AFRICA ENVIRONMENTAL REVIEW Journal
ISSN: 1727-8341

AER Journal Volume 3, Issue 1, pp. 82-93, 2018

RESEARCH ARTICLE
Available Online at *http://www.aer-journal.info*

Impacts of Forest Disturbance on Food Trees of *Colobus angolensis* in Kibonge Forest, Kenya

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Abstract

Forest disturbances by anthropogenic activities affects the size of a forest by reducing its size or changing the structure. This presents challenges to animals who depend on it for food and to environmental conservationists for it causes changes in hydrological cycles. Change of diet may be an important strategy to adjust to forest degradation. This study examines how changes in habitat, impact on food trees preferred by the folivorous C. angolensis, in Kibonge forest in Elgeyo- Marakwet County, Kenya. Data were collected between, July 2016 and July 2017. Observations were made to identify the level of forest disturbance on forest size and tree species fed on by two groups of C. angolensis in two regions of Kibonge forest (Mwen and Segen). Amount of canopy cover and nature of disturbance were established through ground field work on 87 sampled vegetation plots each measuring, 20m x 10m. Food trees were identified in the field and unidentified samples at the university of Eldoret arboretum. Selection ratio (S.R) were calculated for each eaten plant species in order to determine food preferred by C. angolensis. Data obtained were analyzed using Maximum Likelihood Classifier (MLC), SPSS, and xLSTAT. Chi square tests were carried out to establish variations between regions and species. Pearson correlation showed a significant reduction of Kibonge forest size ($n=7$, $r=0.0956$, $p< 0.001$). More tree species were concentrated on altitude 2400m ($\chi^2=610.95$, $df=78$, $p<0.001$). In dry season tree species preferred by C. angolensis were Dombeya goetenzii, Nuxia congesta, and Cuppressus lustanica. In wet season were Prunus africana, Croton macrostachyus, Ficus thoninngii and Polyscius kikuyunensis. Defforestation of food trees is the major threat to C. angolensis in Kibonge forest. Afforestation, use of legislature and public awareness are possible mitigation measures.

Key Words: Disturbance, *C. angolensis*, Selection Ratio, Food Preference and Afforestation

INTRODUCTION

Habitat degradation and loss are the greatest threats to terrestrial species (Baillie *et al.*, 2004). Estimates of annual loss of tropical forest range from 8.7 – 12.5 M ha (Chapman and Treves 2004; Mayaux *et al.*, 2005). An area between half and equal size to this, is degraded by selective logging, mining, slash and burn agriculture and other exploitative forms each year (Achard *et al.*, 2002). Tropical forest loss and degradation also have implications for climate change, hydrology, nutrient cycling, natural resource availability and quality of wildlife (Whitmore, 1998). In fact without serious mitigation measures to forest destruction, the number of species threatened with extinction in tropical forests is predicted to increase (Whitmore, 1998).

East African forests such as Budongo Forest Reserve of Uganda, Kakamega forest and Kibonge forest in Kenya, conserves endemic

species of trees and shrubs and act as homes for the endemic primate– the black and white colobus (C. *angolensis*) (Dunham, 2017) .However, these forests have largely been disturbed such that their restoration has become one of greatest challenges for ecologists this century (Duncan and Chapman, 2003). Ground surveys is a good method for quantification of the effects of disturbance in a forest though it would be tasking given the large area and the species involved. However use of sampling plots assist in making more rapid assessments and give more accurate results. Determining the impact of disturbance on rare species is also applied for determination of habitat requirements for management (Lindenmayer, 1999).

