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S Djego-Djossou
(1) Department of Zoology, Faculty of Science and Technique, University of Abomey-Calavi (Bénin) 01 BP 6270
(2) Laboratory of Applied Ecology; Faculty of Agrornomic Sciences, University of Abomey-Calavi (Bénin)

E Wiafe
Department of Environmental and Natural Resources Management, Presbyterian University College, Ghana

D Hakizamana
Department of Biology, University of Burundi, Burundi

GA Mensah
Centre de Recherches Agricoles d'Agonkanmey, Institut National des Recherches Agricoles du Bénin,

BA Sinsin
Laboratory of Applied Ecology ; Faculty of Agrornomic Sciences, University of Abomey-Calavi (Bénin)

Correspondence
S Djego-Djossou
(1) Department of Zoology, Faculty of Science and Technique, University of Abomey-Calavi (Bénin) 01 BP 6270
(2). Laboratory of Applied Ecology; Faculty of Agrornomic Sciences, University of Abomey-Calavi (Bénin)

Comparative of feeding ecology and dietary between olive colobus monkey (*Procolobus verus*) groups in forest fragments and continuous forest, Benin

S Djego-Djossou, E Wiafe, D Hakizamana, GA Mensah and BA Sinsin

Abstract
In order to understand the feeding behavior of olive colobus, in southern Benin (West Africa), we conducted a study on food ecology and diet of this species in two different habitats. Ad libitum sampling procedure conducted with four unhabituated groups of olive colobus living in continuous forest and forest fragments, indicate that, this monkey feeds on foliage in both forest. However, leaves are the most important food in continuous forest compared with forest fragments but fruits, the least important in continuous forest. Results also show that olive colobus feeds on 37 parts of 25 plants species in forest fragments, 42 parts of 32 plants species in continuous forest. Specific richness for both forests is 47 species, Sorensen similary index is 18% and 10 species are commonly occurred in two forests : *Albizia zygia, Cleistopholis patens, Cynometra megalophylla, Leucaniodiscus cupanioides, Pauridiantha hirtella, Psychotria calva, Pterocarpus santalinoides, Spondianthus preussii, Terminalia avicennioides, Xylopia parviflora.*

Keywords: *Procolobus verus*, feeding, *ab libitum*, forest fragments, continuous forest, diet

Introduction
Plants provide energy to animals by serving as a food source. Among primates, the diet is enormously varied [1]. Studies on African white and black colobus as well as Asian colobus such *Presbytis* showed that, their diet is characterized by an important consumption of leaves [2-4]. In this way, colobus was described as folivores for long time. However, fruits and others parts constitute diet of olive colobus. Few studies have been carried out on olive colobus and little is known about their feeding ecology and diet in continuous forest as well as forest fragments. Preliminary studies on their diet were based on analysis of stomach contents, in Ghana and Liberia [5, 6]. More recently, studies based on direct observations have been documented [7, 8] in the Taï National Park in Côte d'Ivoire; and on the Island of Tiwaï in Sierra Leone [9, 10].
In Benin, research on olive colobus is still limited in its local distribution. This species occurs in several sites mainly, protected forest of Lama and forest fragments of Domè [11]. The density of species is high in forest fragments and low in protected forest [12]. However, hunting activities constitute a main threat for this primate population in forest fragments [11]. In Benin, no study did focus on feeding ecology and diet of olive colobus monkeys. But, the need to study food resources, choice and/or requirements becomes very important to get information for some conservation strategies such as captive breeding. Forest fragmentation research is now widespread throughout the world, as human pressures on the environment have resulted in the clearing of forested areas that were previously intact. This research has identified certain general patterns and processes that occur when an area of forest is isolated. Futhermore, the effects of fragmentation are not identical for all situations, and there are many aspects of this process that are not yet understood [13]. It is important to study feeding ecology in forest fragments to understand the capacity of primates to adapt in their environment [14]. In this way, our objective is to improve understanding of olive colobus feeding ecology in forest fragments as well as forest continuous. Using primate feeding observations; we investigate whatever difference occurs in feeding ecology and dietary between olive colobus living in forest fragments and continuous forest. Specific objectives allow us to characterize and to identify the plant food species and plants parts in diet.

2. Methods

2.1 Study sites

The current study was conducted in Protected Forest of Lama located between 6° 55' to 7°00' N and 2°04' to 2° 12'E, and in Community Forest of Domè (forest fragments).

