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Hippotragus equinus (É. Geoffroy Saint-Hilaire, 1803) and *Kobus ellipsiprymnus defassa* (Rüppell, 1835) diet in semi-captivity in the urban park Bangr-Weoogo (Burkina Faso)

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We have performed a study on the diet of Roan antelope (*Hippotragus equinus*) and Defassa waterbuck (*Kobus ellipsiprymnus defassa*) from April to August 2006 in the urban park Bangr-Weoogo (Burkina Faso). The aim of this survey was to determine plant species that constitute the diets of these two animals in the park and to determine whether or not part of these diets was identical. To achieve this objective, we did a microscopic analysis of the faeces to find out which fragments of plants appear. Then, we compared these fragments to a selection of plants that we took from the survey area. Results from this research show that both Roan antelope and Defassa waterbuck have a diversified diet. The Roan antelope consumes 26 species of plants distributed into 18 families while the Defassa waterbuck integrate 14 species from 7 families in its diet. These diets are correlated to the food resources availability. Roan antelope preferably feeds on woody while Defassa waterbuck prefers woody plants as well as herbaceous but especially herbaceous in the wet season. The ability of these two species to segregate their diet following resources scarceness allows them to cohabit in the reduced space of zoological park in Bangr-Weoogo. Thus the two species could coexist (to an optimum level of resources) without thereby threatening the survival of either species.

Key words: Diet, *Hippotragus equinus*, *Kobus ellipsiprymnus defassa*, Bangr-Weoogo, Burkina Faso.

INTRODUCTION

Burkina Faso occupies a special place for wildlife conservation in West Africa. Contrary to other West Africa countries, big fauna is still relatively abundant and diversified. Protected areas now cover about 29,000 km^2 in Burkina Faso and represent 10.6% of the country (Cornelis et al., 2000). These areas devoted to the protection of natural and cultural resources (Vives-Aveling, 2001) constitute the latest refugees for biodiversity (Belemsobgo et al., 2010) and then contribute greatly to its protection and conservation. Conservation of these ecosystems helps maintain human populations and ensure some revenues. These revenues provided by hunting, tourism and various activities related to these resources, contribute to reducing poverty and improving

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the living conditions of the surrounding population.

However, many impacts from human activities stress communities and command for good management tools. Among stressors, we have high population growth that drives to constant search for new urban and agricultural spaces and significantly reducing natural spaces. Expansion of cotton cultivation, poaching, illegal grazing and deforestation lead to the degradation of protected areas. Animal and plant species disappear, endangering the natural heritage. Address this environmental problem requires detailed knowledge of the ecology of these animals and especially their diet. For example, to protect an animal species, to introduce it into a new environment, to recolonize former territory or to raise a species, it is essential to correctly know its diet and trophic relations. Indeed, feeding and trophic relations are the principal keys to sustainably living species in a particular environment.

The urban park Bangr-Weoogo, located in Ouagadougou, the capital city of Burkina Faso, houses a very diverse fauna and flora. It constitutes an ideal location for research. Despite the strong human pressure it faced with more than one million people around, this urban forest today still retains a significant floristic diversity (Gnoumou et al., 2008). The big important mammals in the park are *Hippotragus equinus*(É. Geoffroy Saint-Hilaire, 1803) and *Kobus ellipsiprymnus defassa* (Rüppell, 1835).

Hippotragus equinus and *Kobus ellipsiprymnus defassa* are endemic to Africa. *Hippotragus equinus* is one of the most common antelopes in West and Central Africa. Roan antelope is known in both savanna woodlands and grasslands of sub-Saharan Africa (Chardonnet & Crosmary, 2013). *Kobus ellipsiprymnus defassa* ranges widely throughout most of sub-Saharan Africa in savanna woodlands and forest-savanna mosaics. Waterbuck is a water-dependent species partial to scattered woodland and bush (Spinage, 2013).

Hippotragus equinus and *Kobus ellipsiprymnus defassa* are herbivores. And according to Jarman (1974) there are three groups of herbivores; the grazers whose diet consists for the most part by herbaceous; browsers whose diet mainly consists of wood; they consume the leaves, fruits, flowers and sometimes bark and roots; mixed-feeders for whom food selection is more about the parts (leaves, fruits, flowers, bark, roots) of ingested plants than on the species.