The study species black and white colobus monkey *(C. angolensis) (Plate 1.2)* are among broadly regarded diverse group of 5 species; *C. santanas, C. polykomos, C. vellerosus, C.guereza and C. angolensis (*Oates, 1994b*). Colobus angolensis* is sub-divided into 6 species; *C. a. angolensis, C. a. cordieri, C. a. cottoni, C. a. pallitus, C. a. prigoginei* and *C. a Ruwenzori* (IUCN, 1996). Of specific interest to this research is *C. angolensis* (Plate 1) found from eastern Nigeria through Cameroon, northern Congo, Gabon, Zaire, Uganda, Rwanda, Ethiopia, Kenya, Tanzania, to the Central African Republic .These monkeys are diurnal and arboreal, rarely descending to the ground, unless necessary to clear a gap in the tree which makes them vulnerable to changes in habitat as well as hunting pressures (Oates, 1994a). They are endemic to tropical rainforests and are currently confined to small pockets of fragmented forests in Eastern Africa (Anderson, 2007a). Group composition structure typically comprises approximately 2-20 individuals, including 1 or more adult males and more than 1 adult female (Oates and Davies, 1994a). Ecologically, *C. a. palliates* is a folivorous primate who spends less time feeding and moving and more time resting, (Oates and Davies, 1994a). They are therefore vulnerable to the current rate of habitat loss (Anderson, 2004) and extinction (Kingdon, 2008) thus calling for new conservation efforts.

Plate 1. Picture of *C. angolensis* Monkey on a Tree, *Dombeya goeetenzi* Species.

They also subsist on fall back foods of exotic species during scarcity period (Harris, 2007).Scarcity of food comes as a result of reduction of canopy cover of trees mainly due to deforestation which makes the monkey to explore and choose from any available food resources.

MATERIALS AND METHODS

Kibonge forest is found in Keiyo District ($0^{o}10^{/}47–0^{o}26^{/}37$N and $35^{o}27^{/}12$-$35^{o}41^{/}43$E) *in* the Rift Valley Province of Kenya. It borders Eldoret East district to the West, Baringo central to the East, Eldama Ravine to the South and Keiyo North to the North (Figure 3.1). The district covers an area of 898 square kilometers. The study was carried out in Chepkorio division in an area of 8.7 ha. Keiyo District has a population of 143.865 (District Development plan, 2010). The forest is situated in Chepkorio Division with a population of 67,062 of which 1000 are in Nyaru town adjacent to the forest. The town is 42 km East of Eldoret town and 56 km south of Iten town.

The study area is divided into three main agro-ecological zones which run parallel to each other in a North-South direction; highland, the Elgeyo escarpment and the Kerio Valley basin. The highland lies at an altitude of approximately 3000 m above the sea level and extends across the constituency from North to South. The land falls precipitously in a series of steep uplands Kapchebelel ranges to the south of Nyaru town, which comprise the Elgeyo escarpment. The Kerio Valley basin is 1000 m above the sea level.

