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Full Length Research Paper

Nutritional status of forage plants and their use by elephant in Waza national park, Cameroon

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We studied the utilization pattern of wild plant species by elephants in relation to their nutritive values in order to provide insight into crop raiding events by the animal in the Waza region. Elephants were selective for food plants in the wilderness. Out of 45 recorded plant species, only 20 plant species were found to be utilized either fully or partially as evident by branch breaking, debarking, and uprooting. Among the plants consumed by the elephants, *Acacia seyal* was the most utilized (34.4% n= 212) followed by *Piliostigma reticulatum* (22.5% n = 128). The barks of *Mitragymna innermis* (11% n = 45) and *Anogeisus leiocarpus* (8% n = 41) were moderately utilized. All other recorded plants were utilized below 5%. Crude protein content in utilized plants varied from 2.97 (*Lannea humilis*) to 12.76% (*Capparis tomentosa*). NDF content ranged from 41.58 (*Feretia apodanthera*) to 7.93% (Acacia ataxacantha). ADF content ranged from 32.26 (*F. apodanthera*) to 56.27% (*Ziziphus mauritiana*). *In vitro* digestibility also varied among the utilized plants. Elephants foraged more on nutritionally rich plants, and because of the generally poor nutritional value of natural fodder, the elephants in Waza National Park frequently break out to feed on nutritive richer agricultural crops.

Key words: Elephants, nutritional value, utilized, plants.

INTRODUCTION

The quality of food an animal feeds on with respect to available nitrogen is important for its well being, as well as for management implications (Crawley, 1983). This is essential in the diet to allow normal growth, to maintain body tissues and other productive functions (Pond et al., 1995). It affects an animal's range of movement (McNab, 1963) and most aspects of the population dynamics of herbivores such as reproduction, fecundity, age at sexual maturity, growth rate and dispersal. Availability of quality food and water, barriers to free movement, spatial distribution, and diversity in habitat types may influence the home range size. For a wide ranging species such as elephant, long distance travel during seasonal movement offers clear ecological advantages to elephants (Sikes, 1971). Elephant move widely to find food patches that are sufficiently rich with resources to support them. The more diverse a region, the smaller the home range can be since elephants would be able to meet their varied seasonal requirements within a relatively restricted area. Nutritive value is an important factor influencing the selection of food plants by elephants. Nutritive value is generally measured by digestibility, crude protein and to lesser extent minerals (Shackleton and Mentis, 1992). According to Bie (1991), a minimum crude protein content of around 7.1% for grazer and 6% for browser such as elephant in the diet is considered necessary for maintenance of good animals' condition (Bie, 1991). Pehrson and Faber (1994) suggested that digestibility is an important measure of the nutritional value of forage with organic matter digestibility as one of the main factors (McDonald et al., 1995). It is positively correlated with energy (crude protein) availability (Soper et al., 1993) and negatively to fibre contents and the degree of lignifications (Pehrson and Faber 1994). Forages with high *in-vitro* dry matter digestibility increase the intake rate,

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require less digestion time and increase nutrient availability (Westenskow-wall et al., 1994).

In the Waza National Park, not more than 200 elephants were estimated in 1936 (Jeannin, 1936) and subsequently doubled between the 1940s and the 1960s. By 1971, increasing elephant numbers were already cause of concern as elephants were destroying Acacia tree woodland in Waza National Park (Corfield and Hamilton, 1971). Most of the increase was associated with the immigration into northern Cameroon from Chad, probably resulting from disturbances there such as the deforestation of the Mandelia Faunal Reserve (Fry, 1970). Throughout Waza Region large tracts of habitat experience various degree of biotic pressure due to agricultural activities with the result that elephants are compressed at high densities into the park. Continuous confinement of this species has led to change in home range, with a negative impact on the park's vegetation (Steehouver and Kouahou, 1988; Tchamba et al., 1994). The decline in woodland savannah becomes a matter of concern when Tchamba (1995) observed large-scale killing of mature trees. The elephants also break out of the park to explore and adapted well to marginal habitat mostly in human settled land, raiding crops to meet their energy requirements. It was estimated that more than 1000 ha of cropland were destroyed annually and the annual cost of crop damage was estimated at more than $200000 (Tchamba, 1996). This situation has exacerbated human-elephant conflict and represents one of the main issue facing managers for conservation of elephants in the area. Up to 21 crop raiding elephants have been shot per year in the region, and in the absence of a practical alternative, the local authorities have seriously considered extermination of the elephant raiding crops.

