palatability than mature leaves when unripe (Eustace *et al.,* 2015).

During the study period, *Colobus guereza* in Group I consumed a total of 15 plant species (one shrub, two climbers and twelve trees) (Table 4). Of these 15 plant species that contributed the overall feeding observation of Group I, the top three species accounted for

56.67% of the plant diet observation. Based on the total percentage contribution of plant food items, *Ilex mitis* had been the most frequently consumed species, accounting for 21.79% followed by *Prunus africana* and *Macaranga capensis* which accounted 21.56%, and 13.32% respectively.

The main food items recorded in Group I were young leaves of *Prunus africana* which accounted for 18.6% followed by the Fruits of *Macaranga capensis* and young leaves of *Ilex mitis* which accounted for 13.32% and 10.9%, respectively. The less frequently consumed food items recorded in this Group were leaf bud of *Croton mastachyus* and young leaves of *Clematis longicaudata* each of them were accounted the same amount 0.1% of the feeding observation of Group I (Table 4).

Table 4: plant species in the diet of *C. guereza* (n=946) by Group I

Local Name	Family Name	Species Name	Growth type	Percentage of food items							Total
				LB	YL	ML	Fruit	Fungi	Petiole	Bark	
Keto	Aquifoliaceae	*Ilex mitis* (L.) Radlk.	T	-	10.9	4.87	6.02	-	-	-	21.79
Ommo	Rosaceae	*Prunus africana*	T	-	18.6	2.96	-	-	-	-	21.56
Shakero	Euphorbiacae	*Macaranga capensis*	T	-	-	-	13.32	-	-	-	13.32
Yino	Myrtaceae	*Syzigium guineense*	T	-	0.74	0.31	7.4	-	-	-	8.45
Ororo	Maliaceae	*Ekebergia capensis* Sparm	T	-	7.93	-	-	-	-	0.21	8.14
Bahirzaf	Mrytaceae	*Eucalyptus globulus*	T	-	1.5	-	-	-	-	5.6	7.10
Chago	Myrsinaceae	*Maesa lanceolata* Forssk.	T	0.63	2.21	3.30	-	-	-	-	6.14
She'o	Sapindaceae	*Allophyllus abyssinicus*	T	0.21	-	-	4.12	-	-	-	4.33
Butoo	Araliaceae	*Scheffleria abyssinica*	T	-	1.50	-	-	-	1.26	-	2.76
Yimamo	Urticaceae	*Urera hypelodendron*	C	-	1.90	-	-	-	-	-	1.90
Beroo	Fabaceae	*Erythrina brucei* Schuleinf	T	-	1.70	-	-	-	-	-	1.70
Degireto	Asteraceae	*Vernonia auriculifera* Miern	T	0.31	-	1.05	-	-	-	-	1.36
Wago	Euphorbiacae	*Croton mastachyus* Del.	T	0.1	0.21	-	-	0.42	-	-	0.73
Caatto	Fabaceae	*Albizia gummifera*	T	-	0.52	-	-	-	-	-	0.52
Shageqombo	Ranunculaceae	*Clematis longicaudata*	C	-	0.10	-	-	-	-	-	0.10
Total				1.25	47.81	12.49	30.86	0.42	1.26	5.81	100

T=Tree, C=Climber, SH=Shrubs, LB=Leave bud, ML=Mature leaves, YL=Young leave

Individuals of Group II consumed 12 plant species included one climber, two shrubs and nine trees (Table 5). In this group, the following three frequently consumed plant species which accounted for 57.26% of the total dietary plant species in their home range were *Prunus africana* which recorded for 25.07%, *Macaranga capensis* 16.65% and *Syzigium guineens* 15.5%, (Table 5).

The main parts of plant species in the feeding observation of Group II were the young leaves of *Prunus africana,* which accounted for 25.07% followed by fruits of *Macaranga capensis* and fruits of *Syzigium guineense* which accounted 12.73% and 10.14% of the feeding observation respectively. The less frequently recorded parts of plant species was young leaves of *Allophyllus abyssinicus* which accounted for 0.07% overall feeding observation (n=1312) during the study periods (Table 5).

Table 5: plant species in the diet of *C. guereza* (n=1312) by Group II

Local Name	Family Name	Species Name	Growth type	Percentage of food items							**Total**
				LB	YL	ML	Fruit	Fungi	Petiole	Flowers	
Ommo	Rosaceae	*Prunus africana*	T	-	25.07	-	-	-	-	-	25.07
Shakero	Euphorbiacae	*Macaranga capensis*	T	0.11	0.23	-	12.73	3.5	-	0.08	16.65
Yino	Myrtaceae	*Syzigium guineense*	T	-	0.77	-	10.14	3.6	-	0.99	15.5
Keto	Aquifoliaceae	*Ilex mitis* (L.) Radlk.	T	-	5.19	3.04	5.64	0.153	-	-	14.02
Chago	Myrsinaceae	*Maesa lanceolata.*	T	-	2.21	5.34	-	-	-	-	7.55
Butoo	Araliaceae	*Scheffleria abyssinica*	T	-	0.6	-	0.61	-	4.8	-	6.01
Ororo	Maliaceae	*Ekebergia capensis* Sparm	T	-	5.25	-	-	-	-	-	5.25
Caatto	Fabaceae	*Albizia gummifera*	T	-	1.21	3.04	-	-	-	-	4.25
Yimamo	Urticaceae	*Urera hypelodendron*	C	-	1.99	0.77	-	-	-	-	2.76
Shikko	Celastraceae	*Mytenus spp.*	SH	-	-	-	1.45	-	-	-	1.45
Beroo	Fabaceae	*Erythrina brucei* Schuleinf	SH	-	1.4	-	-	-	-	-	1.4
She'o	Sapindaceae	*Allophyllus abyssinicus*	T	-	0.07	-	-	-	-	-	0.07
Total				0.11	44	12.19	30.57	7.25	4.8	1.07	100

