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Short note

Preliminary description of the diet of *Hippopotamus amphibius* L. in Loango National Park (Gabon)

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Due to the paucity of suitable habitat, hippos are very rare in the Congo Bassin. Compared to East-African populations, Central African populations of hippos have been less studied. Information found in the literature regarding the animal's basic ecology is limited. This study focuses on the description of the diet of an isolated hippo population in Loango National Park (Gabon), comparing faecal analysis with a reference collection of herbaceous species from the savannas. The effectiveness of using faecal analysis *versus* using the floristic description of hippos' pastures was demonstrated. The most frequent herbaceous species identified in faeces samples were *Paspalum vaginatum*, *Axonopus compressus*, *Stenotaphrum secundatum* (Poaceae) and *Desmodium triflorum* (Fabaceae). The voluntary consumption of a dicotyledonous species (*Desmodium triflorum*) is novel for this species.

Keywords. Hippopotamuses, diet, ecology, habitat, wildlife conservation, faecal analysis, Gabon.

Première description du régime alimentaire de *Hippopotamus amphibius* L. au Parc National de Loango (Gabon). L'Afrique Centrale, avec ses faibles densités en milieux ouverts, compte peu de populations d'hippopotames. En comparaison avec les populations d'Afrique de l'Est, les populations de cette région sont très rarement abordées par la recherche scientifique. Des informations élémentaires sur leur écologie sont extrêmement rares. Cette étude décrit le régime alimentaire d'une population isolée d'hippopotames au Parc National de Loango (Gabon) en comparant des résidus végétaux présents dans les fèces à un herbier des espèces herbacées présentes dans les savanes environnant la population. Ces travaux démontrent également l'efficacité de l'utilisation de l'analyse des fèces comparée à une étude strictement floristique. Les espèces les plus fréquentes dans les échantillons étaient *Paspalum vaginatum*, *Axonopus compressus*, *Stenotaphrum secundatum* (Poaceae) et *Desmodium triflorum* (Fabaceae). La description d'une consommation active d'une dicotylédone est une première pour cette espèce.

Mots-clés. Hippopotame, régime alimentaire, écologie, habitat, conservation de la grande faune, analyse de fecès, Gabon.

1. INTRODUCTION

Compared to East African populations, Central African *Hippopotamus amphibius* [Linnaeus, 1758] populations have been understudied. Information regarding their basic ecology (*e.g.* diet, reproduction, adaptations to forested habitat) is seldom found in the literature. The present study analyzed faeces samples in order to describe the diet of a particular hippo population. The aim was to increase the data available for scientists and managers of protected areas who are generally confronted with a lack of information regarding this charismatic herbivore species.

There are several possible options in studying a herbivore's diet. The technique that provides the most accurate composition of the diet is arguably stomach contents analysis. This technique was applied in Queen Elizabeth National Park Uganda during the 1960-70s where hippos were culled in large numbers (Field, 1970). As the species was classified as "vulnerable" in 2006 (IUCN, 2009), stomach content analysis has limited relevance today outside of opportunistic carcass collection. Direct observation of feeding behavior represents a simple technique. However this approach is difficult to implement with a species such as the hippopotamus, because of its potential aggressiveness,

its foraging behaviour occurring mainly at night and its ability to forage up to 10 km away from water (Delvingt, 1978; Eltringham, 1999).

Hippo grazing leads to the formation of typical "hippo lawns" (Olivier et al., 1974; Eltringham, 1999), which contain a higher rate of protein and soluble carbohydrates (Arsenault et al., 2002; Verweij et al., 2006). With its big and uniform lips, the hippopotamus does not select *in situ* species but rather chooses grasslands containing a certain threshold of palatable species, in which all the species are consumed (Scotcher et al., 1978; Eltringham, 1999; Noirard et al., 2004). Consequently, for a given hippo population, the determination of the floristic composition of these hippo lawns provides an initial – but not complete – diet description without the need to observe the animals directly. In order to complement this diet description approach, different authors have performed faecal analysis (Scotcher et al., 1978; Eltringham, 1999; Noirard et al., 2004) to identify plants fragments remaining in the faeces. Our study is focused on both approaches (floristic description of hippo lawns and faecal analysis), comparing the analysis of plants fragments remaining in faeces to a reference collection of plant photographs. This study demonstrates how faecal analyses complement the broad diet descriptions obtained by the floristic analysis of the hippo lawns. It also addresses the information gap regarding hippo populations in Central Africa.