Forest of the Lama, is protected by laws where hunting is prohibiting, this forest is filling the criteria of UICN to be classified as "protected area", and in this paper, its nommed « continuous forest ». Furthur, data were also collected in the pacthes forest of Domè, qualified « forest fragments ». These two forests are both located in zone guinean and then, benefit the same subequatorial climate with two dry seasons and two rainy seasons. But, in spite of existence of several occurrence sites for olive colobus in its range, the choice of these two forests is related to the accessibility of their vegetation and they constitute the sites where the study on olive colobus's behavior is possible.

The protected forest of Lama covered 162.50 km² in size with a central core completely protected of 47.77 km² in size and distributed in a mosaic of plant community. This forest is characterized by an important fauna. Concerned primates species, olive colobus share its habitat with seven other primates species: *Colobus vellerosus*, *Cercopithecus mona*, *Cercopithecus erythrogaster erythrogaster*, *Chlorocebus aethiops tantalus*, *Galago thomasii*, *G. senegalensis*, *Peridicticus potto*. Diversity plants in study area was investigated by plots and estimated at 158 species in central core. But, considered all the size of this protected forest, its composition is more than 200 species. This vegetation is developing on a characteristic hydromorphic soil called vertisol.

As for the forest fragments, it is located approximately at 20 km of protected forest and is presented in the form of several patches forests (future site of ranch of Zogbodomey) crossed by the Tohouè river (Figure 1). The permanent humidification of study site is due to water of flood provenant of the upstream of the Zou river which communicates with the Tohoué river. The soils are the vertisols.

The vegetation presentes various aspects. In certain sites, it is the more or less opened flooded forest with *Raphia hoockeri*, in other sites, the periodically flooded dense forest with *Ficus congensis* and *Raphia hoockeri*, or along the water beaches of the settlements of *Cynometra megaphylla* or the patches of marshy forests with *Nauclea diderrichii* and *Spondianthus preussii* (personal observations).

The fauna is diversified and several mammals species were met during our prospections : marshbuck (*Tragelaphus spekei*), werstern Buffon's kob (*Kobus kob*), bushbuck (*Tragelaphus scriptus*), the céphalophe of Maxwell (*Cephalophus maxwelli)*, common warthog (*Phacochoerus aethiopicus*) and various primates species such as the green monkey (*Chlorocebus aethiops tantalus*), the mona monkey (*Cercopithecus mona*) and the olive colobus (*Procolobus verus*).

Human environment: socio-economic characteristic of site reveal the presence of three main ethnic groups (Fon, Mahi and Peulh). Agriculture is the main activity of *Fon* and *Mahi* ethnic groups and the research for fertile soils emblave at each season new areas in olive colobus's habitat, but harvest are weak because of the floods due to water of the Zou river which damages the cultures. The population made the adapted cultures to the wetlands like the rice of hollow. The level of poverty of local populations is great so that a high pressure is exerted on the natural resources, considered by their inexhaustible and free (communication). Peulh are breeders, and cohabitation between these various ethnic groups causes often conflicts because of the damage caused by the bovine herds and small ruminant of Peulhs on the cultures.

Inventory of study site: the forest fragments does not have any legal protection. Several farms are installed there such as palm plantation, banana plantation. Serious threats due to the agricultural, with the exploitation of the wine of Raphia, the forestry of *Pterocarpus erinaceus* and pastoralism weigh already on the survival of the animal species. Very coveted fauna is object of an intense hunting. Moreover, this intense hunting is selective neither in terms of age group, nor of sexes or driven out species. Consequently, the primates appear in the table of hunting and this situation partly explains the threat which weights on the olive colobus in this study area.