T=Tree, SH=shrub, C=climber, YL=young leaves, ML=matures leaves, LB=leaves bud

The *Colobus guereza* in Group I foraged 15 plant species and *Colobus guereza* dwelling in Group II foraged 12 plant species. Of these species 11 plant species are common species foraged by both of the two guereza groups 4 plant species were foraged by Group I only 1 plant species was foraged by Group II and totally 16 different plant species belonging to 13 families were foraged by the two groups throughout the study period. In Group I, guerezas foraged a higher number of plant species than guerezas found in Group II. This difference in dietary diversity might be associated with habitat quality. As reported by Lowe and Sturrock, (1998) habitat quality play an important role in determining dietary diversity, with animals living in nutrient poor habitats having higher dietary diversity than good habitats.

The result of this study is in line with the findings of Enstam and Isbell (2007) who reported most members of colobines are generalists inhabiting a variety of habitat types and feeding on a wide array of food sources. Guerezas in the transitional zone of the biosphere (Group I) spent their time in different habitat types such as grazing land, farm land, plantation forest and fragmented forest. These different habitats comprised a variety of plant species, conversely, there is scarcity of preferred dietary species, and thereby guerezas will be forced to feed a high number of plant species to fulfill their consumption needs. While guerezas in the core zone (Group II) used two habitat types (primary and riparian forest habitats) which are more or less uniform vegetation cover and comprised dietary preferred plant species such as *Prunus african*, *Ilex mitis* were more abundant compared to the habitats of Group I.

The number of plant species identified and being consumed by *Colobus guereza* in this study were more compared to the findings of Shumet and Yihune (2017) who reported 11 plant species at Fenot Selam Forest, Ethiopia and Petros *et al.* (2018) who reported 8 plant species in Bale Mountains National Park, Southeast Ethiopia. The difference in the number of plant species consumed by *Colobus guereza* in this study area and the former might be due to the duration of study periods, the availability of preferred plants and geographical variation. Similarly, Kim (2002) reported that the diet of guerezas varied seasonally and geographically.

Differences in the utilization of different plant species between the two groups most likely reflect variation in the availability of these plants in the group's respective home ranges. The probable reason for this variation could be associated with nutritional properties of plant species. For instance folivorous monkeys such as guerezas preferred most nutritive and easily digestible food resources to supplement their diet (Chapman and Chapman, 2002; Hanya and Chapman, 2013; Kibaja, 2014). Further studies in different parts of Ethiopia showed that the plant species mostly consumed by these groups also consumed by other of species. For example, *Ilex mitis*, was the third most preferred species by *Colobus guereza* in central highland Ethiopia (Dereje, 2018); *Prunus africana* was the first preferred plant species by *Colobus guereza* in Sidama Zone, Ethiopia (Mohamed and Desalegn, 2017) and *Syzigium guinensis* the second preferred plant species by Boutourlini's blue monkeys in Jibat forest Ethiopia (Dereje, 2010).

According to NABU, (2017) report, *Prunus Africana* and *Erythrina brucei* are endangered plant species from 16 plant species recorded as endangered species and *Clematis longicaudata* was endemic (found only in kaffa biosphere reserve). Hence, management activities are needed for the future survival of guerezas in the transitional zone of Kaffa biosphere reserve because the extinction of dietary plant species causes the extinct species which depend on them. Similarly Addisu *et al*. (2010) has reported that the more specialized guerezas diet, the greater is its risk of extinction. The African cherry tree (*Prunus africana*), a sometimes favored food for guerezas, has exhibited a notable decline across sub-Saharan Africa. While predominantly due to the harvesting of its bark for medicines, at least some of its deaths could be due to other factors, such as disease, insects, nutrient deficiency, or climate (Fashing 2004). For the future the decline of this plant species might be negatively affects the guereza populations that rely upon it.

The percentage of monthly feeding records of different food items from different plants in the diet of Group I (Table 6), young leaves were the top food item for most months (range 43.3–66.9%) during the study period. Fruits (16.24-46.21%) and mature leaves (5.9–20.00%) were the second and the third most frequently consumed food items in all months during the study period. Barks (0.0-8.9%), leaf bud (0.0-6.7%), fungi (0.0-2.6%) and petiole (0.0-7.37%) were recorded in few for a few months only (Table 6).

Table 6: Percentage of monthly feeding records of different food items in the diet of *Colobus guereza* during the study period (January, 2019 – June, 2019) by Group I

Month	LB	Bark	Fruit	Fungi	ML	YL	Petiole	Total
April	0.00	8.50	16.24	2.6	5.90	66.90	0.00	100
February	0.00	0.00	46.21	0.00	9.09	44.70	0.00	100
January	6.75	6.14	26.99	0.00	7.98	44.78	7.37	100
March	0.00	0.00	45.80	0.00	9.16	45.03	0.00	100
May	0.00	8.90	27.77	0.00	20.00	43.33	0.00	100
Jun.	0.54	8.60	27.96	0.00	19.35	43.55	0.00	100

LB=leaf bud, ML=matured leaves, YL=young leaves

The monthly percentage of feeding records of different food items from different plants in the diet of Group II are presented in Table 7. Like Group I, this group was predominantly observed in the young leaves range (30.88- 64.47%). They also feed fruits (3.48-37.98%) and petiole (4.32-5.24%) during almost all months of the study period. Leaf bud (0.0-0.77%), fungi (0.0-25.87%), and flowers (0.0-2.4%) were recorded in few for one to four months. Mature leaves were recorded (0.0-26.47%) for five months out of six months during the whole study period. Unlike Group I, bark was not recorded in Group II during the study period (Table 7).