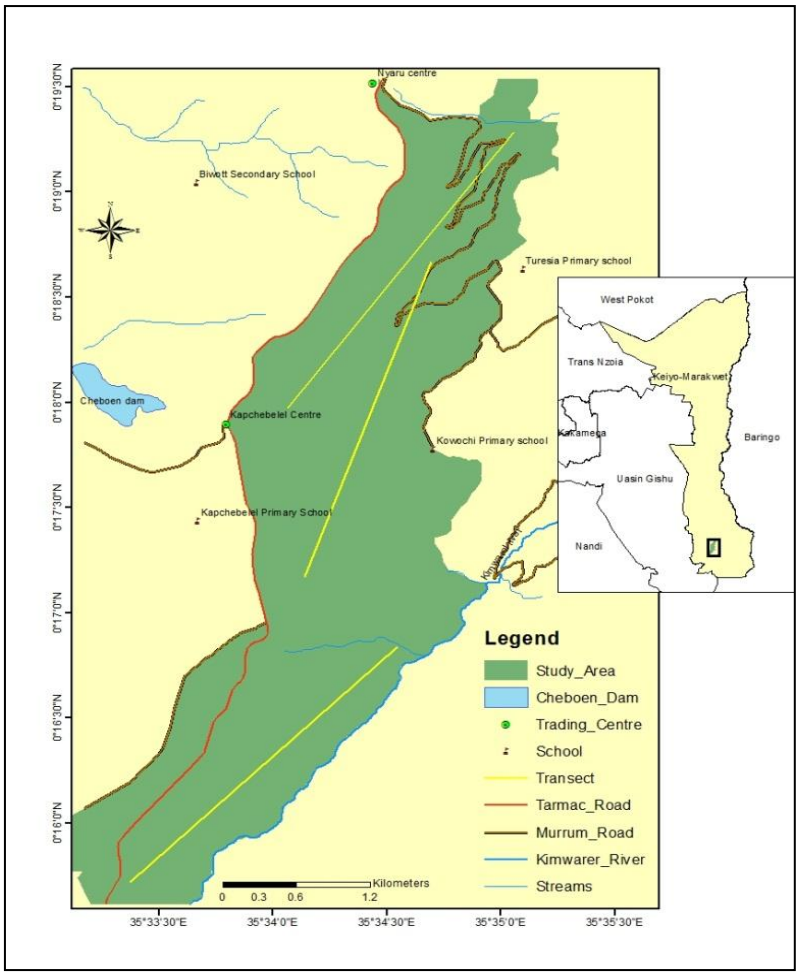

Figure 1. Map of Elgeyo Marakwet County Showing the Study Area

Climate

Mean annual rainfall in the study area, varies with altitude and ranges between 600–1400 mm. The highland, where the study area lies is relatively wet with an annual rainfall of 1400 mm while the Kerio basin is drier with an annual rainfall of 600mm.The long rains are received between March to August with the wettest and coldest months being July and August. Short rains are between October and December. Temperatures on the highland vary from, 4^0C during the wet season and 18^0C during the dry season. In the valley the temperatures are higher ranging from 15-28 degrees centigrade.

Soils and Vegetation

The area has a wide range of soils but it is largely dominated by volcanic loam soils. The Kerio basin is covered with sedimentary rocks which comprise of fertile loam soils. The steep slope has thin layers of soil due to increased erodibility of soil. The study area is covered with indigenous forest of a typical rainforest which is highly concentrated on the steep slopes. On the gentle sloping area and along the road, are plantations of *Cyprus spp and Pinus spp* and Wattle trees. The forest has greatly been excised due to increased need for more land for grazing livestock and crop farming.

Socio-Economic Activities

The main economic activity in the study area is agriculture, Transportation of farm produce, fluorspar mining and trade. Mining of fluorite by the Kenya Fluorspar Company is the largest industry in the study area (Muchemi *et al.,* 2008).The area is used by local and foreign athletes for high-altitude training because of the varied terrain and the cool climate attributed to the presence of forests and the steep escarpment. There are several schools and trading centers at the highland which largely depend on the forest for timber and poles for house constructions.

Establishment of Study Plots and Assessment of Human Disturbance

This was aimed to assess the level of human disturbance based on tree cutting, timber extraction and other forms such as burning and firewood collection. The procedure (Frontier Tanzania, 2001) used was as follows.

Three transect lines were marked running on East -West direction; 150 m apart in each level of altitude (2300 m, 2400, and 2500 m) in three sites of Kibonge forest, Kona mbili, Kona mboga and View point. On the transects and using a pre-measured 50m rope, a clinometers, a pair of compass and colored plastic tags, 50 m sections were cut through the forest on a 90 or 180 degree bearing regardless of the vegetation type, two plastic tags were placed at each 50m interval along the transect where the distance along that transect section was written. For example, at 50 m along the transect, the tags were marked. After another 50 m, the two tags were marked "100 m" etc. This continued to 1000 m where three tags were placed to mark the beginning of the next section along the transect. Transects were numbered sequentially and cut as straight as possible, although difficult terrain and irregularly-shaped habitat meant that transects contained many turns. The, 50 m x 20 m vegetation plots were marked systematically after every 50 m marked on alternating sides of the laid transects using a GPS recorder and pre measured ropes (2 x 20 m ropes and 2 x 50 m ropes). The 50 m ropes were laid on a 180 or 90 degree (East – West) bearing and the 20 m ropes were laid on 0 or 270 degree (North – South) bearing, the ropes remained laid out while the trees were being measured and marked.

