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Quantifying poached wildlife mammal species in Center-western region of Côte d'Ivoire

Félix KouadioYéboué[1,2], Mathurin Koffi[1*], Idrissa Sylla[1], Innocent Allepo Abe[1,3], Bernardin Ahouty[1,3], Martial Kassi N'Djetchi[1], Siriki Simaro[1], Thomas Konan[1], Abiba Sanogo Tidou[1] and Béné Jean-Claude Koffi[2]

[1]Unité de Recherche en Génétique et Epidémiologie Moléculaire (URGEM), Laboratoire de Biodiversité et Gestion durable des Ecosystèmes Tropicaux, UFR Environnement, Université Jean Lorougnon Guédé, BP 150 Daloa, Côte d'Ivoire.
[2]Unité de recherche en Primatologie, Laboratoire de Biodiversité et Gestion durable des Ecosystèmes Tropicaux, UFR Environnement, Université Jean Lorougnon Guédé, BP 150 Daloa, Côte d'Ivoire.
[3]Laboratoire De Génétique, UFR Biosciences, Université Félix Houphouët-Boigny, 22 BP 582 Abidjan 22, Côte d'Ivoire.

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Poaching or illegal hunting of wildlife for bushmeat is common in Côte d'Ivoire and particularly in center-western regions where it is actually a major income source contrary to traditional livelihood need. In order to assess the threat and impact of illegal bushmeat off take on sustainable biodiversity and conservation of wildlife resources to fill the information gap we examined the quality and quantity of extracted wildlife fauna for bushmeat in these regions from September 2018 to April 2019. Forty-seven bushmeat data collection sites were considered. Data collection was designed to collect information on the species poached, quantity, sex of poached animals, age estimate as well as poaching methods. A total of 352 wildlife mammals corresponding to 8 orders and 18 species was collected from bushmeat traders and markets. The order of rodents comes largely in the lead with more than half of the specimens encountered that is, 67.05% and the grass cutter species, *Thryonomys swinderianusis* the most poached and the only one found in all the sites investigated. A significant sex-specific pressure ($p<0.009$) was noted. Despite 77.78% of the species collected are classified minor concern, it is undeniable that the conservation status of wildlife biodiversity will always be threatened by illegal hunting. It is therefore up to the state authorities to officially cover hunting with clear control measures for the sustainable management of wildlife biodiversity.

Key words: Bushmeat, illegal hunting, poaching, biodiversity, wildlife, harvest, conservation.

INTRODUCTION

Bushmeat, defined as meat and organs derived from wildlife species has always been a source of food for humans living in rural areas in many parts of the world (Milner-Gulland and Bennett, 2003). Todays, consumption of bushmeat, besides being an important source of protein for rural households, has implications for food security and income generation for millions of people in tropical areas (Nasi et al., 2008). Bushmeat is increasingly

becoming a preferred meat compared to domestic meat for urban populations in many African countries (Codjia and Assogbadjo, 2004; Williamson and Bakker, 2017).

However, current population growth, increased access of hunters to row forests due to expansion of roads, marketing of bushmeat in large urban cities, taste preference and illegal hunting procedure have resulted in hunting and related bushmeat trade activities which negatively impact wildlife worldwide, with serious implications for biodiversity conservation (Chaves et al., 2019; Gonçalves et al., 2019).

In most areas where hunting has been studied, vertebrates represent almost all of the meat of wild animals consumed and traded. By category, mammals are the most common (Pimm et al., 2014). Around the 1990s, it was estimated that more than 5 million tons of wild mammals' meat were consumed each year, including 4.9 million tons in tropical Africa areas (Fa and Peres, 2001). More recent estimates suggest that almost six million tons of wild mammal meat are consumed each year in the neo-tropical and tropical Africa regions (Nasi et al., 2011), with up to 301 species of terrestrial mammals currently threatened with extinction (Ripple et al, 2016).

