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Feeding Habits of *Hippopotamus amphibius* and Carrying Capacity in the Biosphere Reserve of "Mare aux Hippopotames" in the South-Sudanian Zone of Burkina Faso

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Abstract.- Herbivore foraging behavior has been studied for a wide range of mega-herbivore species including wildlife and livestock. However, the existing scientific knowledge of hippopotamus (*Hippopotamus amphibius)* feeding behavior and ecology is far from comprehensive. This study aims to establish the carrying capacity of the "Mare aux Hippopotames", a protected area and Biosphere Reserve in Burkina Faso which hosts one of the major hippo populations of the country. We first investigated the availability of forage and the feeding habits of hippos in four pastures situated at different elevation with respect to the water and different distance from the lake; three of these pastures are used by hippos in the dry season while the fourth pasture located at higher elevation is used during the rainy season. We also estimated biomass and used this to assess the carrying capacity of the area for hippopotamus. Of the 44 plant species with significant biomass (*e.g.* a cover > 1%), 34 were eaten by hippos. Species consumed are *Andropogon africanus, Andropogon ascinodis, Cyperus distans, Cyperus haspan, Aspilia bussei, Daniellia oliveri, Setaria barbata.* The vegetation biomass in the pastures frequented by hippopotamus was 3.12 t/ha, resulting in a total average fresh biomass of 4617.6 t. The available biomass would allow to sustain a hippo population of 128 individuals, and factors other than food limitation are likely to explain why the current hippo population remains at lower levels.

Key words: Megaherbivore, hippopotamus, biosphere reserve, foraging ecology, West Africa

INTRODUCTION

The common hippopotamus (*Hippopotamus amphibius* Linnaeus 1758) is atypical African large mammal with five or three subspecies (Delvingt, 1978; Eltringham, 1999; Okello *et al*., 2005). Until the early 20th century, hippos were common amphibians across the African continent from the Nile to the Cape, wherever there was adequate water and forage. Hippos were distributed in a wide range of environments including rivers, marshes, estuaries and occasionally even the sea upto an altitude of 2,000 m (Eltringham, 1999; Kingdom, 1997).

The situation is drastically different today when most hippopotamus are confined to protected areas. Hippo populations are threatened with extinction across the continent through habitat loss, hunting and armed conflict. In Democratic Republic of Congo where hippo population was estimated to 30000 individuals at National Park of Virunga (Delvingt, 1978), only 3000 individuals are currently enumerated (IUCN, 2006).

Worldwide, the number of hippos in the world today was estimated between 125,680 and 149,230 individuals (IUCN, 2006). However, populations of hippos are highly fragmented, which poses risk of local extinction. For example, hippo populations in various countries of West Africa consist mostly of small groups of 50 to 500 animals (Noirard *et al.,* 2004).

The International Union for Conservation of Nature (IUCN), considering this fragmentation and the declining trend, classified the hippopotamus as vulnerable in its Red List of Threatened Species (IUCN, 2006).

In Burkina Faso, the hippo population was estimated at 500 individuals in 1982 (Bousquet, 1982; SP/CONAGESE, 2002). Their distribution was highly dispersed (Coulibaly and Dibloni, 2007),

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with small populations spread over the W-Arly-Pendjari rivers complex in the east of the country, and the Biosphere Reserve of "Mare aux Hippopotames" (RBMH), the lakes of Bagré and Tingréla, the rivers Comoé, Léraba, Sourou, Bougouriba and the plain of Banzon in the West (Fig. 1).

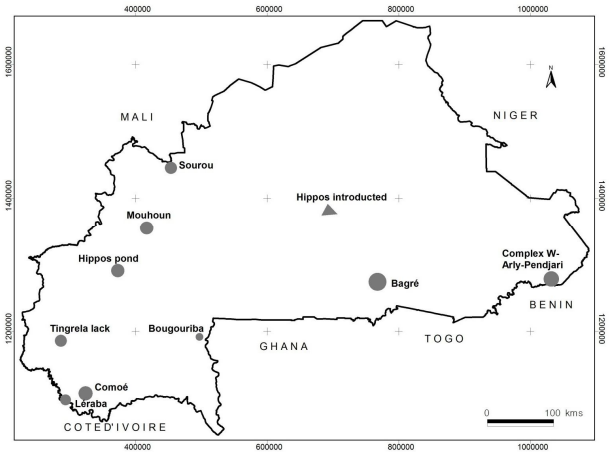

Fig. 1. Distribution of hippopotamus populations in Burkina Faso (Source: Coulibaly and Dibloni, 2007)

Following a further reduction of the population as a result of severe drought in the 1970s and 1980s, the hippo was raised to the status of an endangered species in Burkina Faso in 1985 and fully protected since then (MECV, 2006). Thus, according to the texts of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) or the Washington Convention that Burkina Faso has ratified (MECV, 2006), the hippo is listed in Annex1.

