International Journal of Multidisciplinary Research and Development
Online ISSN: 2349-4182, Print ISSN: 2349-5979; Impact Factor: RJIF 5.72
Received: 10-11-2020; Accepted: 25-11-2020; Published: 13-12-2020
www.allsubjectjournal.com
Volume 7; Issue 12; 2020; Page No. 54-61

Feeding behaviour of elephants (*Loxodonta africana* Blumenbach, 1797) and its impact on vegetation: in mosi-oa-tunya national park, Zambia

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Abstract
The purpose of the study was to investigate the feeding behaviour of elephants and its impact on the vegetation in the Mosi-Oa-Tunya National park. The study main objective: was to determine the habitat damage resulting from the feeding behaviour of elephants. The study required stratification of the study area into vegetation types, and total of five transects and fifty plots were established and distributed in all habitats. Data collection was done in both rain and dry seasons on habitat damage from 2016 to 2017. Results of the study indicated that in Mopane habitat 53.1% of different trees of 14 wood plant species were extensively damaged. This was followed by the scrub habitat in which 35.59% different shrubs of 15 wood plant species were damaged while in Miombo (5.17%), Mkusi (3.52%) and Riverline (2.61%) habitats were less damaged. Further analysis for habitat damage using ANOVA showed that there was a significant ($F=3.31$, $p<.001$) difference in the habitat damage due to the feeding behaviour of elephants. Increase in the number of trees damaged in Mopane habitat and scrub habitat resulted in the habitat damage by creation of open woodland in Mopane habitat and stunted but reproductive growth in Scrub habitat compared to the Habitats in which damaged was less. Findings of the study indicated that the elephants damaged Mopane habitat by their feeding behaviour. Although studies on this subject are limited in this region, these results provide additional information on the existing argument that the rapidly growing human population and changes in land use are a major threat to wildlife habitats. It was concluded that carrying capacity of the national park was severely exceeded and cannot sustain the elephant feeding pressure.

Keywords: elephants, feeding behaviour, mosi oa tunya national park, habitat preference, vegetation damage

Introduction

Background

The rapidly expanding human populations and changes in land use are a major cause limiting elephant population distribution in protected areas leading to severe loss of wildlife habitats. The survival of the African Elephant (*Loxodonta Africana* Blumenbach, 1797) largely depends on the availability of extensive habitat free from human habitations and adequate protection (Biru and Bekere, 2012) [2], and there has been increasing concern following its sharp decline since 1970 and 1980s as a result of poaching and loss of its habitat (Kangwana, 1996) [13]. Despite numerous studies on elephant, conservation of the species worldwide remains a major challenge as the species distribution continues to be threatened by increasing conflict between man and the elephant for the available resources and space. The future conservation and management of the elephant will obviously require good understanding of the species on its distribution, density, dietary needs and its impact on an ecosystem. Knowledge on this is severely limited. An elephant is a bulky feeder and requires a large home range, yet most elephant populations have been restricted to protected areas. Since habitat requirement for elephant in Mosi-oa-tunya National Park has not been well documented, this study therefore seeks to investigate the feeding behaviour of elephants and its impact on vegetation. The knowledge is intended to provide baseline data for the effective management and conservation of the species in this National Park.

Cumming *et al*. (1997) [7] and Weber (2014) [25] noted that woodlands mostly converted to shrub land where elephant density exceed 0.5km^2 potentially resulting in a loose of vulnerable tree species. Such changes in vegetation composition are the consequences of the elephant foraging behaviour, potentially leading to the habitat degradation and therefore, controlling the resources availability of other species. In order to mitigate these impacts, effective management principles have to be established and thus, a sound understanding of both local vegetation and composition of species and the elephant feeding behaviour and distribution are essential (Weber, 2014) [25]. Although considerable research on elephant habitat interaction exist elsewhere, very little is known in Mosi-Oa-Tunya national park.

The Zambian government through the Department of National Parks and wildlife has continued ensuring that animals in national Parks are protected and reserved for future use. To the contrary, Nyirenda *et al* (2012) [17] noted that animals such as elephants are a threat to human beings due to their destructive way of feeding as well as attacks to humanity. In addition, people who live near protected areas including game authorities also risks their lives because sometime elephants depend on crops and most of the times destroy the crops, attack human beings and destroy their camping areas. This situation makes villagers and tourists to live in fear, not knowing what to do when they were faced with such attacks or problems.