On the plots, all trees and shrubs of 10cm dbh and above within the 50 m x 20 m plot, were numbered sequentially beginning at "1". This individual tree identification number was written directly below the dbh line. Above the dbh line, the number of the vegetation plot was marked also. The level of disturbance on trees with DBH= >15 cm was assessed in terms of tree cutting, debarking, pruning ,fires and footpaths and even the number of trees cut or left standing in a plot by a team of three people, two observers and one recorder. They started collecting data at the beginning

of the transect line. One observer described one side of the transect, while the second observer described the other side, and the recorder noted down all observations on a data sheet. On each plot, the dbh of every live tree, naturally dead tree, cut tree stump were measured by the observers within the disturbance transect. Any cut, standing and naturally fallen trees were counted and identified where possible and findings recorded immediately on a data sheet by the recorder. Cut trees and poles were described as 'old cut' if there is any sign of blackening of the stump, if none, it was recorded as 'fresh cut'. Fallen tree trunks or branches were not counted in order to reduce any possible duplicate counts as one does not count a trunk then further along the transect count the base from which it came. Each transect line was surveyed separately. Opportunistic notes on other human disturbance such as traps, pitsaws, cleared areas or evidence of fire, seen along the transect were recorded.

Data Collection on Seasons and Feeding Behavior

Using Trail method, Colobus monkey troops were followed all day for feeding behaviour .The trails were conducted in two seasons**,** wet season and dry season partitioned on the basis of mean rainfall and temperature (Nowak, 2007). Rainfall peaks occurred during the long rainy season, March–June and the hottest dry period was between November and February.

Troop observations started on mid-March, the beginning of the long rains period, and ended in mid-June, just at the end of this period for the wet season and in mid-November to mid - March of the following year for dry season. Colobus angolensis monkey species have two major feeding bouts, one in the morning from around 6 am to 9am and another one in the evening from around 4 pm to 6 pm. They also have a smaller feeding bout around 1pm. Following this information, we trailed the identified troops during census, one in Segen section and the other in Mwen section, of the study area. We observed focal animals in the troop one at a time in morning and afternoon sessions spanning from 06:20 am to 09:00 am in the morning and 16:00 pm to 18:15 pm in the evening .Visibility conditions were better at 06:20am as the sun had risen, so this was chosen as a start time. For the first week the troops were observed until 9:15 am but this did not provide any more feeding data so 9 am was used from then on. Also in the first week the troops were observed until 6 pm, but we noticed that they kept feeding until sun set, so after the first week, the evening observation times were extended to 6:15 pm as that was as long as visibility conditions allowed.

At the first encounter with a monkey and using a pair of binoculars to view the animal, the following information was recorded on a recording sheet; tree species fed on by the colobus monkey, part of the tree eaten, and time spent feeding on the tree part and its diameter at breast height (DBH) and height. DBH and height were to be used to calculate the canopy cover of trees in Kibonge forest. Coverage % would be equal to area covered by a species (Basal area) in a line transect divided by the total area covered by all the species multiplied by 100. Samples of the identical plant parts were collected from the tree or the ground and put in a field bag for preservation through pressing. Then a field bag was put on the transect at the point from which the first animal was seen, to act as a reference point from which other measurements could be made and where food samples would be collected from.

Determination of Selection Ratios (Food Preference)

All of the feeding behaviors by tree species were compiled and frequencies converted into percentages to be used in calculation of selection ratio.

Selection ratio (SR) = [(% of total feeding records made on species) / (% canopy cover of tree species in the vegetation sample)] x 10.