Table 7: Percentage of monthly feeding records of different food items in the diet of *Colobus guereza* during the study period (January, 2019 – June, 2019) by Group II)

Month	**LB**	**Bark**	**Fruit**	**Fungi**	**ML**	**YL**	**Petiole**	**Flowers**	**Total**
April	0.00	0.00	34.94	7.86	8.73	41.92	5.24	1.31	100
February	0.00	0.00	37.98	2.40	7.69	45.2	4.32	2.40	100
January	0.77	0.00	3.48	25.87	0.00	64.47	5.01	0.39	100
March	0.00	0.00	37.98	0.00	9.16	45.2	4.32	2.40	100
May	0.00	0.00	37.94	0.00	26.47	30.88	4.90	0.00	100
Jun.	0.00	0.00	37.94	0.00	26.47	30.88	4.90	0.00	100

LB=leaf bud, ML=matured leaves, YL=young leaves

Primates, including *Colobus guereza* may select certain food items based on accessibility, economic exploitation, availability throughout the year, nutritional content, or simply preference (Dereje, 2018). It is likely that guerezas in Kaffa biosphere selected certain species based on a combination of these factors.

The present study revealed that the main diet of guerezas in Group I and Group II was young leaves of different plant species which accounted the highest proportions in this study. This is in line with the finding of Mohammed and Dessalegn, (2017) for the sister subspecies (*C. g. gallarum*) who reported young leaves are the most preferred food items also Oates and Davies (1994) reported that guerezas consumed mainly on young leaves of different plant species to maximize their physiological demand and minimize toxicity from mature leaves whereby they rarely include more than 30% mature leaves in their diet unless they are of good quality.

The dietary selection ratio of the plant species recorded during the feeding records of guerezas during the study period in the home range of the animal is presented in Table 8. Based on the dietary preference ratio, *Ekebergia capensis* was the most selected plant species by Group I with a selection ratio of 23.94 followed by *Ilex mitis* and Scheffleria *abyssinica,* which accounted for 21.36 and 8.12 respectively. *Prunus africana*, *Scheffleria abyssinica*, *Albizia gummifera* were the first, second and third selected species with a selection ratio of 20.89, 20.03 and 7.08 in the Group II, respectively

Plant species most frequently consumed by guerezas in this study period such as *Macaranga capensis* and *Syzigium guineens* had low selection ration (3 and 4.12) in Group I (2.95 and 3.45) in Group II, respectively. Conversely, *Croton mastachyus* and *Allophyllus abyssinicus* had a low selection ratio (0.42 and 0.12) despite the lowest percentage overall the feeding observation of guerezas diet in the study area.

Assessment of the quantity and the quality of the most and the least consumed plant species is important to make the bulk density of the diet of herbivores (Petros *et al.*, 2018). The highest selection ratio of the plant parts suggests that a preference for the food items that the plant species provided while low selection ratio indicates not preferred (Mekonen and Hailemariyam, 2016).

Table 8: Dietary selection ratio of guerezas based on stem density (individuals/ ha) and percentage of feeding records (proportion of the total number of foraging scans).

GROUP I					GROUP II				
Rank	Species consumed	% of AD	% of SD	SR by SD	Rank	Species consumed	% of AD	% of SD	SR BY SD
1	*Ekebergia capensis* Sparm	8.14	0.34	23.94	1	*Prunus africana*	25.07	1.2	20.89
2	*Ilex mitis* (L.) Radlk.	21.79	1.02	21.36	2	*Scheffleria abyssinica*	6.01	0.3	20.03
3	*Scheffleria abyssinica*	2.76	0.34	8.12	3	*Albizia gummifera*	4.25	0.6	7.08
4	*Maesalance olata* Forssk.	6.14	1.37	4.48	4	*Ekebergia capensis* Sparm	5.25	0.9	5.83
5	*Syzigium guineense*	8.45	2.05	4.12	5	*Maesa lanceolata.*	7.55	2.1	3.6
6	*Macaranga capensis*	13.32	4.44	3	6	*Syzigium guineens*	15.5	4.49	3.45
7	*Albizia gummifera*	0.52	0.34	1.53	7	*Ilex mitis* (L.) Radlk.	14.02	4.46	3.14
8	*Erythrin abrucei* Schuleinf	1.7	2.39	0.71	8	*Macaranga capensis*	16.65	5.69	2.93
9	*Eucalyptus globulus*	7.1	11.95	0.59	9	*Mytenus spp.*	1.45	10.48	0.14
10	*Vernonia auriculifera* Miern	1.36	3.07	0.44	10	*Allophyllus abyssinicus*	0.07	0.6	0.12
11	*Croton mastachyus* Del.	0.73	1.72	0.42	-	-	-	-	-

AD=annual diet, SD=selection ratio, SD=stems density

4.3 Ranging ecology

4.3.1 Home range

The area ranged by Group I during wet and dry seasons together had an extent of 63.33 ha and that of Group II had 67.22 ha (Figure 4).