The elephant's sensitivity for crop depredation on broad spatial scale was mainly related to the arrangement of landscape through Waza National Park with intact vegetation cover and agriculture matrices. Availability of moderate to high vegetation cover found mainly in the park in such situation is a strategic requirement for elephants to avoid human-induced interference. Nevertheless, elephants range over large areas in order to meet their huge requirements of food, water and shelter. Elephants consume wild plants as well as cultivated agricultural crops mostly sorghum fields in the Waza region. Although elephants are generally coarse feeders and they feed on a wide variety of plants (Santra et al., 2008), the elephants in Waza region selectively consume some wild plant species.

The factors that influence the decision to consume a plant are palatability of the item (Sukumar, 1990). Ungulates show a positive selection of plant species with the highest protein value (Field, 1976) or minerals such as sodium (Belovsky, 1981). In this study we hypothesized that elephant use of cultivated crops such as sorghum bicolor occurs as a function of the nutritional value of this plants compared to some wild plants they selectively fed upon. Therefore, the present study was undertaken to understand the utilization patterns of various wild food plants by the elephants as part of their feeding strategy in terms of nutritive values in other to provide insight into agricultural crops depredation around Waza National Park.

MATERIALS AND METHODS

Waza National Park is located in the Northern Province of Cameroon and lies between 11°00'-11°30'N and 14°30'-14°75'E. It covers an area of approximately 170 000 ha with an average altitude of 300 - 320 m, rising to 500 m on the rocky outcrops around Waza village. Soils are mainly ferruginous tropical with various catenas, hydromorphic soils and vertisols. The climate of the region is semi-arid, with a dry season extending from October to May. Rainfall is irregular, with an annual mean of 700 mm. The mean annual temperature is 28°C. Three forest types are found: The open combretaceous shrub savanna with *Sclerocarya birrea* tree savanna, *Combretum* and *Terminalia* shrubs and stands of *Hyphaena thebaica*; *Anogeissus leiocarpus* woodland on sandy soil; *Acacia seyal* tree savanna on black clay soils which are saturated with water in the rainy season and the Yaéré floodplains populated with perennial grasses such as *Vetiveria nigitana, Oriza longistaminata, Echinocloa pyramidalis, E. stagnina* and some herbaceous legumes including *Sesbania pachycarpa*. Water continues to be one of the most serious problems for Waza. Recently, important dry season waterholes have been created and managed in the Yaéré floodplain.

Even though elephants can consume a substantial amount of either grass or forbs during certain seasons, only woody plant species were recorded because in the study area they fed mostly by browsing and feeding signs attributable to this animal are readily distinguishable. Fields data were gathered in the dry season, as the park is not always accessible during the rainy season period due to flooding. During this period, elephant always spill out of the park and migrate in areas far south. Eleven plots, each measuring 2500 m² were studied in three forests viz: Woodland, *Acacia seyal* and floodplain zone to record the pattern of consumption of different woody plant species by elephants. These plots were located in the known core elephant range. Direct observations of feeding by elephants were made using the opportunistic scoring focal sampling techniques (Forthman-Quick and Demment, 1988) from a viewing distance of approximately 40 m from the roof of a vehicle using a standard 7 × 50 binocular during day time. The studied plots were immediately examined after the herd left for another location. The first animal seen or the closest one at the beginning of the observations was used as the focal animal for that observation. For each observation the following records were made: the plant species or food item taken and, the specific part of the food item actually eaten. The following categories of plant part were considered: Leaves, branches, bark, stem and fruits (Merz, 1981; Tchamba and Seme, 1993).