Mosi-oa-tunya National Park is among the smallest National Parks in Zambia and covers approximately 23.4 Km^2 but surrounded by rural settlements and part of Livingstone

town urban settlement. Information on the feeding behaviour of the Elephant and food availability is lacking, and this study will help in the planning for management and conservation of the species in this National Park and stimulate further research on the Elephant (Zambia Wildlife Authority, 2016).

Therefore the overall objective of the study was to determine the feeding behaviour of elephants and its impact on vegetation in Mosi-oa-tunya National Park in Zambia.

Literature Review

Feeding behaviour of elephants and its impact on Habitat and Biodiversity

Elephants are extremely adaptable to the environment when feeding, occupying a variety of habitats from desert to savannah and gallery forest. Environmental factors affect elephant population dynamics, home range, migration patterns, diet, group size and composition, all of which can vary tremendously, in turn influencing the dynamics of elephants and their habitats. During feeding ventures, elephants are capable of greatly affecting the structure of vegetation and perhaps animal communities. At high densities elephants reduce woodlands, converting them to more open grassland. In many areas human expansion and poaching have forced elephants to alter traditional migration patterns and concentrate in protected areas (Guy, 1974) [10].

Laws (1966) [15] indicated that when grazing and browsing, elephants especially the male fork spent about 1:20 times as long as the females in feeding (grazing and browsing), and had a feeding rate 1:13 times than that of the females. On the assumption that mouthful size is approximately similar for both sexes, this differential would suggest that the males eat more food than the females as would be expected because of their greater mass. The elephants spent more time browsing than grazing in both the cold and hot seasons. In the wet season however, there is an obvious change in feeding preference with grazing becoming more important. The clear preference for grass over browse exhibited by elephant in the wet season is probably related to the protein content of the food available as this is apparently a limiting factor in any herbivore/resource relationship (Sinclair 1975). As long as elephants continue to be found in unrestricted or unprotected areas, human beings living near national parks will continue encountering problems caused by elephant's feeding behaviours.

As elephants graze, the process continues throughout the year and only decreases in importance when the grass becomes dry and coarse. There is a corresponding increase in browsing, so that browsing increases in importance as the dry season progresses, and as it was also observed by Wing and Buss (1970) and Field (1971) [9] who revealed that there was a decrease in browsing with an increase in rainfall. It could also be argued that elephants are primarily grazers because large quantities of grass are eaten even when large quantities of browse are available. It does not seem that elephants have been forced to adopt a primarily grazing habit, as asserted by Sikes (1971) [22], but have in fact always been grazers, and will always graze when large enough quantities of grass are available, yet factors such as digestibility, quality of food and ease of gathering must also be taken into account.

Kerley and Landman (2006) [14] conducted a study titled "Impact of elephants on the subtropical thickets of the eastern cape province as a contribution to the current debate around biodiversity and the need to manage Elephant populations." Observation method was used to assess the richness and biomass of plants inside and outside the elephant enclosure and assumed that any difference was due to elephants. The results of research on elephant's impact associated with this population had shown that these animals influence many ecological processes, and patterns, including soil features, landscape patchiness and plant biomass and diversity.

Furthermore, elephants influence insects, birds and Antelope abundances and reduce browse availability for black Rhinoceros. The study was done in Eastern Cape Province in South Africa, it was largely qualitative and focused at the impact of elephants on ecological process and patterns. The study did not take into consideration the feeding behaviour of elephant and its impact on biodiversity. This study therefore has been designed to cover Mosi-oa-tunya National park in Zambia on feeding behaviour of elephant and its impact on vegetation. It will also invoke mixed research design where both qualitative and quantitative research methods will be used in data collection and data analysis which was not treated in Kerley & Landman' research

Robert and Ruch (2007) [21] conducted a study entitled "The impact of Elephants on plants and their community variables in South Africa's Maputaland." Direct observations of elephant feeding, sign on food trails were the methods used in the study. It was observed that Elephants had a clear influence on vegetation at the species level. However, at the community level they had no apparent effect on woodland, specific abundance-incidences and rank abundance relationships. The study present useful information on the impact of Elephants on plant and their community variables in South Africa's Maputaland but it did not present the information on the feeding behaviour of Elephants and its impact on biodiversity in Mosi-oa-tunya National Park hence the current study.