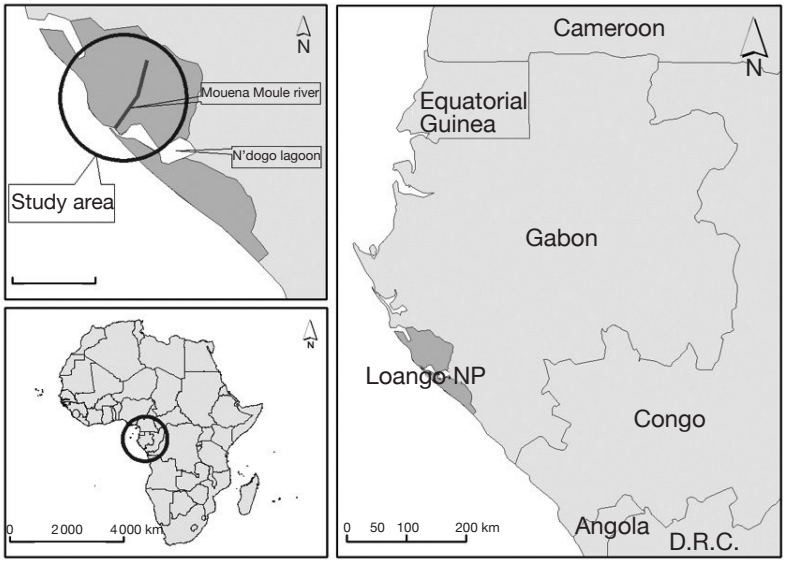

Figure 1. Study site — *Zone d'étude*.

2. METHODS

The present study was conducted during the second rainy season (February-May 2006) on an isolated population of hippos living in the Mouena Moule River. This river is located near the Mouth of the N'Dogo lagoon (**Figure 1**), in the southern part of Loango National Park, Gabon (2°25 S, 9°40 E).

We used a methodology based on the work of Noirard et al. (2004). Plant fragments remaining in faeces were compared with a reference collection of macrophotographs of the stems, leaves, roots, and fruits of plants in the study area. Stems, leaves, roots, and fruits were chosen because of their low digestibility and consequently their high probability of remaining in faeces (Noirard et al., 2004). Whereas Noirard et al. (2004) collected plants within the hippo lawns only, here we collected plant samples from all the savannas located within a 10 km radius around the population's preferred place in the Mouena Moule.

The faeces sampling consisted of a random grab sample from four equal segments of a given hippo dung pat. The four subsamples were then stored together (minimum 50 g) in alcohol. Faeces samples (17) were collected between 16/04/2006 and 05/05/2006 in the grazing area. Identifications were performed in the laboratory of "Écologie des Hydrosystèmes Fluviaux", at the Claude Bernard University in Lyon (France). **Figures 2**, **3** and **4** present some examples of plant fragments in different samples compared with the macrophotographs that enabled their identification.

Following the method of Noirard et al. (2004), 3 g (fresh weight) were selected randomly from each of the 17 original samples. In each sample, plant fragments were sorted by species and plant part (*i.e.* fruit, root, leaf, and stem). Each of the fragments was dried for 3 h in a drying oven at 70 °C and then weighed. Unidentified parts were also dried and weighed. The weights represent the sample abundance estimates and are not a direct expression of the diet composition.

3. RESULTS AND DISCUSSION

The mean proportion of identifiable material was 45.7% ± 9.9% of sample dry weight. This proportion is high compared to that found by Noirard et al. (2004). Nine species were identified here. Among these *Paspalum vaginatum* [Swainson, 1839] was the most abundant (**Table 1**). Three other species were found to occur very frequently: *Desmodium triflorum* ([L.] DC.), *Axonopus compressus* ([Sw.] P.Beauv.) and *Stenotaphrum secundatum* ([Walter] Kuntze). *Paspalum vaginatum* is a typical species of wetland savannas regularly found along the Mouena Moule

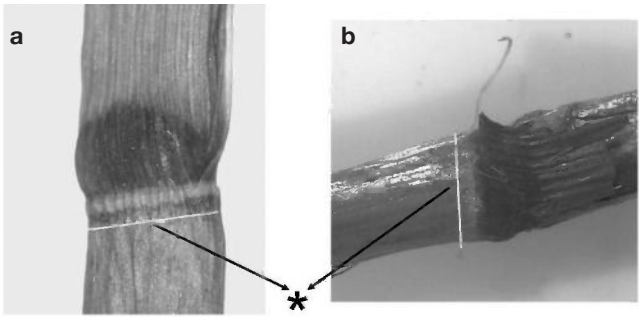

Figure 2. Node of *Paspalum vaginatum — Noeud de* Paspalum vaginatum.

a: herbarium sample — *échantillon d'herbier* ; **b**: fragment from faeces sample — *fragment issu d'un échantillon de fecès*; *: distinctive feature — *trait distinctif*.