The hippo population in the "Mare aux Hippopotames" has fluctuated over the last few decades. It was estimated at 68 heads in June 1985 (Bakyono and Bortoli, 1985), and 33 individuals in November 1991 and December 2004 (Poussy and Bakyono, 1991; UCF/Hauts Bassins, 2004). The population has increased to 42 individuals more recently, following the discouragement of poaching and grazing of domestic livestock in the reserve, conservation measures implemented by the Ministry of the Environment in collaboration with the villagers living near the reserve (Dibloni *et al*., 2010).

The hippopotamus is a non-ruminant herbivore with a gregarious and sedentary life style, spending the whole day in water. At night, hippos come out of the water to graze the surrounding pastures (Haltenorth and Diller, 1977). Poaceae and Cyperaceae are included in its diet (Noirard *et al.*, 2004; Amoussou *et al.*, 2006; Kabré *et al*., 2006), and its daily food intake ranges between 35-50 kg of fresh biomass (Haltenorth and Diller, 1977; Eltringham, 1999). Hippos nourish themselves only in grasslands of short vegetal species (Oliver and Laurie, 1974; Eltringham, 1999; Michez, 2006).

Despite the abundance of feeding areas located along rivers, only a small portion is suitable for feeding of this mammal (Harrison *et al*., 2007), which creates an over grazing of favorable areas. The common hippo is, like the African elephant and black rhino (*Diceros bicornis*), a mega-herbivore that significantly influences the grasslands it grazes, creating vegetation mosaics and changing the habitat structure (Owen-Smith, 1988; Lewisson and Carter, 2004). Such patterns are noticeable also in the Mare aux Hippopotamus, but it is not clear where the current hippo population of 42 animals is over grazing the area. It was thus deemed appropriate to look into this issue of grazing and assess the carrying capacity of the reserve and in this context the present study was conducted with the objective to know the fodder availability and feeding habits of hippos in the Biosphere Reserve of Mare aux Hippos in order to establish the carrying capacity of the reserve.

MATERIALS AND METHODS

Study site

The study was conducted in the Biosphere reserve "Mare aux Hippopotames" (Pond of Hippopotamus) located at (11°36′43″N 3°55′0″E) at do not underline an altitude of 300m in Burkina Faso, West Africa. It is a national park created around a fresh water lake and surrounding pools and marshes in the flood plain of the Mouhoun River (formerly known as Black Volta). The reserve covers an area of 19,200 ha and is located about 60 km North of Bobo Dioulasso 1,299 and 1,271 km North of the Equator and 369 and 382 km East of

the null Meridian (Fig. 2). The reserve gained conservation status under order n° 8336SE March 26, 1937 and has been registered by UNESCO in the network of Biosphere Reserves since January 12th, 1987 (Chardonnet, 1995; Poda, 1997; Taïta, 1997). The reserve is also included in the List of Ramsar Wetlands of International Importance and supports a rich diversity mammal and bird species. The climate is of the south-Sudanian type with average annual rainfall for the period 2007-2009 of 1,094 (±55 mm) distributed over 81±10 rainy days. A change in climatic conditions, with a reduction of rainfall, has been reported for the area (Dibloni, 2011). The vegetation is composed of aquatic species, dense thickets of *Ficus congoensis* and *Canthium cornelia*, herbaceous plants, a well-developed gallery forest (composed of *Berlinia grandiflora*, *Vitex doniana* etc.), dense dry forest, and open dry forest/shrubby savanna (Taïta, 1997; Bélem, 2008). The Biosphere Reserve also hosts a rich fauna (Poussy and Bakyono, 1991) consisting of mammal species such as the hippopotamus, elephant (*Loxodonta africana* Cuvier), bushbuck (*Tragelaphus scriptus* Pallas), roan antelope (*Hippotragus equinus* Desmarest), warthog (*Phacocoerus africanus* Gmelin), Oribi (*Ourebia ourebi* Zimmerman), duiker (*Sylvicapra grimmia* L.), patas monkey (*Erythrocebus patas* Schreber), green monkey (*Cercopithecus aethiops* L.) and baboon (*Papio Anubis* Lesson) (ENGREF, 1989; Bouché, 2005; Dibloni, 2011).