Guy (1976) [11] carried a research on the feeding behaviour of elephants in the Sengwa area, Rhodesia. The purpose of the study was to explain the reason behind the feeding of elephants and its selective damage to certain species and habitats. Direct method such as observation was used in the collection of the data. The study showed that elephants select a wide range of species, generally eating the species in quantities proportional to their occurrence within the woodlands although some specific species are positively selected or avoided. Because most of the feeding is carried out on vegetation below 2m, elephants compete direct with other herbivores occurring in the same habitat where food requirements of animal species in fact overlap. Males in particular push over trees and can account for nine trees each per day in the dry season, or 4-5 trees per day throughout the year. Codron *et al* (2006) [6] add that social display by males appears to be part and parcel of the reason for the uprooting of trees. Therefore, Guy's study is vital to the current study in that, it guides the researcher with some measurements within which areas Elephants are found. However, the study did not examine habitats and plant species in order to discover those which are damaged to a greater extent. In view of this, the current study endeavoured to uncover that which was not treated in the Guy's study particularly on feeding behaviour of Elephants and its impact on Mosi-oa-tunya national park in, Zambia.

Lowel (1998) [16] conducted a study in east Africa on

Feeding Style of Elephants in African game reserves. The study found that elephants' destruction had become so complex that it made game rangers and other responsible government workers in game reserves appear not to have adequate skills or measures to enable them handle elephant-human conflict. Each area of concern to elephant-humanity conflict had become very complex and elephants feeding habits had become a specialised area, which required special skills and strategies that many game rangers in the national parks may not possess.

Additionally, elephants feeding had become very complex and human beings found it difficult to survive and lived in fear. Though the government of Zambia tries to keep animals in limited area with limited foods, elephant have continued to feed in nearby farming areas outside Mosi-oa-tunya national park in Livingstone. Lowel's study is important to the current in that, it provides an insight on the feeding styles of Elephants. Nevertheless, the current study sought to investigate the feeding behaviour of Elephants and its impact on biodiversity in Mosi-oa-tunya national park in Zambia.

Nyirenda, Myburgh and Reilly (2012) [17] conducted a study in the Luangwa valley, eastern Zambia entitled "Predicting environmental factors influencing crop raiding by African elephants (*Loxodonta Africana*)." The purpose of the study was to examine environmental factors influencing occurrence of crop raiding by interrogating effectiveness of counter measures implemented by local farmers in Luangwa valley, eastern Zambia. In order to come up with the findings of the study, the researchers employed two methods and these were predictive models of binary logistic regression and questionnaire surveys. The study showed that smaller crop fields were more vulnerable than larger ones. Most crop fields surrounded by Brachystegia and acacia dominated vegetation communities were damaged largely due to high tree fruiting which were elephant attractants. It was posited that additional capacity development of local farmers was required particularly, in participatory integrative land use practices to minimize elephant crop raiding. The study is rich to contribute to the current study in that it has shown how smaller crop fields were more vulnerable than larger ones to Elephants. However, the study did not determine whether the feeding behaviour of elephants cause destruction and damage to plant species, an element that made the current worth undertaken.

Material and methods

Description of the study area

Location

The research area was located at Mosi-oa-Tunya National park in Livingstone in Southern province of Zambia. It is situated at 17.85˚ South Latitude, 25.87˚ East Longitude and 897 meters elevation above the sea level (Youldon, 2017) [26] (Figure 1).

Topography

Mosi-oa-tunya National Park covers an area of approximately 6600ha, with a fence zone in the western section approximately 2990ha, known as the old Zoological park (OZP). The Dambwa local forest No; 22 lies between 17° 39.962'-17° 49.300'S and 25° 46.122'-25° 798'E. It covers an area of 13746 ha and lies to the North of, and shares a 4Km border with the Old Zoological Park. MoTNP is surrounded by Livingstone town, several villages, small scale and commercial farms, and communal lands (Youldon 2017) [26]. Special features are the Zambezi River and the Victoria falls on the Southern part of MoTNP (Youldon 2017) [26].

