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International Journal of Biodiversity and Conservation

Full Length Research Paper

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

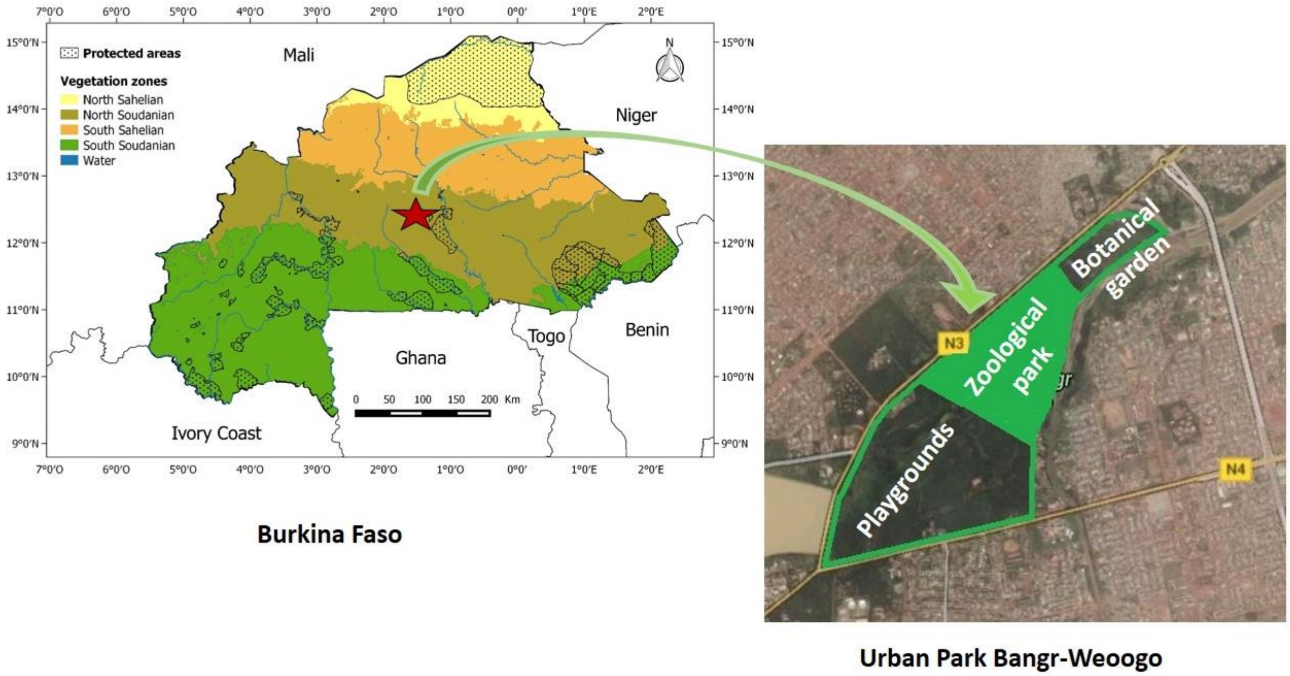

Figure 1. Location of the urban park Bangr-Weoogo.

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.

$$H' = -\Sigma\, p_i \log_2 p_i$$

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* (I.) 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

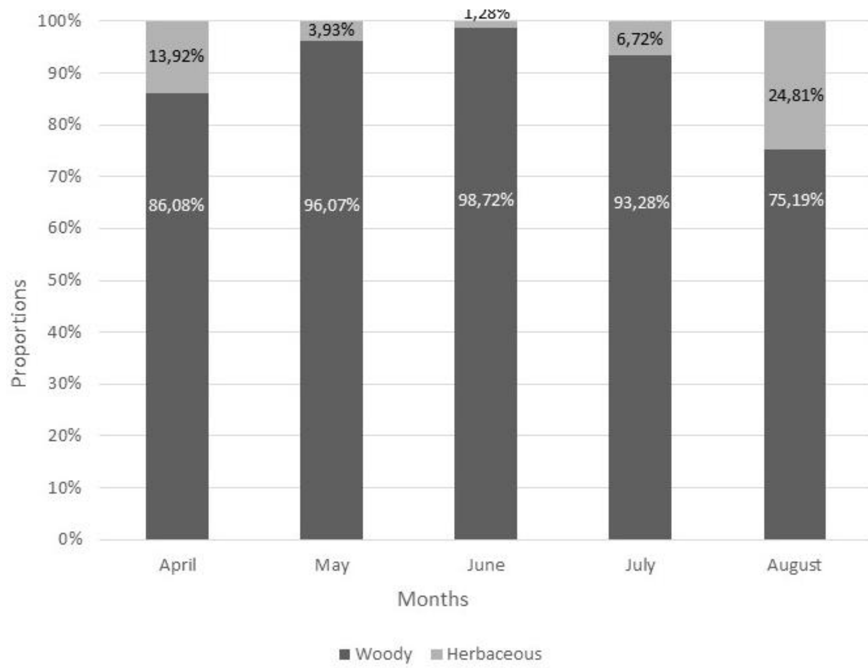

Figure 2. Proportion of woody and herbaceous species found in the faeces of *Hippotragus equinus.*

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

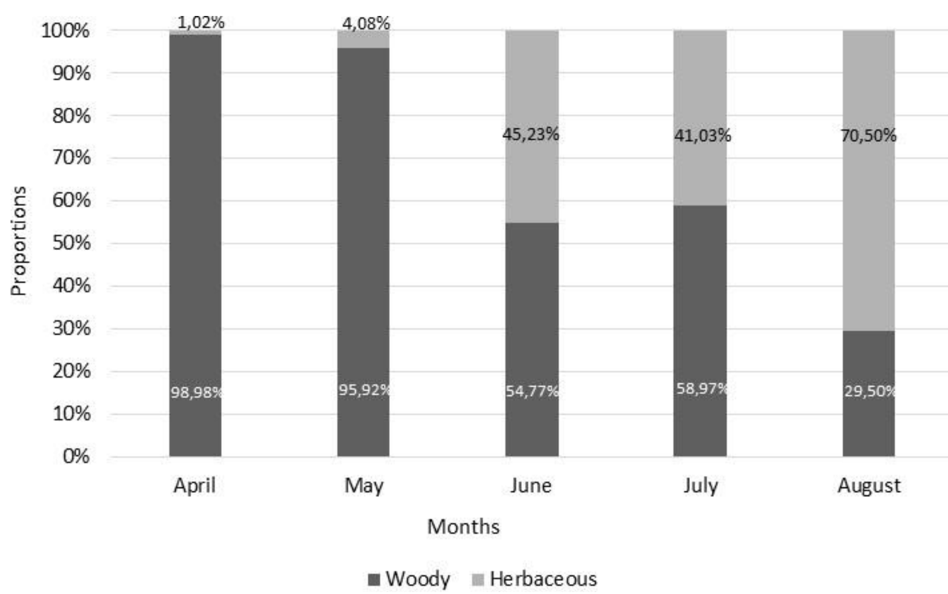

Figure 3. Proportion of woody and herbaceous species found in the faeces of *Kobus ellipsiprymnus defassa*

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.

