Resource Partitioning by the Black Rhinoceros (D*iceros Bicornis*), Elephant (*Loxodonta Africana*) and the Giraffe (*Giraffa Camelopardalis*) in Tsavo West National Park, Kenya

F. K. Waweru[1*] and A.N. Githaiga[2]

1 Dedan Kimathi University of Technology, P.O. Box 695-10100, Nyeri, Kenya

2 African wildlife Foundation P.O. Box 310 – 00502. Nairobi, Kenya

Abstract

This study was conducted in Ngulia Rhino Sanctuary (NRS) and the Intensive Protected Zone (IPZ) both located inside Tsavo West National park, to investigate browse availability and dietary composition of three main mega-herbivores (black Rhinoceros, Giraffe and Elephant) and determined the browse overlap between them. The Point Centered Quadrant (PCQ) method was used to assess browse availability and the micro-histological technique to determine dietary composition. The results indicated that there was variation in browse availability in the NRS and the IPZ. The t-test results indicated there was no significant difference in terms of density between the two sites as $p>0.05$ in all cases. A total of 51 plant species identified in the feacal samples for the species in both the wet and the dry seasons. Each of the three mega-herbivores had their preferred plant species at any one particular time and location, *nevertheless the three browsers greatly overlapped in their diet indicating that long-time coexistence in an enclosed area like the sanctuary would not be sustainable hence continuous monitoring and evaluation of their population with regards to the vegetation dynamics of NRS and IPZ should be prioritized in the management plans of Tsavo West National Park.*

Key words: Browse, Availability, Sanctuary, Mega-Herbivores

1.0: Introduction

The ecological impact of large herbivores on ecosystems ranges from driving large-scale changes in vegetation structure (Prins and Van der Jeugd, 2003) to influencing system nutrient cycling (Augustine *et al.* 2003) and vegetation species composition (Augustine and McNaughton 1998) and production (McNaughton, 1976). By shaping the systems they inhabit, large herbivores influence communities of many other taxa that depend on these systems (from arthropods (Gonzalez-Megias *et al.* 2004),) and large carnivores (Sinclair *et al.* 2003)). Several studies, moreover, discuss the importance of species-diverse herbivore systems for the functioning of grazing systems because species differ in the way they shape their environment (Bakker *et al.* 2004, Cumming and Cumming, 2003; Hobbs and Searle, 2005).

Heavy commercial poaching in Africa is the primary reason for black rhino decline in the last half of the twentieth century, from around 100,000 black rhinos in 1960 to only 2,410 by 1995 (Emslie and Brooks, 1999). Since then black rhinoceros numbers in Africa have slowly increased reaching 3,725 by the end of 2005 (Brooks, 2006). In 2005, around 80% of Africa's black rhino resided in 93 fenced protected areas where good security was ensured (Brooks, 2006). The Kenya government through Kenya Wildlife Service (KWS) recognized that the only way for protecting the remaining black rhinoceros population lay in concentrating security within smaller areas of intensive protection (KWS, 2007). However the concentration of wildlife due to the fence, while improving habitat and security for some herbivore species, ends up having detrimental effects on plant diversity in general within the sanctuary (Cassidy, *et. al.;*2013 Staub, *et. al*.;2013),

Resources and manpower had been previously spread too thinly over large areas (Leader-Williams, 1990). From 1984 an active conservation policy was devoted to the recovery of the species and the policy centered on the development of rhino sanctuaries (KWS, 2007). However Elephants have a major influence on vegetation structure, composition and ecosystem processes, and are primary agents of habitat change in Africa. At moderate-to-high population densities, elephants can damage vegetation, especially when enclosed in protected areas. Knowledge of time- and site-specific factors affecting elephant browsing can be used to forecast future habitat transformations (Cassidy, *et. al.;* 2013; Staub, *et. al*.;2013)

Historical and current population numbers and trends of black rhinoceros in Kenya

Historically, like all black rhinoceros, *D. b michaeli* declined throughout its range in the 1970s and 1980s as a result of illegal killing to supply international demand in rhino horn mainly in Asia and Middle East *a*nd clearing land and nuisance animals for settlement and agriculture (Anon. 1993). Similar conclusions were reached by Emslie and Brooks (1999) for the period between 1970 and 1992. This sharp decline was perpetuated by eras of economic, political instability and internal corruption in a number of range states, which presented organised poachers with a virtually free hand to kill rhinos with little likelihood of apprehension (Emslie and Brooks 1999).

