HUNTING TECHNIQUES, WILDLIFE OFFTAKE AND MARKET INTEGRATION. A PERSPECTIVE FROM INDIVIDUAL VARIATIONS AMONG THE BAKA (CAMEROON)

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ABSTRACT Hunting is a main threat for wildlife conservation in Central Africa, but remains an essential component of local people's livelihoods. Research suggests that hunters engage in hunting in different ways, especially according to various technical means, which might potentially have differentiated impacts on wildlife. Using quantitative data collected over a 12 months period, we analyse different hunter's profiles among the Baka of Southeastern Cameroon, and compare socio-economic and hunting offtake data across profiles. We monitored 719 hunting events, recording 579 catches (belonging to 32 species). Most Baka hunters engage in snare trapping, a relatively low-efficiency hunting technique, while a reduced number of Baka hunters use firearms. Firearm users obtain the highest offtake and sell most of it. This study therefore suggests the emergence of specialized hunters in shotgun hunting with a higher integration in market economy. Disentangling the effects of hunting techniques and their relations to socio-economic status might help design wildlife management strategies that take into consideration the diversity and the complexity of practices among local populations.

Key Words: Bushmeat; Baka hunter-gatherers; Hunting practices; Pygmies; Access to market; Wildlife conservation.

INTRODUCTION

Hunting constitutes one of the major hurdles for managing the biodiversity crisis in Africa (Wilkie et al., 2011). This is so largely because hunting is a two-sided coin: while wild meat consumption remains an essential component of indigenous and rural peoples' livelihoods and culture (Bennett & Robinson, 2000), a main source of protein (Kümpel et al., 2010), and an occasional source of income (Angelsen et al., 2014), unsustainable hunting practices have made the conservation status of some game species alarming (Taylor et al., 2015). In the last decades, unsustainable hunting practices have largely increased driven by factors such as access to improved technology (Robinson et al., 1999), better road access to previously remote areas (Brodie et al., 2015), and the growth in demand for bushmeat, mostly from the fast expanding African urban centers (Brashares et al., 2011) which has risen the monetary incentives for local people to engage in hunting (Robinson et al., 1999). Therefore, overhunting is putting at risk food security and peoples livelihoods (Nasi et al., 2011) but also has led to a rapid defaunation, typically referred to as the "bushmeat crisis" (e.g., Bowen-Jones & Pendry, 1999), with potential ecological effects not only on local wildlife, but also on the overall structure and composition of local ecosystems (Effiom et al., 2013; Ripple et al., 2016).

In such a dynamic context, research addressing the complexity of the interactions among ecological, socio-economic and cultural aspects of bushmeat hunting is critically needed (van Vliet et al., 2010; Nasi et al., 2011). Previous research on the topic has determined harvest rates to assess whether levels of exploitation are sustainable (e.g., Fa & Brown, 2009; Bobo et al., 2015), or has estimated the importance of bushmeat for urban markets (Fa et al., 2006; Kümpel et al., 2010) and rural livelihoods (Wilkie & Carpenter 1999; Bakarr et al., 2001). Anthropologists have often studied subsistence hunting as a cultural practice in which skills and knowledge are acquired and reproduced within a social context (Gurven et al., 2006). But research also suggest that hunting practices also vary according to individual characteristics such as for instance education level—as schooling might allow people to acquire new skills, change their behaviors, beliefs, or their roles in society (Luz et al., 2015)—or such as monetary income or the frequency of travel to a market town (Koster et al., 2010; Brashares et al., 2011; Reyes-García et al., 2016a).

However, we still lack a complete understanding of the interactions between the ecological, socio-economic and cultural aspects of bushmeat hunting. One potential way of addressing this issue is to study the relations between hunters' socio-economic characteristics and their choices of hunting techniques (see for example Kümpel et al., 2009; Gill et al., 2012).