In Côte d'Ivoire, during decades, biodiversity has been subject to various pressures such as extensive slash-and-burn agriculture, agro-industrial plantations, uncontrolled exploitation of forest products and unauthorized hunting (Goné Bi et al., 2013) although around independence first years, a series of laws aimed at creating national parks, natural reserves and protected forests for biodiversity purpose has been adopted (Monza, 1996). Currently, many households, in both rural and urban areas depend on wildlife resources for their livelihoods and as a source of income with serious impact on biodiversity (Fa and Brown, 2009; Gonédélé et al., 2017). Despite the growing offtake bushmeat leading to biodiversity threatened in Côte d'Ivoire, scientific literature to quantify the importance of the concern are scarce leading to lack of information. The objective of this work is to examine the diversity and quantity of species hunted in Center-western Côte d'Ivoire to raise awareness to policymakers for conservation strategies.

METHODOLOGY

Study area and sampling sites

Bonon, Daloa, Gonaté, Issia, Sinfra, Vavoua and Zoukougbeu are Ivorian cities located in the Central-western part of the country, visited to collect specimen and information on the bushmeat poaching and trade. This area straddles savannah and forest vegetation, surround the Marahoué National Park and numerous protected forests, with the most important being the Haut-Sassandra protected forest. The climate is shared between a warm and humid equatorial on one hand and a subtropical on other hand. The main activity is agriculture with numerous coffee and cocoa plantations.

Forty-seven sample collection sites were visited, including nine in Bonon, nine in Daloa, four in Gonaté, five in Issia, seven in Sinfra, eight in Vavoua and five in Zoukougbeu (Figure 1) according to the availability of traders.

Data collection

Collection of bushmeat samples was conducted over 8 months' period (September 2018- April 2019) in cities mentioned above in 47 collection sites. The bushmeat sample collectors were introduced to traders to develop mutual confidence. Each site was surveyed two time per day (from 6:30 a.m. to 10:00 a.m. and from 4:00 p.m. to 6:30 p.m.) looking for availability of bushmeat based on testimonials bushmeat traders during a pre-survey phase. These two visits time correspond to the usual delivery times for hunters or suppliers. Unexpected visits are sometimes carried out in addition to regular visits time.

When a bushmeat is found, morphological identification of the species is made based on the field guide of Jonathan Kingdon (Kingdon, 1997). In some cases, we relied on local knowledge for identification. Interviews to traders were conducted either in French or local languages to get information about hunting tools, local knowledge on species, most preferred species etc.

Data analysis

Qualitative and quantitative parameters of illegal hunting species and links between the hunting grounds and the samples were assessed with the following calculations:

(i) The Relative Abundance Index (RAI) with the formula: RAI (%) = ni / N × 100
with RAI the relative abundance, ni the number of individuals of the species considered and N the total number of individuals of all species combined;
(ii) Shannon - Weaver (H') specific diversity index applied to the species killed with the formula:

$$H' = -\sum [(ni / N) \log2 (ni / N)]$$

where H' represented the specific diversity, ∑ the sum of the results obtained for each of the species represented, ni the size of the species i, N the total number of individuals observed with respect to all the species together;
(iii) Simpson Index (S) was calculate with the formula:

$$\lambda = \sum_{i=1}^{R} p_i^2,$$

and measure the degree of concentration when individuals are classified into subtypes or the probability that two entities taken at random from the dataset of interest represent the same subtype. R the richness is the total number of types in the dataset and pi the

*Corresponding author. E-mail: m9koffi@yahoo.fr. Tel: +225 09454945.