The situation was improved in African rhinoceros range states in the late 1980s through implementation of different management strategies, mainly to protect rhinoceros in order to scale down poaching and increase rhinos to genetically viable populations. For its part, Kenya managed to turn around the situation by adopting effective conservation initiatives (Anon, 1993). The main guiding policy for the conservation of rhinos in Kenya in the late 1980s and 1990s was protection, and thus a combination of approaches were implemented; including the establishment of special rhinoceros sanctuaries (Ritchie 1963; Leader-Williams *et al.* 1993), collaboration between KWS and the private and community ranches, increased law enforcement , improved staff numbers and capacities, revision of staff remuneration, and drastic managerial changes within the National Parks. The decline was halted and numbers increased from 380 in 1987 (Emslie and Brooks, 1999) to 458 in 2003 (Mulama and Okita, 2004). Similar turns of events were also evident in other range states (Emslie and Brooks 1999) and Africa's black rhino populations have since then shown an overall increase.

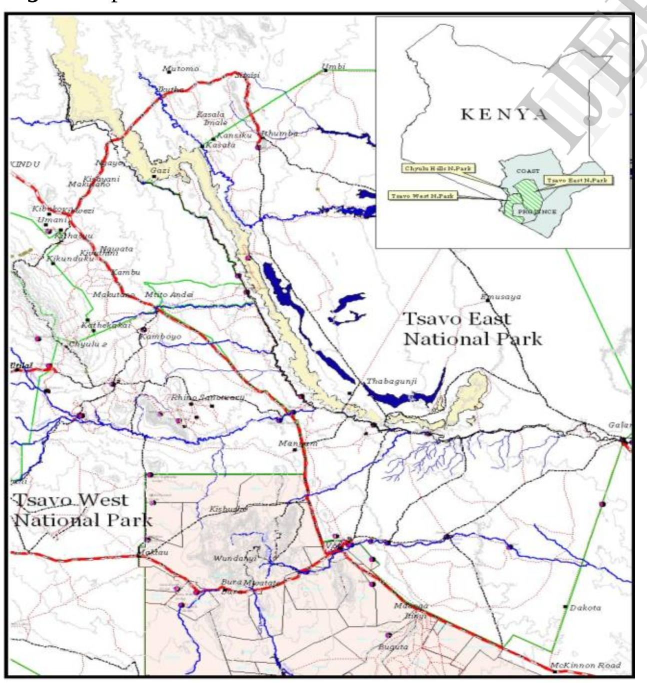
Even though Kenya is the a stronghold of *D. b michaeli* worldwide, and rhino numbers are increasing, meta-population growth rates have fallen below the minimum target level of 5% per annum (Anon, 1993; Anon, 2003a). For this reason, Kenya has increased the emphasis on improved biological and security monitoring in all its populations to ensure that poaching does not recur and population growth can be enhanced and in so doing meet recovery targets and maintain long term demographic and genetic viability.

2.0: Materials and Research Methodology

2.1 Study area

Tsavo West National Park is located in southern Kenya between 3^0 01'S to 3^0 06' S and 38^0 06'E to 38^0 10'E. Altitude Ranges from 600m above sea level of low lands to 1800m above sea level of craggy hills, with average annual rainfall of 600mm. The park is a vast expanse of savanna stretching from the Athi river, north of Mombasa-Nairobi road and south to the Tanzania border. The north-eastern boundary along the Athi river adjoins Tsavo East National Park (Figure 1). There are numerous rocky outcrops and ridges and part of the park, towards the Chyulu Hills, is of resent volcanic origin with lava flows and ash cones including the shetani lava. In the far south western corner on the Kenya-Tanzania border is Lake Jipe, part of which is in the park. There is only one permanent river in this vast area, the Tsavo River, which has its source in Mount Kilimanjaro and is greatly supplemented by a huge

Fig 1. Map of Tsavo West National Park



underground river from Mzima springs that lie in the northern part of the park. The vegetation is thickly wooded by *Commiphora-Acacia* woodland, dotted with baobab trees *Adansonia digitata* and *Delonix elata.* In Ngulia area, a range of hills reaching around 1800m above sea level and is heavily wooded. The southern sector consists of open grassy plains. The permanent Tsavo River runs through the northern part of the park with a fringe of riverrine *Acacia elatior* and *Hyphaene comprressa* wooldland. Lake Jipe is bordered by extensive beds of Typha in the large permanent swamps at its eastern and western ends. Mzima springs, is fringed by *Raphia farinifera* and *Phoenix reclinata* palms.

Ngulia Rhino Sanctuary was established in 1984 as an area where surviving rhinos in the Tsavo Conservation Areas could be protected from the intense poaching pressure the area was suffering at that time. Tsavo is surrounded by many community wildlife ranches, pastroral communities and farming communities. The local people around Tsavo West National Park are mainly of Bantu speaking origin like the Pare and Chagga (on the Tanzanian side) and the Taita, Masaai, Kamba and Taveta on the Kenyan side. A few families of the Taveta on the Kenyan side practice pastroralism. With the exception of the Maasai who are pastoralists, the rest are subsistence and mixed agriculturists.