In this article we analyse the relation between individual socio-economic features (i.e. schooling, cash income, and visits to the market town) and the choice of different hunting strategies (i.e., weapon used, game hunted, and hunting efficiency) among the Baka of Southeastern Cameroon. Specifically, we i) describe hunting offtake and techniques used by the Baka, ii) analyse the individual variations in hunting practices categorizing hunters in different profiles, and iii) study the socio-economic characteristics associated to such profiles. We aim with this paper to contribute to the understanding of the relationship between the socio-economic and cultural contexts of the bushmeat crisis and the impact of different hunting strategies.

MATERIALS AND METHODS

I. Study Area

Our study was conducted in the Lomié and Messok districts, Haut-Nyong department, southeastern Cameroon. The region, covered by semi-deciduous lowland forest, counted three protected areas: the Boumba-Bek and the Nki National Parks and the Dja Biosphere Reserve. This ecosystem shelters many representatives of the region's mega fauna including the forest elephant Loxodonta cyclotis, the chimpanzee *Pan troglodytes*, the western lowland *gorilla Gorilla gorilla*, and the African forest buffalo *Syncerus caffer nanus*. Over the last decades, it has been shown that such large mammals are highly vulnerable to the increase of hunting pressure which has been acknowledged as unsustainable (Bowen-Jones, 1998; Wilkie et al., 2011). Thus, the conservation status of such species has rapidly reached an alarming point, has been classified from 'near threatened' to 'critically endangered' by the IUCN (2015), and in three protection classes (A, B, C) by the Forestry & Wildlife Law (Republic of Cameroon, 1994). Moreover, smaller species, although more abundant, also seem to suffer the consequences of overhunting (Bennett & Robinson, 2000). The duikers, forest antelopes, are the most frequently hunted species of the area, as well as one of the most abundant and widespread mammals group (Yasuoka, 2006; Bobo et al., 2014).

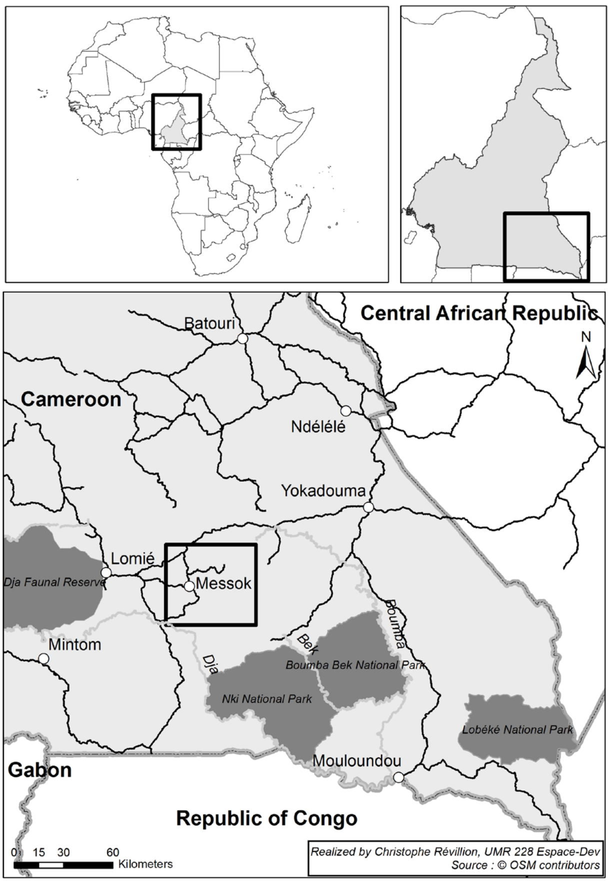

Fig. 1. Map of the study area

II. Human Population

Before the turn of the 1960s, when the Baka adopted agriculture (Leclerc, 2012), their subsistence was based on a combination of hunting, gathering, fishing, "paracultivation" of wild yams, and the acquisition of cultivated products by barter (Bahuchet et al., 1991; Dounias, 2001). After the adoption of agriculture, the Baka started to spend longer periods in villages along logging roads (Leclerc, 2012) increasing the frequency of economic exchanges with non-Baka such as the Nzime, agriculturalists, the other main ethnolinguistic group co-existing in the study area. Nowadays, most Baka in the study site engage in wage labour in Nzime fields, and occasionally in cacao plantations or logging camps, and obtain cash from the sale of bushmeat or non-timber forest products (NTFP) in addition to their traditional activities such as hunting and gathering.