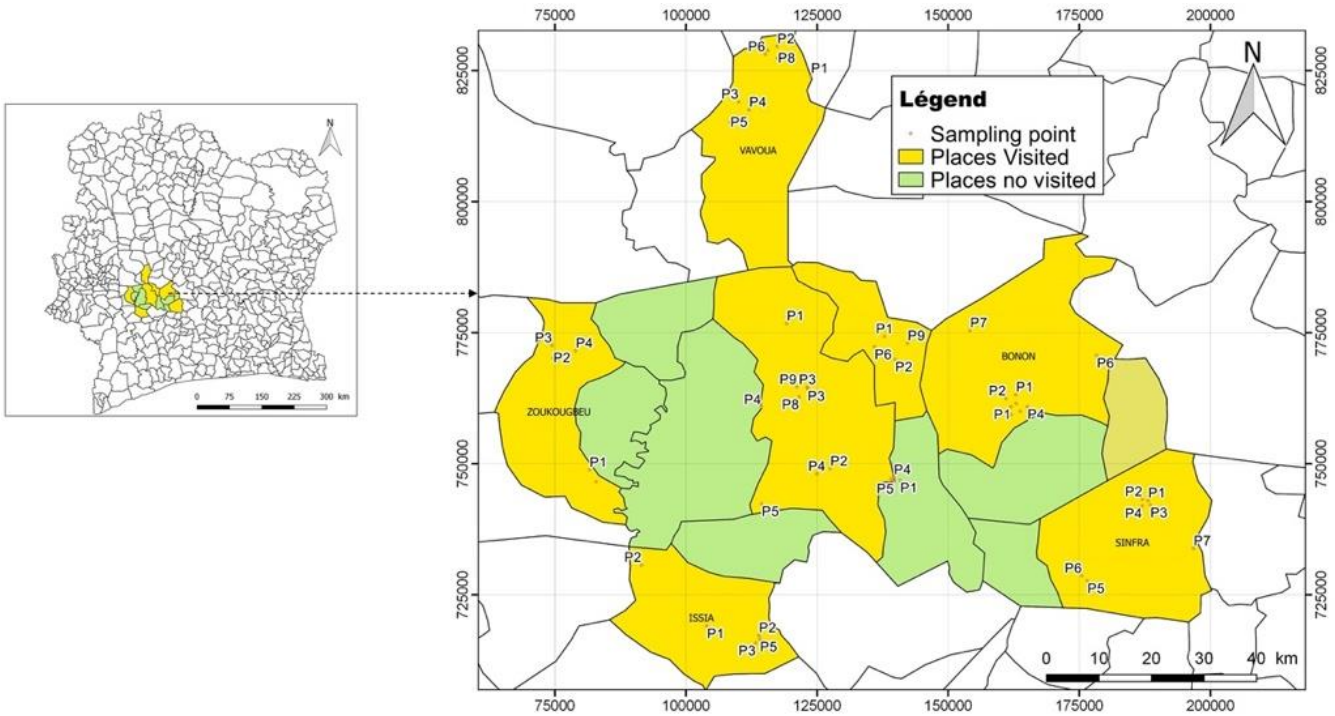

Figure 1. Bushmeat sales outlets in seven cities in the Center-West of Côte d'Ivoire.

arithmetic mean weighted of the proportional abundances of the types of interest.

(iv) Fairness index (J) was used to estimate the distribution of species within the surveys by evaluating the proportion of dominant and dominated species and calculated from the value of H' and the specific richness S with the formula:

$$J = H' / H_{max} = H'/ \log_2 (S).$$

(v) Poaching pressure on wildlife species was the analysis regarding sex of the species slaughtered, the age group and physiological state of the females using generalized linear mixed effect models (Bolker et al., 2009) with the lme4 package (Bates et al., 2015).

The conservation status was analyzed using local information and that provided by IUCN website (www.iucnredlist.org)(IUCN, 2020).

RESULTS

Diversity and abundance of wildlife poached and trade

A total of 352 wildlife mammals corresponding to 8 orders and 18 species was collected from bushmeat traders and markets of the seven cities visited. The site from Vavoua area provided a greater number of bushmeat (69) corresponding to 13 out of 18 species observed. The order of rodents comes largely in the lead with more than half of the specimens encountered that is, (67.05%). The primate order was represented by one species, *Cercopithecus petaurista,* only found in Daloa and Issia (Table 1 and Figure 2). At the specific level, the grass cutter species *Thryonomys swinderianus* is the most poached species (141 out of the 352 specimens collected) and the only one found on all the sites investigated. It presents a substantially equal abundance in all the regions visited and is followed by the species *Cricetomys gambianus*, both belonging to the rodent order (Table 1 and Figure 3). Two species *Funisciurus* sp and *Dendrohyrax dorsalis sylvestris* were observed only once each at Vavoua and Gonaté respectively.