02.2 Research methodology

2.2.1 Research Design

The study was carried out based on case study research design. This design facilitated an in-depth, empirical investigation of the events of interest in this case within its real life context using multiple sources of evidence in Tsavo West National Park. In this method rather than using samples and following a rigid protocol to examine the issues that the study attempts to address an in-depth usually longitudinal (over a long period of time) was carried out.

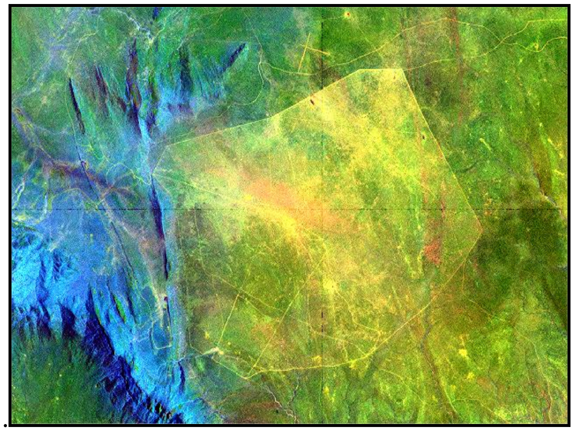
2.2.2 Browse availability

Stuart-Hill (1989) described a method for thicket vegetation involving the point centered quarter (PCQ) method developed by Cottam and Curtis (1956) for conducting bush surveys. This plot less (distance) method is more time efficient than methods involving belt transects and is much more flexible because the sample size does not need to be adjusted for the particular density of the vegetation type being studied (Cottam and Curtis, 1956; Mueller-Dombois and Elenberg, 1986; Farid and Nico, 2006). Hence more suited to the dense shrub vegetation of Tsavo West National Park.

Before data collection, reconnaissance survey was carried out for the various vegetation types to select the suitable sites for laying transects for sampling. Vegetation was grouped into a number of stands in each stand at least 2 transects were laid out. The stands were mapped out of a satellite image of the Sanctuary taken in 2001, showing extent of vegetation degradation Image courtesy of Keryn Adcock through DEFRA Darwin Initiative funding. (Figure. 2).

The PCQ method was used to get the density and the species composition for each stand by recording all the different species identified and their relative frequencies. Analysis was based on formulae used for the PCQ Method

Fig. 2: Satellite image of NRS and IPZ



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2.2.3: Micro histological analysis

Determination of the diet through analysis of fecal material collected from the field as used by Waweru (1985), and Barker (1986) was adopted in this study. Unlike other food habits techniques the micro histological fecal analysis techniques has an objective way to provide proof for the validity of records reported by an observer. The basis of this technique is the ability to identify fragments of plants in herbivore fecal material mounted on the microscopic slides .The sampling involves gathering of the fecal material which is relatively simple A representative sample of what was eaten by the herbivore population can be obtained through sub-sampling from 10-15 defecations per species per study area .The basic problem is that plant pigments make identification of epidermal material difficult, however, sample preparation techniques to reduce this problem have been developed and discussed by), Varva and Holechek (1980). The hertwigs' clearing solution has been used to remove the plant pigment. In this study Sodium hypochlorite was used for bleaching of samples before making slides to overcome this problem.

2.2.4: Sample collection

Sample of fecal material were collected from fresh dung. From each dung pile several Subsamples are taken, whenever possible, the subsample were collected from different dung balls where scraping had not fully broken them down. Amount taken from each sample was about 2 gms. To enhance fragmentation identification the samples were preserved to stop microbial activity by adding common salt and thoroughly mixing it with the sample.

The fecal material was then washed through a series of sieves, 500um, 250um, 200um, (Barker, 1986). The material that remained in the 200um sieve was further washed by running water and the filtrate collected in a container placed at the bottom. All the fecal filtrates were oven dried and subjected to the same grinding procedure. The resulting ground samples were then put in self sealing polythene bags and stored for slide preparation.

2.2.5: Slide preparation

The ground reference samples and prepared fecal samples were placed in test tubes into which sodium hypochlorite solution was added and heated for a minute. The tube was then left to stand until most of the pigment had disappeared then the bleach was then washed off using warm water.

2.2.6: Plant identification

Using a binocular compound microscope equipped with phase contrast, the reference slides were studied and for each plant species the identifiable unique characteristic were noted and digital photos taken. On each slides 10 microscopic fields were studied and in every field identifiable fragments were recorded using present or absent technique. A minimum of 3 characteristics were used for species identification.