Traditional Baka hunting always implied the use of spear (Bahuchet, 1992), either employed in individual hunting with dogs or in cooperative expeditions targeting hogs or elephants. Other traditional hunting techniques, still in use, include unearthing burrowing animals with fire and smoking hornbills Bucerotidae or hyraxes Hyracoidea out from their nests. During short stays in forest, hunters aim for porcupines *Atherurus africana* or lure small duikers by imitating their distressed call. Attracted animals are then cornered by dogs and killed with machete or spear. The hunt of large mammals requires specific social and technical organization (Joiris, 1998). Elephant hunting carries the highest social and symbolic importance, although smaller and less ritualized hunts are of primary importance for daily food supply (Bahuchet, 1992).

All through the Congo Basin, ancestral migrations and socio-political relations between ethnic groups have led to technical changes in hunting practices since the beginning of the twentieth century, notably in the southern Cameroon (Dounias, 2016). More recently, social-ecological changes are pushing hunters from all the Congo Basin to adopt more efficient hunting techniques, such as steel cable snares and 12-gauge shotguns (van Vliet & Nasi, 2008; Kümpel et al., 2009; Yasuoka, 2014) although their use is forbidden by the Cameroonian forest reform. Although "Pygmies" populations rarely own firearms, shotguns are common and might often be lent to them by outsiders who contracted them to hunt for commercial purposes (Riddell, 2013). Hunters from different communities are thus not equally affected by recent changes. Strong disparities exist between "Pygmies" and "non-Pygmies" in hunting revenue, wealth and bushmeat dependence (Rickenbach, 2015), but also in hunting pressure and species targeted (Fa et al., 2016). Moreover, in Cameroon, the implementation of hunting regulations under the forest reform of 1994 has posed a new challenge to local people by restricting hunting grounds, methods and species targeted. This situation, by making most of the local hunting practices illegal, might have severe impacts on livelihood, already affected by ecological problems (Ichikawa et al., 2016).

III. Data Collection

Data were collected between July 2012 and August 2013. Intensive fieldwork was conducted in two Baka villages, with a population varying between 200 and 300 individuals, depending on the season. The two sampled villages were settled along the logging roads, at 51 and 65 km from the main town in the area, Lomié. We sampled all adults (≥ 16 years of age) present in both villages during at least six of the 12 months of fieldwork (n = 269), and identified the hunters (n = 100) defined here as any men or women reporting at least three hunting trips during the study-period. Most data collection was helped by a Nzime or a Baka translator. To reduce reporting bias, much effort was put in establishing relations of trust with the informants, including learning Baka language and ensuring participants' anonymity. Before the onset of data collection, we obtained Free Prior and Informed Consent of each village and individual participant. This research adheres to the Code of Ethics of the International Society of Ethnobiology and has received the approval of the ethics committee of the Autonomous University of Barcelona (CEEAH-04102010).

IV. Assessment of Hunting Behavior

We conducted weekly recalls of the main activities performed by individuals in the sample such as hunting, house construction, domestic work, gathering, small or large scale agriculture, etc. We used scan observations, an anthropological technique developed for non-literate, foraging societies (Reyes-García et al., 2009). Each week, on a day chosen at random we visited each household and asked each adult about the main activity performed during the two previous days. When hunting was not reported as the main activity, we specifically asked whether the person went hunting during those two days (either as complementary or as opportunistic activity). For each hunting expedition we recorded the Baka name of game killed, the sex and age-category of the animal (juvenile/adult), the estimated time invested in the expedition, the number of people participating in it, and the weapons used. To avoid double counting, for any hunted animal, we carefully noted who had caught the prey and attributed each prey only to one hunter. Baka names were matched with scientific names based on zoological references (mostly Gautier-Hion et al., 1999; Kingdon, 2001). The hunting duration was estimated by informants using as a bench mark sun's positions or events occurred during the studied period, with a maximum duration assigned of 48 hours.