Total number of plants of each species consumed with respect to the total number of plants present in the plots was recorded through evidences of branch breaking, main-stem breaking, stem twisting, bark peeling, uprooting and tusk markings (Ishwaran, 1983). The degree of utilization was calculated based on the ratio of total number of plants of a species consumed to total number of plants of that species in the plot. All plants on which elephants were observed to feed in the study area were identified at the herbarium of the Wildlife School of Garoua, Cameroon. Owing to the diverse diet of elephant and the number of different species of plants available to them in the study area, a subsample of plants was collected for chemical analysis. The plant materials were oven-dried at 80°C for 24 h, grounded into powder in a large mill to a grain size of 1 mm as suggested by Minson (1990) and stored in sealed plastic bags. Proximate analysis of those food plants consumed by elephants has been done as per AOAC (1980). The dry matter (DM) and organic matter (OM) were gained from the samples in order to aid in the calculation of the following analyses performed.

The digestibility

In vitro digestibility following the procedure of Van Soest (1982);

The fibre content

This was done using a variety of indicators: Percentage neutral detergent fibre (NDF), Percentage acid detergent fibre (ADF) and Percentage lignin content (% lignin) (Van Soest 1982). From these percentages the cellulose and hemicelluloses percentages were derived; with hemicelluloses being the difference between NDF and ADF and cellulose the difference between ADF and lignin percentage;

The energy content

Represented by the crude protein percentage (%CP), was calculated by multiplying the N content by a factor of 6.25 because proteins contain about 16% N (McDonald et al., 1995). Nitrogen concentrations were gathered using the Kjeldahl analysis. These results were used to derive the regression equations for calibrating the near-infrared reflectance spectroscopy metre. Highly significant correlation coefficients ($R^2 = 1$) enabled the direct prediction of the nutritive value from wavelengths with auto-analyzer reading (Figure 1). All results were expressed on a percentage organic matter basis. The correlation between the energy levels, fibre content and the level of digestibility, were calculated for the woody species. Because of the limited available resources, we make the assumption that the value of a foodstuff is adequately indexed by N concentration alone. While this may be an acceptable basis for the study, it is readily apparent that elephants may consume some foodstuffs for other returns, such as sugars in the phloem tissue when debarking. The limitations of using only one indicator for an animal which is attempting to meet diverse nutritional needs should be properly recognized in further study.

RESULTS

Pattern of food plant utilization

Elephants consumed different plant species with varying degree of preference. Twenty plant species viz: *Acacia* seyal, Acacia athaxacantha, Anogeisus leiocarpus, Balanites aegyptiaca, Capparis tomentosa, Celtis integrifolia, Combretum aculeatum, Combretum glutinosum, Crateva adansonii, Feretia apodanthera, Guierra Senegalensis, Lannea humilis, Lonchocarpus laciflorus, Mitragymna innermis, Piliostigma reticulatum, Sclerocarya birrea, Stereospermum kunthianum, Tamarindus indica, Terminalia avicenoides, and Ziziphus Mauritiana, were consumed by elephants as food plants. They consumed plant parts viz: Leaves + twigs, bark, stem and fruits. Overall utilization of food plants by elephants revealed maximum utilization of *Acacia seyal* (37%, n = 212) followed by *P reticulatum* (22.5% n = 128), *B. aegyptiaca* (15% n = 88) *C. aculeatum* (12% n = 65), *M. innermis* (11% n = 45), *C. tomentosa* (9.5% n = 39), *A. leiocarpus* (8% n = 41), *C. adansonii* (7% n = 37) and *F. apodanthera* (5% n = 35). The distribution of these species might influence the ranging patterns of elephants in the park. The most important part of plant intake is that of *A. seyal*. Not surprisingly, this species forms a dominant vegetation community in the park environment and the most important in terms of total plant density. The bulk of the species, in terms of number of plant species eaten, came from leaves + twigs, branches and stems (over 70%). The consumption of other food plants seemed variable and might be related to the availability of important and presumably preferred foods. Eleven plants species (out of the twenty plant species) were present in less than 5%. Although, these species also contribute to the elephant's diet, they might play a secondary role, as they are not taken in the same proportion as the major plants species recorded. Compared to species such as *A. seyal* or *P. reticulatum* these species are patchily distributed throughout the park.