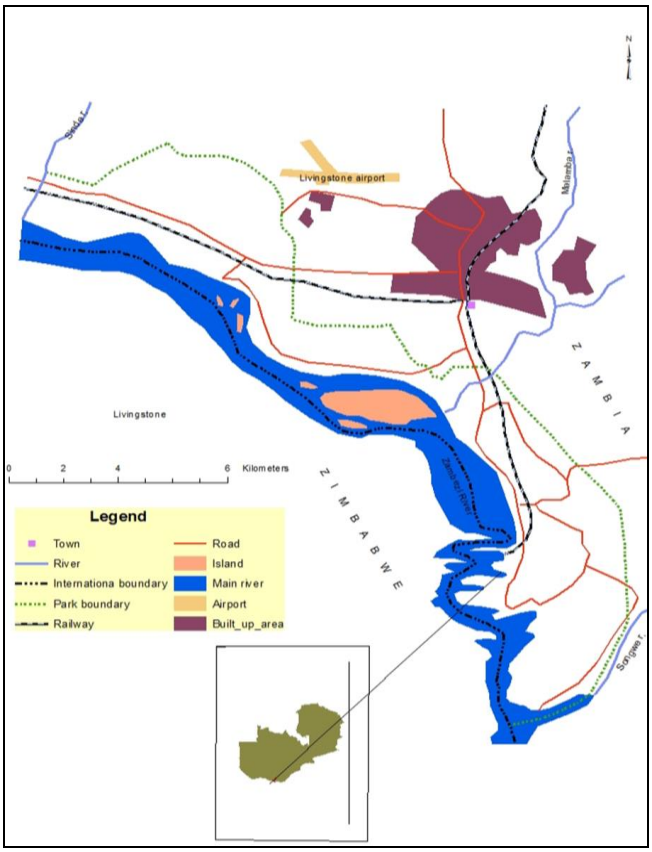

Fig 1: Location of Mosi-oa-Tunya National Park in Zambia

Climate

The annual rainfall averages approximately 600mm of which two-thirds fall in the three months December, January and February. Average rainfall from November to March is 780mm.But it is 700mm for October and April being the onset and departure months for rainfall (Bwalya and Naidoo, 2003) [3].

According to the Zambia Meteorological Department (ZMD 2004) [27], temperatures in Livingstone vary considerately between the cool and hot seasons. They range from 0.0 degrees Celsius in the cool season (May to June) to 40.0 degree Celsius in the hot season (September to October). Mean minimum temperature do exceed 19 degrees Celsius in any month so nights are usually uncomfortable and very hot day time temperatures are so limited to a relatively short season. The maximum temperature average over 25 degrees Celsius in June and July. Temperatures are fairly constant from December to March and then start decreasing in late April or May. Highest temperatures occur in October. The daily range of temperature is least during the cool season (ZMD, 2004) [27].

Vegetation

The principal vegetation type in the Southern region is woodland. The woody flora is in the region of 500 species, the total flora including herbs, grasses, sedges and ferns is about 1000 species (Fanshawe, 1972) [8]. Vegetation in the Mosi-oa-tunya National Park is of two types and these are closed forest and Open forest. Under closed forest there is riparian forest and riparian woodland. Riparian forest is found in a gorge just below the falls on the Zambian side and the dominant tall trees are *Syzygium guineense* subsp, *Mimusops zeyheri* and *Syzygium cordatum* (Fagan, 1964). Riparian woodland is found along the Zambezi River and the common tall trees are *Diospyros mespiliformis*, the figs, *Ficus capensis* and *F. sycomorus, Garcinia livingstonei, Homalium abdessammadii, Trichilia emetica* and *Syzygium guineense subsp. barotsense*. Open forest include Kalahari woodland, Mopane woodland and Deciduous woodland. Kalahari woodland with *Baikiaea* occurs on the old river sandbanks from just east of Livingstone to north of the town. It is dominated by *Brachystegia spp, Julbernadia globiflora, Burkea africana, Baikiaea plurijuga* and *Ricinodendron rautanen*ii. Deciduous woodland is the most interesting in the area, partly because of its novelty and partly the difficulty of getting down among it to find out what is growing there. It is dominated by *Brachystegia glaucescens* and *B.speciformis, Commiphora marlothii* and *Manilkara mochisia*. Predominant wood species in the district are Mukwa (*Pterocarpus angolensis*), Mukusi (*Baikiaea plurijuga*) and Mungongo (*Schinziophyton rautanenii*) (Riley, 1996) [20]. The vegetation is scanty and of a secondary type. The open nature of vegetation in the area is without doubt a result of wide spread cutting down of trees to pave way for development in the district. Four major groupings have been distinguished namely Scrub vegetation, Mopani woodlands, Miombo woodlands and Mkusi woodlands (Figure 2), mainly in a well-drained soils. Scrub vegetation covers most of the Park (Figure 2) with scattered tall trees on shallow stony basalt soils in the southeast and on shallow sandy soils in the northwest of the Mo NP. Mopani woodland is the second largest vegetation community (Figure 1) and best suited to soils with poor drainage. It's mainly dominated by *Colophospernum mopane*. The third is the Miombo woodlands dominated by *Brachystegia boehmii* on the Kalahari sands in the north of the Mo NP. The fourth is the Mkusi woodlands (Figure 2) on the well-drained Kalahari sands found on the plateau overlooking the Zambezi valley at the falls (Fanshawe, 1972) [8].