V. Measurement of Hunter's Socio-Economic Characteristics

We conducted a census to collect information on hunter's i) age, ii) sex and iii) schooling (maximum school grade completed). As most Baka cannot recall their birth date, we traced the kinship relations of people living in different households in the village and used the information to estimate informants'ages. The level of schooling was coded from 1 to 5 according to the maximum school grade completed. No one in the sample had completed beyond 5th grade.

We used different socio-economic proxies to characterize hunters: i) wealth, defined as the monetary value of a set of 10 commercial items owned or not by the subject, and representative of the wealth variations in the villages (radio, large cooking pot, machete, torch, petrol lamp, wire snares, chicken, bag, toothbrush, sheet/bed linen); ii) income from sales of wild meat, agricultural and forest products; iii) income received from wage labour and iv) number of visits to the market town in the last month. For the two measures of income (sales and wage labour), we asked for all inputs received in the 15 days previous to the survey. We considered both cash and in-kind income, this latter being converted to their monetary equivalent. Income data and frequency of visits to the market town were collected every three months, and then averaged to obtain a single measure for each individual. The economic values, recorded in Cameroonian currency (US$ 1 = 602.5 XAF, July 2014) were transformed into PPP value (Purchasing Power Parity; 251 XAF: 1$ppp according to Word Development Indicators website).

VI. Data Analysis

We calculated hunting efficiency or catch-per-unit-of-effort (CPUE) as the amount of game (in weight) killed per hour invested in hunting. As it was not possible to weight all the preys reported we used published data to estimate animal's weight according to the age category and the sex of the animal[(1)] (Gautier-Hion et al., 1999; Kingdon, 2001). Juveniles' weight varies rapidly, so we assigned the value of half the weight of the male adult to any juvenile reported. To understand the structure of game community captured by the Baka, we followed Peres (2000) and Luz (2012) and used weight estimations to classify game species in four biomass classes: small species (<1 kg), medium species (1–5 kg), large species (5–15 kg), and very large species (>15 kg) (Table 1).

We first analysed the frequency, percentage, and body-weight of catches across prey genera and family. We then used information from scans to describe hunting expeditions based on the main technique brought for the hunt. Thus, we generated four categories, two related to modern weapons (shotgun and snare made of steel wire) and two corresponding to traditional techniques (the use of fire for smoking out preys and "others" including machete, spear, barehanded catch, bow, crossbow and mice trap). For each category we computed i) the total number of

Table 1. Game community captured according to biomass classes

Small species (<1 kg)	Squirrels, mice, forest hinge-back tortoise.
Medium species (1–5 kg)	Giant pouched rat, blue duiker, red flanked duiker, brush-tailed porcupine, marsh mongoose, tree pangolin, black-footed mongoose, african palm civet, tree hyraxe, crowned monkey, moustached monkey, white-thighted hornbill, black-casqued hornbill, plumed guinea fowl, great blue turaco.
Large species (6–15 kg)	Mantled guereza, grey-cheeked mangabey, agile mangabey, putty-nosed monkey, water chevrotain, nile monitor, rhinoceros viper.
Very large species (>15 kg)	Bay duiker, Peter's duiker, yellow-back duiker, red river hog, gorilla.

observations and kills reported, ii) the mean number of game caught per hunting trip, iii) the mean weight of each prey caught, iv) the total and mean duration in hours, and v) hunting efficiency of the technique (CPUE in kg/hours).