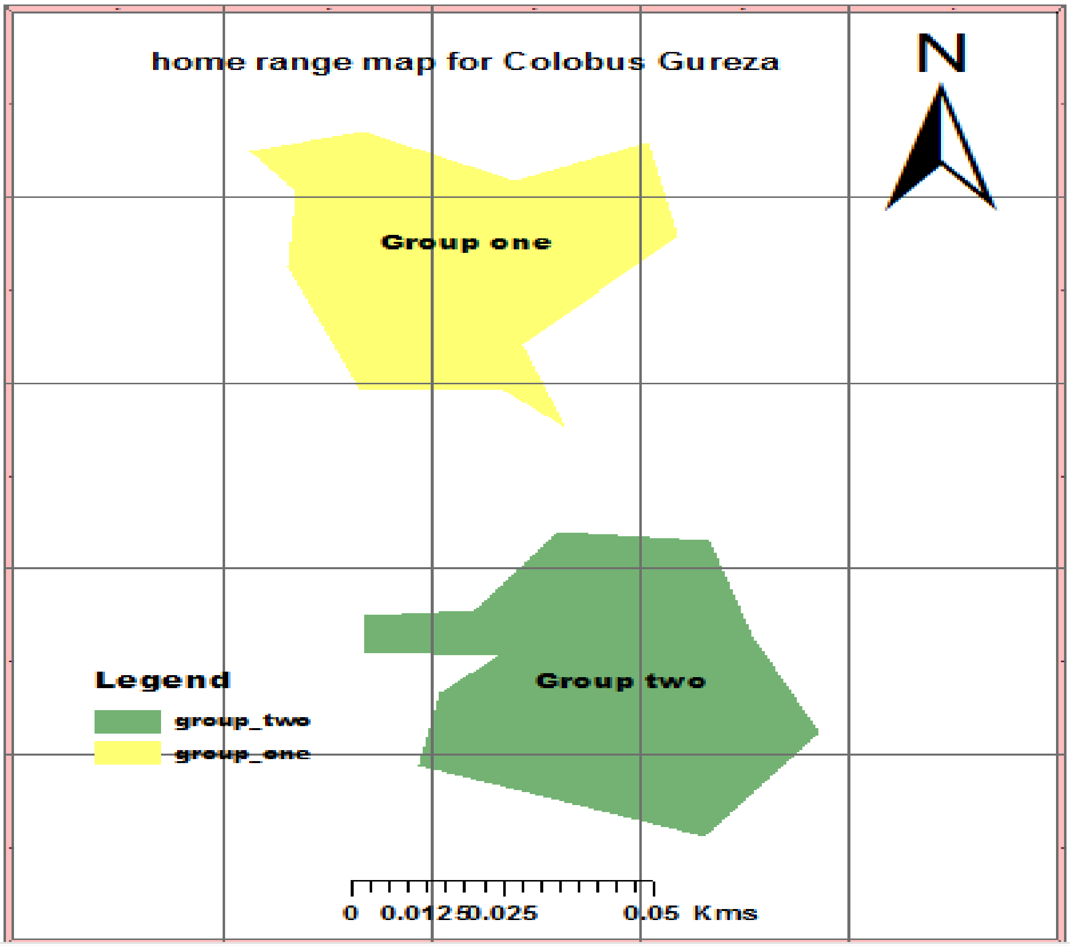


Figure 4: Total home range of two study groups of *Colobus guereza*

Seasonal variation of home range was observed between the groups. The home range size for Group I was 60.27 ha during the dry season and 53.20 ha during the wet season as shown in (Figure 5). The home range size of Group I showed no significant differences between the dry and wet seasons (x^2=3.1, P > 0.05). This study revealed that the home range size of guerezas showed little variation between the groups in dry and wet seasons. This variation might be associated with the availability and distribution of preferred food items in their home range.

