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Full Length Research

Botanical composition and some nutrient contents of the diet consumed by waterbuck (*Kobus ellipsiprymnusdefassa*) in Dinder National Park, Sudan

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ABSTRACT: This study was conducted in the Dinder National Park (DNP) at approximately 11 to 13°N and long 34 to 36°E) in 2010 and 2011, in order to determine the botanical composition of the waterbuck's (*Kobus ellipsiprymnusdefassa*) diet. The study was mainly done at Abd el Ghani Maya (meadow). A micro-histological technique was used to determine the dietary botanical composition in which samples of plant species and faecal droppings encountered in and around the Maya were collected, dried and grounded to pass 1-mm mesh. Reference slides were prepared from the ground samples of the plant species whose epidermal characteristics were compared with their counterparts in similar slides prepared from the faecal droppings. In addition, nitrogen, phosphorous and calcium concentrations in plant samples were determined. Twenty-one plant species were recorded from waterbuck faecal in 2010 and 19 in the year 2011. The grass species comprising high proportions in the diet were *Echinochloa* sp., *Cyprus* sp., *kylinga* sp. and *Sorghum arundinaceum*; forbs (broad-leaved herbs) were *Corchorus depressus*, *Ipomoea aquatica* and *Polygonum* sp.; and woody vegetation (trees and shrubs) were *Acacia seiberiana*, *Balanites aegyptiaca, Ziziphus-spina-christi*and *Crativa adonsonii*. Early in the dry season, grasses and forbs constituted 80% of the diet, trees and shrubs 20%. However, during the late dry season, grasses and forbs comprise about 40% of the diet; whereas trees and shrubs constituted 60%. Among food plants *Cyprus* sp. and *Acacia*s contained the highest nitrogen and phosphorus concentrations. The diet of waterbuck was more diverse in the late dry season than that of the early dry season. It is concluded that waterbuck preferred few succulent, nutritious grasses in the early dry season and shifts to diverse herbaceous and woody vegetation with relatively high nutrient contents when the grasses dry up late in the dry season. Nutritional studies about grasses, leguminous trees and other plant species eaten by the wild animals are lacking. Intensive nutritional studies are needed to cover all possible nutritional aspects of the wild animals in the park.

Key words: Forbs, grasses, micro-histological technique, woody trees.

INTRODUCTION

Deutsh and Murray (2001) described waterbuck (Kobus ellipsiprymnusdefassa) as 'the largest antelope of the Reduncini tribe, the height at shoulders on averages being 700 to 1,360 mm (Plate 1). Males (250 kg) are larger than females (170 kg). The hair is long, coarse, and usually with some shade of brown, ranging from yellow to nearly black, with white patches. The males have impressive backward-curving horns and females without horns. Ears are big and rounded. There are white patches just above the eyes, around the mouth, the nose and on the throat; the coat becomes progressively darker with age. Males tend to be darker and greyer than females. All waterbucks have a large, white patch on their rump (Estes 1991).

Plant cover and plant diversity, an important component of wildlife habitat, provides waterbuck, like other wildlife herbivores, with food and shelter. Knowledge of the plants eaten by the waterbuck (feeding habit or diet selection) is vital for the proper management of its habitat. In the African savanna ecosystems, the

Plate 1. Waterbuck (*Kobus ellipsiprymnusdefassa)* grazing in Abdel Ghani Maya, Dinder National Park, Sudan.

mortality is either induced by food shortage or by a significant decrease in food quality can even exceed the deaths of wild animals caused by the various predators (Sinclair 1977).