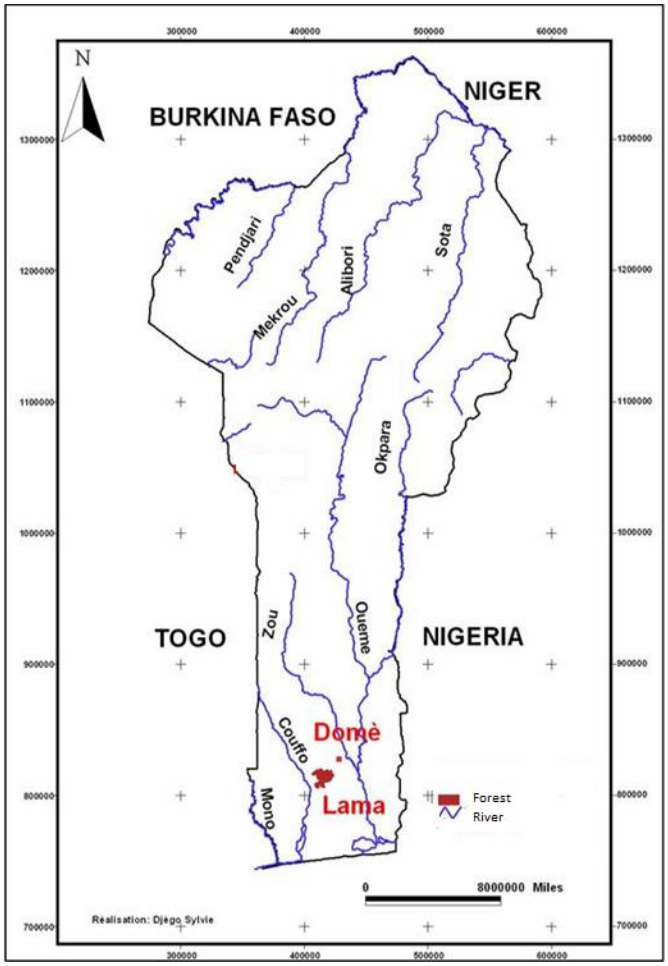

Fig 1: Location of the forest fragments (Domè) and continuous forest (Lama forest), Benin.

2.2 Data collection

Dietary and feeding data on olive colobus were collected using "*ad libitum"* sampling method which consists to record any behaviors that seem interesting or important on the olive colobus as far as possible because of the low visibility and the cryptic behavior of this primate species. This method was used by [9] on olive colobus in Sierra Leone. Thus, we followed two groups of olive colobus in each type of forest from dawn until dusk. In total, 4 groups of monkeys were observed with 136 days and 80 days of observations in continuous forest and forest fragments respectively. Only the feeding events (when monkeys put plant part in their mouth) were taken into account in the data processing of this paper. In this procedure, "events" of feeding on particular food items

are recorded; feeding included the gathering, processing, and/or ingestion of food.
For dietary, we use five foods classes (young leaves, matures leaves, immature fruits, matures fruits and others plants parts)

2.3 Data analysis
First, we established a list of plants species in feeding ecology with riverains and scientifics collaboration using data collected.
Second, we used a frequency method to calculate the percentage between the number of events feeding concerning each foods classe and the total number of food events concerning all items in each type of forest.
Finally, to compare feeding species, we calculated Sorensen similary index with number of species common of both quadrats between number of species in unique quadrat.

3. Results
3.1 Characterization of feeding plants and dietary diversity
3.1.1 Forest fragments
We recorded 68 plants species in forest fragments and Olive colobus fed 37 items ranged in 25 plant species (37%) and belonging in 13 families (Table 1)

Table 1: Plants species consumed by olive colobus and dietary diversity

Plant species	Local names	Families	Items consumed
Albizia zygia	Akla	Leg/Mimosaceae	YL, FP and FI
Alchornea cordifolia	Akamlin	Euphorbiaceae	YL
Anthocleista vogelii	Gotun	Loganiaceae	FM
Artocarpus heterophyllus	Blèfoutoutin	Moraceae	F
Calopogonium muconoides	Akpama	Leg/Papilionaceae	YL
Cleistopholis patens	Houndakan	Annonaceae	P/MF
Cola cordifolia	Houtin	Sterculiaceae	P
Cynometra megaphylla	Botin	Leg/Papilionacea	YL
Dialum guineense	Asonswen	Leg/Caesalpiniaceae	FI
Ficus congensis	Houmbo	Moraceae	YL, FI.
Ficus vogelii	Votin	Moraceae	YL, FI
Grewia barombiensis	Agbankan	Tiliaceae	YL
Irvingia gabonensis	Asro	Irvingiaceae	YL
Leucaniodiscus cupanioïdes	Ganxotin	Sapindaceae	YL, FI
Lonchocarpus cyanensens	Ahoma	Leg/Papilionaceae	YL, FI
Lonchocarpus sericeus	Gnonzoubla	Leg/Papilionaceae	YL, FI
Nauclea diderrichii	Agban	Rubiaceae	YL
Pauridiantha hirtella	Hêlouvokan	Rubiaceae	YL
Psychotria apple-brandy	Djètin	Rubiaceae	P/YL
Pterocarpus santalinoides	Gbègbè	Leg/Papilionaceae	YL, FI, flowers
Raphia hoockeri	Dètin	Arecaceae	Fruits (pericarp)
Spondianthus preussii	Kakè	Euphorbiaceae	YL
Spondias mombin	Akikon	Anarcadiaceae	YL
Terminalia avicennioides		Combretaceae	YL
Xylopia parviflora	Lobowé	Annonaceae	P/MF
25 species		13 families	37 items