In a second step, we classified hunters in three categories based on their use of technology. We first identified the techniques most frequently used by each hunter in weekly scans: shotgun, snare traps, or traditional techniques (merging smoking out, spear, machete, catapult, mouse trap, or bow); hunters who have used a technique in 50% or more of the reported hunting events were assigned to a category. We only used data of people who had reported at least three hunting expeditions.

Lastly, we analysed differences across those hunter's profiles in terms of i) socio-demographic characteristics, ii) economic characteristics, and iii) hunting offtake measurements using analysis of variance (one-way ANOVA) with a Bonferroni adjustment with $\alpha = 0.005$ for post-hoc comparisons among groups. For statistical analysis we used Stata 11 for Windows.

RESULTS

I. The Prevalence of Wildlife Hunting among the Baka

We collected weekly information from 269 individuals (156 women, 113 men, average number of interviews: 17; SD = 0.6; min = 1; max = 39) for a total of 4,506 observations, where an observation is defined as a structured interview about a person's main activities during the two days before the interview. As observations include a two-day recall, we recorded data for a total of 9,012 person/days. Hunting, either successful or not, was reported as the main activity in 580 person/days (6.4%). Compared to other main activities, hunting appears as the fourth most frequent activity reported, after agricultural work (36.1%), gathering (10.3%), and leisure/resting (9.8%). Hunting is more prominent for the sample of men, for which is the third most frequent activity (14%), after agriculture (25%) and leisure/resting (17%).

We recorded information from 719 hunting events (563 for men, 156 for women). From the 269 people interviewed at least once, 99 individuals did not report any participation in hunting events (84% of them were women). All added, the total duration of hunting events is of 3,878 hours, including opportunistic encounters with animals during forest wandering and hunting expeditions lasting several days. The average time devoted to one hunting trip was of 5.4 hours (SD = 0.16; min = 0.25; max = 24).

II. Prey Species

A total of 579 animal catches were reported during scans (17% juvenile; 44% female) corresponding to 32 species. Some species were caught more frequently than others (Table 2). Thus, 56% of the preys harvested belong to two species: giant pouched rat (28% of the catches) and blue duiker (28%). Other species commonly hunted include the brush-tailed porcupine (9%) and monkeys (an aggregated category representing 12% of catches). Some animals traditionally hunted by the Baka (Bahuchet, 1992) are marginally represented in our dataset. For example, the medium-sized duikers (or "red duikers", *Cephalophus spp.*) and represent only 6 % of the catches and red river hogs less than 1%.

Game harvested by the Baka is dominated by medium-size species (78% of all preys). Other body-weight categories appear secondarily: small species represent 8.6% of the overall harvest, whereas large species represent 6.4%. Very large species represent 7% of the preys harvested. In terms of biomass, the catches reported amounted to 3,111 kg, with duikers contributing with a larger biomass 1,622 kg, followed by rodents (porcupine, rat, mice) with 509 kg, and arboreal monkeys with 356 kg. The report of two gorillas raised the primates' contribution to 597 kg. Despite low individual body-weight, the giant pouched rat represents the third highest contribution in terms of biomass harvested (11%), after the blue duiker (22%) and the Peter's duiker (18%).

Species integrally protected by current hunting regulations (Class A) total 1.39% of individual preys catch and 14% of the biomass. From participant observation we also know that a few elephants (Class A) were hunted during the study period. However, as hunters did not voluntarily report such catches during scans, we do not include them in the analysis. Wildlife species under partial protection (Class B) represent 9.50% of the catches and 34% of the biomass.

III. Hunting Techniques and Efficiency

Snare trapping was the most frequent technique reported (47.6% of the hunting events), followed by the use of fire to smoke out the preys (24.2%), and "other" techniques (including spear, machete, catapult, mouse trap) (16.3%); shotgun hunting was reported in 12% of the hunting events (Table 3).