The diet of herbivorous ungulates varies between seasons and nutrient levels vary among plant species with the seasonal advance: as the plants become mature and their nutrient contents decrease (Mowat et al. 1965; Georgiadis and McNaughton 1990). It is suggested that plant species with comparatively low nutrient levels in the wet season might become relatively of high quality and hence more attractive for herbivores later than in the dry season when other herbaceous plants dry out (Mowat et al. 1965; Prins and Beekman 1989; Georgiadis and McNaughton 1990; Ben-Shahar and Coe 1992). This explains why the diet botanical composition of ungulates varies between seasons in many studies (Prins and Beekman 1989; Ego et al. 2003; Macandza 2004; Omphile et al. 2004). Literally, the quality and availability of food plants are constraints to the population dynamics of ungulates (Sinclair 1977; Boyce 1992; Mwangi and Western 1998).

Epidermal characteristics of plant species recovered in fragmentary conditions from faeces were widely applied for studying herbivorous diets (Dussi 1949). The main purpose of applying this technique to free-ranging wild animals is the identification of forage plants after being ingested by the animal. The identification of epidermal fragments in feces was proven to be successful, especially in areas where several animal species were feeding together on rich herbaceous flora such as that of East African plains (Stewart 1967). Waterbuck, as noticed by East (1984), feeds selectively but on less widely dispersed forage parts as compared to other ungulates. It moves from one habitat to the next habitat, searching for high quality food (Traill 2004).

Considerable research is being conducted on feeding preference and fluctuations in nutritive values of food plants of domestic livestock. However similar studies on wild herbivorous ungulates are scarce. In addition, most information on plant-herbivore interactions in savanna ecosystems was obtained in moist savannahs which may be different from semi-arid regions. The main objective of this study was to determine the botanical composition, and nitrogen, phosphorus and calcium contents as well as the seasonal shift in the diet consumed by the waterbuck in Dinder National Park during the dry season of 2010 and 2011.

MATERIALS AND METHODS

The study area

This study was conducted in the Dinder National Park (DNP), which is located in the Sennar State between latitudes 11 to 13^{o} N and longitudes 34 to 36^{o} E, adjacent to the Ethiopian border at a distance of 550 km south east of Khartoum. It is drained by two seasonal rivers, Dinder and Rahad, and the area covers 10,290 km^{2}. The climatic conditions of park in general, can be summarized as cool and dry in winter and wet and warm in summer. The wet season starts in May and ends in November,

during which the area receives an annual rain fall ranging 600 to 1000 mm, increasing southwards and peaking in August. The temperature range from as low as 20°C at the begging of the dry season in December to as high as 42°C in March and April, towards the end of the dry season. Rahad and Dinder Rivers start flooding in July, reaching their peak in September. The annual mean relative humidity varies between 35% and 45% but higher value of 79% was recorded during the peak of the rains in August (Kanno 2004). The dry season extends from December to April, with maximum temperature of 38°C in April, the winter is cool with mean average temperature of 30°C (Kanno 2004).

Data and sample collection

The samplings used follow the method of Hashim (1987, 1996). The faecal pellets of the waterbuck were counted in circular plots of 1 m radius, along randomly selected four lines transects that radiated from the center of the *Maya* and ended beyond its periphery to a distance of 1 km. Plots were spaced at 50 m intervals where faecal pellet-groups were collected for micro-histological analysis; each pellet group was kept separately in a paper bag and sun dried. In total, 1850 pellet samples, representing 10 to 50 pellets/groups were collected. There were no errors in identifying the faecal pellet-groups because their shapes and sizes were species specific. No distinction was made between the animal sexes, but juvenile' faeces were excluded from the analyses.

Plant species were counted in the plots along the same line transects used for the sampling of the faecal pellet-groups. Grasses, forbs and branches of tree species in the plots were clipped for chemical analysis. Each plant species was kept separately in a paper bag and dried in the sun. Ripe, fallen seed pods of the leguminous trees encountered during the sampling were also collected and kept for the laboratory analysis.

The micro-histological analysis was used to determine the dietary composition of the waterbuck (Stewart 1967). It is based on the fact that, fragments of epidermis and cuticles of plants ingested by animals remain intact as they pass through the digestive system and could be identified in the dung. Based on the shape and distribution of epidermal cell forms, the plant fragments found in the dung can be identified up to the species or genus level. Accordingly, reference slides were prepared from leaves of all grass, forbs and tree species available in the DNP as well as seed pods of the leguminous trees, according to Essas (1963).