For Kingdon and Hoffmann (2013), *Hippotragus equinus* and *Kobus ellipsiprymnus defassa* are grazers. Is it the same for the two species in the urban park of Bangr-Weoogo where grasses are present only during the wet season? Thereby, this study will answer two main questions concerning the diet of the two species. What kind of herbivorous are the two species; grazers, browsers or mixed-feeders? Which diets do the plant species rely on? And finally, is there an overlap of the diet of the two species and a potential competition between the two species?

MATERIALS AND METHODS

Study site

The urban park Bangr-Weoogo (in Mooré language the name means "forest where you acquire knowledge") is located in the heart of the city of Ouagadougou. The urban park Bangr-Weoogo is between parallel 12°22'59, 4'' and 12° 23'01, 7'' of latitude north and between the meridians 1°30'10,00'' and 1°37'12,2'' of West longitude (Gnoumou et al., 2008).

The vegetation in the Bangr-Weoogo consists of native and exotic species and belong to the North-sudanian vegetation zone (Guinko, 1984). According to Belem (1997) and Gnoumou et al. (2008) flora in Bangr-Weoogo is constituted by above 327 to 337 species dominated by herbaceous (66.2 to 71 % of the species). The fauna consists of antelopes (roan antelope, waterbuck), crocodiles, turtles, monkeys, squirrels, lizards, bats and many species of birds. The hydrographic network consists of a river that goes through the park and receives waters from tributaries draining the city. The climate in Ouagadougou and Bangr-Weoogo area is characterized by a rainy season lasting from early June to late September and a dry season going from October to May. The maximum temperatures range from 34° to 41° C and minimum from 16° to 26° C.

The urban park Bangr-Weoogo covers an area of approximately 265 hectares (Koadima & Sarr, 2010). Before 1995, the park was subject to various degradations due to human impact. In 1995 a fence of 7.5 km and a checkpoint were built to renovate the park. The renovation provided some facilities. For example a botanical garden of 8 hectares; a zoological park; a museum; a sports park; a children's playground and space for relaxation and recreation was built.

Located between the botanical garden and playgrounds, the zoological park has a size of 72 ha (Figure 1). It is in the zoological park that the present study was conducted.

Data collection

To study the diets of the two species, we used the method of Butet (1985) which analyzes the content of the faeces. This method is based on the assumption that, we can found in the faeces of herbivorous fragments that are characteristic of consumed plants. Such fragments, constituted mainly by epidermis could be easily identified by comparison to a reference catalog of available plants epidermis. Thereby three steps are necessary to implement this method: constitution of the photographic reference atlas, the collection and treatment of faeces and the identification and recognition of plant species.

Elaboration of the photographic reference atlas

A core species was selected to make the photographic reference atlas. Species was selected according to their dominance in the flora (by literature) and according to grazing indices such as grazing impact on leaves/stem, footprints near the trees. 45 plant species belonging to 24 families were then selected. 33 are woody species belonging and 12 belong to herbaceous (Table 1).

Fresh leaves of selected species was collected, preserved in 70° alcohol, labeled and carried to the laboratory. Fragments of epidermis were obtained through mechanical separation. The epidermis is gently detached from the underlying tissue by scraping with a knife or a razor blade. The epidermis fragments obtained are left to soak in sodium hypochlorite (NaOCl) to destroy the cellular