3.0: Results

3.1 Browse availability

Browse availability and dietary composition of the rhino, the giraffe and the elephant were studied within Ngulia Rhino Sanctuary (NRS) and in the Intensive Protection Zone (IPZ) during the dry and wet seasons between the year 2009 and 2010. The wet season, between April and May, then, November to December and the dry season, this occurs between January to March and then June to October. A total of 78 plant species were identified in the vegetation study done in the Sanctuary and the IPZ in both the wet and the dry season. 44 (56%) plant species were identified in the IPZ while 55 (70%) plant species were identified in the Sanctuary, 21 (26%) plant species were found to occur in both the Sanctuary and the IPZ. 33 species occurred exclusively inside the sanctuary while 21 were recorded exclusively in the IPZ

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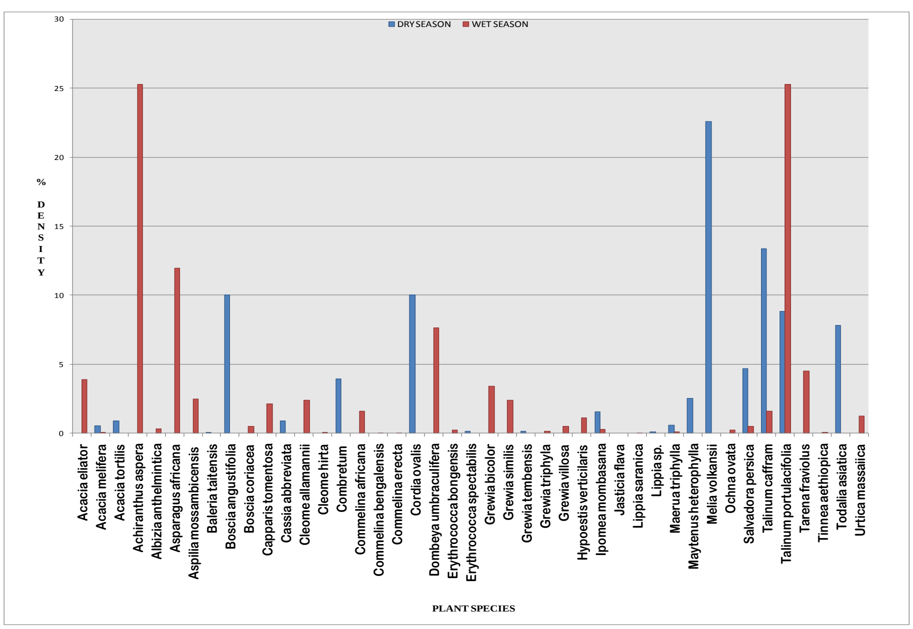

Figure 3: Plant species availability in IPZ during dry and wet seasons

underground river from Mzima springs that lie in the northern part of the park. The vegetation is thickly wooded by *Commiphora-Acacia* woodland, dotted with baobab trees *Adansonia digitata* and *Delonix elata.* In Ngulia area, a range of hills reaching around 1800m above sea level and is heavily wooded. The southern sector consists of open grassy plains. The permanent Tsavo River runs through the northern part of the park with a fringe of riverrine *Acacia elatior* and *Hyphaene comprressa* wooldland. Lake Jipe is bordered by extensive beds of Typha in the large permanent swamps at its eastern and western ends. Mzima springs, is fringed by *Raphia farinifera* and *Phoenix reclinata* palms.

percentage ground density cover (Figure 3). During the wet season 49 plant species were recorded with *Acrnthes aspera* 25.30%, *Talinum partulacifolia* 25.30, *Asparagus Africana* 11.96% and *Dombea umbraculifera* 7.65% had the highest percentage ground density cover while *Justica flava* 0.00%, *Lippia saranica* 0.01%, *Commelina bengalensis* 0.02% and *Commelina erecta* 0.03% had the lowest percentage ground density (Figure 3).

In the Sanctuary during the dry season 21 plant species were recorded with *Solanum incanum* 55.08%, *Asparagus Africana* 14.02%, *Sericocomopsis pallida* 12.74% *Euphobia espinosa* (6.85%) had the highest percentage ground density cover while *Bauhinia taitensis* 0.00%, *Commiphora africana* 0.00%, *Premna resnosa* 0.00% and *Hibiscus taitensis* 0.00% are among the many that had the lowest percentage density cover.

During the wet season 41 plant species were recorded in the sanctuary. *Gloriosa sapperpa* 24.42%, *Commelina bengalensis* 18.39%, *Erythrococca bongensii* 10.89%, *Cordia ovalis* 10.35% had the highest percentage density cover while *Bauhinia taitensis* 0.00%, *Cleome monophyla* 0.00% *Commiphora campestris* 0.00%, *Grewia bicolor* 0.00% are among the many that had the lowest percentage in density cover as shown in Figure 4.

4.2 Browse utilization

The elephant debarked and broke tree and shrub species in the sanctuary and the IPZ. The *Acacia tortilis*, *Bauhinia taitensis*, *Melia volkensii* and *platyceliphium voence* are among the most affected by Elephants debarking.