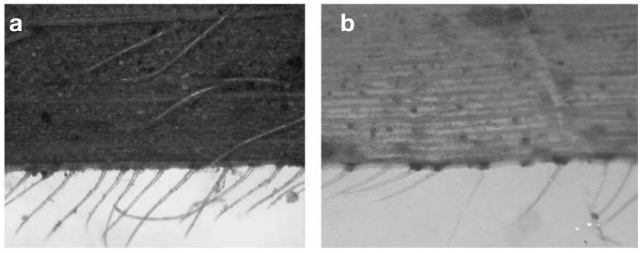

Figure 4. Leaf of *Axonopus compressus — Feuille de* Axonopus compressus.

a: herbarium sample — *échantillon d'herbier* ; **b**: fragment from faeces sample — *fragment issu d'un échantillon de fecès*.

River. Being almost monospecific, with a very low vegetation cover, the *P. vaginatum* savannas clearly differ from the other savannas and were not recorded as hippo lawns during field surveys (Michez, 2006).

Table 1. Pooled proportions of all fragments (total dry weight of species in all samples / total dry weight all samples) and frequency in samples — *Proportion dans l'ensemble des fragments (poids sec total de l'espèce considérée / poids sec total des échantillons)*.

Species	Family	Proportion of all fragments	Frequency in samples
Paspalum vaginatum	Poaceae	81%	100%
Desmodium triflorum	Fabaceae	6%	88%
Axonopus compressus	Poaceae	9%	53%
Stenotaphrum secundatum	Poaceae	8%	53%
Sporobolus virginicus	Poaceae	<1%	24%
Hydrocotyle bonariensis	Apiaceae	<1%	12%
Vigna gracilis	Fabaceae	<1%	6%
Eleusine indica	Poaceae	<1%	6%
Anthephora cristata	Poaceae	<1%	6%

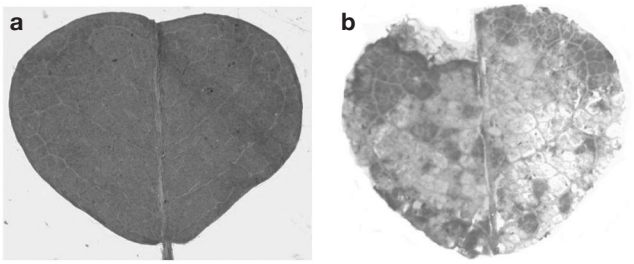

Figure 3. Leaf of *Desmodium triflorum — Feuille de* Desmodium triflorum.

a: herbarium sample — *échantillon d'herbier* ; **b**: fragment from faeces sample — *fragment issu d'un échantillon de fecès*.

Desmodium triflorum and *A. compressus* are typical species of the hippo lawns located along the Loango National Park coast (Michez, 2006). *Stenotaphrum secundatum* was also present in hippo lawns but at a lower level of cover. However the plant was also present along the coastal savannas. Among these species, *Vigna gracilis* ([Guill. & Perr.] Hook.f.) and *Hydrocotyle bonariensis* (Lam.) cover are very sparse in Loango hippo lawns (Michez, 2006). Due to their inability to select plants within a pasture (Scotcher et al., 1978; Eltringham, 1999; Noirard et al., 2004), these two species must be considered as having been "accidentally" consumed.

Table 2 demonstrates the dominant ingestion of Poaceae by hippos, notably the following genus: *Sporobolus* sp., *Cynodon* sp., *Eragrostis* sp., *Hyparrhenia* sp., *Panicum* sp., *Andropogon* sp. The genus *Cyperus* sp. (Cyperaceae) is also common in the hippo diet. More generally hippos seem to eat exclusively Monocotyledonous species. Eltringham (1999) considers Dicotyledonous species as being only accidentally ingested and Scotcher et al. (1978) consider Dicotyledonous species as "non-significant as a food resource" while noting cases of voluntary consumption of Dicotyledonous species.