The overall Shannon H index observed on all the sites visited is equal to 2.03 with more or less significant differences between the sites. The Gonaté site has the highest H index, while the Daloa site has the lowest H index, reflecting a great disparity in the abundance of species on this site. Regarding the spatial distribution of species, the Global Fairness Index of 0.70 reflects the lack of fairness between the different poached species and their numbers. However, with a fairness index of 0.84, close to 1, Gonaté's site tends towards a fairness between species and number of animals killed (Table 2).

Wildlife slaughter pressure and conservation status

The pressure on wildlife was measured taking into account the age of the animals slaughtered, the gestational status, the poaching method and the sex. Our investigations showed that there is a significant difference ($p < 0.001$) between adults and juveniles poached; adults

Table 1. Order, species and number of wildlife hunted in study site in survey period.

Order	Animal species	Visited localities							Total
		BONON	DALOA	GONATE	ISSIA	SINFRA	VAVOUA	ZOUKOUGBEU	
Rodentia	*Cricetomys gambianus*	9	-	13	-	13	13	2	50
	Funisciurus sp.	-	-	-	-		1	-	1
	Thryonomys swinderianus	22	26	11	33	22	13	14	141
	Xerus erythropus	5	-	7	-	6	16	2	36
	Atherurus africanus	1	1	1	1	-	3	1	8
	Philantomba maxwellii	5	-	1	2	-	1	-	9
	Cephalophus dorsalis	-	-	-	-	-	3	-	3
	Phacochoerus aethiopicus africanus	-	1	-	-	-	1	-	2
Artiodactyla	*Tragelaphus scriptus*	2	3	3	8	-	9	6	31
	Civettictis civetta	3	1	2	-	4	1	1	12
	Genetta pardina	1	-	4	-	-	3	-	8
	Atilax paludinosus	-	-	-	2	-	-	-	2
Carnivora	*Galerella sanguinea*	-	-	1	-	1	3	-	5
Primates	*Cercopithecus petaurista*	-	4	-	2	-	-	-	8
Pholidota	*Manis tricuspis*	-	-	1	2	-	-	-	3
Lagomorpha	*Lepus microtis*	-	-	6	-	6	2	-	23
Hyracoidea	*Dendrohyrax dorsalis sylvestris*	-	-	1	-	-	-	-	1
Chiroptera	*Eidolon helvum*	-	6	-	3	-	-	-	9
Total		59	42	51	53	52	69	26	352

being the most hunted. However, there is a selective pressure according to sex ($p < 0.009$) with male the most poached animals (Table 3). The most common method used by illegal hunters is the rifle ($p=0.001$) from afar followed by the snares although the later has low cost (Table 4). There are significantly more non-pregnant females killed ($p<0.001$), although the 13.86% of pregnant females killed is not negligible at all (Figure 4).

This pressure can also be examined by assessing the poached species included in the IUCN red list (Table 5). It appears that 77, 78% of the species collected are classified Least concern (LC) and only 5.55% endangered (EN) and 16.67% classified as almost threatened. At the local level, according to the protection criteria in Côte d'Ivoire, 83.83% of the species are considered to be abundant whereas the Western tree hyrax considered LC by IUCN is found in the category of rare species (Table 5).

DISCUSSION

Illegal hunting or poaching can have direct effects on wildlife populations and indirect effects on the functioning, structure and composition of the ecosystems of which they are part (Nasi et al., 2010). Evidence of the effects of depletion exists in some African regions where more than half of the forest mammals are considered to be hunted unsustainably (Fa and Peres 2001; Fa et al., 2002).