A total of 51 plant species were identified in the fecal samples collected in the field in both the wet and the dry season. The samples from the sanctuary had a total of 47 plant species identified, 42 during the dry season and 40 during the wet season for all the three study animals. The IPZ had 44 plant species in total recorded from the fecal samples with 38 plant species recorded during the dry season and 36 during the wet season.

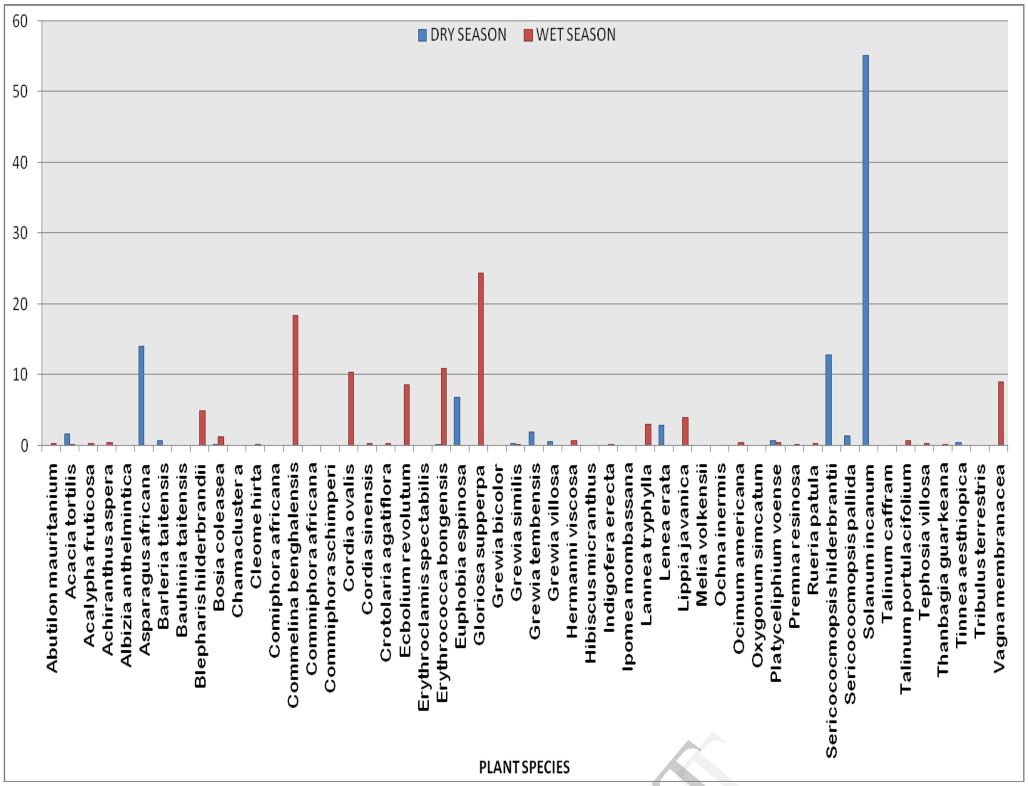

Figure 4: Plant species availability in NRS during dry and wet seasons

Finally T- Test was done for comparisons of the total density (stems/sq km^2) in the two locations in the two seasons. This was done after transformation by log 10 to enable parametric tests.

No comparison yielded significant difference between each pair of means as p>0.05 in all cases (Table1.)

Table 1: Summary of the T- test on the vegetation density

Test	t-statistics	Df	Probability
T-Test For comparison of density between IPZ and NRS	**-0.233**	**119**	**0.816**
T-Test for comparison of density between wet and dry season in NRS	**1.491**	**68**	**0.141**
T-Test for comparison of density between wet and dry seasons in IPZ	**0.414**	**49**	**0.681**
T-Test for comparison of density between IPZ and NRS in dry season	**-0.799**	**39**	**0.429**
T-Test for comparison of density between IPZ and NRS in wet season	**0.143**	**78**	**0.887**
T-Test for comparison of density between IPZ and NRS in dry season	**-0.799**	**39**	**0.429**

Table 2: Number of plant species recorded from the faecal samples.

SANCTUARY DRY SEASON				**SANCTUARY WET SEASON**			
Giraffe	Elephant	Rhino	**Total**	Giraffe	Elephant	Rhino	**Total**
32	29	19	**42**	26	29	26	**40**
IPZ DRY SEASON				IPZ WET SEASON			
Giraffe	Elephant	Rhino	**Total**	Giraffe	Elephant	Rhino	**Total**
24	**27**	**19**	**38**	**19**	**31**	**24**	**36**

Principal species were considered to be those species that contributed ≥5% to the diet (Table 3). Important principal plant species in the sanctuary and IPZ were *Melia volkensii*, *Astripomea hyoscyamides*, *Grewia tembensis*, *platyceliphium voence*, *Acacia tortilis* among others (Table 3). Any reference to the importance of species refers to their importance in terms of their percent contribution to the diet.