In this study, *D. triflorum* was found in more than 80% of the samples. Moreover, it provides quality forage (FAO, 2013) and is referred to by Delvingt (1978) as being palatable to hippos. Thus, the hippo diet analyzed in the present study presents the novel finding of an apparently deliberate consumption of a Dicotyledonous species: *D. triflorum*. By identifying *P. vaginatum* (a species not present in identified hippo lawns of Loango NP) as being consumed by hippos, this study also highlights the effectiveness

Table 2. Hippo diet in literature — *Régime alimentaire de l'hippopotame dans la littérature*.

Reference	Country	Species ingested
Field, 1970	Uganda	*Sporobolus pyramidalis*, *Brachiara decumbens*, *Cynodon dactilon*, *Themeda triandra*, *Botriochloetum* sp.
Oliver et al., 1974	Tanzania	*Themeda trianra*, *Cynodon dactylon*, *Chloris gayana*, *Andropogon schiresis*, *Bothriochloa insculpta*, *Eragrostis racemosa*, *Hyparrhenia filipendula*, *Panicum maximum*, *Panicum* sp., *Sporobolus pellucidus*, *Eragrostis tennifolia*, *Heteropogon contortus*, *Cyperus merkeri*
Mackie, 1976	Zimbabwe	*Pogonarthria squarrosa*, *Urochloa mosambicensis*, *Digitaria milanjiana*, *Sporobolus panicoides*, *Tragus berteronianus*
Delvingt, 1978	R.D.C.	*Sporoboletum sanguinei*, *Craterostigmetum*, *Sporoboletum pyramidalii*, *Botriochloetum* sp.
Scotcher et al., 1978	South Africa	*Panicum maximum*, *Urochloa mosambicensis*, *Cynodon dactylon*, *Hemarthia altissima*, *Echinochloa pyramidalis*, *Cyperus fastigiatus*
Kingdon et al., 1997	Africa	*Brachiara* sp., *Themeda* sp., *Chloris* sp., *Setaria* sp.
Noirard et al., 2004	Niger	*Oryza brachyantha*, *Cynodon dactylon*, *Echinocloa colona*, *Commelina nudiflora*, *Paspalum scrobiculatum*, *Cyperus* sp.

of using faecal analysis *vs* floristic description of hippo pastures.

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Bibliography

Arsenault R. & Owen-Smith N., 2002. Facilitation *versus* competition in grazing herbivore assemblages. *Oikos*, **97**, 313-318.

Delvingt W., 1978. *Écologie de l'hippopotame (*Hippopotamus amphibius*) au Parc National des Virunga (Zaïre)*. PhD thesis: Faculté universitaire des Sciences agronomiques de Gembloux (Belgium).

Eltringham S.K., 1999. *The hippos: natural history and conservation*. London: Academic Press.

FAO, 2013. *Grassland species index*, http://www.fao.org/ag/AGP/AGPC/doc/GBASE/Default.htm, (09/01/2013).

Field C.R., 1970. A study of the feeding habits of the hippopotamus in the Queen Elizabeth National Park, Uganda, with some management implications. *Zool. Afr.*, **5**, 71-86.

IUCN, 2009. *IUCN red list of threatened species. Version 2009/2*, http://www.iucnredlist.org, (09/01/2013).

Kingdon J. & Pagel M., 1997. *The Kingdon field guide to African mammals*. London: Academic Press.

Mackie C., 1976. Feeding habits of the hippopotamus on the Lundie River, Rhodesia. *Arnoldia (Rhod)*, **7**, 1-16.

Michez A., 2006. *Étude de la population d'hippopotames (*Hippopotamus amphibius *L.) de la rivière Mouena Mouele au Parc National du Loango-Sud (Gabon)*. Msc thesis: Faculté universitaire des Sciences agronomiques de Gembloux (Belgium).

Noirard C. et al., 2004. Diets of sympatric hippopotamus (*Hippopotamus amphibius*) and zebus (*Bosindicus*) during the dry season in the "W" National Park (Niger Republic). *Game Wildl. Sci.*, **21**, 423-431.

Olivier R.C.D. & Laurie W.A., 1974. Habitat utilization by *Hippopotamus* in the Mara river. *East Afr. Wildl. J.*, **12**, 249-271.

Scotcher J.S.B., Stewart D.R.M. & Breen C.M., 1978. The diet of the *Hippopotamus* in Ndumu Game Reserve, Natal, as determined by faecal analysis. *S. Afr. J. Wildl. Res.*, **8**, 1-11.

Verweij R.J.T. et al., 2006. Grazing lawns contribute to the subsistence of mesoherbivores on dystrophic savannas. *Oikos*, **114**, 108-116.

(13 ref.)