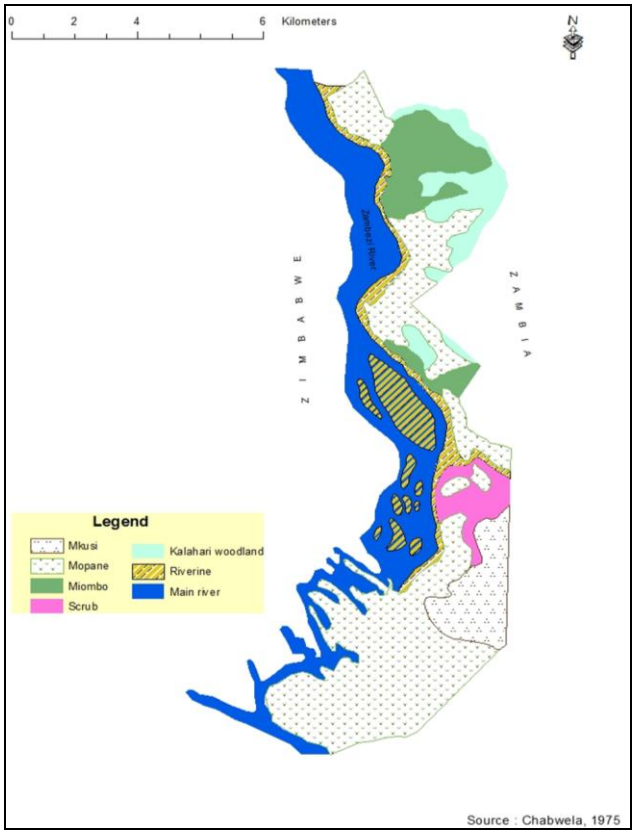

Fig 2: Distribution of vegetation types in Mosi-oa-Tunya National Park

Common wildlife species

The fauna in the Mosi-oa-Tunya National Park include the Zebra (*Equus burchelii*) Hippopotamus (*Hippopotamus amphibious*), African buffalo (*Syncerus caffer*), African elephants *(Loxodonta africana*), Giraffe (*Giraffa camelopardilis*), Impala (*Aepyceros melampus*), Kudu (*Tragelaphus imberbis*), Waterbuck (*Kobus elipsiprimnus*), Warthog (*Phancochoerus aethiopicus*), Eland (*Taurotragus oryx*), Chacma Baboons (*Papio ursinus*), Vervet monkeys (*Chlorocebus pygerythrus*),White Rhino (*Ceratotherium simum*) (Phillipson, 1990) [19].

Sampling design and data collection

Vegetation Surveys and sampling

Initial field surveys involved the use of maps of 1:50,000 and existing field maps (Chabwela, 1975) to design transect surveys in the habitat types. Established transects were traversed on foot and plant species identification was achieved by the use of field guide books (Storrs, 1979; Palgrave, 1990) [24, 18] and samples of plant species which were difficult to identify in the field were taken to the herbarium at the University of Zambia and Kitwe for identification. The study area was stratified to habitats types:

1. Mopane woodland
2. Scrub vegetation
3. Mkusi woodland
4. Miombo woodland
5. Riverline forest

And ten sample plots of 20m x 20m were established in each habitat type.