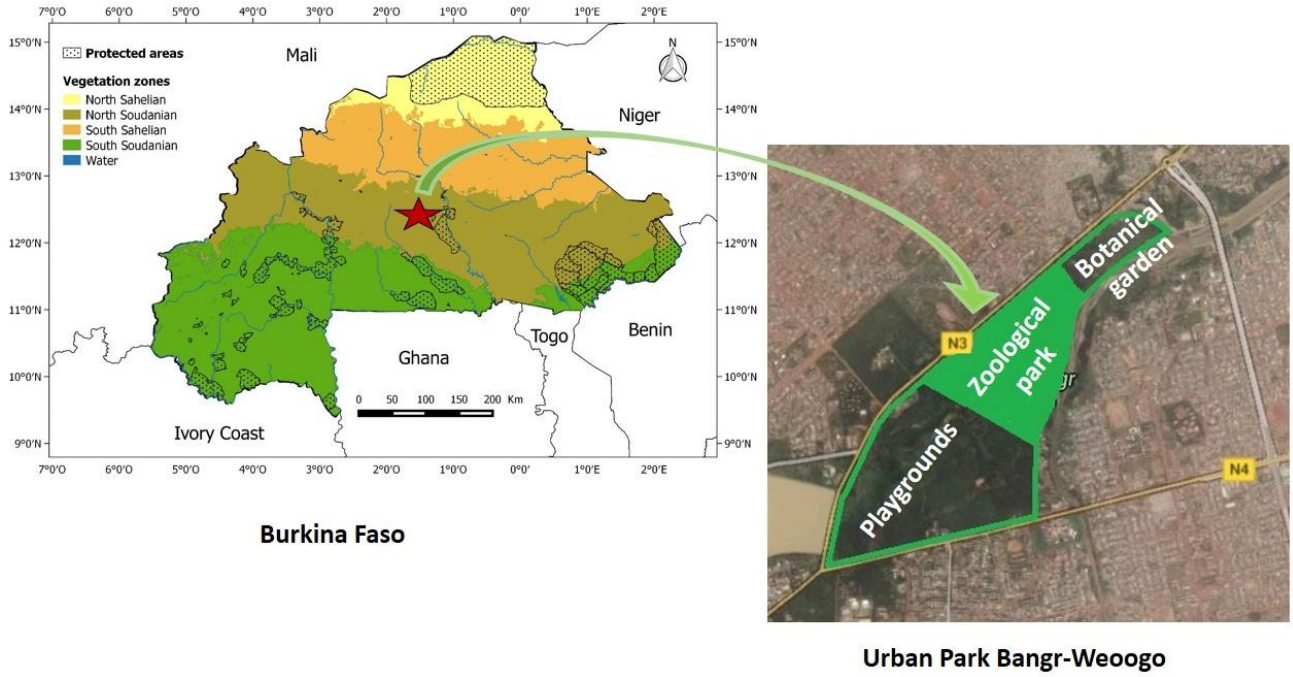

Figure 1. Location of the urban park Bangr-Weoogo.

components, leaving only the hard tissues. Thinned fragments were mounted between slide and cover slip in a drop of glycerol. After mounting, the photographs of epidermal structures, were performed using a digital camera. After this, each picture was rigorously labeled with the species name and the face of the epidermis. Following Butet (1987), we used epidermis of both face (inferior and superior) of plant leaves.

Faeces collection and processing

According to Lamarque (2014), Roan antelope (*H. equinus*) faeces have a length of about 1.5 to 2 cm. They are globular shaped and generally have a small point at the tip, when dry. Defassa waterbuck (*K. defassa*) faeces are spherical with about 1.5 cm diameter, and are often agglomerated together in the rainy season. Faeces of both species were collected every two weeks during 5 months (April to August) in the zoological park where animals are enclosed. Fresh droppings are then returned to the laboratory and dried in the open air on the paper. They are then crushed delicately in a mortar with a pestle, so that they are loosened more easily. The resulting fecal material is homogenized in a sodium hypochlorite (NaOCl) which allows to quickly get a good bleaching without destroying fragments. This is followed by a first filtering of the preparation with a 0.50 mm mesh sieve. Coarse particles are retained in the sieve while the bleach solution and small fragments are collected in a container. This first filtrate is again filtered through a sieve of 200 micron mesh. The filtrate collected contains fine particles of epidermis which will be mounted in a drop of glycerol, between slide and slip and observed under a light microscope.

Identification of plant species in the antelope's diets

Fragments found in the faeces are compared to the reference atlas. The main criteria for species determination are: orientation from nervations; shape, size and arrangement of the epidermis cells; the color and the thickness of the fragments; the inclusion bodies; structure, density, location and distribution of stomata and finally the presence of trichomes. These determinations were made under light microscope using the objectives 10 and 40.