The protected area is renowned for its hippo population, which permanently inhabits the lake, hence the name "Mare aux Hippopotames" (French for "Hippo Pond"). Ten villages with about 29,800 inhabitants surround the reserve. The main ethnic groups are the native Bobo; besides there are various immigrant groups such as the Mossé, Fulani, San and Marka. People make their living mainly from fishing, stock raising, collection of fruits, honey and firewood and eco-tourism (Dibloni *et al.*, 2009). Major threats to the core area, which also comprises sacred sites, are illicit poaching, grazing and bush fires. Climatic constraints have led to more migration resulting in significant anthropogenic pressure around the biosphere reserve. The combined effects of climate change and unsustainable land management causes problems of desertification outside the reserve as well as concerns over the sustainability of the conservation of the hippo and other biodiversity inside the protected area.

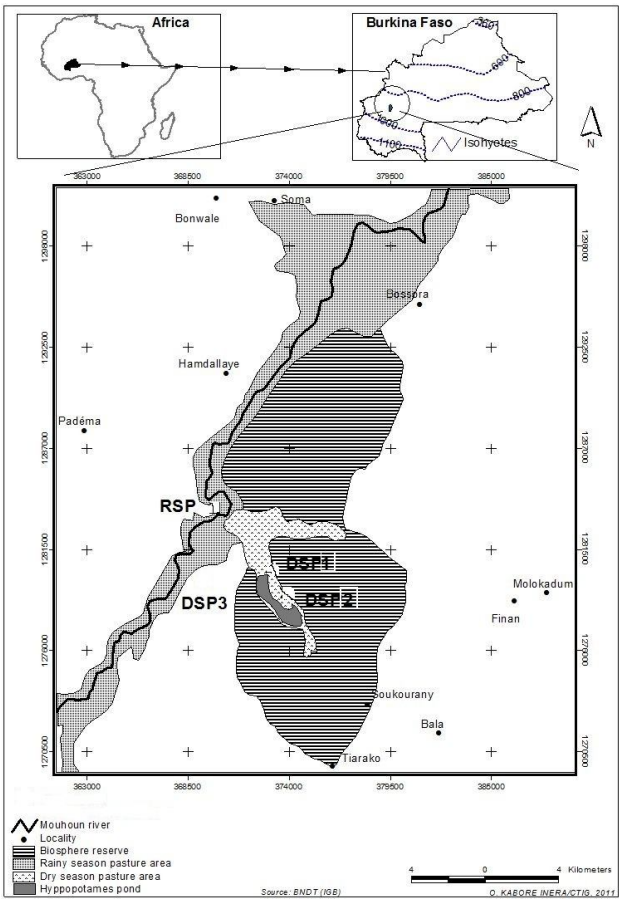

Fig. 2. Localization map of pastures inventoried in the Biosphere reserve of the "Mare aux Hippopotames" (Source: Dibloni *et al*., 2010).

Data collection

Data were collected over three consecutive years in 2007, 2008 and 2009. Investigation was made on species diversity of the pasture lands, species grazed by the hippos and the evaluation of the above-ground biomass and the carrying capacity for hippos during the dry season.

Pasture composition

The species composition of the pastures was assessed using the point-intercept sampling procedure (Daget and Poissonet, 1971). We established four 50 by 50 m plots, three in pastures

which were frequented by hippos during the dry season, between November and June, and the fourth in an area grazed during the rainy season from July to October (Fig. 2). We then established in every plot four transects arranged along the median and diagonal, and recorded the species occurring at every meter along these transects, which resulted in four hundred points recorded for every plot. At every 1 m a pin of 6 mm diameter, taller than the maximum height of the vegetation was lowered from above; and a species was considered as present if the pin hit any of its live parts. These floristic inventories were carried out in June and October for the dry season and rainy season pastures respectively during the three years of observation. They allowed comparison of the specific contribution of two types of pasture lands (burned and non-burned). Fire is deliberately set in the flooded zones following the withdrawal of water by herders to improve the pastures early in November (Dibloni *et al.*, 2010). Unburned pastures concerned migration areas of hippos during the rainy season where the development of herbaceous biomass is related to rain water.