Elephant Feeding

Direct observation of elephant feeding, involved following a herd of elephants for several days and data were collected on:

a. Plant species that were browsed or grazed by elephants,
b. GPS position
c. Parts of plants which were browsed

Habitat utilisation

This was determined by categorising habitat use by the elephants. This assessment was based on:

1. The amount of browse in each sample plots
2. The presence of foot prints and faecal matter.

The habitat use was scaled categorically based on the degree of browse and tree damage, and the presence of trucks and faecal matter (Greyling, 2004). This was scaled as follows:

1. Habitat use between 75% and 100% was defined as heavy use of the habitat.
2. Habitat use between 50% and 75% was defined as Moderate use of the habitat.
3. Habitat use between 25% and 50% was defined as less use of the habitat.
4. Habitat use between 0% and 25% was defined as no effect on the habitat.

Habitat damage

Habitat damage was defined as a decline in the number of woody plant species in a particular habitat due to the type of elephant damage such as Tertiary branches broken, secondary branches broken, primary branches broken, main trunk broken, ring barking, pushing over living trees and degradation from closed woody land to open woodland **(**Haig, 1999) [12].

Type of Elephant damage

The following describes the ranking of damage:

a. Tertiary branches broken: Breaking of small plant parts that were consumed partly or entirely.
b. Secondary branches broken: Breaking of small branches that emerge from primary branches.
c. Primary branches broken: Breaking of lager branches in order to access smaller plant parts
d. Main trunk broken: Breaking of the main stem
e. Ring barking: Removal of a strip of bark from around the entire circumference of a trunk.
f. Pushing over living trees: Uprooting of the living trees.

Method of Data Analysis

Statistical Analysis

The following statistical packages were used during the analysis of the data:

a. Microsoft office excel 2007
b. Genstat 14th edition

Data Analysis

Data were entered into the computer using Microsoft office excel 2007 for graphical and descriptive statistics while all statistical analysis were performed using Genstat 14th Edition. ANOVA was used to test the null hypothesis. The Least Significant Difference test (LSD) was used to compare damage differences among plant species and differences were declared significant at $p < 0.05$.Data that was collected on seasonal feeding behaviour of elephants and preference was coded and analysed using Microsoft excel. Various tables and tabulations were used to present the findings of the study so as to give a clear meaning of the data collected. Chi-Square test was used to determine if there was association between the feeding behaviour of elephant and the damage of woody plant species among seasons. Graphs were used to depict different parameters of dry and wet seasons. Plant species and the habitat that suffered the greatest amount of damage was analysed by identifying the different species of plants consumed by elephants and ranking them using parametric test.

Results

Habitat damage resulting from feeding behaviour of elephants

Figure 3 revealed that in Mopane habitat 53.1% of different trees of 14 wood plant species were extensively damaged. This was followed by the scrub habitat in which 35.59% different shrubs of 15 wood plant species were damaged while in Miombo (5.17%), Mkusi (3.52%) and Riverline (2.61%) habitats were less damaged. Further analysis for habitat damage using ANOVA showed that there was a significant ($F=3.31$, $p<.001$) difference in the habitat damage due the feeding behaviour of elephants. Increase in the number of trees damaged in mopane habitat and scrub habitat resulted in the habitat damage by creation of open woodland in Mopane habitat and stunted but reproductive growth in Scrub habitat compared to the Habitats in which damaged was less. Findings of the study indicated that the elephants damaged Mopane habitat by their feeding behaviour. The results are presented in figure 14 in the five

habitats of Mosi-oa-tunya National Park.

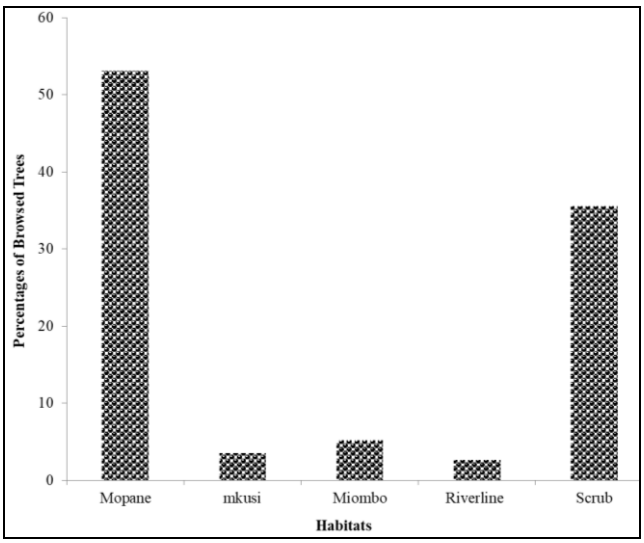

Fig 3: Percentages of damaged trees in five habitats of Mosi-oa-tunya National Park