Analysis of the results

Several parameters were calculated to characterize the two antelope's diets. First, plant diversity in the diets was evaluated using the species richness. According to Daget (1976), species richness is the number of species in a community. Here, it therefore represents the number of plant species in the diet to each animal. Relative abundance of each plant species was also evaluated. This abundance index (*pi*) was calculated as the Number of fragments of a given species divided by the Total number of fragments. The Shannon diversity index H' (Shannon, 1948) was also used to assess the diversity in the diet of each ungulate. It also give an estimation of the trophic niche width. The index is calculated following the relation below were *pi* is the proportion of the species *i* in the diet.

$H' = -\Sigma\, pi \log 2\, pi$

Diet overlap between the antelopes was estimated using the Schoener index (α). α is calculated using the formula above were *pxi* and *pyi* are the proportions of plant *i* respectively in the diet of the species x and y. *n* is the total number of species consumed by two animals. α varies from 0 to 1 (Schoener, 1970); α is equal to 0 when there is no overlap and α is equal to 1 when the overlap is total. According to Wallace (1981), when α is greater than 0.6, the overlap can lead to competition between the two species.

$$\alpha = 1 - 0{,}5\left(\sum_{i=1}^{n} \left| p_{xi} - p_{yi} \right|\right)$$

Table 1. List of plant species used for the photographic reference atlas.

Woody	
Family	**Species**
Anacardiaceae	*Lannea acida* A. Rich.
Arecaceae	*Borassus aethiopum* Mart.
Balanitaceae	*Balanites aegyptiaca* (l.) Del.
Bignoniaceae	*Stereospermum kunthianum* Cham.
Bombacacea	*Bombax costatum* Pell. et Vuill.
Caesalpiniaceae	*Cassia sieberiana* DC.
	Detarium microcarpum G. et Perr.
	Piliostigma thonningii (Sch.) Miln-Redh.
	Tamarindus indica L.
Capparidaceae	*Cadaba farinosa* Forsk.
	Capparis corymbosa Lam.
Celastraceae	*Maytenus senegalensis* (Lam.)
Combretaceae	*Combretum aculeatum* Vent.
Ebenaceae	*Diospyros mespiliformis* Hochst.
Euphorbiaceae	*Securinega virosa* (Roxb.) Baill.
Fabaceae	*Pterocarpus erinaceus* Poir.
	Lonchocarpus laxiflorus G. et Perr.
Loganiaceae	*Strychnos innocua* Del.
Mimosaceae	*Acacia dudgeoni* Craib.
	Acacia gourmaensis A. Chev.
	Acacia macrostachya Reich.
	Acacia seyal Del.
	Albizia chevalieri Harms.
	Dichrostachys cinerea (L.) Wight et Arn.
Olacaceae	*Ximenia americana* L.
Polygalaceae	*Securidaca longipeduncula* Fres.
Rubiaceae	*Feretia apodanthera* Del.
	Gardenia erubescens Stapf.
	Gardenia ternifolia K. Echum.
Rhamnaceae	*Ziziphus mauritiana* Lam.
Sterculiaceae	*Sterculia setigera* Del.
Tiliaceae	*Grewia bicolor* Juss.
	Grewia flavescens Juss.
Herbaceous	
Family	**Species**
Caesalpiniaceae	*Cassia nigricans* Vahl.
	Cassia tora L.
Cyperaceae	*Cyperus reduncus* Hochst.
	Fimbristylis sp
Malvaveae	*Hibiscus asper* Hook.
Poaceae	*Andropogon gayanus* Kunth.
	Brachiara jubata (Fig. & De Not.) Stapf.
	Pennisetum pedicellatum Trin.
	Setaria pumila (Poir.) Roem. & Scult.
	Sporobolus pyramidalis P. Beauv.
	Sporobolus sp
Sterculiaceae	*Wissadula amplissima* (L.) Fries

Table 2. List and proportions of plant species consumed by *Hippotragus equinus* in the urban park Bangr-Weoogo.