Symbols: FP = floral parts, YL = young leaves, ML = Mature leaves, P = petioles, FI = Immature fruits, FM= Matures fruits, Leg: Leguminous

Table 1 shows that olive colobus incorporate a higher percentage of Leguminous plants (28%) in their diet, followed by Moraceae family (12%) and Rubiaceae family (12%). Top seven food species consumed plants by olive colobus were : *Nauclea diderrichii*, *Pterocarpus santalinoides*, *Raphia hoockeri*, *Ficus congensis*, *Lonchocarpus sericeus*, *Anthocleista vogelii* and *Dialum guineense*.

The leaves (young, mature and petioles) and the fruits (ripe and unripe) are the main items consumed and constitute more than 97% of their diet, whereas floral parts constitute less than 3%. The young leaves constitute 88, 50% of leaves consumed and 51, 20% of the diet. Olive colobus's diet include 57, 85% of leaves, 39, 51% of fruits and 2, 62% of floral buds. The Figure 2 presentes the percentages of different items (leaves, fruits and floral parts) consumed by olive colobus.

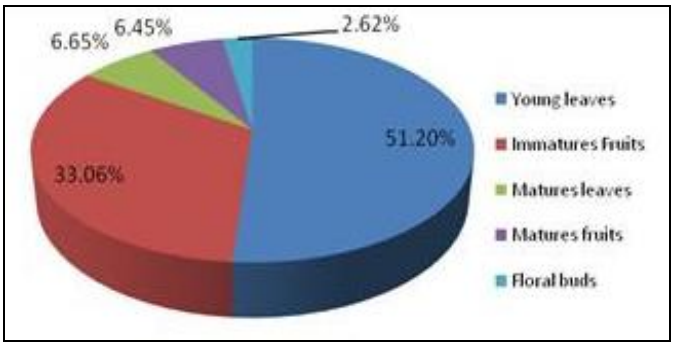

Fig 2: Composition of the diet of olive colobus, forest fragments

3.1.2 Continuous forest

We recorded 158 plants species in central core in continuous forest and Olive colobus fed on 42 items from 32 plant species (20%) belonging in 11 families (Table 2).

Table 2: Plants species consumed by olive colobus and dietary diversity

Species	Families	Consumed parts
Albizia zygia	Lég.-Mimosoideae	YF, IF
Antiaris africana	Moraceae	YF
Bridelia micrantha	Euphorbiaceae	YF
Capparis thonningii	Capparidacea	YF
Cassipourae barteri	Rhizophoraceae	YF
Ceiba will pentandra	Bombacaceae	FrI, YF, Fl
Celtis brownii	Ulmaceae	YF
Cleistopholis patens	Annonaceae	Fr
Combretum glutinosum	Combretaceae	F, bFl
Combretum micranthum	Combretaceae	F, F
Cynometra megalophylla	Leg.-Caes.	YF
Dialum guineense	Leg.-Caes.	MF
Drypetes floribunda	Euphorbiaceae	YF
Dyospyros mespiliformis	Ebenaceae	Fr
Eugenia sp.	Ebenaceae	IF
Erythrophleum africanum	Leg.-Caes.	YF
Ficus capensis	Moraceea	IF
Holarrhena floribunda	Apocynaceae	YF,
Leucaniodiscus cupanioides	Sapindaceae	IF
Manilkara multinermis	Sapotaceae	F
Milicia excelsa	Moraceae	F
Millettia thonningii	Leg.-PAP.	YF, IF
Morinda lucida	Rubiaceae	YF
Napoleonea vogelii	Lecythidaceae	YF
Pauridiantha hirtella	Rubiaceae	YF
Psidium guayava	Myrtaceae	F
Psychotria apple-brandy	Rubiaceae	P
Pterocarpus santalinoides	Leg.-PAP.	MF, YF
Spondianthus preussii	Euphorbiaceae	YF
Terminalia avicennioides	Combreataceae	YF
Vitex doniana	Verbenaceae	YF
Xylopia will parviflora	Annonaceae	YF
32 species	11 families	42 items

Symbols: P = petiole, IF = Immature fruits, MF = Matures fruits, YF = young leaves, B = buds, Fl = flowers.