Selection ratios larger than 10 suggest a particular species is chosen more often than

its abundance would predict if food is chosen at random. Similarly, selection ratios lower than 10 suggest the opposite that a particular species is chosen less often than its abundance would predict if food is chosen at random.

RESULTS

Nature and Level of Tree Disturbance

Data of undisturbed and disturbed Trees were collected from 87 vegetation plots for both regions, which amounted to an area of 8.7 Ha. A total of 327 trees were disturbed. Of the tree population n=227 (69.4%) were damaged by cutting, then by pruning (16.5%), and debarking (8.9%) and burning (1.8%), (Table 9). Other forms of disturbance recorded were firewood collection, pitsaws and by natural disasters such as landslide which occurred in Mwen region during the study period which accounted for 3.4%. Chi square test posted a significant correlation between type of disturbance and DBH of trees (χ^2< 48.767, df =20, p< 0.0001). The greatest form of disturbance in Kibonge is by cutting of trees of medium size with range of DBH between 10- 40cm (62.1%) (Table 1). Burning affected only the small sized trees DBH (10-40 cm) whereas debarking was prevalent in the smallest (DBH 0-10 cm) and on largest trees DBH (>50 cm).

Table 1. Cross Tabulation of Nature of Disturbance against Tree Diameter

Diameter	**Type of Disturbance**										**Total**	**%**
	Burnt	**%**	**Cut**	**%**	**Debark**	**%**	**Others**	**%**	**Pruned**	**%**		
0-10	0	0	26	11.45	6	20.68	0	0	4	7.4	36	11.0
10-20	1	16.67	57	25.11	3	10.34	0	0	15	27.78	76	23.2
20-30	4	66.67	23	10.13	4	13.79	3	27.27	11	20.37	45	13.8
30-40	1	16.67	61	26.87	5	17.24	1	9.09	16	29.63	84	25.7
40-50	0	0	24	10.57	4	13.79	5	45.45	3	5.56	36	11.0
50+	0	0	36	15.86	7	24.14	2	18.18	5	9.26	50	15.3
Total	**6**	**100**	**227**	**100**	**29**	**100**	**11**	**100**	**54**	**100**	**327**	**100**
%Total	**1.8**		**69.4**		**8.9**		**3.4**		**16.5**		**100**	

Black and White Colobus Diet and Food Preference (Selection Ratio)

Trees used as food by *C. angolensis* in Kibonge forest during wet and dry seasons are shown in Table 2. During the dry season, trees highly preferred for food measured by percentage feeding time in Mwen in order of merit were *Dombeya spp* (52.5%), *Nuxia congesta* (17.6%), *and Cupressus lustanica* (18.2%) *Podocarpus falcutus*, *Markhamia lutea, Eucalyptus saligna* and *Acacia mearnsi* (Table 2). In Segen *Cupressus lustanica (*78.9%), *Dombeya goetznii (*20.6%), were highly selected all being indigenous species with a greater basal area (Table 2). During the wet season, *Polyscius kikuyuensis* (23.96%), *Dombeya goetznii (*66.82%), *Croton macrostachyus* (4.3%), were the highly preferred food trees in Mwen, while *Macaranda kilimandascharica* (21%), *Polyscius kikuyuensis* (20.7%) and *Prunus africana* (21.1%) were preferred in Segen. There was no correlation between food availability and food preference (n= 9, r= -0.354, p= 0.436) by *C. angolensis* monkey. Meaning an increase or decrease in food supply does not influence what the monkey will choose to consume at a given time.