	Family	Species	Proportions (%)
Woody	Arecaceae	*Borassus aethiopum*	6.09
	Balanitaceae	*Balanites aegyptiaca*	1.12
	Bombacacea	*Bombax costatum*	0.79
	Caesalpiniaceae	*Piliostigma thonningii*	0.70
	Capparidaceae	*Cadaba farinosa*	2.60
		Capparis corymbosa	0.60
	Celastraceae	*Maytenus senegalensis*	1.58
	Combretaceae	*Combretum aculeatum*	1.21
	Ebenaceae	*Diospyros mespiliformis*	1.49
	Fabaceae	*Pterocarpus erinaceus*	1.25
	Mimosaceae	*Acacia dudgeoni*	5.44
		Acacia gourmaensis	2.56
		Albizia chevalieri	4.88
		Dichrostachys cinerea	18.40
	Olacaceae	*Ximenia americana*	0.05
	Rhamnaceae	*Ziziphus mauritiana*	0.60
	Rubiaceae	*Gardenia* sp	4.04
	Tiliaceae	*Grewia* sp	9.48
	Unidentified woody		26.30
Herbaceous	Caesalpiniaceae	*Cassia nigricans*	1.21
		Cassia tora	1.67
	Cyperaceae	*Cyperus reduncus*	2.23
		Fimbristylis sp	0.37
	Poaceae	*Brachiara jubata*	0.19
		Pennisetum pedicellatum	3.02
		Sporobolus sp	0.93
	Sterculiaceae	*Wissadula amplissima*	0.56
	Unidentified herbaceous		0.65

RESULTS

Hippotragus equinus diet

In the zoological park inside the urban park Bangr-Weoogo, *H. equinus* consumes 26 plant species belonging to 18 families (Table 2). Among the 26 species, 18 are woody species and belong to 14 families. The 8 other species that belong to 4 families are herbaceous. Woody and herbaceous species represent respectively 89.17 and 10.83% of the diet of *H. equinus*. Mimosaceae (31.27%) are the most important family in the diet of *H. equinus*. There are followed by Tiliaceae and Arecaceae that represent respectively 9.48 and 6.09% of the fragments in the diet of *H. equinus*. Proportion of herbaceous in the diet of this species show a little decrease from April to June (the last period of the dry season) and some significant increase from June to august (during the rainy season) (Figure 2). The Shannon diversity index H', in Table 3 varies between 2 and 4. H' values are higher in the rainy period than the dry one. These value are indicator of medium diversity in the species diet.

Kobus ellipsiprymnus defassa diet

Defassa waterbuck consumes 14 plant species belonging to 7 families. We distinguish 7 species belonging to 3 woody families and 7 species belonging to 4 herbaceous families (Table 4). Woody species represent 63.96% of the diet of *K. defassa* and herbaceous represent 36.04%. Mimosaceae (4 species) which are woody represents 27.25% of *K. defassa* diet. Poaceae (3 species) and Cyperaceae (2 species) which are herbaceous represent respectively 18.02% and 12.95% of the fragments. In April and May, grasses are less important in *K. defasa* diet. From June its consumption of herbaceous increases greatly (Figure 3). It consumes more wood in dry periods and herbaceous wet period. *Kobus defassa* is a mixed consumer. The Shannon diversity index H' is between 2 and 4, with the exception of April (Table 3). It increases