Crude protein content analysis

The chemical values of some wild plants consumed by elephants are given in Table 1. Percent crude protein content varied from 2.97 (*L. humilis*) to 12.76% (*C. tomentosa*). Bark of *A. leiocarpus* was found to have higher crude protein than leaves + twigs of many species. The maximum number of forage plants (70%) was found to have crude protein level above the minimum value of 7.1% viz: Higher level of crude protein content was recorded in *C. tomentosa* (12.76%) followed by *A. leiocarpus* (12.12%), *C. adansonii* (11.05%) and *C. integrifolia* (10.60%).

In vitro digestibility and fibre content analysis

In vitro digestibility of forage plants ranged from 33.71 (*G. senegalensis*) to 68.1% (*F. apondanthera*). The digestibility level was higher than the average of 50% in most species (55% of forage plants). High variation in the fibre composition existed in the forage plants studied. The neutral detergent fibre (NDF), acid detergent fibre (ADF) and lignin contents of those forage plants are summarized in Table 2. NDF content ranged from 41.58 (*F. apodanthera*) to 7.93% (*A. ataxacantha*). ADF content ranged from 32.26 (*F. apodanthera*) to 56.27% (*Z. mauritiana*). Lignin content of studied plants ranged from 9.92 (*S. khuntianum*) to 33.31% (*G. senegalensis*) while cellulose content range from13.89 (*A. leocarpus*) to 38.2% (*A. athaxacantha*) and hemicelluloses from 7.87

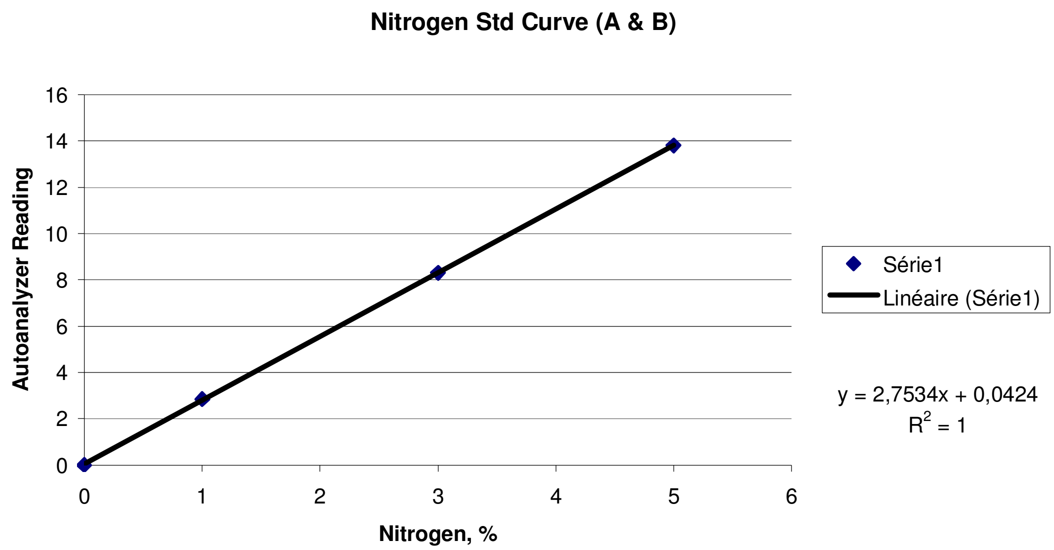

Figure 1. Regression equation of chemical analysis for the percentage of nitrogen concentration in plant materials in the Waza national park.

Table 1. Chemical composition of some wild plants in the Waza national park (mean values based on 3 replicates).