Figure 4 shows the frequencies of the trees pulled down by elephants in the MoT NP. The findings indicated that there were more trees pulled down in Mopane habitat compared to the trees that remained standing due to the elephant feeding behaviour. Mopane habitat (35.96%) showed that it was highly affected followed by Miombo habitat (19.19%), Mkusi habitat (17.39%), Riverline habitat (16.33%) and the least affected was Scrub habitat (11.2%). The analysis showed that the habitat that suffered the greatest amount of damage was Mopane habitat in MoTNP.

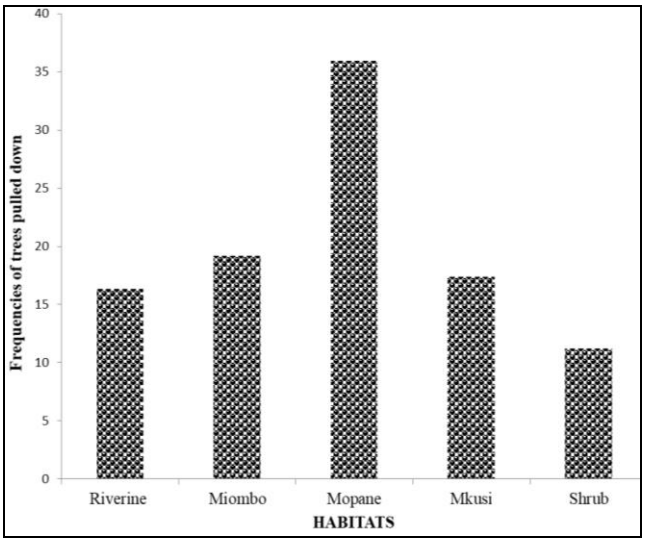

Fig 4: Frequencies of the trees pulled down by elephant

Results in figure 5 revealed that there were dead woody plant species in the five habitats that were sampled in MoT NP. A total of 1158 dead woody plant species were recorded in all the five sample habitats (Appendix 4). 27.72% of dead woody plant species was recorded in Mopane habitat; this was followed by 22.88% in Scrub habitat, 17.01% in Miombo habitat, 16.93% in Mkushi habitat and 15.46% in Riverline habitat. During the dry season, the number of dead woody plant species increased by 30.75% from the wet season. The increase in dead woody plant species was the result of Elephant damage and this was evidenced by the signs of severe bark stripping and ring barking on *Colophospernum mopane* and *Acacia Polyacantha*. Figures 6, 7, and 8 below shows photos of dead woody plants.