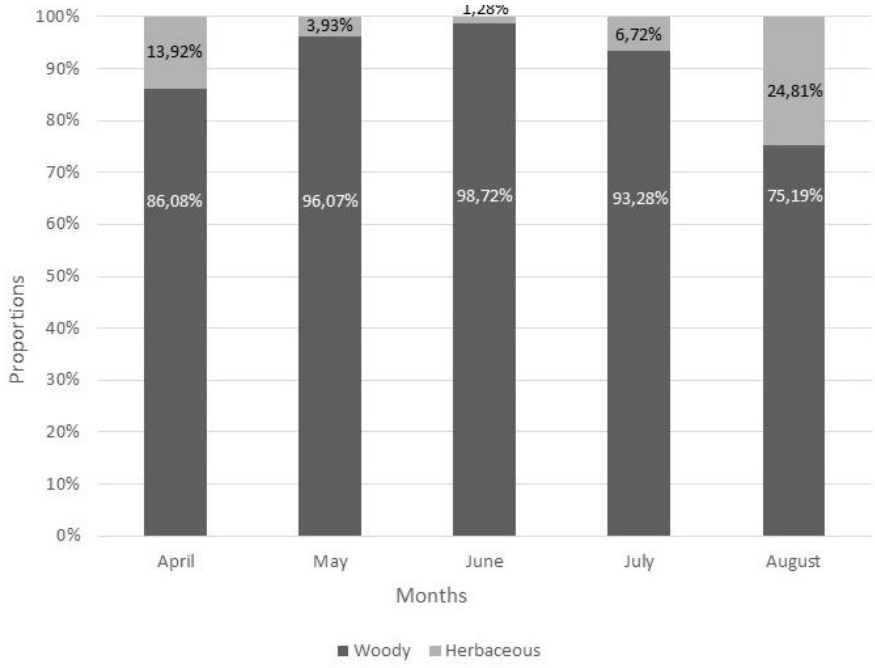

Figure 2. Proportion of woody and herbaceous species found in the faeces of *Hippotragus equinus.*

Table 3. The Shannon and Schoener index for *Hippotragus equinus* and *Kobus ellipsiprymnus defassa.*

Index	April	May	June	July	August	Mean
Index of Shannon H' (*Hippotragus equinus)*	2.87	2.63	2.96	3.35	3.19	**3.69**
Index of Shannon H' (*Kobus ellipsiprymnus defassa)*	1	2.44	2.92	3.03	3.07	**3.39**
Index of Schoener (α)	0.43	0.49	0.46	0.5	0.5	**0.5**

from April to August. The diversity of *K. defassa* food space is a little bit smaller than those of *H. equinus*. It increase over the months from April to August.

Diet overlap

The overlap index during the dry period (0.4) is different from that obtained during the wet period (0.5) (Table 3). The overlap is more important in the wet season than the dry period. For each month and for the entire study period, α is less than 0.6. Figure 4 shows the distribution of resources between the two ungulates. Even if, almost all species consumed by *K. defassa* are include in the diet of *H. equinus* (Table 5), the two species do not forage on the available resources with the same preferences. *Hippotragus equinus* prefers woody species whereas *K. defassa* prefers herbaceous.

DISCUSSION

Successively in 1995 and 2002, N'Do (1995) and Dibloni (2002) described the diet of *H. equinus* in the Nazinga ranch (Burkina Faso) by observing the rumen content. Dibloni (2002) found 15 plant species in the rumen; composed by 10 woody species and 5 grasses species. N'Do (1995) has observed 19 woody species and 4 herbaceous. Whereas these finding, in line with this study, confirms the preference of *H. equinus* for woody species, it highlight the fact faeces analyses can give good result. In fact, in this study we found largely more species in the faeces analyses than the two authors. On this basis, we can conclude that *H. equinus* are browsers. However, Cerling et al. (2003) and Codron et al. (2007), after doing carbon isotope analysis, found that *H. equinus* respectively from the East African national parks and reserves, and the Kruger National Park in South Africa rely on C4 plant (grass) for its diet. Same finding was reported by Ayegnon (2004) that descript this species as a grazer in the W park based on faeces analysis. According to Yameogo (2005), *H. equinus* from the Nazinga game Ranch is mixed consumer. So, as stated by Codron et al. (2007) these variations can be accounted for by seasonal and/or regional dietary

Table 4. List and proportions of plant species consumed by *Kobus ellipsiprymnus defassa* in the urban park Bangr-Weoogo.