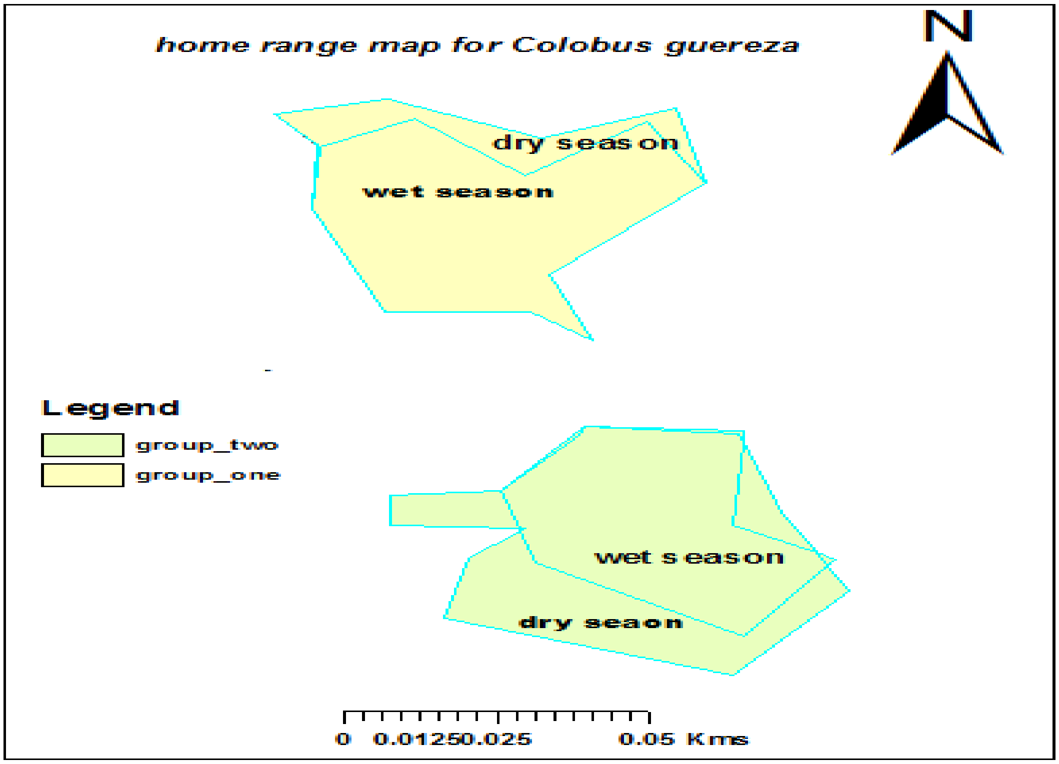


Figure 5: seasonal home range variation of the study groups

The wet and dry season home range sizes were overlapped in the area of both these groups. Home range area in Group II showed variation between the dry and wet seasons. It was 56.85 ha during the dry season and 49.82 ha during the wet season. A value of the chi - square test showed no significant difference in home range size for Group II between the two seasons (x^2=2, P > 0.05). The home range area of Group I was less than the home range area of Group II. The probable reason for the variation of home range size could be associated with human pressure in the transitional zone of biosphere reserve. For instance, there is no human activity in Core zone of the Kaffa biosphere reserve (Group II) because it's protected by law and demarcated as a protected area while the transitional zone (Group I) accommodate more high-impact and economic land-uses and may contain a variety of agricultural activities, settlements and other land use types.

The other variation of home range size between the groups might be associated with the group size. Guerezas in the core zone (Group II) were larger in group size (twelve members) than Group I which was eight. Reports indicated home range size within a species tends to increase with increasing group size and a similar relationship between group biomass and range size has also been found to hold at the interspecific level (Dunbar, 1988).

As reported by Milton (1998) despite the variations in home range size, according to differences in food abundance and quality across sites, daily ranging may be physiologically constrained in primates due to their high consumption of low energy food, such as mature leaves for Howler monkeys. In this study, home range size ranged from 63.33 ha (Group I) to 67.22 ha (Group II). These findings were remarkably less than what has been reported by Bocian (1997) (100 ha, Ituri), Fashing et al. (2007b) (2440 ha, Rwanda) and greater than what has been reported by Dereje (2018) (5.4ha, Ethiopia), Oates (1977) (32 ha, Kibale), and Fashing (2001a) (18 ha, Kakamega). The probable reason for this variation between the countries could be associated with the availability of food resource, distribution and ecological variations (Wong and Sicotte, 2007).

4.3.2 Daily range

The average daily range distance for Group I and Group II during the study period was 558.77m and 495m, respectively (Table 9). The combined mean daily range distance covered by the two study groups was found to be 526.88 m.

Table 9: Mean daily travel distance of guerezas in Group I and Group II during dry and wet season

Group	Season	MDTD (m)	SD	HRA(ha)
I	Dry	607.54 (n=135)	83	60.27
II	Dry	570.00 (n=99)	81	56.85
I	Wet	510.00 (n=124)	45	53.2
II	Wet	420.00 (n=80)	43	49.82

MDTD= Mean daily travelled distance, m=meter, SD= Standard deviation, HRA=home range area, ha=hectare, n=number of observations

The value of the Chi - square test showed a significant difference in the daily range lengths of *C. guereza* between the groups in dry and wet seasons ($x^2 = 5.4$, $P < 0.05$). The greatest mean daily range length recorded in Group I during the dry season of this study, which was 607.54 m and the smallest mean daily range length recorded in the wet season by Group II which was

420m. This variation in daily range length might be associated with the length of corridors available in Group I which is between human settlements that forced them to have long distance while guerezas in Group II move shorter distance freely without any disturbance.

At present, humans are likely to be threat for guerezas in Group I compared to guerezas in Group II, *Colobus guereza* which are fearful of the presence of humans (personal observation). Therefore, they may travel long distances in search of large trees to shade themselves for greater security. The guereza is strongly influenced by habitat disturbances and habitat degradation (Chapman *et al*., 2000; Fashing 2002; Lwanga 2006; Harris & Chapman 2007).

The other probable reason for variation in daily length path between the two seasons could be associated with the availability of food resources in their home range. Guerezas did increase their daily travel distance (DTD), percentage of time budgets to move, or their travel rate during the dry season because of lower food availability and the daily path length become short during the wet season due to the presence of ample diet in their home range though these variables are expected to force guerezas to visit additional food sources each day in the dry season. As reported by Smith *et al*. (2013) day-range lengths guerezas were similarly linked to the availability of food resources. The home range and day range results of this study is in line with the findings of Fashing and Cords, (2000); Fashing, (2007); Boyle and Smith, (2010) who reported that habitat loss causes temporal and spatial variation in primates feeding ecology, home range size and daily path length. Primates living in fragmented habitats have smaller home ranges due to limited resource availability travel greater daily distances, and spend more time traveling and less time resting which all affects their fitness.

4.4 Vegetation composition

A total of 34 plant species in 22 families in the home range of Group I and 46 plant species in 27 families in the home range of Group II were enumerated that included 293 and 336 individual stems respectively with varying sizes (Appendix 2 and Appendix 3). The plant species diversity (H’) and evenness (J) in the home ranges of the study groups were 2.80 (0.8) and 3.00 (0.78) for Group I and Group II, respectively.