Nutrient analysis

Nitrogen was determined by the Kjeldahl digestion (Bradstreet 1965). Plant materials were ground and incubated at 420°C for one hour with 5 ml of concentrated sulphuric acid (H_2SO_4) and a Kjeldahl tablet. The digested solution was then transferred into a 100 ml Erlenmeyer flask and filled up with distilled water. This solution was neutralized and the total nitrogen concentrations were measured by means of the Flow Injection Analysis. Crude protein content was calculated as 6.25 times the nitrogen concentration, as proteins on average consist of 16% nitrogen (Robbins 1993). Phosphorus, ash and calcium were determined according to Van Soest (1975) and then Ca/P ratio of each sample was calculated.

Microsoft excel computer program was used to analyze the seasonal shift in the diet of waterbuck as well as nitrogen, phosphorus, and calcium concentrations.

RESULTS

Diet composition

The diets' botanical composition of waterbuck in the early and late dry seasons of 2010 and 2011 are shown in Table 1 and Table 2. Among the 21 plant species recovered in the early dry season (Table 1), 49.3% were grasses, 22.4% forbs and 28.3% trees. Seven grass species dominated the diet composition; their proportions range from 9.0 to 5.9%. These plants, in the order of their high proportion, were *Echinochloa* sp., *Cyprus* sp., *Kylinga* sp., *Sorghum arundinaceum* and *Pennise tum*sp. The proportion of forbs (22.4%) did not differ very much as they range from 2.3 to 4.8%. The woody vegetation, however, comprised 28.3% of the diet. *Setaria* sp. and *Setaria verticillata* (grasses), and the three tree species (*Balanites aegyptiaca, Ziziphus-spina-christi* and *Crativa adonsonii*) were not recovered.

Plant species indicating recovered high diet proportion (7.3 to 5.1%) late in the dry season comprised 40.8% trees (*Acacia nilotica*, *Acacia seiberiana*, *Acacia seyal*, *Acacia fistula* and *Crativa adonsonii*), and 27.6% grasses (*Setaria verticillata* and *Setaria* sp.) and 15% forbs (*Astercantha longifolia*, *Polygonum* sp. and *Hibiscus pando niformis*). Although they were avoided in the early dry season, *Setaria verticillata*, *Balanites aegyptiaca* and *Ziziphus-spina-christi* were consumed late in the dry season.

In 2016, 19 plant species were recovered during the early dry season (Table 2). Among these, 10 species had high proportions (11.4 to 5.3%) in the diet. These constituted 70% grasses (*Cyprus gigantia*, *Echinochloa* sp., *Kylinga* sp., *Sorghum arundinaceum, Cyprus imbricatus*, *Hyparhernia rufa* and *Pennise tum*sp.); 20% forbs (*Ipomoea equatica* and *Asparagus* sp.), and 10% trees (*Acacia seiberiana*). In the late dry season proportion of the 22 plant species that were selected ranged from 8.5 to 1.4%. The species with relatively high proportions (8.5% to 5.0%) were 58% trees (*Acacia*

Table 1. Diet botanical composition of waterbuck (*Kobus ellipsiprymnusdefassa*) in the early and late dry season of 2010 at Dinder National Park.