Plant species	Family	Species	Proportions (%)
Woody	Mimosaceae	*Acacia dudgeoni*	2.03
		Acacia gourmaensis	1.46
		Albizia chevalieri	10.36
		Dichrostachys cinerea	13.40
	Rubiaceae	*Ferethia apodanthera*	2.25
		Gardenia sp	6.64
	Tiliaceae	*Grewia* sp	4.39
	Unidentified woody		23.42
Herbaceous	Poaceae	*Andropogon gayanus*	11.37
		Brachiara jubata	0.23
		Pennicetum pedicelatum	6.42
	Caesalpiniaceae	*Cassia nigricans*	0.45
	Cyperaceae	*Cyperus reduncus*	10.02
		Fimbristylis sp	2.93
	Sterculiaceae	*Wissadula amplissima*	1.24
	Unidentified herbaceous		3.38

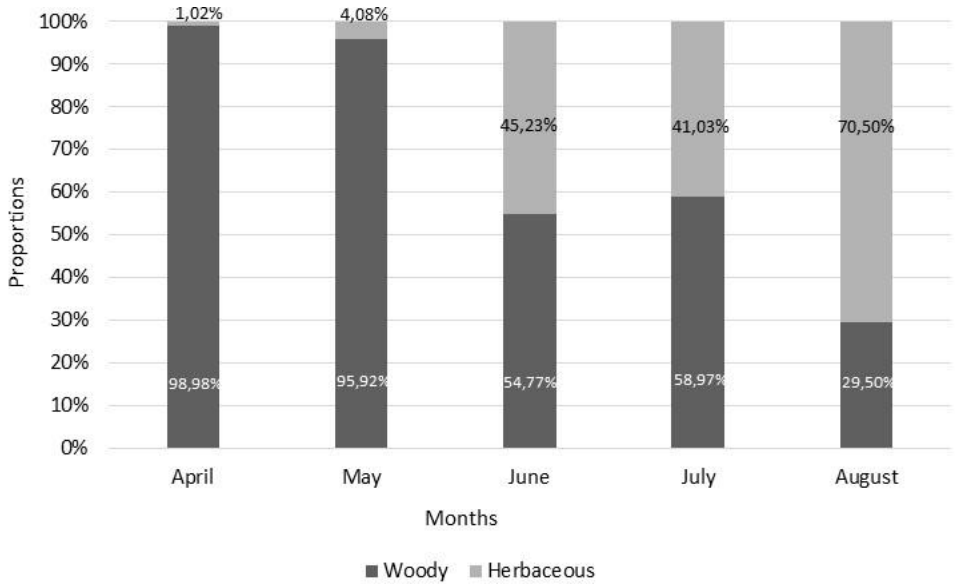

Figure 3. Proportion of woody and herbaceous species found in the faeces of *Kobus ellipsiprymnus defassa*

differences, probably liked to food availability and potential completion. Woody species importance in the diet of *H. equinus* in Bangr-Weoogo is surely related to plant availability. Indeed, in this park grasses availability is very low in the dry season. So, according to the optimal foraging theory (Emlen, 1966, MacArthur, 1966 and Charnov, 1976), *H. equinus* will shift from grasses to the most profitable resources which is the woody species. In the wet season as the grasses became more and more available it increases its consumption of herbaceous. Lamarque (2004) corroborates this hypotheses as he showed that *H. equinus* feeding depends on habitat; grazer in grassland, it essentially becomes browser in woodland.

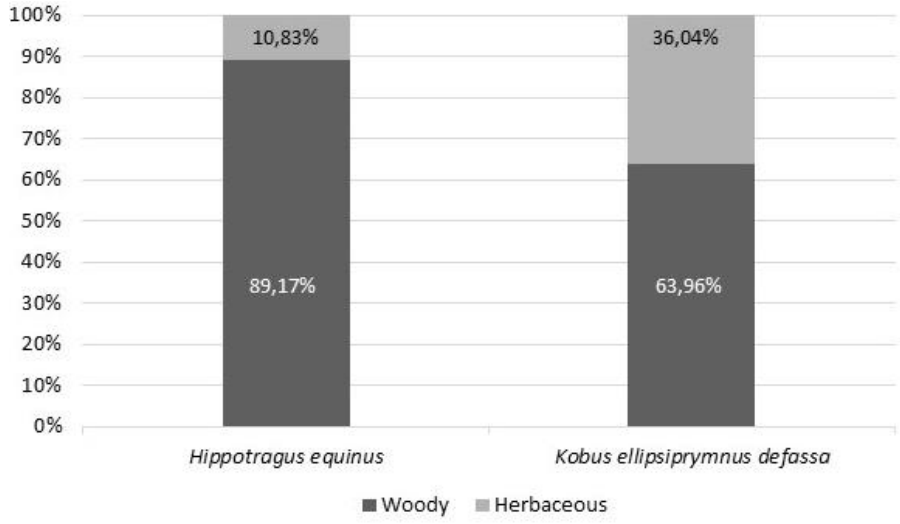

Figure 4. Proportion of plant species found in the faeces of *Hippotragus equinus* and *Kobus ellipsiprymnus defassa*