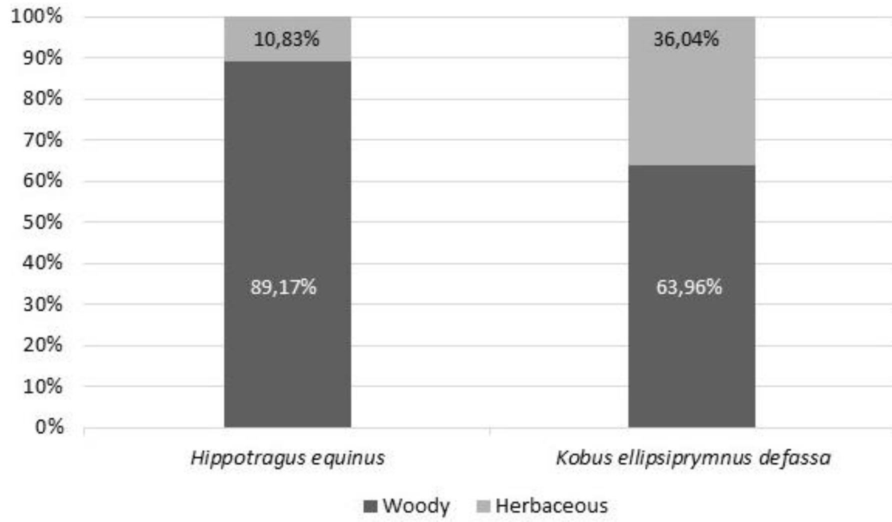

Figure 4. Proportion of plant species found in the faeces of *Hippotragus equinus* and *Kobus ellipsiprymnus defassa*

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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How does the cost of raid influence tolerance and support of local communities for a wildlife reserve?

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This study was carried out to investigate local people's tolerance to wildlife raids. This was done by estimating costs of raids and interviewing affected communities around Mole National Park in Ghana. Multiple regression was done to predict local people's tolerance. Results revealed there was loss of tolerance with time mainly due to the effect of cost of raid acting in synergy with the number of farmers affected. It also raised suspicions that other factors, possibly including mistrust, account for loss of tolerance. Plans for management-community collaboration should be reviewed recognizing the local people's views, concerns, and needs, addressing also the area of mistrust, if any, and proposing some long-term and tangible benefits for government implementation and donor support at fringe communities. Evidence from this study suggests that review measures need expedited action because tolerance reduces as time progresses.

Key words: Crop raids, multiple regression, tolerance, local people, wildlife reserve, elephant.

INTRODUCTION

For large-bodied mammals living in biodiversity-rich tropics, mitigating human-wildlife conflicts (HWC) is a conservation priority. These conflicts have been widely documented in each tropical continent and involve problem animals such as elephants (*Loxodonta africana)* that raid crops in Kenya (Sitati et al., 2003; Chiyo et al., 2011) and Ghana (Monney et al., 2010), leopards (*Panthera pardus*) that kill livestock in Pakistan (Dar et al., 2009) and jaguars (*Panthera onca*) that attack humans in Brazil (Zimmermann et al., 2005). If solutions to alleviate the negative impacts of wildlife, notably elephants, are not found, persistent raiding of crops may compromise their conservation (Chiyo and Cochrane, 2005), like in many societies, where traditional farmers self-compensate for losses of human wildlife conflict by hunting and consuming the animals.

Mammals continue to be under pressure from high human population densities and as expanding human populations compete with these mammals for habitat, the future of mammal populations may soon depend entirely on protected areas (Barnes, 1999). On the other hand, as wildlife competes with humans for resources, mainly crops and livestock, mammal populations may also depend on the extent of farmers' co-operation and

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and vigilance, and the economic and social sacrifices involved in living next to a wildlife protected area.

Human communities are located adjacent to wildlife reserves, and interactions often have adverse effects on humans as well as wildlife, particularly when they compete for resources (Conover, 2002). Many wildlife species raid crops and livestock for food and cause considerable damage with corresponding impacts on community livelihoods. It is the same local communities whose livelihoods are directly or indirectly affected by the establishment and conservation of these wildlife reserves (Hens, 2006; Abbot et al., 2001). In addition, some forms of restrictions of access to resources from the reserves are put on members of the local communities (Bergseng and Vatn, 2009). Ironically, in most developing countries, the local communities who are affected by these restrictions are generally poor (Das Kanti, 2005) and so attempts by farmers to protect their crops from raids by wildlife from reserves may be relatively costly in terms of time and resources, and are often limited in effect. It may involve strategic barriers, buffers, and/or improving the efficacy of guarding, deterrents, and repellents (Conover, 2002); the costs of all these may also reduce local people's tolerance to wildlife and support for conservation programmes.

Ensuring farmers' livelihoods and food security through reduction of human-wildlife conflict is an internationally agreed goal (Parker et al., 2007) and conservation managers today are required to tackle this complex issue in collaboration with communities in order to achieve conservation objectives (Parker et al., 2007). To avert the current biodiversity extinction crisis, conservation practitioners require a clear understanding of the prevailing threats and the strategies to mitigate them. Whilst the threats are usually known and primarily relate to the competition between humans and biodiversity for limited space and resources (Sodhi et al., 2009), the recent calls for evidence-based conservation indicate that the appropriate solutions are not yet fully known (Sutherland et al., 2004; Ferraro and Pattanayak, 2006).