Scientific name	Part analysed	OM %	CP%	In vitro %
A. athaxacantha	Leaves + twigs	93.98	6.63	31.41
A. seyal	Leaves + twigs	93.13	11.29	62.68
A. leiocarpus	Bark	90.83	12.12	60.4
B. aegyptiaca	Leaves + twigs	92.28	8.73	59.54
C. tomentosa	Leaves + twigs	91.62	12,76	48.33
C. integrifolia	Leaves + twigs	79.83	10.6	65.86
C. aculeatum	Leaves + twigs	93.27	8.59	52.84
C. glutinosum	Leaves	94.05	6.35	43.63
C. adansonii	Leaves	91.63	11.05	58.55
F. apodanthera	Leaves + twigs	93.39	8.42	68.1
G. Senegalensis	Leaves + twigs	95.07	9.19	33.71
L. humilis	Leaves + twigs	91.34	2.97	47.48
L. laciflorus	Leaves + twigs	90.41	9.78	46.13
M. innermis	Bark	94.2	7.69	51.61
P. reticulatum	Leaves + Fruit	90.18	7.64	51.67
P. reticulatum	Leaves + twigs	94.25	6.98	46.92
S. birrea	Leaves + twigs	91.49	6.28	51.41*
S. kunthianum	Leaves	88.22	8.1	63.55
T. indica	Leaves + twigs	91.31	6.8	44.16
T. avicenoides	Twigs	92.96	7.76	52.79
Z. Mauritiana	Leaves + twigs	96.64	5.6	35.94

(*A. leocarpus*) to 19.45% (*C. tomentosa*). The correlations between the energy content, the fibre content and the digestibility are presented in Figure 2. The fibre content, represented by the NDF, ADF and cellulose levels, has a negative correlation with the digestibility, represented by the *in-vitro* digestibility analyses. This suggested that *in-vitro* digestibility is strongly influenced by the amount of fibre in the plant tissues. The correlation diagram in Figure 2 shows that, mainly the cellulose component of the fibre suppresses the *in-vitro*

Table 2. The dry matter (DM), neutral detergent fibre (NDF), acid detergent fibre (ADF) and lignin contents of some wild plants (mean values based on 3 replicates).

Species	Part analysed	DM %	NDF%	ADF%	Hemicellulose	Cellulose	Lignin
A. athaxacantha	Leaves + twigs	96.08	71.93	55.09	16.85	38.2	15.69
A. seyal	Leaves + twigs	95.65	56.87	42.5	1437	30.97	11.09
A. leiocarpus	Bark	95.66	48.71	40.85	7.87	13.89	26.67
B. aegyptiaca	Leaves + twigs	96.59	50.07	32.4	17.67	21.38	10.71
C. tomentosa	Leaves + twigs	94.62	60.18	40.73	19.45	28.71	10.34
C. integrifolia	Leaves + twigs	92.16	47.37	37.55	9.82	16.5	17.94
C. aculeatum	Leaves + twigs	94.46	54.92	39.81	15.12	27.62	11.41
C. glutinosum	Leaves	94.56	63.44	47.21	16.23	33.3	13.6
C. adansonii	Leaves	94.93	53.95	36.96	16.99	23.81	11.75
F. apodanthera	Leaves + twigs	95.27	41.58	32.26	9.32	15.51	13.35
G. Senegalensis	Leaves + twigs	96.31	67.45	56.17	11.28	22.26	33.31
L. humilis	Bark	95.68	55.72	47.7	8.02	30.12	17.95
L. laciflorus	Leaves + twigs	96.06	63.61	44.92	18.69	29.82	13.85
M. innermis	Bark	94.48	56.3	42.25	14.05	23.62	17.84
P. reticulatum	Fruit	94.12	57.4	46.79	10.6	19.54	27.11
P. reticulatum	Leaves + twigs	93.64	59.87	47.12	12.74	23.83	23.4
S. birrea	leaves+ twigs	94.5	46.65	35.36	11.28	20.83	13.69
S. kunthianum	Leaves	95.19	51.39	37	14.39	26.11	9.92
T. indica	Leaves + twigs	93.63	60.99	47.51	13.48	27.25	19.83
T. avicenoides	Twigs	95.63	54.33	44.8	9.53	20.56	23.43
Z. Mauritiana	Leaves + twigs	95.79	71.54	56.27	15.27	38.14	17.29