Identification of consumed plant species

The plant species consumed by hippos were identified through direct observation at the beginning of the flowering stage of grasses in the pasture lands, a method successfully used by previous researchers (Téhou and Sinsin, 1999; Noirard *et al.*, 2004; Amoussou *et al*., 2006; Kabré *et al*., 2006). Feeding records were collected during patrols early in the morning after the passage of hippos. The assistant noted the point on transect, thus assigning the record to a locality and vegetation type, and collected the food plant, which had to show signs of having been bitten or plucked by the animal to be accepted as a feeding record. Collected specimens were labeled, and samples were identified at the national herbarium of the Institute for Environmental and Agricultural Research (INERA) or at the Laboratory of Plant Ecology of the University of Ouagadougou, using the flora of Senegal (Berhaut, 1971). For the species that were hard to identify without flowers, we asked local people for their local names and identification was done when they flowered.

Biomass evaluation and pasture lands capacity

To assess the carrying capacity of the pastures around the lake we first measured the biomass produced in these pasture lands and later extrapolated these biomass estimates to the total area of pasture to assess the number of hippos that could potentially be sustained. To estimate the above ground biomass in the dry season we measured the biomass at three sites in the dry season pastures (Fig. 2). In each pasture site, we established three plots 100 m distant from each other. After the early burning, we identified non grazed areas in each plot where we assessed the herbaceous biomass by clipping the grass in ten subplots of one m² each selected at random. Hippopotamus are known to practice a patchy grazing (Harrison *et al.*, 2007. Grasses and shoots located within each plot were clipped to 5 cm above ground level. The operation was carried out over the study period each time in the month of June. The biomass was weighed fresh bagged and later dried in an oven at 70°C for 72 hours and weighed to determine dry matter content. The total biomass production of the pastures surrounding the Lake was then estimated by multiplying the average biomass (both fresh and dry matters) for the nine plots with the extent of the pasture area used by hippos in the dry season.

The capacity of the pastures to sustain hippos was calculated while considering that an adult hippo consumes a maximum of 50 kg of fresh biomass per day (Haltehorth and Diller, 1977), and that the hippos use these pastures for 8 months (November till June). We further considered that one third of the potential production would be consumable by herbivores (Boudet, 1991). The carrying capacity (CC) of the pasture surrounding the Lake was then obtained as follows:

$$CC = TPP / 3\ FRAH$$

where, TPP is total pasture production in kg, FRAH, food requirement per adult hippo for 8 months in kg 1/3 one out three of the total production of a pasture land consumed by livestock.

Data analysis

From the point-intercept sampling we computed the following parameters of the

vegetation according to Daget and Poissonet (1971): FS_i, the frequency of species i, FS_i which corresponds to the number of hits of the species along the four transects within a plot;
CS_i, the contribution of species i to the sum of the frequencies of all species; it reflects the abundance of a species and expressed as percentage:

$$CS_i = \frac{FS_i}{\sum_{i=1}^{n} FS_i} \times 100 \text{ where } \sum_{i=1}^{n} FS_i = \text{Sum of}$$

frequency of species *i* in the pasture land.

To examine the temporal variability in the total above ground biomass, we used repeated-measures analysis of variance (Davis, 2002). The analysis of variance was performed following the general linear model (GLM) for repeated measures:

$$Y_{ijk} = \mu + \beta_i + \lambda_j + (\beta\lambda)_{ij} + \varepsilon_{j(i)} + \varepsilon_{j(k)}$$

where Y_{ijk} was the response variable for the herbaceous vegetation, μ was the overall mean, β_i was the effect of the between-subject factors, *i* (site), λ_j was the effect of the within-subject factor, *j*, year, $(\beta\lambda)_{ij}$ was the interaction of the between- and within subject factors. The parameters $\varepsilon_{j(i)}$ and $\varepsilon_{j(k)}$ are random errors of the between-subject and the within-subject factor, respectively with k number of replicates. The homogeneity of variance assumption was checked and violated, according to Mauchly's test of Sphericity, therefore the degrees of freedom for testing the significance of the within-subject factors were adjusted using Huynh-Feldt correction factor, which is less biased than other correction factors (Davis, 2002).