Plant species	Percentage	
	Early dry season	Late dry season
Grasses		
Cyprus gigantia	8.3	5.2
Cyprus imbricatus	7.4	4.1
*Kylinga*sp.	6.1	4.4
*Echinochloa*sp.	9.0	2.1
*Echinochloa*sp.	8.0	4.8
*Pennisetum*sp.	4.6	1.9
*Setaria*sp.	0	2.3
Setariaverticillata	0	6.0
arundinaceum	5.9	3.3
Total	49.3	34.1
Forbs		
Asparagus sp.	4.8	1.3
Hibiscus pandoniformis	3.3	5.3
Ipomoea equatica	2.7	1.4
Corchorusdepressus	3.2	2.2
Helolropiumsupinum	3.1	2.6
*Polygonum*sp.	3.0	5.1
Astercanthalongifolia	2.3	7.2
Total	22.4	25.1
Woody trees		
Acacia seibriana	5.9	7.2
Acacia polycantha	3.6	4.6
Acacia fistula	3.6	6.6
Acacia nilotica	5.3	7.3
Acacia seyal	2.4	7.0
Combretumhartmannianum	1.7	3.5
*Leptadinia*sp.	1.8	3.7
Balanitesaegyptiaca	0	0.2
Ziziphus-spina- Christi	0	0.2
Crativaadonsonii	0	0.3
Unidentified items	4	0.2
Total	28.3	40.8

nilotica, *Acacia seiberiana*, *Acacia seyal, Combretum hartmannianum*, *Ziziphus-spina-christi* and *Acacia fistula*); 21% grasses (*Sorghum arundinaceum*, *Echinochloa*sp., *Cyprus gigantia* and *Setaria*s p.), and 21% forbs (*Ipomoea equatica and Asparagus* sp). Among the grass species, only *Setaria* sp. was not recovered in the early dry season. *Kyliga* sp., *Hyparherina rufa* and *pennesetum* sp. were not recovered in the late dry season although their proportion in the diet early in the dry season was 91.6%. Obviously, the diet of waterbuck shifted from herbs (grasses and forbs) in the early dry season to trees and shrubs in the late dry season (Figure 1).

Nutrient content

Crude protein, phosphorous and calcium concentrations

Table 2. Diet botanical composition of waterbuck (*Kobus ellipsiprymnusdefassa*) in the early and late dry season of 2011 at Dinder National Park, Sudan.

Plant species	Percentage	
	Early dry season	Late dry season
Grasses		
Cyprus gigantia	11.4	6.3
Cyprus imbricatus	6.8	2.3
*Kylinga*sp	8.7	0
Hyparrheniarufa	5.6	0
*Pennisetum*sp.	5.3	0
*Echinochloa*sp.	9.1	6.4
*Setaria*sp.	0.0	5.5
Sorghum arundinaceum	7.2	7.1
Total	54.1	27.6
Forbs		
Ipomoea equatica	5.9	2.0
Hibiscus pandoniformis	0.7	2.0
Asparagus sp	6.9	0
Heliotropiumsupinum	4.0	3.2
Astercanthalongifolia	3.9	5.0
*Polygonum*sp	3.6	3.3
Total	25.0	15
Woody trees		
Acacia sieberiana	6.7	8.2
Acacia polycantha	2.2	4.4
Acacia fistula	0	5.2
Acacia nilotica	4.3	8.5
Acacia seyal	2.7	6.5
Combretumhartmannianum	0	5.6
*Leptadinia*sp	1.4	5.9
Balanitesaegyptiaca	0	1.7
Ziziphu-sspina-christi	0	5.4
Crativaadonsonii	0	2.4
Acacia melifera	0	1.4
Entadasudanica	3.1	1.7
Unidentified items	0.5	0
Total	20.9	56.9

varied between seasons. In the early dry season, the crude protein concentration in trees/shrubs and grasses was slightly more than that in forbs. The same trend was indicated in the late dry season, but the concentration in trees/shrubs was almost equal to that of the early dry season (Figure 2). Concerning the plants recovered from waterbuck faecal in the early dry season, the phosphorous concentration was relatively high in trees/shrubs compared to grasses and forbs, the grasses indicated slightly more concentration than forbs. The same trend was followed in the late dry season, but the phosphorous concentration was higher in the recovered plants in this season compared with their counterparts in the early dry season (Figure 3).