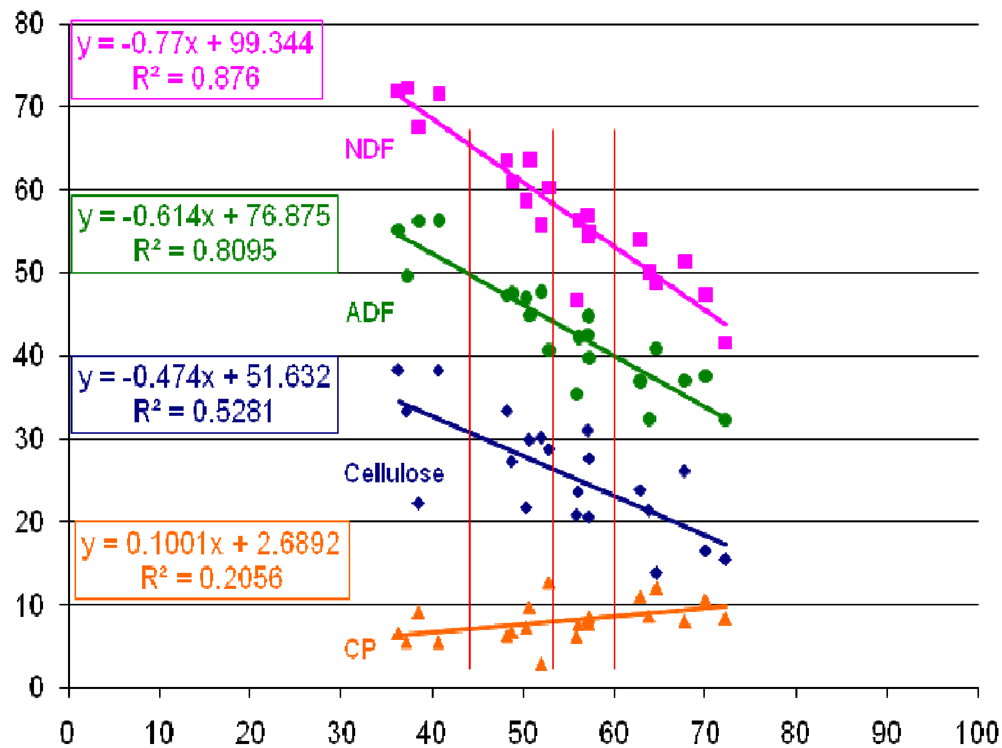

Figure 2. Fibre content (NDF, ADF and Cellulose) and energy content (crude protein) in relation to the digestibility (*in vitro*) of different woody species in the Waza national park.

digestibility. The energy content represented by the crude protein level, shows different pattern with respect to the digestibility. We found that changes in the *in-vitro* digestibility are positively correlated to those in crude protein levels.

DISCUSSION

Utilization pattern of wild plant species by elephants in the Waza National Park revealed that out of 45 plant species recorded in the region, elephants selectively foraged on 20 food plants. Low number of plant species consumed by the elephants in the wilderness is due to their dependency on cultivated crops such as sorghum bicolor, which have higher palatability and nutritive value (its crude protein analysis and digestibility level were15 and 74.5% of organic matter respectively) than wild plants. Among these food plants elephants selectively foraged on, preference for some species over others was found. Nine plants were recorded as the most consumed. These include *A. seyal, P. reticulatum, B. aegyptiaca, C. aculeatum, M. innermis, C. tomentosa, A. leiocarpus, C. adansonii* and *F. apodanthera*. Among them *A. seyal* was by far the most dominant species in the diet with respect to browsing, followed by *P. reticulatum*. *Acacia* sp. topped the list of preferred species in the Sahelo-Soudanian region of Congo (Pamo and Tchamba, 2001). Species selection in elephants' foraging behaviour has been observed elsewhere in the past by Smallie and O'Connor (2000) and Holdo (2003). The selected species are not always used in a similar proportion (Van Wyk and Fairall, 1969). High proportion of *A. seyal* in the species assemblage had higher numbers of heavily used trees. Overall stem density of *A. seyal* in addition to the organic matter digestibility and crude protein level might play a key role. As these plants are utilized more by elephants, they should be protected from encroachment, by dissuading people from harvesting them for fuel wood.