Table 3: Percentage frequency of appearance of fragments of principle plant species recorded in the feacal samples

SPECIES	**NRS WET SEASON**			**NRS DRY SEASON**			**IPZ WET SEASON**			**IPZ DRY SEASON**		
	R	**E**	**G**	**R**	**E**	**G**	**R**	**E**	**G**	**R**	**E**	**G**
Abutilon Mauritanium	2	4	3	1	4	2	4	1	3	6	1	2
Acacia mellifera	0	0	9	0	0	6	1	0	7	0	0	12
Acacia tortilis	5	6	21	14	6	13	2	12	17	7	14	20
Astripomeahyoscyamoide	10	11	1	1	11	0	7	11	8	0	5	2
Bauhinia taitensis	5	4	3	5	4	1	4	1	0	2	7	6
Barleria taitensis	1	2	2	0	2	1	3	1	9	0	3	1
Cleome hirta	5	0	0	0	0	0	6	0	0	0	0	0
Melia volkensii	15	10	6	8	10	6	21	9	3	20	16	6
Platyceliphium voence	9	10	6	15	5	6	8	8	5	8	8	8
Grewia tembensis	10	3	7	37	3	4	4	4	9	30	9	8
Grewia villosa	4	6	11	1	6	6	1	6	17	2	2	33
Cassia abbreviate	6	2	5	2	2	2	4	2	2	3	2	5
Ochna inermi	5	6	1	1	2	2	2	1	9	1	3	4

Solanum incunum	4	5	0	1	3	6	2	5	0	3	1	0
Ehretia taitensis	0	1	1	0	1	0	5	2	1	0	0	0
Oxygonum sinuatum	0	8	0	0	2	0	0	0	0	0	0	0

NRS=Ngulia Rhino Sanctuary IPZ= Intensive Protection Zone R=Rhino E=Elephant G=Giraffe

3.3 Diet overlap

Diet overlaps in the three animals diet in both the wet and dry season was recorded both inside the NRS and the IPZ. The most common plant species identified in almost all the three animals diet in all seasons were *Abutilon mauritanium*, *Acacia tortilis*, *Albizia anthelmintica*, *Astripomea lachnosperma*, *Bauhinia taitensis*, *Cassia abbreviate*, *Grewia similis*, *grewia tembensis*, *grewia villosa*, *Melia volkensii*, *Ochna inermis*, *Platyceliphium voense*, *premna oligotricha and Tephrosia villosa*.s

Table 4: Dietary overlap in NRS and IPZ during the wet and dry season

	NRS Dry Season				**IPZ Dry Season**			
	All Three Animals	Giraffe Vs Elephant	Giraffe Vs Rhino	Elephant Vs Rhino	All Three Animals	Giraffe Vs Elephant	Giraffe Vs Rhino	Elephant Vs Rhino
No. of Plant species overlapped	**14**	**20**	**15**	**17**	**11**	**16**	**11**	**16**
% overlap	**33.333**	**47.619**	**35.7143**	**40.476**	**28.94737**	**42.105**	**28.9474**	**42.105**
	NRS Wet Season				**IPZ Wet Season**			
	All Three Animals	Giraffe Vs Elephant	Giraffe Vs Rhino	Elephant Vs Rhino	All Three Animals	Giraffe Vs Elephant	Giraffe Vs Rhino	Elephant Vs Rhino
No. of Plant species overlapped	**15**	**19**	**17**	**20**	**15**	**17**	**16**	**20**

% overlap	**37.5**	**47.5**	**42.5**	**50**	**41.6667**	**47.222**	**44.4444**	**55.556**

4.0 Discussion

To determine whether rhinos, elephants and giraffe can coexist (over a long period of time) in an enclosed area, on the basis of differential browse utilization, one has to demonstrate that the three animals do not share similar browse resources and if they do they should have different food preference. Alternatively they should be indiscriminate feeders whose feeding is determined by availability; abundant food can only be eaten only and until critical levels are reached then a switch to other abundant food plants would occur to allow vegetation regeneration of diminished plant species. For the black rhino, young regenerating leguminous twigs have been reported to provide the main food, but these may be so together with grasses in some marginal habitats (Kingdon, 2001). In this study 33 plant species were identified in the black rhinos diet which was mainly dominated by *Grewia tembensis* at 37% and 30% of the diet in the sanctuary and IPZ respectively during the dry season. In the wet season *Melia volkensii* was the most preferred plant species at 15% and 21% of the diet in the sanctuary and IPZ respectively. Among other important plant species that were preferred by the black rhino were *Platyceliphium voence, Acacia tortilis, Astripomea hyoscyamides, Abutilon mauritanium* etc. Other studies have reported over 200 plant species (from 50 families) have been utilized by black rhino Goddard (1970), indicating that some *Acacia, Commiphora, Grewia, cordial, Lannea, Euphobia, Adenia, Bauhinia, sericomopsis, Crotolaria* and *Trifolium* are among the greatly favored. However, certain dominant plant species in Tsavo like *Boscia* and *Thylachium* were not eaten at all (Schenkel and Schenkel-Hulliger, 1969; Goddard, 1970). Similar observations were made in the present study; apparently, black rhinos have the ability to select food.