The calcium concentration indicated quite a different trend, being equal in grasses and forbs in the early dry season, but it was slightly higher in trees/shrubs. However, in the late dry season, however, the calcium concentration was higher in grasses compared to that of forbs, and in tress/shrubs, even exceeded the concentra-

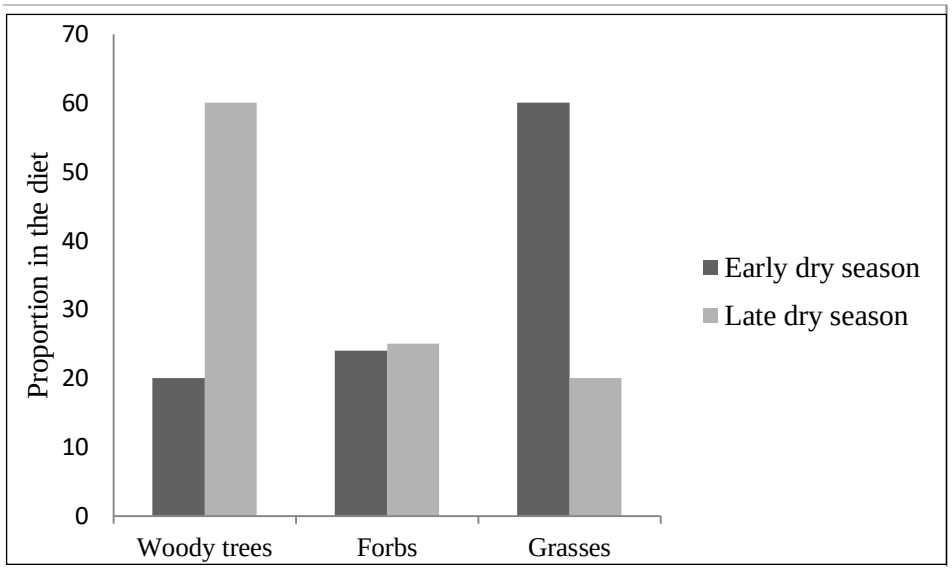

Figure 1. Average seasonal shift in proportion of dietary plant of waterbuck (*Kobus ellipsiprymnusdefassa*) in the early and late dry season of 2010 and 2011 at Dinder National Park, Sudan.

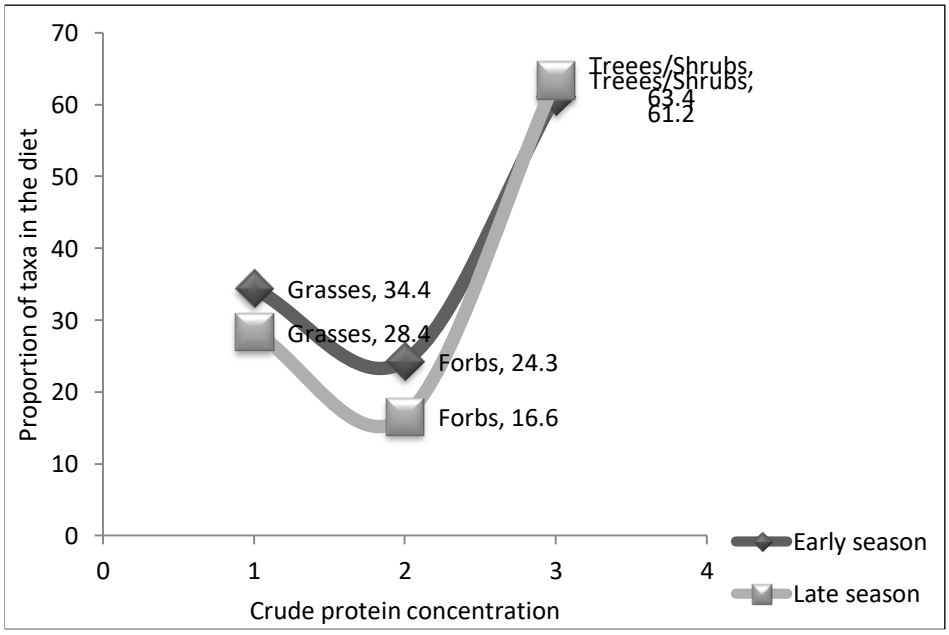

Figure 2. Crude protein concentration in taxarecovered from waterbuck(*Kobus ellipsiprymnusdefassa*)faecal material with seasonal advance in Dinder National Park, Sudan.

tion in the early dry season (Figure 4).