All these plants were found to have *in vitro* digestibility (51.61 - 68.1%) and crude protein/energy content (7.64 – 12.76) sufficient to maintain basic metabolism of elephants (Bie, 1991). The different use intensities between trees are also a factor of the species assemblage since different species are preferred in variation with their nutritive value. The level of protein in the plant also plays a role. Field (1976) has previously postulated that ungulates show a positive selection of plant species and plant parts with highest protein value. For a species, which bases its foraging strategy on a maximisation of digestibility rate and energy, the efficiency of digestion of food depends on a combination of the passage rate of food through the digestive track and the rate of nutrient extraction (Van Soest, 1982). The relationship between these two factors may be an important determinant of how well elephants can use a particular food source, and this has been found to influence food choice in several groups of herbivores (Hongh, 1996).

The nitrogen or protein content of a plant is only one of the many plant characteristics that are vitally important to herbivores (Mattson, 1980). Food quality is affected by the density of nutrients, amongst other factors (Georgiadis and McNaughton, 1990). Large grazing mammals must exploit a nutritional environment that is complex in composition (McNaughton and Georgiadis, 1986). Dörgeloh (1999) further postulated that dietary protein requirements for growth in weaned mammals are 13 - 20% for deer and other ruminants, and 5 - 9% for maintenance of adult wild ruminants. As mentioned by Robbins (1993), these minimum dietary protein requirements differ between 4.5% for grazers and 6.0% for browsers such as elephant, which corroborate well with our findings.

Bark of *A. leiocarpus* was also selected because of its high protein content (12.12%). Ungulates can select food of desired nutritive value by applying their nutritional wisdom (Field, 1976). Debarking of many food plants by elephants has been observed in various parts of the tropics (Olivier, 1978). Feeding on bark may help maintain an optimum fibre: Protein ratio to ensure proper digestion of protein (Laws et al., 1975) or supply minerals (Bax and Sheldrick, 1963). The fibre in bark may help elephants to avoid colic, to which they are prone (Eltringham, 1982). The present study also shows that a species such as *T. avicenoides* having crude protein (7.76%) and digestibility (52.79%) in acceptable level for basic metabolism of elephant was poorly used. Though some factors such as food-dispersal pattern, nutritive value and toxicity are important in influencing selection of food plants by elephants (Olivier, 1978), it is unlikely that any single factor would explain the elephant's preferences (Ishwaran, 1983). The present investigation therefore, concludes that nutritive values of plant species probably influence the decision to consume, as conveyed to the mega - herbivore. A possible factor contributing to dispersal of elephants away from the park zone is availability of alternative sources of food with high nutritive value such as agricultural crops populated with *sorghum bicolor*. Therefore, the foraging strategy of choosing nutritive richer plants results in the preference for agricultural crops over the natural fodder (Santra et al., 2008) by elephants in the Waza region. According to Westoby (1974), large generalist herbivores such as elephant, face a limit on how much material they can digest. If their diet selection is largely driven by the necessity to meet a nutritional need, their response to availability of particular foods should not be continuous but take the form of a cutoff at very low availability. This implies that as food becomes scarce in a plant community, grazing pressure on it will increase, at least until the cutoff is reached. It also implies that human-elephant conflicts will remain due to the availability of nutritive food which requires less energy to actually acquire-being that you just dig it up or taken it from its stalk opposed to debarking a tree for example in communities near protected areas.

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