All statistical analyses were done with SPSS 19 software package (Copyright SPSS for Windows, Release 2010 Chicago: SPSS Inc.).

RESULTS

Specific diversity of pasture lands

Altogether in the pastures, 44 plant species were identified with a cover percentage above 1% (Table I). Species number was highest (26 species) in the rainy season pastures (RSP), while the dry-season pastures (DSP) 2, 3 and 1 hosted 19, 17 and 12 plant species with cover above 1% (Table I). In the dry season pasture (DSP) number 1 *Andropogon africanus* was the dominant of the 12 recorded species, with a CSi of 35.92% (Table I). *Cyperus haspan* was the dominant species in DSP 2 and 3. *Paspalum scrobiculatum* was the dominant species in the rainy season pastures (RSP) with a specific contribution of 39.4% (Table I).

Vegetation species consumed by hippos

The records from the patrols were analyzed with the rationale that each feeding record indicates the activity of the animal at that moment, and that the accumulated records consequently reflect the relative time devoted by the hippo to feeding from each plant species. The composition of the recorded diet was 44 plant species identified according to their intensity use by hippos (Table I). In the pastures, there were: (1) 23 species extensively consumed including *Andropogon africanus*, *Andropogon ascinodis*, *Andropogon gayanus*, *Cissampelos mucronata*, *Cyperus distans*, *Cyperus haspan*, *Digitaria horizontalis*, *Echinochloa stagnina* and others. (2) 11 species consumed moderately as *Aeschynomene indica*, *Aspilia bussei*, *Daniellia oliveri*, *Mitragyna inermis*, *Piliostigma thonningii*, *Setaria barbata*, *Stylochiton hypogaeus* and other. (3) 10 plant species, of no value to the hippos, composed of *Cardiospermum halicacabum*, *Corchorus tridens*, *Crotalaria retusa*, *Herderia truncata*, *Indigofera Colutea*, *Melochia corchorifolia*, *Merremia tridenta*, *Moghania faginea*, *Panicum wallense* and *Tephrosia pedicellata*.

In addition to the species found in pastures, crops seedlings (maize, rice, cotton) were heavily consumed when located near the tracks used by the hippos.

Above-ground biomass and dry season pasture lands capacity

Vegetal biomass produced in the hippos route area

The above-ground biomass of the three dry season pasture lands around the lake was estimated at 115.7 tons for the DSP 1, 213.1 tons for DSP 2

Table I.- Percentage cover of plant species in the four pasture sites (DSP= dry season pasture ; RSP= rainy season pasture) and the intensity of consumptive use of these species by hippos (++: intensively consumed; +: occasionally eaten; –: no sign of grazing).

Species Number	Scientific Names	Pasture lands				Observed used
		DSP 1	DSP 2	DSP 3	RSP	
1	*Andropogon africanus*	**34.9**			3.1	++
2	*Andropogon ascinodis*	**17.4**				++
3	*Andropogon gayanus*	2.9			3.1	++
4	*Aeschynomene indica*				1.6	+
5	*Aspilia bussei*			1.2	0.05	+
6	*Azolla africana*		1.1			++
7	*Cardiospermum halicacabum*		7.3	6.4		-
8	*Cissampelos mucronata*		**10.8**	**13.7**		++
9	*Corchorus tridens*		2.1	0.05	1.1	-
10	*Crotalaria retusa*				1.6	-
11	*Cyperus distans*		7.7	1.3		++
12	*Cyperus haspan*	0.4	**24.6**	**22.3**		++
13	*Daniellia oliveri*	2.6			3.2	+
14	*Digitaria horizontalis*		3.9			++
15	*Echinochloa stagnina*		1.2			++
16	*Herderiatruncata*		4.8	**21.3**		-
17	*Indigofera colutea*				7.8	-
18	*Ipomoea aquatica*		3.2	2.1		++
19	*Ipomoea eriocarpa*				5	++
20	*Ipomoeavagans*		1.6	3.3	0.4	++
21	*Leersia hexandra*		2.1			++
22	*Loudetia simplex*	**18.8**				++
23	*Melochia corchorifolia*		3.3	6	3.4	-
24	*Merremia tridenta*		1.4	3.6		-
25	*Mitragynainermis*	1.3			0.3	+
26	*Moghania faginea*				1.1	-
27	*Oriza longistaminata*				1	++
28	*Panicum wallense*				5.1	-
29	*Paspalum scrobuculatum*			0.4	**39.4**	**++**
30	*Phyllanthus amarus*	0.3	2.1	0.2	0.05	+
31	*Piliostigma thonningii*	1.1			0.3	+
32	*Polygonome senegalensis*		0.9	3.3		++
33	*Schizachyrium sanguineum*	8.8				++
34	*Scleria foliosa*	5.2				++
35	*Sesbania sesban*		8.1	4		+
36	*Setaria barbata*		5.1	2.4		+
37	*Setaria pimula*				1.3	+
38	*Sida stipulata*				1.8	+
39	*Sorghastrum stipoides*				8.5	++
40	*Sporobolus pyramidalis*				6	++
41	*Stylochiton hypogaeus*	3.4			0.3	+
42	*Tephrosia pedicellata*				2.6	-
43	*Vetiveria nigritana*		3.8	1.3	0.3	++
44	*Vigna filicaulis*				3.9	++