DISCUSSION

Waterbuck has consistently selected almost similar food items in early and late dry seasons of both 2010 and 2011 years. In the early dry season the diet is mostly composed of grasses, followed by forbs and trees/shrubs. In the late dry season, the tress/shrubs dominate the diet, followed by grasses and forbs. Similar findings were previously reported by Muya (1993).

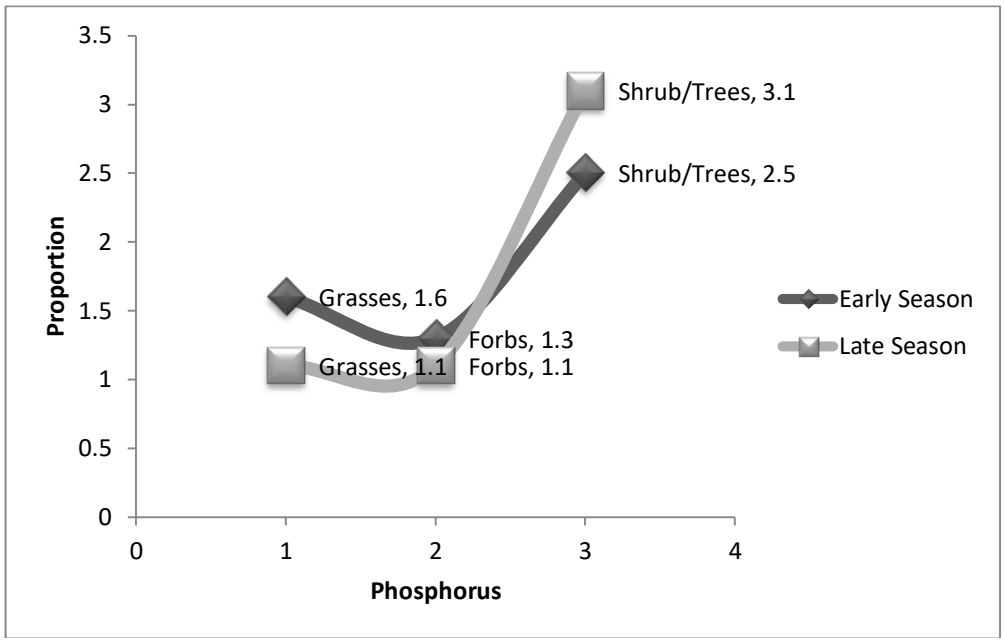

Figure 3. Phosphorus contents of taxarecovered from waterbuck faecal material with seasonal advance inDinder National Park, Sudan.