Table 2. Preferred Food Trees and their Selection Ratio (SR)

REGION	SEASON	Tree name	%Feeding record time	%Canopy cover	Selection Ratio (SR)
MWEN	DRY	*Dombeya goetenzii*	37.57	31.66	11.87
		Nuxia congesta	23.12	2.87	80.44
		Acacia mearnsii	1.03	1.15	8.96
		Cupressus lustanica	17.93	1.89	94.94
		Eucalyptus saligna	0.34	0.86	3.95
		Markhamia lutea	0.25	1.33	1.92
		Macaranda kilimandascharica	1.25	11.83	1.06
		Croton macrostachyus	0.79	4.12	1.92
		Podocarpus falcutus	0.17	1.02	1.66
		Ekerbergia capensis	0.45	2.71	1.67
	WET	*Polyscius Kikuyuensis*	34.83	9.4	37.06
		Dombeya goetenzii	48.89	31.66	15.45
		Croton macrostachyus	8.29	4.12	20.12
		Cupressus lustanica	0.98	1.89	51.67
		Acacia mearnsii	0.43	1.59	2.73
		Ekerbergia capensis	0.72	2.71	2.67
		Eucalyptus saligna	0.58	0.86	6.76
		Podocarpus falcutus	0.14	1.02	1.42
		Prunus africana	5.13	23.753	2.16
SEGEN	DRY	*Cupressus lustanica*	78.46	60.81	12.9
		Podocarpus gracillior	0.41	0.78	5.23
		Dombeya goetenzii	20.5	8.86	23.14
		Ekerbergia capensis	0.63	0.45	13.91
	WET	*Macaranda kilimandascharica*	19.69	6.66	29.59
		Polyscius kikuyuensis	19.13	2.14	89.56
		Prunus africana	19.77	7.44	26.59
		Nuxia congesta	0.11	0.14	7.69
		Grewia bicolor	1.64	1.78	9.21
		Cupressus lustanica	20.1	60.81	3.31
		Ficus thoninngii	18.29	2.83	64.65

Tree Disturbance and Food Tree

Percentage Canopy covers of disturbed and undisturbed highly selected foods were compared (Table 3). Much of the canopy lost was seen in food trees *Nuxia congesta by 2.26% , Ekerbagia capensis by 15.2%, Croton macrostachyus by 2.36%, Prunus africana by 16.48%, Ficus thonningii by 7.28%* and *M. kilimandascharica by 8.7%.* When the percentage *c*anopy cover of food trees disturbed and the undisturbed food trees were correlated, there existed a significant difference (n=9, r=0.788, p= 0.02). The relationship between canopy cover of life trees and disturbed trees in wet and dry seasons were not statistically significant, (n=9, r = 0.492, p = 0.088). This implies that canopy cover of food trees undisturbed is directly proportional to the canopy cover of the disturbed trees such that as more trees are destroyed, canopy cover reduces. This effect has great implications to food supply of *C. angolensis*.

Table 3. Percentage Canopy covers of both Disturbed and Undisturbed Highly Selected Food Trees by *C. angolensis* monkey. Negation Represents the Percentage Loss of Canopy

Selected food tree	%Canopy cover of Undisturbed trees	%Canopy cover of Disturbed trees lost	Deviation
Dombeya goetenzii	33.4	4.89	28.56
Nuxia congesta	0.3	2.7	-2.26
Cupressus lustanica	26.6	5.08	21.6
Ekerbergia capensis	0.5	15.77	-15.20
Polyscius kikuyuensis	9.4	6.63	2.77
Croton macrostachyus	2.8	5.27	-2.36
Prunus Africana	6.9	23.41	-16.48
Ficus thonningii	15.0	22.29	-7.28
M.kilimandascharica	5.1	13.93	-8.7
Total	**100**	**100**	