and 171.4 tons for DSP 3. The average productivity of the three pasture lands was 3.12 tons/ha of fresh biomass with a standard deviation of 2.26 tons. When reporting this productivity to the hippopotamus vital domain which is 14.8 km², the average production was evaluated as 4,617 tons; corresponding as 1,085 tons of dry material.

Statistical analysis revealed that above ground biomass differed significantly between sites ($p<0.001$, Table II), with site 1 having a lower biomass than site 2 (3.672±0.234 tons/ha) and site 3 (3.707±0.231 tons/ha), which did not differ significantly from each other. This difference between the sites is likely to be the result of a

difference in elevation and a related difference in ground water depth.

Table II.- Summary of repeated measures ANOVA for testing the significance of the site and year on total above ground biomass in the Biosphere Reserve "Mare aux Hippopotames" Burkina Faso

Source of variation	df	F	p-value
Between subject factor			
Site	2	19.058	0.000
Error	87		
Within subject factors			
Year	2	1.335	0.265
Year × Site	4	7.661	0.000
Error	153		

Note that the degrees of freedom for the within-subject factor for testing abundance were Huynh-Feldt adjusted

The above ground biomass did not show a significant inter-annual variation ($p = 0.265$), but the interaction between year and site was significant. For Site 1, the total aboveground biomass of the second and third year was more than double of the first year (Fig. 3). At Site 2, total above ground biomass of the last year of investigation was higher than the first two years which were similar. At Site 3, total above ground biomass was substantially higher during the second year of investigation.

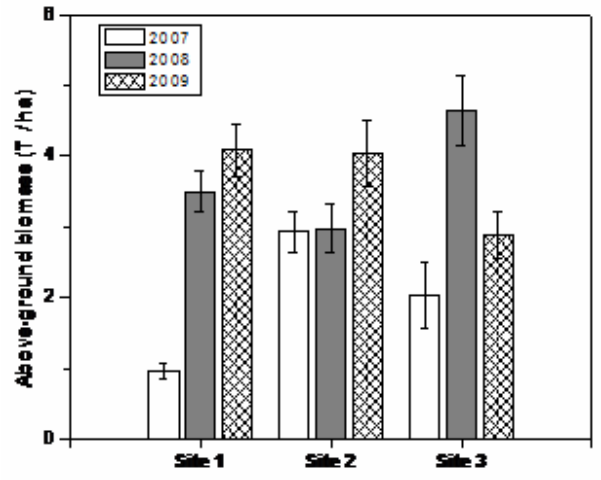

Fig. 3. Temporal variation in above-ground biomass at three sites in the Biosphere Reserve "Mare aux Hippopotames" Burkina Faso.

Carrying capacity of the hippopotamus vital domain

We arrived at an estimated carrying capacity of the reserve of 128 hippos. This estimate is based on the assumption that hippos consume 50 kg of fresh biomass and reside in the area for eight months per year, leading to a forage requirement of 12 tons per animal. The pastures in the reserve have a total production from November to June (8 months) of 4,617 tons. Considering that one third, or 1538 ton, would be effectively available for consumption, leads to an estimate of the carrying capacity of 1538/12 = 128 animals that could be fed with the forage produced in the reserve.