Conservation and development are linked and so can protected areas provide development opportunities for communities (Furze et al., 1996). In the developing world, increased concern over the burden that conservation often places on local communities has led to efforts to incorporate development goals into conservation practices (Hulme and Murphree, 2001). The coalescing of development and conservation gave rise to community-based conservation or community-based natural resource management (CBNRM), a participatory model which has provided the opportunity for conservation to produce tangible benefits for rural development (Wells et al., 1992; Munasinghe and McNeely, 1994; Western and Wright, 1994; Steiner and Rihoy, 1995; Brechin et al., 2002). In Ghana, the introduction of community-based conservation programs such as the Community Resource Management Areas (CREMAs) and Community Based Tourism (CBT) ventures is an effort to gain local support for conservation through participatory management and benefit-sharing.

Given the recurring nature of conflict between conservation and local communities, it is critical that conservationists better understand local views with respect to wildlife and protected areas, particularly the cost of living next to a wildlife protected area, the sacrifices of accepting the establishment of a protected area and their readiness to tolerate raid emergencies. Unfortunately, no study has quantified losses of crops and livestock in terms of cash around the Mole National Park (MNP) and therefore the threshold to which communities can sacrifice and tolerate raids remains unknown. An important first step is to determine how much losses in cash are suffered every year through crop and livestock raids, and how this has affected collaboration with the local people, which is the basis of this study. From this, appropriate and, where necessary, alternative conservation intervention measures could be developed to serve as guidelines for outlining strategies for successful management schemes that may eventually lead to the improvement of livelihoods for the many households.

MATERIALS AND METHODS

Study area

The MNP (Figure 1) lies between 9° 11' and 10° 10' N and between 1° 22' and 2° 13' W; it covers a land area of about 4,840 km^2 as Ghana's largest wildlife refuge. The park is located in Northwest Ghana on grassland savanna and riparian ecosystems at an elevation of 150 m, with sharp escarpment forming the southern boundary of the park. The park's lands were initially set aside as a wildlife refuge in 1958, and later designated a National Park in 1971 after the small human population of the area was relocated.

Tree species of the park include *Burkea africana* (an important tropical hardwood), *Isoberlinia doka*, and *Butyrospernum paradoxum* (shea butter tree), which is important medicinally to treat infectious diseases. The savanna grasses are somewhat low in diversity, but known species include spike sedge, *Kyllinga echinata*, *Ancilema setiferum,* two endemic members of the Asclepiadaceae subfamily, the vine *Gongronema obscurum*, and the edible geophyte, *Raphionacme vignei.* The park is home to over 93 mammal species, and the large mammals of the park include the savanna elephant (*Loxodonta africana africana*), hippopotamus (*Hippopotamus amphibius*) and African buffalo (*Syncerus caffer*), which provide the park with a great potential for tourism and boost livelihood of the local people. Elephant (Blanc, 2008) and hippopotamus (Lewison and Oliver, 2008) are listed as vulnerable in IUCN's conservation status red list, but the buffalo is listed as least concern (IUCN, 2008). Thirty-three species of reptiles and 344 bird species have been listed. To ensure effective management, the park is divided into four ranges, namely, Bawena, Dusie, Headquarters, and Jang (Figure 2). Patrol staff are deployed to patrol from each range camp. The park is bordered by 33 communities, with a total estimated population of about 35,000. Most of these communities are poorly accessible and depend

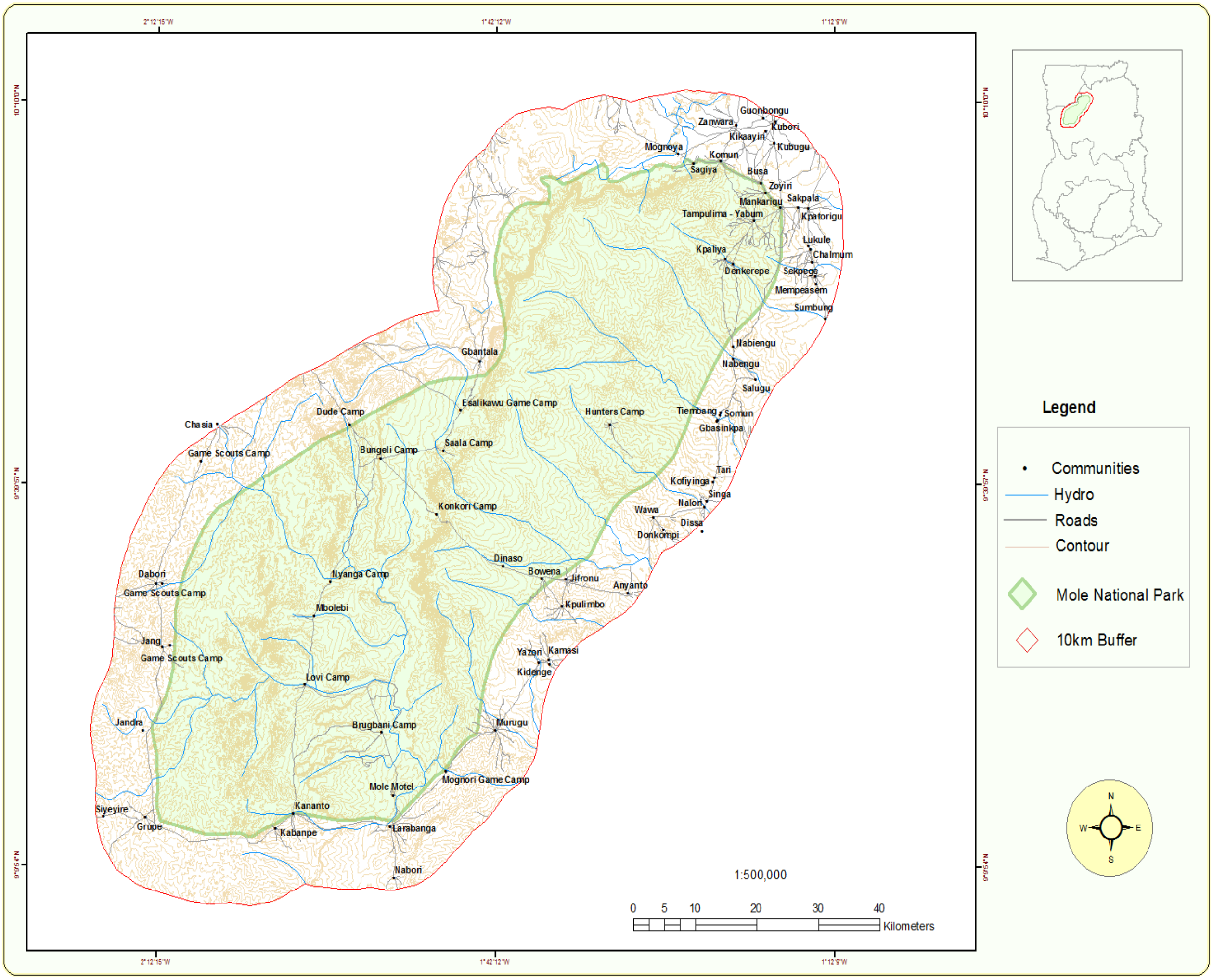

Figure 1. Topo map showing Mole National Park (as an inset from Ghana map) and some communities (around it) and patrol camps (inside).