In this region of Center-West of Côte d'Ivoire which is the subject of our study, the period from September to April corresponds to the period where poaching is most practiced unlike the period from May to August, period of heavy rains, devoted to agricultural activities. The period of our investigation therefore provides a real view of the diversity and abundance of bushmeat harvesting. It appears that the wild fauna commonly poached and sold in restaurants in west-central Côte d'Ivoire is largely made up of small mammal

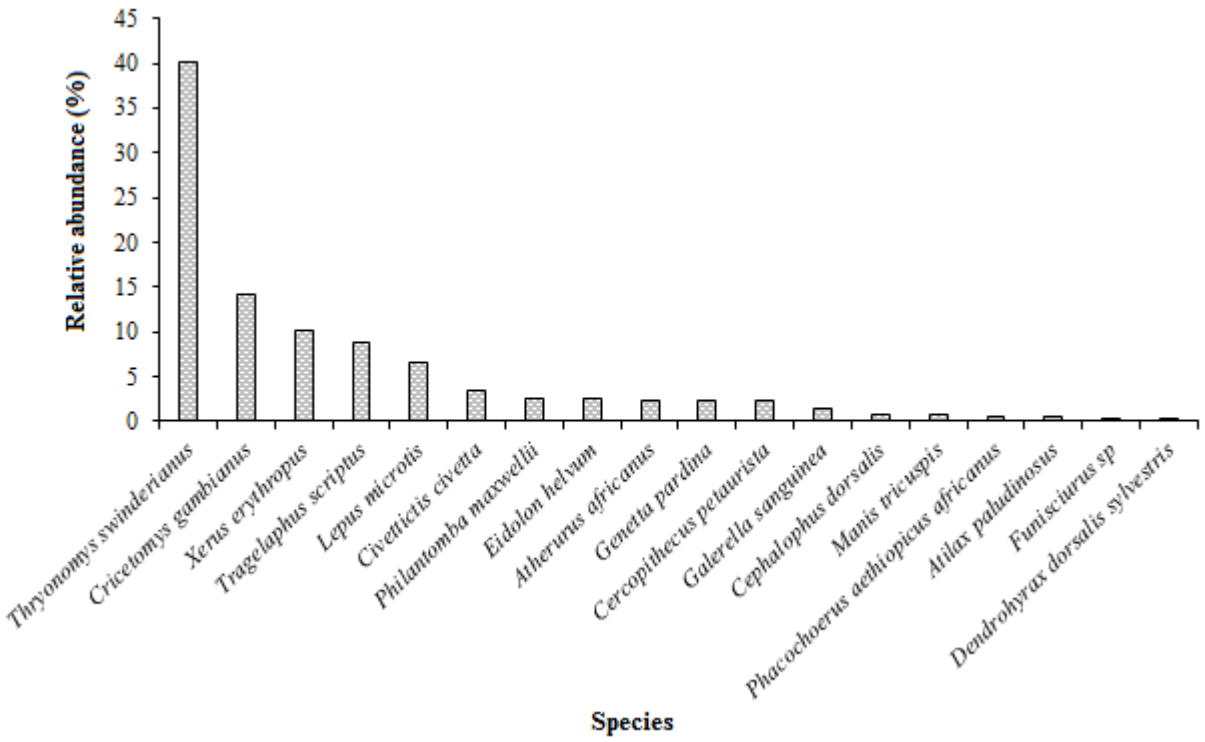

Figure 2. Comparative abundance of bushmeat species in whole area surveyed.