DISCUSSION

Agents of Forest Disturbances

The significant findings on cutting down (deforestation) of trees in Kibonge, is enough evidence to raise an alarm on the seriousness of the activity in Kenya. There are many reasons for deforestation, such as agriculture expansion, population growth, industrialization and so on. Excessive population growth increases the demand for forest resources (Gibbs *et al.*, 2010). People in developing countries overexploit natural resources to improve financial incomes. In East Africa, fuelwood use and population growth are important contributors to deforestation (FAO, 2010), in 1980s and 1990s Rudel *et al*., (2009). Habitat destruction is considered the key cause of species extinction (Pimm and Raven, 2000). Thus, in forests with high rates of deforestation and encroachment, the decrease in forest fragment area will result in a decrease in number of species found. A 22 year investigation of ecosystem decay in Amazonian forest fragments found a relationship between species richness and forest fragment size; intact forests contained a higher number of species per unit area than in fragmented forests (Laurance, 2004). A large proportion of species richness is required to maintain ecosystem stability and sustain function (Schwartz *et al.*, 2000) for ecosystem properties depend on the characteristics of biodiversity, the size of the forest and the time in the ecosystem (Hooper, 2005). Also local extinctions of species can occur after a time lag following habitat loss or degradation (Kuussaari *et al.*, 2009). For instance, a 10 year lag period after the 90% loss of major food resources had a significant decline in Ververts (*Cercopithecus aethiops*) in Kenya (Struhsaker, (1997a) and caused fragmentation of forests (Laurance, 2004). Habitat fragmentation has 3 key impacts on forests; a decrease in the size of the forest, an increase in fragment isolation and an increase in total forest edge (Fahrig, 2003). Habitat fragmentation has a consequent effect on primates for it lowers amount of available food and exposes them to predators (Chapman *et al.*, 2007, Arroyo-Rodriguez and Mandujano, 2009, Wong and Sicotte, 2006, Wahungu *et al.*, 2005,) .As a result the following may occur, death of some primate food tree species which cannot cope with the new prevailing environmental condition, new invasions of plants on bare land. In the advent of these changes, primates will experience food scarcity and get exposed to predators for their is lack of canopy cover resulting into their extinction.

Nature and Level of Disturbance on Colobus Food Tree

The greatest significant form of disturbance in Kibonge is by cutting. Trees cut were within the range of DBH >0-10 cm to 10- 20 cm followed in the order, then with DBH=20- 50. Tree-stem density was lower in more intensely exploited plots, but smaller-diameter trees were more affected than larger ones. These results are in tandem with a study done by Borghesio (2008) were he reported

52- 73% fewer small trees (diameters < 20 cm) and 15% fewer large trees in plots with high levels of wood collection than in plots with low intensity of wood collection. 29.1% of trees were disturbed in Kibonge forest. Of the population 69.4% were damaged by cutting, 16.5% by pruning, and 8.9% by debarking (Plate 4). Other forms of disturbance recorded were burning (1.8%) (Plate 5), firewood collection (Plate 6), pitsaws and by natural disasters such as landslide (Plate 7) which occurred in Mwen region during the study period. The most disturbed trees were *Cuppressus lustanica, Dombeya goetenzii, Macaranda kilimandascharica, Prunus africana, Croton macrostachyus and Polyscias kikuyuensis*, most of which were highly selected by *C. angolensis* monkey for food. A similar study done by Vunyiya *et al.*, (2014) on the impacts of human activities on the tree species richness and diversity in Kakamega forest showed similar results. Human activities noted within the three study site in Kakamega forest included logging, charcoal burning, debarking and grazing and the most exploited trees for logging in the region include hardwood like *olea carpensis, Prunus africanus and celtis africana*. We can deduce that deforestation and logging have the greatest impacts on biodiversity in tropical forests.

Plate 2.Debarked Tree in Kibonge Forest for Purposes of Getting Bark for Harvesting Honey and Dry Tree used for Firewood

Plate 3.Charred Tree by Fire during Fire Outbreaks in Kibonge Forest during the Dry Season