The density of stems in the home range of Group I was 293 stems per hectare and 336 stems per hectare in Group II. The total basal areas of trees were $16.65m^2$ in the home range of Group I and $52.49m^2$ in the home range of Group II. The top three dominant species in study groups were *Eucalyptus globulus* (71.71%), *Macaranga capensis* (12.92%) and *Syzigium guineense* (4.33%) in the home range of Group I and *Syzigium guineense* (45.40%), *Ilex mitis* (31.89%) and *Macaranga capensis* (8.99%) in the home range of Group II

Furthermore, Chi-square test showed significant difference found between the basal areas of trees across the two home ranges were compared (x^2=14.14, $p < 0.01$) and there was no significant difference when the diversity, density, relative dominance across the two home ranges of Group I and Group II. The variations in species stem density, composition, richness and diversity among the two habitat types have the potential to offer a great deal of services other living species that depend on the vegetation (Wiafe, 2014).

The present study revealed that the daily activity time budget of *Colobus* guereza may likely be influenced by the heterogeneity of the vegetation composition. This is because, as the area occupied by larger trees (home range of Group II) may offer places for sleeping and refuge for the guerezas, while the home range of Group I may be considered as places of foraging. This may explain the reasons for the activity pattern variation associated with *Colobus guereza* found in different habitats. Furthermore, in contrast with Group I and Group II the basal area trees were showing significant difference. This might be associated with anthropogenic influence of largest trees in the transitional zone of the biosphere reserve being deforested due to expansion of agriculture and commercial uses.

Forest landscapes are changing and even at an accelerated rate due to expansion of agriculture in natural environments (Addisu, *et al*., 2010). The result discussed above was important to indicate the variations in the community characteristics of the habitat types can be used to offer an understanding of the behavior of the species sharing resources in space and time. The fewer trees encountered in the more opened habitat types (Group I) means more human preferred crops in these areas and if the guerezas utilize them it suggest that a deepening conflict between human and wildlife.

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The present study offers valuable information on different aspects of the ecology of guerezas activity pattern, ranging and feeding ecology in Kaffa biosphere reserve Saylem District. Two selected *Colobus guereza* groups from the transitional (Group I) and core zone of biosphere reserve (Group II) which serve as a spark plug to ignite conservation demands to concerned bodies for correlating the management of the forest directly with the wildlife dwelling within.

Even though the activity time budgets of *Colobus guereza* were different in the two different groups and seasons because the spatial pattern and distributions of dietary plants are different in the zone. The long- term conservation of colobus in the transitional zones of the biosphere is promising. Guereza in both groups spent more time in resting compared to the other activities which might be associated with diet quality. The diet of *Colobus guereza* mostly depends on leaves followed by fruits in each group in the study area. However, the leaves were the most often consumed food items of the overall feeding records during the study period followed by fruits. Barks and fungi were the least consumed food items of *Colobus guereza*. Besides these, food items have been eaten by this animal according to their availability during dry and wet seasons. Therefore, the survival of the species depends comprehensively on planning and implementing on the conservation and management of their food plants and habitats.

The day range length showed significant difference between the groups. Due to the reduction of large trees in Group I habitats were constrained guereza to move greater distances per day for searching of trees which using for refuge and resting. However the day ranges of colobus in the transition zone is better value for the survival of colobus but, it is essential to combine with preferred species of plants to ensure the quality of the habitat for their survival.

5.2 Recommendations

Based on the findings of this study the following recommendations were forwarded.

- ✓ The daily activity time budgets of *Colobus guereza* in the core and transition zones are associated with the availability of food plants in their home range therefore special attention should be given to conserve diet plants of this animal.
- ✓ The findings in the home ranges of the two-guereza groups are nearly the same. This indicates the transitional zone can also play the role of core areas for the Colobus therefore, sustainable conservation of the transitional zone should also be recommended to conserve the animal.
- ✓ Dietary plants preferred in the transitional zone of the biosphere should have to be a mixed type of species with different fruit bearing trees that serve as a food source for Colobus monkeys than monoculture types. The most preferred plant species in the guereza diet should be monitored to get an understanding of food available in the area. The nutritional content of food plant species should also be investigated to give special conservation emphasis and enhance plantation to highly nutritious preferred dietary plants. This may reduce the daily travel of species and expenditure of energy and make them to invest their time more on productive activities.
- ✓ A large-scale survey to assess the population of *Colobus* guereza across the three Zones of Kaffa Biosphere reserve is needed to ensure the habitat preference of the species and to evaluate the UNESCO conservation program.

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APPENDECES

Appendix 1: Data collection format

Study Area KB Saylem District Season _____ Date______ Observer________ Group size---------Season ___________

Time	GPS location		Altitude	Age class	Activity	Habitat type	If feeding				Distance from water	Group spread	Large mammals close to study group	
	x	y	m				Active individuals in feeding	Growth type	Species eaten	Preferred parts			Species seen	Distance to the group

- ✓ Age class/sex: Adult male (AM); Adult Female (AF);sub adult male (SAM);Sub Adult Female(SAF) Juvenile male (JM); Juvenile female (JF)
- ✓ Activity: Feeding (F), Moving (M), Resting (R), playing (P), Aggression (A), Grooming (G), sexual activity (SA), drinking (D)
- ✓ Habitat type: Primary forest (PF) Pristine Secondary Forest (PF), FC, SFC, GC, and PC. Fragmented forest (FF), grass land (GL), Other (Specify) ______
- ✓ Food type or Preferred plant parts: young tree leaves (YL), mature leaves (ML), leaf buds (LB), seeds (S), green stems (GS), flowers (FL), fruits (FR), flower buds (FB), petioles (P), stem (St), epiphytes (E), fungi (FU) or animal prey (A) Others (OS)