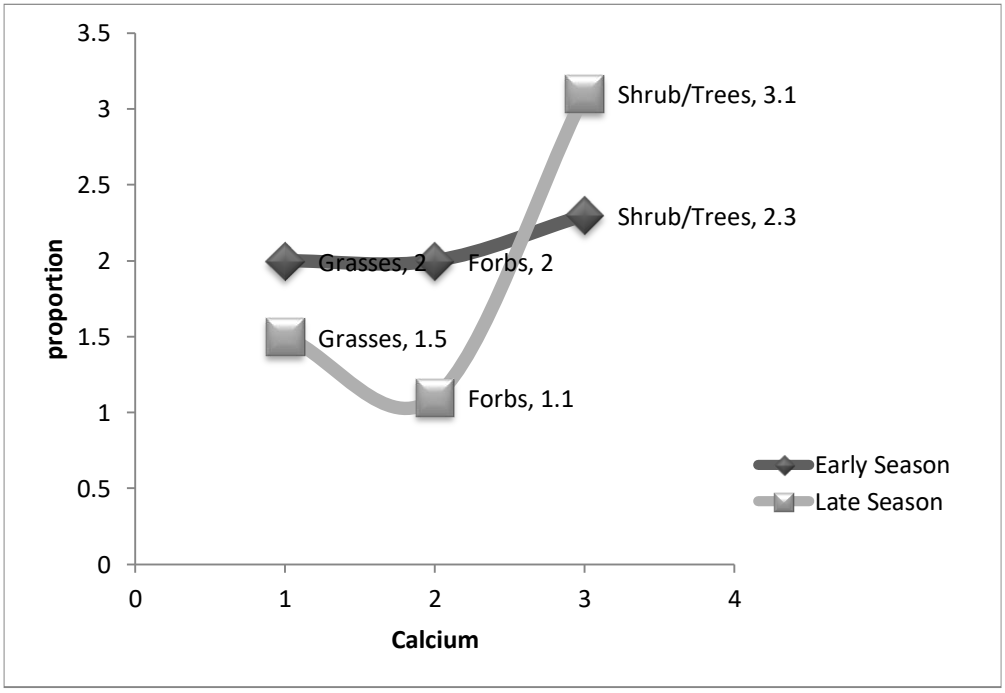

Figure 4. Calcium concentration in taxa recovered from waterbuck faecal material with seasonal advance in Dinder National Park, Sudan.

However there is a discrepancy concerning availability of plants that are not recovered: *Setaria* sp., *Balanites aegyptiaca, Ziziphus-spina-christi* and *Crativa adonsonii* were not consumed in the early dry season in the first year but were consumed in the late dry season. In the second year *Setaria* sp. Was not consumed again but

Kyliga sp., *Hyparherina rufa* and *pennesetum* sp. were eaten in the early dry season. These have not appeared in the diet in the late dry season. Apparently, *Seraria* sp. is unpalatable. Taking the first year as an example, taxa refused in the early dry season might be consumed in the late dry season as they were absent in the diet. It is likely that *Kyliga* sp., *Hyparherina rufa* and *pennesetum* sp. were over consumed early in the dry season so that they were no longer available late in the dry season. Elhassan (2011) investigated that 2011 was a drought year and food was not probably adequately available in the area.

The crude protein, phosphorous and calcium concentrations are consistently higher in trees/shrubs compared to grasses and forbs, and the concentrations of these nutrients vary slightly between grasses and forbs. Apparently, the consumed herbs indicate more nutrient concentrations than the refused. The phosphorous concentration is more in the consumed herbs than those that were refused by the waterbuck. The waterbuck shifts its herb-dominated diet in the early dry season to tree/shrub-dominated diet in the late dry season so as to obtain these much needed nutrients at such critical time of the year. Taxa that were selected in both seasons have relatively high nutrient concentrations. Sinclair (1977) found that buffalo (*Syncerus caffer*) and wildebeest (*Connochae testaurinus*) in Serengeti National Park in Tanzania experienced severe food shortage and sharp reduction in protein and phosphorous concentration in the dry season. Previous investigators, Sinclair (1977) and Ego et al. (2003) reported that the diet of waterbuck was made up of plant species with more proportions of nutrient concentrations compared to the plant species that were not eaten.

In conclusion, waterbuck prefers few succulent, nutritious grasses in early dry season and shifts to diverse herbaceous and woody vegetation with relatively high nutrient contents when the grasses dry up in the late dry season.

Recommendation

i. Control of the wild fires that might burn fallen seed pods of Acacias that were preferred by waterbuck late in the dry season.
ii. Mayas are critical sites that contain water and green fodder for the waterbuck and other herbivores. It is imperative to improve them and increase this water holding capacity.
iii. Observationtal and nutritional studies must be conducted during the rainy season in the park to know the seasonal variation in the activities, diet composition and national requirements.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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