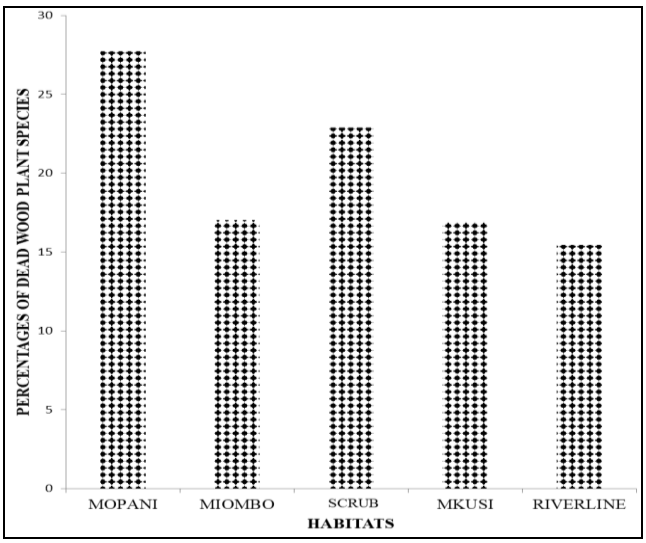

Fig 5: Percentage of dead plant species in five Habitats

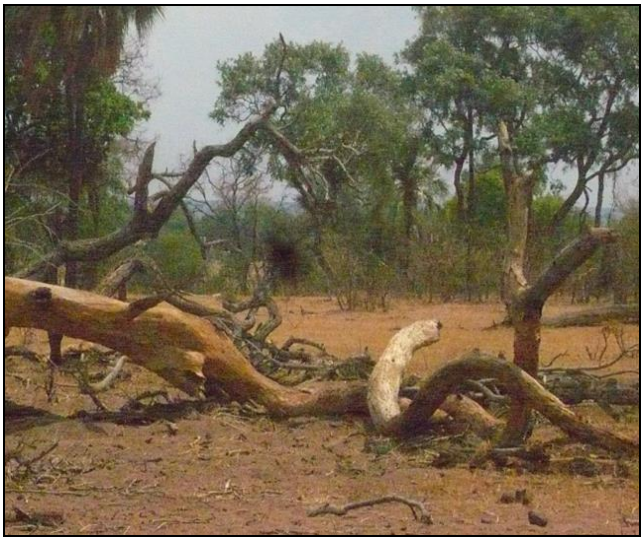

Fig 6: Dead Mopane woody plants

Fig 7: Dead Mopane woody plants

Fig 8: Dead *Acacia Polyacantha* woody plants

Discussion of findings

Habitat damage resulting from feeding behaviour of elephants

Although the results showed that the feeding behaviour of elephants was accompanied by pulling down of woody plants species in all the five habitats, more trees were pulled down in Mopane habitat compared to the trees that remained standing due to the elephant feeding behaviour.

This result is evidence enough that elephant most preferred Mopane Habitat in Mo NP. There are several possible explanations for this result; firstly, during the dry season, Mopane trees have tender twigs mostly at the summit of the tree and in order for them to reach and feed on these, elephants tend to pull them down. Secondly, fruits on trees get ripe during dry seasons and thirdly; there is no other alternative source of food during dry seasons except for these trees. Besides that there was an increase in dead woody plant species in dry season with a decrease in wet season (Appendix 6). Similarly, the presence of elephant in Mosi-oa-tunya National park decreases with the onset of the rain season. The number of dead woody plant species was found to be high in Mopane habitat than in Scrub, Miombo, Mkusi and Riverline habitats. The higher concentration of elephants in Mopane habitat have resulted to destruction of woody plant species, hence the high number of dead woody plant species. The fact that dead woody plant species were more in the dry season than in the rain season this suggest that more damage was done in the dry season. And largely because of this we can safely conclude that Mopane habitat was highly affected followed by Scrub habitat, Miombo habitat, Mkusi habitat and Riverline habitat. Literature by Guy (1976) [11] agrees to the study findings in that male elephants in particular push over trees and can account for nine trees each per day in the dry season, or 4-5 trees per day throughout the year. Codron *et al* (2006) [6] add that the social display by males appears to be part and parcel of the reason for the uprooting of trees. The areas where the elephants feed from in MoT NP were the most affected regarding the highest number of damaged trees and vegetation. This then meant that the presence of elephants in Mopane habitat was evidenced by the dead woody plant, damaged trees and vegetation. The more frequent the elephants feed from Mopane habitat, the more the destruction to the trees was done. And this was what the Mosi- oa- Tunya national park witnessed.

Conclusion and Recommendations

Conclusion

The study examined the feeding behaviour of elephants and its impact on vegetation in the Mosi- Oa- Tunya national park. In line with the findings and discussion presented in this paper, the following are some important conclusion:

1. Elephants are selective in their feeding habits. The mopane habitat was the most preferred and consequently most destroyed. Thus the hypothesis that the feeding behaviour of elephants in Mosi-oa-Tunya National Park does not destroy the habitat is false. Nearly all the five habitats and a number of plant species were damaged as a result of elephant feeding habits. Elephants attacked preferred plants through debarking, uprooting and pulling down trees. The hypothesis that 'there was no habitats selection by elephants in Mosi-Oa-Tunya National Park is false. This is so because the elephants preferred Mopane habitats and scrubs.
2. The principal finding of the study is that substantial information in this report has pointed out that Mosi-oa-tunya National Park cannot sustain the current elephant population. Similar studies elsewhere on elephant-habitat interaction and area stocking rates have made recommendation for a reduction of populations of elephants to allow the habitat to recover. This study has a similar view that in the absence of the National Park area extension, the elephant population should be significantly reduced. Obviously, confirmation of this view calls for further studies on this subject.

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