In continuous forest, the diet was dominated by Rubiaceae family with 20% of the diet, followed by Euphorbiaceae with 15% and Combretaceae with 15%. Top seven plant species consumed plants by olive colobus in this forest were : *Drypetes floribunda, Morinda lucida Pauridiantha hirtella, Combretum micranthum,Spondianthus pressii, Albizia zygia, Pterocarpus santalinoides*.

The young leaves dominated in the diet and constituted more than 50% of the diet (Figure 3).

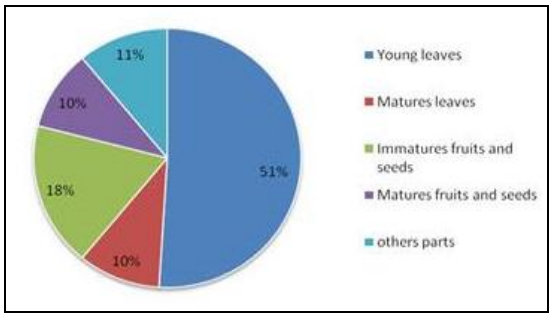

Fig 3: Diet composition of olive colobus in continuous forest

3.2 Comparison in feeding ecology and dietary: Sorensen similarity value

The Sorensen similarity index between feeding plants species of olive colobus in forest fragments and continuous forest was 18%. In continuous forest, 20% of plant species were exploited for food against 37% in forest fragments. Table 3 summarizes the comparison of the plants feeding and diet in two forests.

Table 3: Comparison of the mediums of study of the various groups of *Procolobus verus*

Forest types	Lama	Dome
Nature of the forest	continuous	fragmented
Nature of the group of monkeys	unhabituated	unhabituated
A number of study groups	2	2
Collected data Method	*ad libitum*	*ad libitum*
Diversity of the plants in the habitats	158 species	68 species
Food species diversity	32 species	25 species

4. Discussion

In the present study, olive colobus living in forest fragments shows a diet with 58% of leaves and 61% in continuous forest with high proportions of young leaves. The contribution of the leaves can lead from 74% to 85% [9]. In several studies, the diet of olive colobus is dominated by young leaves [15, 10, 8], but this primate species is physiologically limited by the consumption of mature leaves [9]. Indeed, small size of olive colobus limit their capacity to be engaged effectively in the stomach processes of fermentation which leads to the extraction of the nutrients content of the mature leaves [16]. Also, Leguminous plants dominated in diet of olive colobus in continuous forest whereas in forest fragments, Rubiacea family did, although the Leguminous plants are dominant in this continuous forest.

According to previous studies (Gombe in Tanzania and Kibale in Uganda), colobines are the folivorous primates [17, 18, 19, 20], but they also consume fruits and seeds. The proportion of these items in their diet varies from 28 to 40% for olive colobus. However, the percentage is higher in dry season because of the leaves shortage. Our results corroborate with those studies of [21, 3], these authors do not support the fact that colobus are considered as folivorous primates, because olive colobus monkeys consume low proportion of leaves in dry season. Thus, the diet composition can be influenced by different factors such as availability of the food resources related to the seasons [22] the quality and the space-time distribution of the food resources. Further, the forest type influences diversity of monkey's diet [23]. In forest fragments, olive colobus diversified their diet (37% of species in this study) because preferred foods are reduced [24, 25], but only 20% (this study) of plant species occurred in monkey's diet in continuous forest where. In this order, several studies show that fragmentation affects the diet composition and animals present behavioral flexibility [26].

5. Conclusion

Our study revealed that olive colobus monkey groups live in continuous forest as well as in forest fragments and are able to feed with degradation in their habitat. This dietary flexibility mays place them at greater risk of hunting by human.