We found important variations in the time invested and type of animal caught depending on the hunting technique used. Trapping is the technique with the largest accumulated duration (1,829 hours). Indeed, the maintenance of snare traps implies regular visits to collect any potential catch or reset the traps. Although such visits are mostly completed in a few hours (the mean duration of such trips is of 5.4 hours), they need to be done frequently. This contrasts with the average duration of hunting expeditions with shotguns, which typically involve longer trips (mean duration 10 hours) but occur less frequently. Shotgun use appears second in terms of accumulated duration (total 866 hours). Traditional hunting techniques appear as the activities with shorter duration (661 hours for smoking out, 521 hours for other techniques).

Regarding the number of kills, shotgun hunting yielded 33.2% of the catches (n = 192) and snare traps 32.5% (n = 188). Each technique was used to target different groups of species. Firearms slaughtered heavier preys (mean = 7.96 kg) than those captured with traditional methods (2.2 kg for smoking out; 2.8 kg for other techniques). As a non-selective method, trapping might result in the harvest of game in all body-size categories; however, data suggest that trapping indeed

Table 2. Game species harvested, body-weight cumulated and conservation status during a twelve-months period in two Baka villages

English name	Latin name	Baka name	Individuals catched		Cumulated weight (kg)	Class in hunting regulatio[(1)]	IUCN status[(2)]
			Frequency	%			
Artiodactyles							
Blue duiker	*Philantomba monticola*	dὲngbὲ	160	27.63%	692.9	C	LC
Peter's duiker	*Cephalophus callipygus*	ngὲndì	28	4.84%	556.9	B	LC
Bay duiker	*Cephalophus dorsalis*	ngbɔmù	9	1.55%	198.0	B	LC
Yellow-back duiker	*Cephalophus sylvicultor*	bèmbà	3	0.52%	170.0	A	LC
Bate's dwarf antelope	*Neotragus batesi*	ekù	2	0.35%	3.9	C	LC
Water chevrotain	*Hyemoschus aquaticus*	gɛkɛ	1	0.17%	6.0	A	LC
Red river hog	*Potamochoerus porcus*	pàmὲ	3	0.52%	270.0	B	LC
Total Artiodactyles:			**206**	**35.58%**	**1,897.7**		
Rodents							
Brush-tailed porcupine	*Atherurus africanus*	mbòke	50	8.64%	132.0	C	LC
Gambian pouched rat	*Cricetomys emini*	gbè	161	27.81%	347.2	C	LC
Mice	n.det. (category)	bílì	40	6.91%	30.0	C	-
Squirrels	n.det. (category)	sende	3	0.52%	0.4	C	-
Total Rodents:			**254**	**43.88%**	**509.6**		
Hyraxes							
Western tree hyraxe	*Dendrohyrax dorsalis*	yòka	2	0.35%	9	C	LC
Pholidotes							
Tree pangolin	*Phataginus tricuspis*	kokòlo	16	2.76%	38	C	NT
Primates							
Lowland gorilla	*Gorilla gorilla*	èɓoɓo	2	0.35%	240.5	A	CE
Guereza colobus	*Colobus guereza*	kàlu	1	0.17%	11.4	A	LC
Putty-nosed monkey	*Cercopithecus nictitans*	kɔyì	22	3.80%	107.6	C	LC
Crested mona monkey	*Cercopithecus pogonias*	màmbè	8	1.38%	27.0	C	LC
Moustached guenon	*Cercopithecus cephus*	gbɛlὲkɛsὲ	4	0.69%	12.5	C	LC
Agile mangabey	*Cercocebus agilis*	tamba	2	0.35%	14.6	A	LC
Grey-cheeked monkey	*Lophocebus albigena*	gaja	2	0.35%	14.0	C	LC

(*continued*)