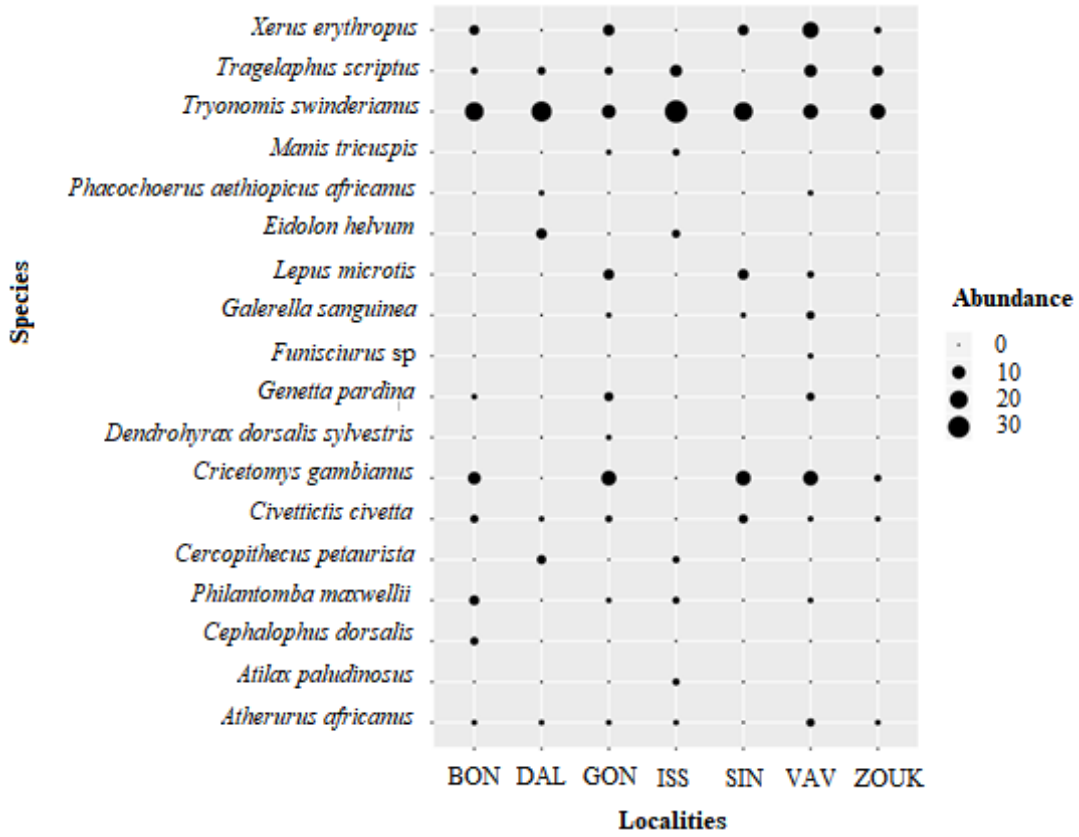

Figure 3. Abundance of bushmeat species traded according to visited localities.

Table 2. Index of diversity of bushmeat in the localities surveyed and throughout the study area.

Index	Localities surveyed							
	BON	**DAL**	**GON**	**ISS**	***SIN***	***VAV***	***ZOUK***	***Global***
Shannon-Weaver (H')	1.74	1.25	2.08	1.31	1.48	2.04	1.32	2.03
Simpson (SI)	0.75	0.58	0.84	0.58	0.73	0.84	0.64	0.78
Equitability (J)	0.79	0.64	0.84	0.63	0.83	0.82	0.74	0.70
Species richness (S)	9	7	12	8	6	13	6	18

BON: Bonon, DAL: Daloa, GON: Gonate, ISS: Issia, SIN: Sinfra, VAV: Vavoua, ZOUK: Zoukougbeu.

Table 3. Sex- and age-specific impact of poaching mortality in regions surveyed.

Parameter	Age categories				*Sex of animals*			
	Adults	**Juveniles**	***t***	***P***	**Females**	**Males**	***t***	***p***
Total	339	13			123	229		
Meanabundance (± sd)	48.4 ±12.8	1.8 ± 0.6	9.5	< 0.001	17.57 ±	32.71± 10.8	3.10	0.009

Table 4. Prevalence of methods used to hunt wildlife for bushmeat in center-western region in Côte d'Ivoire.