DISCUSSION

The study reveals that in dry season, hippos graze in pasture lands situated immediately around the lake and Mouhoun river branches Wolo, Tinamou and Leyessa. These pasture lands are the flooded area, burnt during the dry season after water retreat. The regrowth form a green and rich pasture lands (Eltringham, 1999; Yaméogo, 1999; Ouédraogo, 2005; Lungreen et Coulibaly, 2008). In rainy season, when it rains abundantly, hippos migrate to the west coast of the Mouhoun River where they stay in little ponds and graze in pasture lands located along the river (Fig. 2). This type of migration allows to some extent to slow down the pressure in pasture lands on territories near permanent lakes (Delvingt, 1978).

Of the 44 plant species with a cover greater than 1%, 34 species are eaten and about 23 of the 34 species are intensively consumed by hippos (Table I). The most palatable species are *Andropogon africanus*, *Andropogon ascinodis*, *Andropogon gayanus*, *Cyperus distans*, *Cyperus haspan*, *Digitaria horizontalis*, *Echinochlo astagnina*, *Loudetia simplex* and *Paspalum scrobuculatum.* The species grazed by hippos in RBMH (Table I) are mainly from Poaceae and Cyperaceae families. This finding is in agreement with previous studies (Téhou and Sinsin, 1999; Noirard *et al.*, 2004; Amoussou *et al.*, 2006; Kabré *et al.*, 2006).

When considering plant species eaten by hippopotamus in the two types of pastures (DSP and RSP), we found 27 species occurring in DSP and 23

in the RSP. The small number of species consumed in these pastures during the rainy season could be complemented by the cereal species, which are often consumed by these megaherbivores (Sam *et al*., 2002; Danquah *et al*., 2006).

With regard to herbaceous biomass produced in the pastures, the multiple comparison tests of Tukey (HSD) for the variable years are not significant differences between years at a confidence interval of 95.00%. The average annual production obtained in 2007, 2008 and 2009 were respectively 2853.778 tons, 3319.444 tons and 3186.111 tons. Considering the different sites, there is an association between sites 2 and 3 which are significantly different from site 1. Their average annual production was of 853.203 tons; 777.161 tons and 568.731 tons respectively for sites 2, 3 and 1. This difference could be explained primarily by the proximity of sites 2 and 3 in the bed of the pond. The resurgence in the dry season due to irrigation of the plots can favor the growth of plants after the passage of fire. As for site 1, which is situated higher than the pond, and receives only its last water reserve there are perennials belonging to species of Andropogoneae that may be rejected (Savadogo *et al*., 2008).

The carrying capacity was computed using the method of Boudet (1991) and the resulting theoretical carrying capacity was about 128 hippopotamus. This carrying capacity is three times superior to the present number of hippopotamus population of the hunting preserve which is 41±2 individuals (Dibloni *et al*., 2010). Likewise, in considering this estimated carrying capacity, the density of the vital domain is 8.7 hippos / km². This density is also three times superior to the present density of hippos (2.8 hippos / km²) in the feeding niches of hippos in the reserve (Dibloni *et al*., 2010). So the inventory of hippos realized by Dibloni *et al*. (2010) revealed the existence of a maximum of 42±2 hippos in the RBMH during December 2008 inventory. This number gives a rough density of 2.8 hippos/km² which is 7 to 42 times inferior to those evaluated in the Virunga National Park pasture lands, of the Democratic Republic of Congo that was, between 21.5 to 117.96 hippos/km² (Delvingt, 1978). Currently, the total density of the hippopotamus in the grazing zone is much below the estimated theoretical carrying capacity. The estimated carrying capacity therefore, shows that pasture lands production is not at all a limitation factor hippo numbers in the Reserve.

Moreover, considering the slight increase of the number of hippos noticed during the last two inventories, it would be necessary for the departments in charge of the supervision to step up in the struggle against poaching. The measures, thus taken shall help increase the number of hippos in the reserve.

Within the frame work of this struggle, the managers of the reserve should take care to prevent livestock use of the feeding niches of hippopotamus, especially during the period from November to June. These precautions would avoid contacts with domestic livestock which are often sources of parasitic and infectious diseases (Coulibaly *et al*., 2007).

To add value to the biomass produced in the hippos' influence area, it would be interesting to incite the riparian populations to reap the produced grass during the rainy season (July-October) for fodder use or domestic needs. This biomass could be a financial encouragement for the riparian populations and could also increase the locals' willingness to protect the hippos.

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