Monkeys	n.det. (category)	kémà	30	5.18%	169.2	/	-
Total Primates:			**71**	**12.27%**	**596.8**		
Carnivores							
African palm civet	*Nandinia binotata*	mboka	8	1.38%	13.9	B	LC
Black-footed mangoose	*Bdeogale nigripes*	ɓùsɛ̀	1	0.17%	2.0	C	LC
Marsh mongoose	*Atilax paludinosus*	nganda	7	1.21%	9.0	C	LC
Total Carnivores :			**16**	**2.76%**	**24.9**		
Birds							
Crested guinea fowl	*Guterra plumifera*	kangà	1	0.17%	1.13	C	LC
White-thighted hornbill	*Bycanistes albotibialis*	kàta	1	0.17%	1.0	C	LC
Great blueturaco	*Corythaecola cristata*	kulungu	2	0.35%	1.9	C	LC
Yellow-casqued hornbill	*Ceratogymna atrata*	mángɔ	1	0.17%	1.0	C	VU
Small-sized birds	n.det. (category)	nu	1	0.17%	0.1	C	-
Total Birds :			**6**	**1.03%**	**5.13**		
Reptiles							
Rhinoceros viper	*Bitis nasicornis*	diàkò	1	0.17%	10.0	C	DD
Forest hinge-back tortoise	*Kinixys erosa*	kùnda	5	0.86%	4.3	B	DD
Nile monitor	*Varanus niloticus*	mbambè	2	0.35%	16.0	B	LC
Total Reptiles :			**8**	**1.38%**	**20.3**		
Total :			**579**	**100%**	**3,101.4**		

(1)Class regulations correspond to the Forestry, Wildlife and Fisheries Regulations Law Government of Cameroon (1994).
A = Totally protected, B = Protected, C = Partially protected.
(2)LC: least threaten; NT: near threaten; V: vulnerable; CE: critically endangered; DD: data deficient (IUCN, 2015).

Table 3. Characteristics of Baka hunting techniques

	Shotgun		**Trapping**		**Smoking out**		**Others**		**Total**	
Observations reported	87	12%	341	47.6%	174	24.2%	117	16.3%	719	100%
Total values	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Duration of hunts (hrs)	866	22.5	1,829	47	661	17	521	13.5	3,878	100
Animals killed	192	33.2	188	32.5	134	23.1	65	11.2	579	100
- *Small-size species*	0	0	25	13.3	0	0	25	38.5	50	8.6
- *Medium-size species*	152	79.2	131	69.7	134	100	34	52.3	451	78
- *Large-size species*	26	13.5	6	3.2	0	0	5	7.7	37	6.4
- *Very large-size species*	14	7.3	26	13.8	0	0	1	1.5	41	7
Cumulated weight of animals killed (kg)	1,528.25	49.1	1,112.34	35.7	291.2	9.4	179.7	5.8	3,111.49	100
Average values	Avg	SD	Avg	SD	Avg	SD	Avg	SD	Avg	SD
Duration (hrs/trip)	10.1	0.75	5.4	0.20	3.8	0.22	4.4	0.28	5.4	0.16
Animals killed per trip	2.60	0.32	0.58	0.04	0.94	0.74	0.66	0.10	0.90	0.05
Weight killed (kg/trip)	8	1.31	5.9	0.54	2.2	0.06	2.8	0.70	5.37	0.48
Efficiency (kg/hr)	1.8	0.07	0.6	0.09	0.4	0.05	0.3	0.14	0.8	0.04

captures mainly medium size species (69.7% of game killed with snare) and a few small (13.3%) and very large species (13.8%) (with an average of 5.9 kg harvested per snaring expedition). Among all the preys captured with snare, 50% are duikers, 35% blue duiker and 15% medium-sized duikers. Rodents represent 39% of the catches done with snares. Smoking out appears as a monospecific method, as it targets mainly giant pouched rats (95% of the catches). The Baka do not seem to target very large species with shotguns (7% of the catches), rather, shotguns are mostly used to target medium-size mammals (80% of the prey), in which blue duikers (48%) and primates (35%) represent the main catches. Animals captured with "other" techniques mainly belong to the categories of small and medium species (birds, rodents, small duikers and small carnivores). However, the contribution of such catches is not trivial (2.76 kg per catch).