almost entirely on the natural resource base for food and income. Virtually, all farming activities are concentrated in the rainy season between May and October and crops like cassava (*Manihot esculenta*), yam (*Dioscorea* species), maize (*Zea mays*), rice (*Oryza sativa*) groundnut (*Arachis hypogea*), cowpea (*Vigna unguiculata*), guinea corn (*Sorghum bicolor)* and millet (*Urochloa ramosa*) are commonly cultivated. Also, guinea fowls (*Numida meleagris*), domestic fowls (*Gallus* species), goats (*Capra hircus*), sheep (*Ovis aries*) and cattle (*Bos primingenious*) are the main livestock reared in the communities around MNP.

Data collection

Crops and livestock raids and estimated cost

Crops and livestock raid activities of mammals from MNP were monitored from 2005 to 2012 from communities that fringe the park. Data were obtained through reports from Community Resource Management Committees in collaboration with the park's staff. Data for the 8-year period included species of animals that raided, their numbers and type of crop or livestock they raided, size of surface area raided, season and time of raids, the community and range in which raids occurred, estimated population of raided communities, nearest distance of communities where questionnaires were administered (including raided and non-raided communities) to the park's boundary and shortest distance from raid occurrence to the park's boundary.

Estimated population of the communities were obtained from Ghana Statistical Services. GPS coordinates were taken at sites where raid incidences occurred and at the centre of each raided community. The mean distances of raid occurrence and distance of communities from the park's boundaries were calculated using the nearest-features extension in ArcGIS (v9.3), based on GPS coordinates of the raid occurrence. Geospatial data on the park's boundaries were obtained from the Centre for Remote Sensing and Geographic Information Systems (CERSGIS), Accra. Costs of destroyed crops and livestock were estimated. In the case of seed crops, cost of crops per acre was calculated as the number of maximum-size bags of seeds obtainable from a hectare of farm

Figure 2. Map of Mole National Park showing the four ranges.

multiplied by the unit cost of bag. In the case of tubers, cost of yam (*Dioscorea* species) was calculated as the average number of 100 tubers that can be obtained from a hectare of a farm multiplied by the unit price; unit price of yam calculated from the cost of 100 tubers of yam. Cassava (*Manihot esculenta*) is priced in terms of a full load of a maximum-size sac and the unit price multiplied by the number of sacs obtainable from a hectare of farm gives an estimate of loss per hectare. Unit prices of one bag of a seed of a crop, 100 tubers of yam, and a sac load of cassava were obtained from the District Agricultural Extension Office of the area of study.

Interviews

Structured questionnaires requiring "yes" or "no" answers were administered in the affected communities. The questions were designed to seek the views of the local people on their levels of acceptance for the National Park by allowing management regulations to prevail to protect wildlife (acceptance) and tolerance to the raids made by wildlife from the National Park irrespective of the attendant problems (tolerance). This was necessary to find out whether attitudes of the local people to the protected area were changing over a time span from 2005 when the study began to 2012 in the face of financial losses to farmers through crop raids by wildlife. 50% of the questions were intended to test the respondents on their acceptance and 50% on their tolerance. Each question was carefully designed in such a way that if a "yes" or "no" response was chosen it would always indicate a positive or negative tolerance, or a positive or negative acceptance, and each question was weighted in such a way that the percentage tolerance or acceptance could be calculated on a 100-scale for each respondent. The questionnaires were administered once every year by wildlife students from the University of Cape Coast. It was assumed that the results reflected the views of the local people throughout the year irrespective of which month they were interviewed. In each community, only heads of 20 households were interviewed. Households selected included those who had been affected by wildlife raids before; and if they were not up to 20, the rest were

Table 1. Pearson's regression correlation and significance (N= 96) between the variables used in the model.

Correlation	Tolerance	Frequency of raids	Estimated cost	Farmers affected	Acceptance	Period
Tolerance	1.000	-0.413**	-0.442**	-0.320**	-0.050	-0.945**
Frequency of raids	-0.413**	1.000	0.972**	0.907**	0.027	0.450**
Estimated Cost	-0.442**	0.972**	1.000	0.892**	0.004	0.472**
Farmers affected	-0.320**	0.907**	0.892**	1.000	0.018	0.367**
Acceptance	-0.050	0.027	0.004	0.018	1.000	-0.128
Period	-0.945**	0.450**	0.472**	0.367**	-0.128	1.000

**Correlation is significant at the 0.01 level (two-tailed).

chosen randomly. The average percentages of responses indicating acceptance or tolerance were calculated for each year.

Analyses of data

Using MINITAB (v14), differences in seasonal raid occurrences (rainy or dry) and time of day (day or night) were tested by chi-square to find out whether they were due to chance or other factors. Correlation between the number of a particular species of animal that raided and the distance of raid occurrence from the park's boundaries was analyzed with MINITAB (v14). Spearman's rho was preferred for not requiring to be represented by a linear relationship (Myers and Well, 2003). The inferential Levene's test of homoscedasticity (Zar, 2010) was used to ascertain if variances were equal for events around all the four ranges and Welch's F-test which does not require equal variances (Welch, 1951; Field, 2009) was used to analyze the significance of the differences in variance.