	Poaching methods				
	Dogs	**Rifles**	**Snares**	**Others**	**P**
Number of poached wildlife	23	277	34	18	
(%)	6.53	78.7	9.66	5.11	0.001

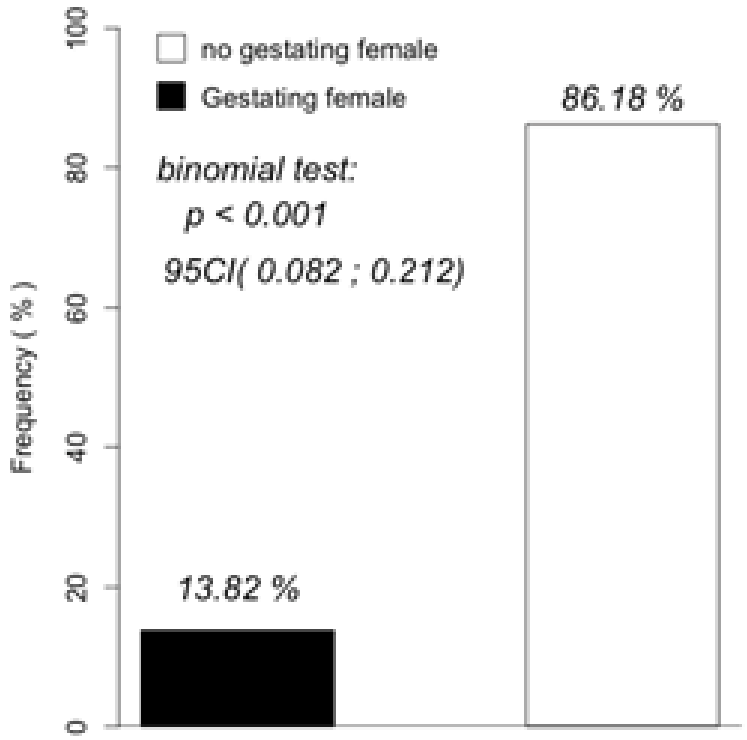

Figure 4. Gestational status of poached females.

Table 5. Wildlife conservation status in Côte d'Ivoire and international level.

Order	Animal species	Common name of species	Conservation status	
			UICN 2020	Local
Rodentia	*Cricetomys gambianus*	Gambian rat	LC	XXX
	Funisciurus sp	Squirrel	LC	XXX
	Thryonomys swinderianus	Marsh cane rat	LC	XXX
	Xerus erythropus	Striped ground squirrel	LC	XXX
Artiodactyla	*Atherurus africanus*	African Brush-tailed porcupine	LC	XX
	Philantomba maxwellii	Maxwell's duiker	LC	XXX
	Cephalophus dorsalis	Bay duiker	NT	X
	Phacochoerus aethiopicus africanus	Common warthog	LC	XXX
	Tragelaphus scriptus	Bushbuck	LC	XXX
Carnivora	*Civettictis civetta*	African civet	LC	XXX
	Genetta pardina	Pardine genet	LC	XXX
	Atilax paludinosus	Marsh mangoose	LC	XX
	Galerella sanguinea	Slender mangoose	LC	XXX
Primates	*Cercopithecus petaurista*	Spot nosed monkey	NT	XX
Pholidota	*Manis tricuspis*	White-bellied pangolin	EN	X
Lagomorpha	*Lepus microtis*	African savanna hare	LC	XXX
Hyracoidea	*Dendrohyrax dorsalis sylvestris*	Western tree hyrax	LC	X
Chiroptera	*Eidolon helvum*	African straw-coloured fruit-bat	NT	XXX

LC : Least concern ; NT: Near threatened; EN: Endangered; XXX : Abundant species; XX : Scarce species; X : Rare species.

species mainly from the rodent order (67.05%) and to a lesser extent, from the order of Lagomorpha (6.23%) as already observed in other regions of Côte d'Ivoire (Gonedelé et al., 2017).