Appendix 2: Species Richness, Relative Density and Relative Dominance of Trees Enumerated in the home range of Group I

Family Name	Species Name	GT	SR	RF	RF in %	BA IN M^2	BA IN %	RD	RD IN %
Acanthaceae	*Acanthus pubescens*	H	5	0.02	1.71	0.00	0.00	0.00	0.00
Acanthaceae	*Justicia schimperiana*	SH	2	0.01	0.68	0.00	0.00	0.00	0.00
Aquifoliaceae	*Ilex mitis* (L.) Radlk.	T	3	0.01	1.02	0.46	2.75	0.01	2.75
Araliaceae	*Scheffleria abyssinica*	T	1	0.00	0.34	0.42	2.53	0.01	2.53
Asteraceae	*Vernonia auriculifera* Miern	SH	9	0.03	3.07	0.00	0.00	0.00	0.00
Asteraceae	*Vernonia amygdalina* Del.	T	4	0.01	1.37	0.05	0.31	0.00	0.31
Asteraceae	*Solanecio mannii*	SH	2	0.01	0.68	0.00	0.00	0.00	0.00
Celastraceae	*Mytenus spp.*	SH	9	0.03	3.07	0.00	0.00	0.00	0.00
Cupressaceae	*Juniperus oxycedrus*	T	3	0.01	1.02	0.07	0.43	0.00	0.43
Euphorbiacae	*Macaranga capensis*	T	13	0.04	4.44	2.15	12.92	0.06	12.92
Euphorbiacae	*Croton mastachyus* Del.	T	5	0.02	1.71	0.50	2.99	0.01	2.99
Euphorbiacae	*Euphorbia candelabrum*	T	5	0.02	1.71	0.00	0.00	0.00	0.00
Euphorbiacae	*Ricinus communis* L.	SH	4	0.01	1.37	0.00	0.00	0.00	0.00
Fabaceae	*Erythrina brucei* Schuleinf	SH	7	0.02	2.39	0.00	0.00	0.00	0.00
Fabaceae	*Millettia ferruginea*	T	1	0.00	0.34	0.01	0.06	0.00	0.06
Fabaceae	*Albizia gummifera*	T	1	0.00	0.34	0.02	0.11	0.00	0.11
Icacinaceae	*Apodytes dimidiata*	T	1	0.00	0.34	0.03	0.20	0.00	0.20

Table 1: (*Continued*)

Lamiaceae	*Pycnostachs recurvata* Rydiag	H	38	0.13	12.97	0.00	0.00	0.00	0.00
Lauraceae	*Persea americana*	T	2	0.01	0.68	0.02	0.13	0.00	0.13
Maliaceae	*Ekebergia capensis* Sparm	T	1	0.00	0.34	0.06	0.39	0.00	0.39
Malianthaceae	*Bersama abssinica* Fresen	T	2	0.01	0.68	0.04	0.23	0.00	0.23
Malvaceae	*Pavonia urens* Cav.	SH	3	0.01	1.02	0.00	0.00	0.00	0.00
Mrytaceae	*Eucalyptus globulus*	T	35	0.12	11.95	11.95	71.71	0.36	71.71
Musaceae	*Ensete ventricosum*	H	2	0.01	0.68	0.00	0.00	0.00	0.00
Muscicapidae	*Catha edulis*	SH	5	0.02	1.71	0.00	0.00	0.00	0.00
Myrinaceae	*Embelia schimper* Vatke	T	7	0.02	2.39	0.00	0.00	0.00	0.00
Myrsinaceae	*Maesa lanceolata* Forssk.	T	4	0.01	1.37	0.16	0.94	0.00	0.94
Myrtaceae	*Syzigium guineense*	T	6	0.02	2.05	0.72	4.30	0.02	4.30
Oleaceae	*Jasminum abyssinicum*	C	2	0.01	0.68	0.00	0.00	0.00	0.00
Oleandraceae	*Arthopteris monocarpa*	F	41	0.14	13.99	0.00	0.00	0.00	0.00
Poaceae	*Arundinaria alpina*	G	51	0.17	17.41	0.00	0.00	0.00	0.00
Cyatheaceae	*Cyathea manniana* Hook.	T	5	0.02	1.71	0.00	0.00	0.00	0.00
Poaceae	*Zea mays*	G	10	0.03	3.41	0.00	0.00	0.00	0.00
Poaceae	*Panicum subabidum* Kunth.	G	4	0.01	1.37	0.00	0.00	0.00	0.00

M^2=Meter square, BA=Basal area, RD=Relative density, RDO=Relative dominance, %=percent, SR=species richness, GT=Growth type

Appendix 3: Species Richness, Relative Density and Relative Dominance of Trees Enumerated in the home range of Group II