Multiple regression

In order to ascertain how decisions of the local people were influenced, multiple regressions were carried out in SPSS v17.0 using the enter method. This was preferred to the stepwise methods (forwards, backwards and stepwise), because there is sound theoretical literature on which to base the model, precluding the need to rely on the computer to select variables based on mathematical criteria (Field, 2009; Groom and Harris, 2009). In addition, this method consistently produced the best model with regard to several different criteria (Groom and Harris, 2009). 'Level of communities' tolerance for wildlife' was entered as the dependent variable (outcome) and six other variables, namely, 'Years of study', 'period of time since the study began in 2005', 'estimated cost of raid', 'frequency of raids', 'number of farmers affected' and 'level of communities' acceptance of the National Park' specified hierarchically as the independent variables (predictors) in the second block; the first block specified by either 'period of time since study began in 2005', 'estimated cost of raid' or 'level of communities' acceptance of the National Park' in turns for three separate outputs.

Assumptions of regression were checked to ensure that the model generalizes beyond the sample (Field, 2009). Variance inflation factor (VIF), tolerance (1/VIF) and eigenvalues were calculated to check the assumption of no perfect multicollinearity between predictors (Field, 2009). Assumptions of linearity, normality and homoscedasticity were ascertained by a histogram and a normal Q-Q probability plot. The case summaries of the final models (including Mahalanobis distances, Cook's distance values, Leverage values and DFBeta values) were examined to ensure there were no individual points which were having an especially strong influence on the model (Groom and Harris, 2009; Field, 2009).

The output of graph data by SPSS's chart builder indicated a perfect collinearity between "Years of study" and "Period of time". Collinearity was also observed between "Years of study" and "Number of farmers affected" and between "Cost of raids" and "Frequency of raids". The regression correlation was significant in each of these pairings (Table 1). Collinearity issues made it necessary to remove "Years of study", "Number of farmers affected" and "Frequency of raids". Only one of "Years of study" and "Period of time" would be useful in this model and the "Period of time" was preferred for being enough as a continuous variable. Also, "Cost of raids" was preferred to "Number of farmers affected" because eigenvalues suggested "Number of farmers affected" appeared to be either co-linear with some other variables or non-linear enough for a linear regression model. The final model thus has "Period of time", "Cost of raids" and "Level of communities' acceptance" as the predictors.

RESULTS

Crops and livestock raids and estimated costs

The study recorded 239 raids over the eight-year period of study. These included 225 crop raids and 14 livestock raids (Table 2). All the crop raids reported were solely elephant activities that destroyed yam, cassava, plantain, maize, rice, guinea corn, groundnuts, millet and cowpea, and these occurred around all the four ranges, though raids occurred more frequently around the headquarters than the other ranges of the park (Figure 3). Larabanga community recorded the highest of 31.6% of all the crop raids followed by Mognori with 20.4%, Murugu 12.9%, Dusie 12.4%, Chasia 12%, and the other communities, namely, Jinfronu, Jang and Jentilpe altogether recording 10.6% with raids occurring only once at Jang and Jentilpe communities (Table 2). Livestock were raided fourteen times by leopards and hyenas in only two communities, Kananto (three times) and Mognori (11 times), both around the headquarters range, and only goats were casualties in all these raids.

The most frequently raided crops were yam and cassava which were raided 105 and 76 times, respectively

Table 2. Communities around the park where questionnaires were administered, their population estimates and distance (km) from the park.

Range	Community	Population	Distance from boundary (km)	Raid events	
				Crops	Livestock
Bawena	Jinfronu	450	8	1	-
	Bawena	1350	5	-	-
	Kpulumbo	320	8	-	-
	Gurubagu	500	2.6	6	-
	Yazori	200	9.2	-	-
Dusie	Chasia	1350	9.9	24	-
	Belepong	690	75.3	-	-
	Grumbelle	770	8.8	-	-
	Holomoni	510	8.3	-	-
	Dusie	1,580	10.8	25	-
Headquarters	Nabori	950	6.3	-	-
	Yepala	1230	27.9	-	-
	Kabampe	640	1.3	-	-
	Mognore	600	1.2	46	11
	Seiyiri	570	34.7	-	-
	Larabanga	2700	0.7	71	-
	Kananto	850	0.8	15	3
	Grupe	780	61	-	-
	Murugu	1060	2.4	29	-
	Nasoyiri	620	50.2	-	-
Jang	Dabori	305	4.4	-	-
	Jang	715	1.4	1	-
	Kong	2300	10.9	-	-
	Jelinkon	2630	15.1	-	-
	Jentilpe	1000	16.2	7	-

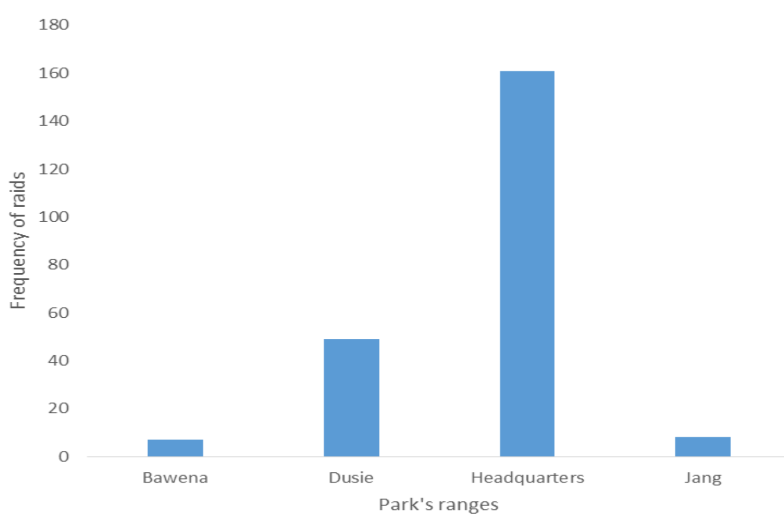

Figure 3. Crop raid frequencies around the Park's ranges.

Table 3. Estimated cost of crops raided from 2005 to 2012.