Given the important role of mammals as key indicators for measuring anthropogenic impacts on biota (Ceballos and Ehrlich, 2002), and the maintenance and functionality of ecosystems through seed and fruit dispersal, pollination, nutrient recycling, and plant succession (Davidson et al., 2012; Ripple et al., 2015), the large poaching of small species that we observed testifies the strong threats to which the wild fauna of this part of the country is subject. In fact, a large part of the forest area in this region of west-central Côte d'Ivoire has been destroyed in favor of cash crops (coffee, cocoa, hevea) or fallow (Sangne et al., 2015; Kouakou et al., 2015) immediately removing large mammals. The current landscape of this region of the country is ideal for the survival of small species where hunting activities are practiced (Gonedelé Bi et al., 2017; Chabi-Boni et al, 2019). The high specific diversity of small mammals observed is in agreement with the studies of Ahmadi et al which affirm that the small species are slaughtered in fields and fallows close to rural habitats while the large species are slaughtered in reserves and protected areas in tropical countries, far from the places where hunters live (Ahmadi et al., 2018).

The mostly poached species is the grass cutter *T. swinderianus*, which alone represents almost half (40.06%) of the wild animals killed and observed in our sampling sites. It is the most abundant in all the sites visited, except in Vavoua where the species *Xerus erythropus* was the most encountered. This confirms the results of our pre-surveys which revealed that the grass cutter was the most popular and observed species in the bushmeat sector in the Haut-Sassandra region. These results are in agreement with studies on the trophic preferences of bushmeat in Ghana, where grass cutter was undoubtedly the most popular and consumed meat with 73% of all poached species (Kuukyi et al., 2014). This strong distribution of the grass cutter in all the sites investigated could be explained by the fact that hunting takes place for the most part in the dry season when water points are scarce and only rivers and their banks attract the animals which come there to drink. Aware of this situation, the hunters in the region made fallows and gallery forests, their preferred hunting area. Fortunately, local conservation data show that grass cutter remains abundant in Côte d'Ivoire and does not suffer from extinction. In addition, research is well advanced for the domestication of grass cutter species in West Africa (Falade et al., 2010; Ibitoye et al., 2019). When wildlife harvesting is not controlled, as it is the case here, when it is poached, the consequences for animal populations and biodiversity are disastrous. Indeed, the results of this study show that juvenile populations and pregnant females do not benefit from preferential treatment from hunters. They are slaughtered in the same way as adults

and non-pregnant even if the proportions remain statistically insignificant. This has already been observed by other researchers working on the conservation of wildlife biodiversity and the inventory of wildlife and wildlife resources in Côte d'Ivoire (Dufour et al., 2015). Animals slaughtered without distinction of sex, age or physiological state exacerbated by a noticeable over-exploitation preventing populations from rebuilding causes the extinction of species. In addition to demographic concern on small populations, age and sex-biased poaching prevalence may contrast sustainable ecosystem complexity (Corlatti et al., 2019). Our results also show that the rifle is the most used hunting tool in the center-west of the country. These results are contrary to those obtained near the Dassioko reserve in other part of Côte d'Ivoire where the use of snares was the dominant hunting method (Gonedelé et al., 2017). These results could be explained by the fact that the socio-political crisis that went through the country for ten years was most felt in the west and the center-west of the country. This led to the proliferation of shotguns and demonstrates the use of more modern hunting tools. These results are consistent with the conclusion of General state of the forest workshop on wildlife and water resources in Côte d'Ivoire (Dufour et al., 2015). Although the majority of the species encountered are considered to be of Least Concern according to IUCN and the national and local status, the species *Cephalophus dorsalis* and the pangolin are part of threatened categories because the laws on hunting are not respected.

Conclusion

Eighteen species of mammal were identified in seven localities in the central west of the Côte d'Ivoire. These species belong to eight taxonomic orders. The rodent order is the most widely represented, with the majority of species being the grass cutter *T. swinderianus*. The main cause of the scarcity of wildlife in Côte d'Ivoire is illegal hunting for commercial purposes, because despite the ban of hunting since 1974, poaching still takes place, beyond the limits of protected areas with various methods, the rifle being the most observed for this study. All these means and methods do not promote sustainable management of wildlife biodiversity. It is undeniable that the conservation status of wildlife biodiversity will always be threatened by illegal hunting. It is therefore up to the state authorities and policy-makers to officially cover hunting with clear control measures for the sustainable management of wildlife biodiversity and promote farming of preferred bushmeat. It is only on this basis that hunters will leave illegality to comply with the established rules.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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