In the present study 36 plant species were recorded in the elephant's diet. *Astripomea hyoscyamides* and *Melia volkensii* contributed 11% and 10% respectively to the elephant's diet in the sanctuary both in the dry and wet season. In the IPZ *Melia volkensii*(16%) and *Acacia tortilis* (14%) were the most preferred during the dry season while *Platyceliphium voense* (14%) and *Acacia tortilis* (12%) are the most preferred during the wet season. *Oxygonum sinuatum, Grewia tembensis, Grewia villosa, Bauhinia taitensis,* and *Solanum incunum* were also readily eaten by the elephants than would have been expected from the browse availability data indicating that elephants feeding habits was independent of availability. Elephants in other ecosystems appear to feed on a variety of foods. They are known to feed primarily on grass (*penissetum purpureum*) in Cameroon, while woody material made smaller proportion of the diet (Tchamba and Seme, 1993). Twenty species of fruits were eaten (Merz, 1981; Tchamba and Seme 1993) indicating that the greatest number of fruits were ingested at a time when fruiting was at its peak. Therefore, as observed forest elephants (Laws, 1975) and Savannah (the Tsavo elephants) are capable of selecting food. Debarking and felling of trees and shrubs was also recorded done mostly by elephants; it was prevalent in *Platyceliphium voense*, *Acacia tortilis, Acacia mellifera* and *Mellia volkensii* mostly during the dry season. The underlying reason(s) of debarking and felling was not the subject of this study hence more research is required.

In this study 37 plant species were recorded in the giraffe's diet. *Acacia tortilis* was the most preferred browse at 13% and 21% of the total diet in the sanctuary during the dry and the wet seasons respectively and at 20% and 17% in the IPZ in the dry and wet seasons respectively. *Acacia mellifera* is the second most preferred plant species by the giraffe followed by *Grewia villosa*. Other preferred species are *Platyceliphium voense, Bauhinia taitensis*, *Solanum incunum, Grewia tembensis* and *Melia volkensii*. From this study it is evident that giraffes are capable of selecting foods and is independent of availability. Studies done in an enclosed black rhino sanctuary in Kenya, reported habitat alteration as populations of elephant, giraffe and black rhino increased (Birkett, 2002).

Essentially, indiscriminate feeders should not show food avoidance, except when food is too rare to be encountered. Further, indiscriminate feeders should not show preference of plant species within certain plant families; they should eat more from a family that has abundant representative species. Specialized feeders would deplete the most preferred food in their locales and would be expected to contribute to species loss. In contrast, because indiscriminate feeders allow rare plants regenerate, differences in species richness between frequently and infrequently browsed areas would not be expected. In this study, usage of plant species far exceeded availability of individual plant species indicating that some plant species were avoided. On this point, one would conclude that the three browsers were discriminating against some plant species. However, families that had higher number of species were utilized more readily than those with fewer species indicating that availability within plant families determined utilization, and therefore the three browsers were indiscriminate- at least at the level of plant families. This can be attributed to evolution where browsers that utilized plants families that had higher species representation than those with lower representation were favored.

The results on diet overlap showed that the three animals overlapped in their food preference; based on the similarities in the number of plant species in their diets, although each species had its specific preferred plant food which was different from the other animals at one particular season, suggesting that the three herbivores have a certain degree of resource partitioning and potential to coexist if free ranging was permitted like in the IPZ.

Vegetation in Ngulia Rhino Sanctuary is affected by the elephant, giraffe and black rhino as in inferred from this study. The observation that some plant species were more preferred than others suggest that the vegetation dynamics of Ngulia and the IPZ is likely to be altered overtime. Tsavo west National Park lies in an eco-climatic zone (VI) that receives scanty rainfall, and since elephants and black rhinos consume more in the dry season (due to increased intake rate to supplement most limiting nutrients) (Field, 1971), it would appear that an increase in elephants, black rhinos and or giraffe within the enclosed sanctuary would result in decreased thickets and tree densities. This was found to be true in another study done in Sweetwater Rhino Sanctuary in Laikipia Kenya (Birkett, 2002).