Crop	Raid frequency	Estimated raid coverage (in hectares)	Estimated cost per hectare	Total estimated cost in Cedis (¢)	Annual loss (¢)	Percentage annual loss
Yam	105	39	3,600	140,400	17,550.00	56.3
Cassava	76	28.2	3,000	84,660	10,582.50	33.9
Guinea corn	11	4.1	1,200	4,942	617.75	2.0
Maize	19	8.7	1,200	10,430	1,303.75	4.2
Rice	3	1.2	2,160	2,592	324.00	1.0
Millet	2	0.8	1,200	960	120.00	0.4
Cowpea	2	0.8	2,000	1,600	200.00	0.6
Plantain	4	1.6	500	800	100.00	0.3
Groundnut	3	1.3	2,400	3,120	390.00	1.3
Total	225	85.7	-	249,514	31,188.00	-

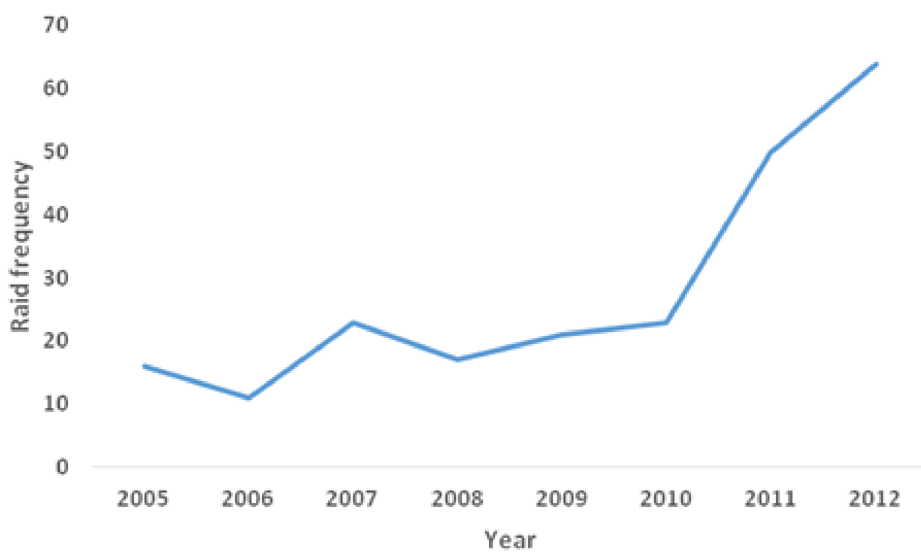

Figure 4. Trend of crop raid frequency from 2005-2012.

around the park. Maize followed with 19 times, guinea corn 11 times, and each of the other five crops was raided less than ten times (Table 3). Even though the trend of raid showed an initial discrepancy and was unpredictable from 2005 to 2008, raids have been predictable and increasing from 2008, and very steeply in the last two years of the study (Figure 4); 2012 recorded the highest of at least three raids per month on average, showing an average increase of 1 raid per month over the 2011 raids. It is suggested that the trend of raids during the study corresponds with the trend of population growth of the elephants over the period; and that increases in raids by the elephants indicate increasing population of the elephant. The difference in crop raids between the rainy and dry seasons was significant (χ^2=26.372, df=6, p= 0.0002). Only 12.1% of crop raids occurred during the dry season; the remaining 87.9% suggests that elephants preferred to raid in the rainy season during which most crops are available. Also, the difference between diurnal raids and nocturnal raids was significant (χ^2=22.393, df=6, p=0.0001). Only 4.7% of the crop raids occurred during the day; the remaining 95.3% suggests that elephants from the park raided at night. The results of Levene's test, p=0.0024, rejected the hypothesis of equal variance for events around the four ranges of the park and Welch F test was not significant ($F_{3,\ 27}$=7.89, df=11.05, p=0.0043); thus, chance alone may account for the differences in raid distribution around the various ranges of the park. There was a very weak negative correlation between distance of raid occurrence from the park's boundary and the number of elephants that raided (Y= -0.0504x + 5, R= -0.038); and as

Spearman's rank correlation (Rho = 0.082, p=0.4060) indicated a no significant relationship, the distance of raid occurrence from the park's boundary could not be said to depend on number of elephants that raided. Also, the results of t-test indicate a significant difference between the communities' populations and communities' nearest distances from the park's boundaries ($t = 6.5057$; $p < 0.001$). But communities' estimated populations and nearest distance of communities from the park's boundaries were poorly correlated and not significant; and so is the regression equation ($Y = 0.003x + 17.601$; $r = -0.091105$, $R^2 = 0.008$; $p > 0.05$). With such a small contribution by raid events (0.8%) accounting for the relationship between the two variables, it could be said that some factors other than raid events may account for the differences between them. Also, the results for only those communities affected by raids indicate a significant difference ($Y = 0.003x + 0.797$; $t = 2.77$; $r = 0.5$; $R^2 = 0.25$; $p < 0.05$), implying that there is a positive correlation between the estimated population of the communities affected by raids over the study period and the communities' nearest distances from the park's boundaries. 25% of raid events account for the relationship between the two variables but other factors may be more important in explaining the relationship between them. The relationship between estimated populations of communities raided over the study period and the frequencies of raids is also significant ($Y = 0.022x – 0.672$; $t = 8.159$; $r = 0.86$; $R^2 = 0.743$; $p < 0.001$). This suggests a strong correlation between the two variables. About 74% of raid events account for the differences. It could be said that the frequency of raids depend on the population size of the community raided. This may be due to increase in the number of farms, the expanse of farms and the diversity of crops in the farms that may accompany large number of farmers in large communities. It implies also that small communities are at a lower risk of crop raids around the park. However, there is no significant difference between the nearest distance of communities from the park and the frequencies of raid occurrence ($Y = 0.785 + 7.304$; $t = 0.931$; $r = 0.19$; $R^2 = 0.036$; $p < 0.05$).

Elephants raided a total surface area of 85.7 ha over the seven-year study period and destroyed crops worth Cedi (¢) 249,504.00 ($77,365.58) at a rate of ¢1,917.79 per hectare and ¢31,188.00 ($9,670.70) per year (Table 3). Yam alone was destroyed over a total surface area of 39 ha, which amounted to an estimated cash value of ¢140,400 ($43,582.99), and recording a loss of ¢17,550.00 ($5,441.86) per year that accounted for 56.3% of the annual loss of crops due to elephant raids. Cassava followed with ¢10,582.50 ($3,281.24) annual loss representing 33.9%; maize, 4.2%; and all of the rest accounting for less than 5.6% (Table 3). Each of the 14 goats raided cost ¢1,200.00 ($372); on average that amounted to ¢1,680.00 ($520.9).

Interviews

The average percentage level of communities' support for the park and average level of communities' tolerance to wildlife raids were 74.2% (range = 65.6 - 81.3%) and 18.9% (range = 10.1 - 31.1%), respectively. Out of the 180 households interviewed, 94 (52.2%) have not experienced crop or livestock raids by wildlife before. This suggests that some raids were not reported. For example, at Jang, reported cases involved one household but results of the questionnaire indicated that 6 households had been raided before within the time frame. These erratic circumstances in the data, however, do not invalidate the analyses and results.