Family	*species Name*	GT	S.R	RF	RF %	BA IN M^2	BA IN %	RD	RD in %
Acanthaceae	*Justicia schimperiana*	SH	6	0.02	1.80	0.00	0.00	0.00	0.00
Aquifoliaceae	*Ilex mitis* (L.) Radlk.	T	15	0.04	4.46	16.74	31.89	0.32	31.89
Araliaceae	*Schefflera abyssinica*	T	1	0.00	0.30	0.72	1.37	0.01	1.37
Araliaceae	*Polyscias fulva* (Hiern.)Harms	T	3	0.01	0.90	0.27	0.52	0.01	0.52
Arecaceae	*Phoenix reclinata* Jacq	T	1	0.00	0.30	0.00	0.00	0.00	0.00
Asteraceae	*Vernonia auriculifera* Miern	T	16	0.05	4.79	0.00	0.00	0.00	0.00
Asteraceae	*Solanecio mannii*	SH	1	0.00	0.30	0.00	0.00	0.00	0.00
Celastraceae	*Mytenus spp.*	SH	35	0.10	10.48	0.00	0.00	0.00	0.00
Celastraceae	*Elaeodendron buchananii*(Loes.)	T	1	0.00	0.30	0.11	0.22	0.00	0.22
Dracanaceae	*Dracaena steudneri* Engl.	T	2	0.01	0.60	0.01	0.02	0.00	0.02
Dracanaceae	*Dracaena fragrans*	SH	2	0.01	0.60	0.00	0.00	0.00	0.00
Ebenaceae	*Diospyros abyssinica*	T	1	0.00	0.30	0.01	0.03	0.00	0.03
Euphorbiacae	*Macaranga capensis*	T	19	0.06	5.69	4.72	8.99	0.09	8.99
Euphorbiacae	*Croton mastachyus* Del.	T	5	0.01	1.50	0.50	0.95	0.01	0.95
Euphorbiacae	*Sapium ellipticum*	T	2	0.01	0.60	0.06	0.11	0.00	0.11
Fabaceae	*Acacia brevispica* Harms	C	2	0.01	0.60	0.00	0.00	0.00	0.00

Table 2: *(Continued)*

Fabaceae	*Albizia gummifera*	T	2	0.01	0.60	0.10	0.18	0.00	0.18
Icacinaceae	*Apodytes dimidiata*	T	1	0.00	0.30	0.11	0.22	0.00	0.22
Lamiaceae	*Pycnostachs recurvata* Rydiag	H	34	0.10	10.18	0.00	0.00	0.00	0.00
Maliaceae	*Ekebergia capensis* Sparm	T	3	0.01	0.90	0.35	0.67	0.01	0.67
Maliaceae	*Lepidotrichilia volkensis*	T	1	0.00	0.30	0.02	0.05	0.00	0.05
Malianthaceae	*Bersama abssinica* Fresen	T	7	0.02	2.10	0.72	1.37	0.01	1.37
Moraceae	*Ficus plamata* Forssk.	T	1	0.00	0.30	0.04	0.07	0.00	0.07
Moraceae	*Ficus platyphylla* Del.	T	1	0.00	0.30	0.02	0.05	0.00	0.05
Moraceae	*Ficus ovata* Vahl	T	3	0.01	0.90	0.18	0.34	0.00	0.34
Moraceae	*Ficus lutea* Vahl	T	4	0.01	1.20	0.35	0.67	0.01	0.67
Moraceae	*Trilepisium madagascariense*	T	1	0.00	0.30	0.16	0.31	0.00	0.31
Myrinaceae	*Embelia schimper* Vatke	T	5	0.01	1.50	0.00	0.00	0.00	0.00
Myrsinaceae	*Maesa lanceolata* Forssk.	T	7	0.02	2.10	0.62	1.19	0.01	1.19
Myrtaceae	*Syzigium guineense*	T	15	0.04	4.49	23.83	45.40	0.45	45.40
Oleaceae	*Jasminum abyssinicum*	C	5	0.01	1.50	0.00	0.00	0.00	0.00
Oleaceae	*Olea welwitschii*	T	1	0.00	0.30	0.01	0.02	0.00	0.02
Oleaceae	*Chionanthus mildbraedii*	T	4	0.01	1.20	0.28	0.54	0.01	0.54
Oleandraceae	*Arthopteris monocarpa*	F	78	0.23	23.35	0.00	0.00	0.00	0.00

Table 2: *(Continued)*

Pittosphoraceae	*Pittosporum virdiflorum* Sims	T	3	0.01	0.90	0.20	0.39	0.00	0.39
Poaceae	*Arthraxon micans*	G	13	0.04	3.89	0.00	0.00	0.00	0.00
Poaceae	*Panicum subabidum* Kunth.	G	12	0.04	3.59	0.00	0.00	0.00	0.00
Rhizophoraceae	*Cassipourea malosana*	T	3	0.01	0.90	0.11	0.22	0.00	0.22
Rosaceae	*Prunus africana*	T	4	0.01	1.20	2.07	3.95	0.04	3.95
Rosaceae	*Hagenia abyssinica*	T	1	0.00	0.30	0.02	0.03	0.00	0.03
Rubiaceae	*Vangueria apiculata* K.schum.	SH	3	0.01	0.90	0.00	0.00	0.00	0.00
Rubiaceae	*Oxyanthus speciosus* Dc.	SH	4	0.01	1.20	0.00	0.00	0.00	0.00
Rubiaceae	*Oxyanthus speciosus*	T	2	0.01	0.60	0.06	0.11	0.00	0.11
Rubiaceae	*Canthium oligocarpum* Hiern	T	1	0.00	0.30	0.01	0.02	0.00	0.02
Rutaceae	*Clausena anisata* (Wild.)	T	3	0.01	0.90	0.00	0.00	0.00	0.00
Sapindaceae	*Allophyllus abyssinicus*	T	2	0.01	0.60	0.06	0.12	0.00	0.12

M^2=Meter square, BA=Basal area, RD=Relative density, RDO=Relative dominance, %=percent, SR=species richness, GT=Growth type