Plate 4. Firewood Collection in Kibonge

Plate 5. Land Slide in Kibonge

Tree Species Preferred for Foraging by *C. angolensis*

Black and white *C. angolensis* are found to spend a large part of their day foraging for food in high to low light conditions (Yamashita *et al.*, 2005). Trees used as food by *C. angolensis* in Kibonge forest varied during wet and dry seasons. The study showed that during the dry season in Mwen were *Dombeya spp*, *Nuxia congesta*, *Cupressus lustanica Podocarpus falcutus*, *Markhamia lutea, Eucalyptus saligna* and *Acacia mearnsi.* While in Segen *Cupressus lustanica, Dombeya goetznii*. During the wet season, *Polyscius kikuyuensis*, *Dombeya goetznii*, *Croton macrostachyus* were the highly preferred food trees in Mwen, while *Macaranda kilimandascharica*, *Polyscius kikuyuensis* and *Prunus africana* .Tree species preference for the *C. angolensis* during the wet season increased, because during the rainy season they have a choice of young leaves but during the dry season they feed on mature leave which are more difficult to digest. However they possess a multi-chambered stomach with special microbes that break down cellulose over an extended time allowing fermentation to occur (Tovar *et al.,* 2005). Our findings relates to a study done by O'Dwyer (2012) on the black-and-white colobus monkeys (*Colobus angolensis palliatus*) of Diani forest, Kenya, showed that on the degraded forest of colobus monkey's, troops utilize the following species; *Bougainville spectabilis, Adansonia digitata*, *Delonix regia*, *Zanthoxylum chalybeum*, and *Majidea zanguebarica*. Their main protein sources were most likely from the leaves and

fruit of *Adenanthera pavonina*, the leaves of *Majidea zanguebarica*, and the fruit (most likely seeds) of *Lecaniodiscus fraxinifolius* and *Lannae welwitschii*. From 72 tree species identified by O'Dwyer (2012), *Ficus sycomorus, Ficus exasperata* and *Delonix regia* are among the tree species utilized by six troops of black-and-white colobus monkeys as food materials. Fashing (2001a) mentioned about colobus monkeys spending more time feeding on *Ficus exasperata* from 32 tree species in Kakamega Forest, Kenya. From the above findings and those of studies in Kibonge forest, it can be concluded that, although *C. angolensis* monkey prefers leaves of indigenous trees as food, it is not specific in its diet choice, but is able to utilize the available resources during times of scarcity.

CONCLUSION

Our study highlights the negative impact of tropical forest habitat destruction on *C. angolensis* in Elgeyo Marakwet County, Kenya. Identification of the actual mechanism responsible for the destruction of a variety of tree foods preferred by primates as reported in many studies is complex especially in reference to the level of disturbance. The significant Chi square test on level of disturbance elaborates further on effects of human encroachment into forest and to colobus monkeys. The majority of these trees were exotic spp. such as *Cupressus lustanica* and also indigenous species (*Nuxia congesta*), which were highly preferred for food by the monkey. Preference of exotic species gives a conclusion that they can be planted to act as buffer zones between human habitation as well as provide alternative foods for the monkey species. Other exotic species may be tried out to see if the monkey can feed on them in order to provide a wide variety of foods which can meet the nutritional demands of the monkey.

RECOMMENDATION

Forest loss and ongoing tree extraction in Elgeyo Marekwet County, is a dynamic and ongoing process even in protected government forests such as Kipkabus and Kaptagat forest reserves. The high degree of human and colobus resource overlap, with local human communities showing a high affinity for extracting the major food trees of colobus, has serious repercussions. As a result of ongoing forest loss and the extraction of food trees remaining in the forests, both availability of food resources and the structure of forest canopy are affected. It is likely that we shall witness future declines of *C. angolensis* and increased population extinctions, over the coming years. It therefore calls for maintenance of large, closed canopy forests within the district and to restore degraded habitat through afforestation whenever possible as well as establishing buffer zones of exotic tree species to act as refuge zones. This will require improved law enforcement of illegal logging, illegal poaching (Mathews and Mathews, 2002), proper forest management to allow forests to regenerate and the promotion of alternative human resources.

Further studies may be done to establish other species of exotic trees having high nutrient content which would be utilized by *C. angolensis*.

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