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7. References

1. Deputte B. Introduction to the Primates http:/www.arfe-cursus.com/primates-introduction.htm. 2001.
2. Oates JF. The natural history of African colobines. In Colobine Monkeys: Their Ecology, Behaviour and Evolution. A.G. Davies & J.F. Oates, eds. Cambridge University Press, 1994, 75-128.
3. Dasilva GL. The ecology of the werstern black and white colobus (Colobus polykomos polykomos Zimmermann, 1780) on a riverine Island in Southeastern Sierra Leone. Dphil thesis, University of Oxford, England, 1989.
4. Yeager CP, Kirkpatrick CR. Asian colobine social structure: ecological and evolutionary constraints. Primates. 1998; 39:147-155.
5. Booth AH. Observations one the natural history of the olive *Colobus* monkey, *Procolobus verus* (Van Beneden). Proceedings of the zoological Socotiety London. 1957; 129:421-430.
6. Kuhn HJ. Zur Kennetnis von Beam und Funktion of Magens der Schlankaffen (Colobinae). Folia Primatologica. 1964; 2:193-221.
7. Galat G, Galat-Luong A. Community of the diurnal primates of the forest of Taï in Côte.d'ivoire. Review of Ecology (Ground and life). 1985; 40:7-32.
8. Korstjens AH. The Mob, Secret The Sorority, and The Phantoms: Year analysis of the socio-ecological strategies of the three colobines of Taï. PhD Thesis. Utrecht University, 2001, 174.
9. Oates JF. The diet of the olive colobus monkey, *Procolobus verus* in Sierra Leone. International Newspaper of Primatology. 1988; 9:457-478.
10. Davies AG, Oates JF, Dasilva GL. Patterns of frugivory in three West African colobine monkeys. International Newspaper of Primatology. 1999; 20:327-357.
11. Djègo-Djossou S, Djègo J, Mensah GA, Huynen MC, Sinsin B. Distribution of the green colobe olive, *Procolobus verus* with Benin and threats weighing on its conservation. African Primates. 2014; 9:23-34.
12. Djègo-Djossou S. Aires d'occurrence et éco-éthologie du colobe de Geoffroy, *Colobus vellerosus* et du colobe olive, *Procolobus verus* au Bénin. Thèse de Doctorat de l'Université d'Abomey-Calavi Bénin. 2013, 190.
13. Laurance WF, Nascimento HEM, Laurance SG, Andrade AC, Fearnside PM, Ribeiro JEL, *et al*. Rain forest fragmentation and the proliferation of successional trees. Ecology. 2006; 87:469-482.
14. Corlett RT. How to be a frugivore (in a changing world).Acta Oecologica. 2011; (37):674-681.
15. McGraw WS. Comparative Locomotion and Lived T Use of Six Monkeys in the Taï Forest, Ivory Coast. American Newspaper Physical Anthropology. 1998; 105:493-510.
16. Kay RNB, Davies GA. Digestive physiology. In Colobine monkeys: Their ecology, behavior and evolution, ED; G A. Davies & J F Oates, Cambridge University Press, 1994, 229-250.
17. Clutton-Brock TH. Feeding behaviour of red colobus and black and white colobus in East Africa. Folia Primatologica. 1975; 23:165-207.
18. Oates JF. The guereza and its food. In Ecology Primate: Studies of Feeding and Ranging Behaviour in Lemurs, Monkeys and Apes, (ED.) T H. Clutton-Brock. London: Academic Press, 1977, 275-321.
19. Struhsaker TT. The Red Colobus Monkey. Chicago University Press, Chicago.
20. Struhsaker TT, Oates JF. Comparison of the behavior and ecology of red colobus and black-and-white colobus in Uganda: With summary. In Tuttle, R. H. (ED), Socioecology and Psychology of Primates, 1975, 103-123.
21. Dasilva GL. The western black-and-white colobus (*Colobus polykomos polykomos)* have has low energy strategist: Activity budgets, energy expenditure and energy intake. Newspaper of Animal Ecology. 1992; 61:79-91.
22. Onderdonk DA, Chapman CA. Coping with forest fragmentation: The primates of Kibale National Park, Uganda. International Journal of Primatology. 2000; 21:587-611.
23. Chaves O, Kathryn E, Arroyo-Rodriguez V. Differences in diet between Spider monkey groups living in forest fragments and continuous forest in Mexico. *Biotropica.* 2012; 44:105-113. Https//doi.org/10.1111/j.1744-7429.2011.00766.x
24. Stevenson PR, Aldana AM. Potential effects of ateline extinction and forest fragmentation on plant diversity and composition in the Western Orinoco basin, Colombia. International Journal of Primatology. 2008; 29:365-377.
25. Addisu Mekonnen K. Effects of habitat fragmentation and degradation on Bale monkeys (*Chlorocebus djamdjamensis*) in southern Ethiopia: Integrating ecology, behaviour and population genetics. Philosopihiae Doctor thesis, Addis Ababa University, Ethiopia, 2018.
26. Stevenson PR, Beltrán ML, Quiñones MJ, Ahumada JA. Differences in home range, activity patterns and diet of red howler monkeys in a continuous forest and a forest fragment in Colombia. Rev. Acad. Colomb. Cienc. Ex. Fis. Nat. 2015; 39(153):503-513. doi:http://dx.doi.org/10.18257/raccefyn.262.