Multiple regression

The R square values from the model summary statistics of three separate outputs indicate that "Period of time" is the most significant predictor among the variables used alternatively as model 1 predictors in the hierarchical method. It accounts for 89.3% of the variation in tolerance to wildlife raids and this is significant ($p<0.001$). The other two variables (when included in model 2) could only account for an additional 3%. "Cost of raids" also accounts for a significant 19.5% of the variation ($p<0.001$) and the other two variables when included in model 2 account for an additional 72.8% that explained quite a large amount of the variation in communities' tolerance to wildlife raids. "Level of communities' acceptance" accounts for 0.3% but this is not significant ($p>0.05$) and the F change statistic is also not significant ($F\Delta$ (94) = 0.240, p=0.625). The F change statistic is significant ($F\Delta$ (94) = 22.769, $p<0.001$) when "Cost of raids" is the initial predictor, and also significant ($F\Delta$ (94) = 786.965, $p<0.001$) for the model in which "Period of time" is the initial predictor. With such a large F change statistic which is very highly significant, the importance of the variable "Period of time" in predicting the outcome (that is, communities' tolerance for wildlife raids) cannot be overemphasized. The adjusted R Square value is very close to the R Square value; the difference for the final model is small (0.002), suggesting that, as a characteristic of a good model, if it were derived from the population rather than a sample it would account for approximately 0.2% less variance in the outcome.

From the output of coefficients of the model parameters (Table 4), as the period of time increases by one standard deviation (27.857 months) (Table 5) tolerance decreases by 0.977 standard deviation (Table 4). The standard deviation for tolerance is 6.2379 (Table 4) and this constitutes a change of 6.09% (that is, 0.977×6.2379). Therefore, it could be said that for every 27.857 months, tolerance reduces significantly by 6.09% if the effects of cost of raids and level of communities'

Table 4. Coefficients and significance of the model parameters (***p<0.001).

Model	B	*SE B*	β
Step 1			
Constant	29.152	0.421	-
Period of time	-0.212	0.008	-0.945***
Step 2			
Constant	44.891	2.642	-
Period of time	-0.219	0.007	-0.977***
Estimated cost of raids	3.857E-5	0.000	0.020
Level of communities' acceptance of the park	-0.209	0.035	-0.175***

Table 5. Descriptive statistics.

Variable	Mean	Std. Deviation	N
Level of communities' tolerance for wildlife (%)	18.888	6.2379	96
Estimated cost of raid (Ghana Cedis)	2786.60	3313.563	96
Level of communities' acceptance of the National Park (%)	74.175	5.2374	96
Period of time (in months) since study began in 2005	48.50	27.857	96

Table 6. Casewise Diagnostics[a] of residuals.

Case number	Std. Residual	Level of communities' tolerance for wildlife (%)	Predicted value	Residual
11	2.146	31.1	27.336	3.7639
12	2.271	31.1	27.117	3.9827
25	-2.182	18.8	22.627	-3.8270
26	-2.071	18.8	22.432	-3.6323

[a]Dependent variable: Level of communities' tolerance to wildlife (%).

acceptance of the park are maintained constant. The same way, every ¢3313.56 ($1027.46) loss of crops increases tolerance by 1.25% (Table 5) but this is not significant. Also, every 5.2374% (Table 5) increase in communities' acceptance of the park decreases communities' tolerance to wildlife raids by 1.1% if the effect of the other variables remains constant. But this can be ignored as there is no correlation between communities' tolerance to wildlife and the communities' tolerance to wildlife raids (Table 1).

The final model in which the "Period of time" is the model 1 predictor is successful in predicting the level of communities' tolerance to wildlife; this model is a good fit and is generalized. The confidence interval is small and does not cross zero (-.227 to -.195). Furthermore, the maximum VIF value is 1.315, the average is 1.157 and the average tolerance (1/VIF) is 0.864. It is a rule of thumb that for no multicollinearity the VIF values should not be greater than 10 (Bowerman and O'Connell, 1990; Myers, 1990), the average VIF should not be substantially greater than 1 (Bowerman and O'Connell, 1990) and the 1/VIF should not be less than 0.2 (Menard, 1995). Therefore, the model does not violate the assumption of no multicollinearity. It is reasonable to expect about 5 cases (5%) out of the 96 samples to have z-scores outside the limit of ±2 and 1% outside the limit of ±2.5 (Field, 2009). This model listed 4 cases (4%) outside the limit of ±2, but none outside ±2.5 (Table 6). Therefore, the results of these diagnostics give no real cause to worry about extreme residual cases and so the sample appears to conform to what we would expect for a fairly accurate model.

In all cases, Cook's distance is <1 suggesting that none of the cases has undue influence on the model (Cook and Weisberg, 1982). Hoaglin and Welsch (1978) recommends, as a measure of influence, that twice the average leverage value {2(k+1)/n; k=number of predictors and n=number of cases} and Stevens (2002) recommends three times the average as cut-off points for identifying cases having undue influence. Three cases (91, 92 and 93) were identified as greater than the limit of Hoaglin and Welsch (1978) and two (92 and 93) were greater than the limit of Stevens (2002). Mahalanobis distance criteria (Barnett and Lewis, 1978) also identified 92 and 93 cases as being too far from the means of predictor variables. By the criteria of Belsey et al. (1980), a case with a covariance ratio lying outside a minimum of 0.875 and a maximum of 1.125 may have an influence on the variances of the model parameters. Again, only cases 92 and 93 are outside the upper limit. All DFBetas lie between ±1 and this confirms that cases do not have undue influence on the regression parameters. However, the evidences suggest that of all the 96, only cases 92 and 93 probably need to be re-examined in order to confirm that there are no influential cases within the data.