Table 5. List and proportions of plant species consumed by both *Hippotragus equinus* and *Kobus ellipsiprymnus defassa* in the urban park Bangr-Weoogo.

Plant species	Family	Species	*Hippotragus equinus* (%)	*Kobus ellipsiprymnus defassa* (%)
Woody	Mimosaceae	*Acacia dudgeoni*	5.44	2.03
		Acacia gourmaensis	2.56	1.46
		Albizia chevalieri	4.88	10.36
		Dichrostachys cinerea	18.40	13.40
	Rubiaceae	*Gardenia sp*	4.04	6.64
	Tiliaceae	*Grewia sp*	9.48	4.39
Herbaceous	Caesalpiniaceae	*Cassia nigricans*	1.21	0.45
	Cyperaceae	*Cyperus reduncus*	2.23	10.02
		Fimbristylis sp	0.37	2.93
	Poaceae	*Brachiara jubata*	0.19	0.23
		Pennisetum pedicellatum	3.02	6.42
	Sterculiaceae	*Wissadula amplissima*	0.56	1.24
Total			52.37	59.57

As we found in this study, Ayegnon (2004) reported an important contribution of *Acacias* to the diet of *K. defassa*. *Kobus defassa,* which is a water subservient animal, prefers fresh vegetation. In wet season, it forages mostly on herbaceous as reported by Kassa et al. (2007). The low availably of fresh herbaceous in the dry season leads to a shift from herbaceous to woody plant, in the diet of this species. Like *H. equinus*, *K. defassa* is then a grazer as reported by Larmarque (2004), Yameogo (2005), Codron et al. (2007) and Kassa et al. (2007); it is able to adapt to the available resources and shifts from grazer diet to browsers diet (Kassa et al., 2007), through a mixed feeder diet (Ayegnon, 2004), according to resources availability.

The ability of these species to expend or adapt their diet is highlighted by the diversity measures. The trophic niches are then more important in the rainy season as food availably increases. Globally, antelopes trophic niche is relatively narrow in the Bangr-Weoogo park compared to the funding of Ayegnon (2004) (H' is above 4.63). These low values are due in large part to the narrow range of the zoological park (72 ha).

Diets overlaps are in the same range as reported by Prins et al. (2006) in the southern Mozambique. In the Bangr-Weoogo park, diet overlap decreases from the dry season to the rainy season. Same result was reported by Schuette et al. (1998) concerning the diet of *Alcelaphus buselaphus* and roan antelope (*H. equinus*). According to Wallace (1981), these values (below 0.6) cannot be regarded as an indicator of likely competition between the

two species. Definitely potential completion between the two species can be refuted, according to Pusey and Bradshaw (1996) and Matthews (1998) who affirm that diet overlap is indicator of completion only if the overlap increase when the resources availability decrease. In the rainy season food is available and accessible to all, then each species forage on the most profitable energy source, as we progress in the dry season food became less available, diets of the two antelopes diverged in order to avoid potential competition.

Conclusion

The diets of *Hippotragus equinus* and *Kobus defassa* in Bangr-Weogo are diversified. From dry season to rainy season, more species are integrated in the diet, leading to an increase of resources breadth. The two species can be seen as grazers that are able to adapt to the coarse conditions in Bangr-Weoogo (especially in the dry season) by shifting to woody species. Despite this situation, the ability of these two species to segregate their diet following resources scarceness allows them to cohabit in this reduced space. Thus the two species could coexist (to an optimum level of resources) without thereby threatening the survival of either species.

Conflict of Interests

The authors have not declared any conflict of interests.

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