While recognizing that this study did sufficiently cover a period of great browse resource scarcity, it is these principal species that should be considered the key browse species for black rhino, elephant and giraffe in the Tsavo ecosystem and should act as the indicators of the condition of the vegetation for the same animals. It is evident that, although the diet of the black rhino was diverse, a few principal species contributed to the bulk of the total forage intake.

Current models of diet selection rely on the assumption that herbivores select a diet that maximizes the intake rate of the most limiting nutrient during foraging periods (Owen-Smith and Novellie, 1982.). If a herbivore is a generalist, it should consume different foods in relations to their abundance. In contrast, a herbivore is a specialist if it selects a diet that optimizes a mixture of nutrients irrespective of availability (Cromsigt and Olff, 2006). The presence of certain plant species in the Tsavo West National park that were absent in the dung samples of the black rhino, elephant and giraffe suggest that the three browsers are not entirely generalist or if they were they were entirely digested beyond recognition. Interestingly, however, from the foods that the three herbivores consume, there existed a preference rating indicating that the feeding habits of the rhino, elephant and giraffe lies between generalized and specialized strategies.

Predicting the dynamics of a sanctuary in relation to foraging pressure is important in the management of endangered species. Prediction models on the long term response of woodlands to herbivory by elephants, black rhino and giraffe has been done (Birkket, 2002), the pertinent features of these predictions are that:- high density of elephant, black rhino and giraffe will kill, reduce trees and shrubs growth rates in all height classes, including trees and seedlings below one meter of height. With the results of this study (diet overlap data) elephants, black rhino and giraffe can alter their own population dynamics and those of others if their densities are not monitored and controlled in an enclosed sanctuary at sustainable numbers. Results of this study give enough evidence to refute the general concept that elephants, giraffes and black rhinos are generalist feeders but are capable of selecting their food.

Owen-smith (1974) suggested that elephants compete for browse with black rhinos. This study provides evidence consistent with Owen-Smith’s hypothesis, predicting lack of longtime coexistence, especially in an enclosed area; the fact that the three browsers diet overlap not less than 28.95% at any particular time. Elephants have a major influence on vegetation structure, composition and ecosystem processes, and are primary agents of habitat change in Africa. At moderate-to-high population densities, elephants can damage vegetation, especially when enclosed in protected areas. Knowledge of time- and site-specific factors affecting elephant browsing can be used to forecast future habitat transformations (Cassidy, *et. al.;* 2013 Staub, et al.; 2013),

Black rhinos are known to eat an extremely wide range of plant species, ranging from trees to shrubs and herbs. Goddard (1968, 1970) listed 191 species eaten in the Ngorongoro and 102 in Tsavo; Muya & Oguge (2000) reported 34 species eaten in Nairobi National Park; Mukinya (1977) noted 70 species eaten in the Maasai Mara; Oloo, Brett & Young (1994) recorded103 food plant species eaten by black rhino in the Ol Ari Nyiro Ranch. Therefore, it seems likely that black rhinoceros may compensate for loss of preferred plant species by switching to other species. However during the dry season food was scarce as compared with the wet season in both NRS and IPZ. This impies the herbivores range was larger in dry season as compared with wet season. The same was recorded by Demeke, *et* *al*.;(2012) in their study in Babile Elephant Sanctuary, Ethiopia. However dispersal in NRS is limited by the fence while in IPZ the herbivores are free to access other alternative food plants because there movement is not limited.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Browse availability varied with seasons and there wae noted extensive scarcity in both the IPZ and NRS during the dry season. The available browse during the dry season was not adequate to sustain the population of the three herbivores although there was more than adequate during the wet season.

The three herbivores had their own preferred principle plant species at one particular time, nevertheless the three browsers greatly overlapped in their diet indicating that long-time coexistence in an enclosed area like the Ngulia rhino sanctuary would not be sustainable. However the IPZ scenario is suitable for the three herbivores because they can easily minimize direct competition during the dry season hence possibility of coexistence.

The findings of this study indicated that elephants, giraffes and black rhinos are capable of selecting their food independent of availability and by so doing they avoid direct competition because they are capable of adapting to feed on different plant species. However long term coexistence inside the sanctuary will solely depend of thee species diversity and productivity of the sanctuary. The population dynamics of the herbivores and vegetation may also play an important role.

5.2 Recommendations

Continuous long term monitoring and evaluation of their population with regards to the vegetation dynamics of the sanctuary and the IPZ should be prioritized in the management plans of Tsavo West National Park. Owing to the recent changes to the rainfall patterns due to climate change the list of principle plant species established in this study can be used as indicator species for the browse availability of the three species during conditions of extreme scarcity in Tsavo conservation area.

The biomass of herbivores more so the browsers should be monitored closely and the primary productivity of the sanctuary assessed in order establish the actual carrying capacities of fenced rhinoceros sanctuaries.

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