DISCUSSION

In designing integrated conservation projects, an understanding of the relationship between local people and protected areas is critical. In particular, it is important to understand the conservation attitudes of local people. Protected area managers have traditionally relied upon law enforcement techniques to resolve conflicts with local people. However, given the nature of these conflicts in Africa, such techniques will be insufficient and in many cases inappropriate. Alternative approaches to reduce conflict will need to be developed that provide tangible benefits to local communities and empower local people to manage natural resources (Govan et al., 1998). Such programmes are now being developed in Africa (Martin, 1984; Lewis et al., 1990), but before they can be designed and implemented successfully, the attitudes and problems of the local people, their relationships with protected areas, the essence of the programme and possible trade-offs must be clearly understood. For instance, a serious consideration of how much annual loss of local people's crops and livestock to wildlife in relation to how much the local people benefit from a protected area need to balance in an agreement to a sustained collaborative conservation.

This study has confirmed that living next to a protected area can be very expensive, especially when farming is the main occupation, and can be very frustrating with the progressive trend of the number of farmers affected, the frequency of raids and estimated costs. Moreover, most raids take place at night that make preventive measures difficult or expensive to implement as elephants raided mostly during the rainy season. For example, the popular chili-pepper method (Osborn, 2002; LeBel et al., 2010; Hedges and Gunaryadi, 2010; Monney et al., 2010), if implemented as a deterrent to prevent elephant raids, is limited in the rainy season when the rain washes away the pepper. Therefore, with such heavy annual crop and livestock losses, it would be worth thinking of compensatory gains in other forms. For the fact that most of the communities are poorly accessible, their remoteness further severely limits access to services of development agencies and depends almost entirely on natural resource base for food and income; such gains in the form of social amenities, scholarships, alternative livelihood ventures, etc., are worth considering and these should be on the government agenda instead of agencies. Unfortunately, this study failed to quantify these gains that would have facilitated sound comparisons and assessments. However, loss of tolerance over the time span of the study provided a clue of what could be missing in this assessment. Contradictory results of percentage level of communities' tolerance to wildlife raids in relation to percentage level of communities' acceptance of the park probably suspect some deception to have characterized the results of acceptance. While it was expected that the relationship would be positively linear, both either reducing or increasing over time, this study rather revealed a negative relation in which tolerance reduces and acceptance increases. Though this was not significant and also as acceptance contributed ignorable and little account for tolerance, it could be suggested that the people revealed their true sentiments in respect of tolerance rating but not for acceptance. Also, with such a heavy financial loss through crops and livestock raiding every year, the expectation for estimated cost to account for a high percentage contribution of tolerance should be normal. However, instead, a small and non-significant contribution was revealed. Importantly, less than 50% of the households interviewed had been raided before and this may suggest that the majority of households did not bother much about the cost of raids. This also may imply that if raids become extensive to involve many farmers, tolerance will reduce markedly. Censuses carried out before the study (Wilson, 1993; Bouché, 2002, 2006; Mackie, 2004) published by IUCN (2010) indicated reducing elephant population from 1993 to 2004 and increasing population from 2004 to 2006. Assuming that increased elephant population would increase crop raids by elephants and decreased elephant population would decrease crop raids, then, if management would step up conservation efforts for the elephants to increase their population, there is the likelihood that there would be more raids and reduced tolerance of farmers. Indeed, elephant raids increased over the period of study, and though censuses have not been carried out currently, this observation lends credence to the prediction that raids will further increase with increasing population after 2006. However, because "period of time" and "estimated cost" did not account for all the tolerance, it could be suggested that the model probably missed some variables outside the domain of this study. Such variables as mistrust for the protected area employees could possibly account for loss of tolerance as observed elsewhere in Tanzania (Songorwa, 1999) where the local people oppose the suggested abolishment of adjacent protected areas, view poachers as law-breakers, but generally do not hold positive attitudes towards protected area employees mainly due to mistrust (Songorwa, 1999). Comparably, around MNP, it could be suggested that the local people approved the park's establishments, but harbor bitter sentiments; and the odds are always against the protected area employees who may be innocent.

Collaborative management is the recognition that people will manage wildlife and other resources when they are given sufficient economic incentives to do so. Through collaborative management, the wildlife division tries to provide the right conditions and incentives for people to manage their resources sustainably, according to Songorwa (1999), the decision to accept and join collaboration for wildlife conservation could be largely influenced by promises of socioeconomic benefits. But if these promises remain unfulfilled, expectations not met, the problems wildlife had long caused the communities remain unsolved and some existing problems such as crop damage increasing and new ones emerging (Songorwa, 1999), then communities can hold strong mistrust for the management. Various protected area participatory platforms have emerged around MNP to enhance wildlife conservation through management-community collaboration. These include Protected Area Management Advisory Board (PAMAB), Protected Area Management Units (PAMAU) and Community Resource Management Committees (CRMC). Common objectives of all these are to identify and integrate local people's concerns into park management; to win local support for park management and wildlife; to collaborate with local people to try to ensure better park management and to reduce conflicts relating to the park and its natural resources. In relation to these, CREMAs have been identified to be a sustainable land use option to secure community resources and judicious use in few communities; CBT ventures offering canoe safari, village walk and cultural drumming and dancing have been based in one of the 33 fringed communities to provide permanent and temporary employment to over 30 community members. Perhaps these projects have been operational for too short a period to be adequately evaluated as observed elsewhere (Newmark et al., 1994; Kiss, 1990; Wells et al., 1992); the communities have to wait for as long as the CREMAs and CBTs are not viable while they still suffer heavy crop losses. It is plausible that the communities did not understand these programs from the beginning and have run out of patience soon. It seems, however, that the government should shoulder the responsibility of providing long-term and tangible benefits to such communities, while management opens up for donor support.

The potential for such mistrust to influence tolerance for wildlife raids around the Mole National Park may be latent, but precarious and in consequence the local people could re-evaluate their decision and start opposing the park and employees. This study missed any chance of evaluating temporal variation in prices of raided crops and livestock over the study period. This would be necessary to establish the effect loss of tolerance could have on the market values of the products which are raided, how this could impact on the economy of the affected people and how it feeds back unto the tolerance of the people in the communities around the park; though it is indubitable that only negative consequences could emanate from this evaluation. The study also missed the opportunity to find out what the local people could do in reaction to the raids under very critical low tolerance level but suffice it to say that these must be avoided. Therefore, it is suggested that the plan for management-community collaboration should be reviewed taking cognizance of the local people's views and concerns and, especially, the area of mistrust, if any should be addressed; some long-term and tangible benefits should be proposed for government implementation and donor support in fringe communities. Evidence from this study suggests that review measures need expedited action because tolerance reduces yearly as period of time progresses.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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