Hunting trips using shotguns result in an average of 2.6 catches per trip whereas hunting trips with snare and traditional techniques (smoke and others) seem less successful (less than 1 catch/trip). In brief, shotgun hunting displays the largest efficiency (CPUE: 1.8 kg/hr) as compared to all other techniques (0.6 kg/hr for trapping; 0.4 for smoking out; and 0.3kg/hr for "others").

IV. Hunters' Profiles

Half of the people who reported at least three hunting trips fall into the category of trapper (n = 48; 49.5%), defined as people who used snare trapping in more than half of their reported hunting events. The second largest profile corresponds to hunters preferably using traditional techniques (n = 38; 39.2 %). Shotgun is the preferred weapon for only a reduced part of the sample (n = 11; 11.3 %). Three individuals did not have a predominant technique and have been excluded from further analysis.

When comparing the socio-demographic characteristics of hunters falling in each of the three profiles, we found that all shotgun hunters and 92% of snare trappers are men, whereas 47% of the traditional hunters are women ($p \leq 0.0001$). The profiles of those who prefer shotguns seem to correspond to younger hunters (avg. age 29.2 vs. 36.3 years for trappers and 32.2 years for traditional), although differences are not statistically significant. Shotgun users also show higher average values for education and travel to town more frequently than hunters in other profiles, although, again, the differences do not appear to be statistically significant (Table 4).

We found several statistically significant differences in the economic characteristics of informants on different hunting profiles (Table 4). Namely, shotgun hunters have larger income from the sale of game than hunters in any of the other categories (7.1 $ppp vs. 1.6 $ppp for trappers and 0.64 $ppp for traditional). Shotgun hunters also have higher income from wage and higher total income than hunters in the other categories. All differences in income across hunters' profiles are statistically significant ($p < 0.0001$). Interestingly, those differences do not reflect in accumulated wealth ($p = 0.173$).

Regarding the characteristics of hunting events, shotgun hunters seem to invest more time on hunting (66.2 hours), catch more preys (15.8 preys) and more bio-

Table 4. Analysis of variance across hunters' profiles in a) socio-demographic characteristics, b) economic characteristics, and c) hunting data. Avg (SD)

N (%)	Shotgun hunters 11 (11.3%)	Snare hunters 48 (49.5%)	Traditional hunters 38 (39.2%)	F	p
Socio-demographic variables					
Male	1 (0)	0.9 (0.04)	0.47 (0.08)	20.12	<0.0001
Age (in years)	29.2 (2.72)	36.3 (1.63)	32.2 (1.99)	1.62	0.1894
Education level (in years)	2.18 (0.4)	1.58 (0.17)	1.65 (0.18)	0.38	0.6817
Travel to town (times per month)	3.1 (1.16)	1.8 (0.38)	1.39 (0.38)	0.77	0.4672
Economic variables (in $ppp)					
Income from sales of game	7.1 (2.5)	1.6 (0.4)	0.64 (0.24)	11.05	<0.0001
Income from all sales	10.8 (3.85)	3 (0.44)	2.28 (0.47)	10.15	<0.0001
Income from wage labour	11.3 (4.6)	6 (1.0)	7.8 (1.19)	3.59	0.0315
Total income	28.7 (4.7)	9.2 (1.1)	10.08 (1.29)	27.07	<0.0001
Wealth	69.9 (15.33)	49.3 (4.7)	47.05 (5.83)	1.80	0.173
Hunting variables					
Total duration of hunts (hrs)	66.2 (12.46)	37.2 (2.98)	22.32 (2.00)	19.07	<0.0001
Number of preys caught	15.8 (3.2)	4.6 (0.53)	3.29 (0.64)	24.57	<0.0001
Total weight of game (in kg)	135.4 (37.7)	22 (2.77)	8.34 (1.94)	34.66	<0.0001
Hunting efficiency (in kg/hr)	2.1 (0.4)	0.6 (0.07)	0.33 (0.05)	31.69	<0.0001

mass (135.4 kg) than hunters in any of the other categories. Consequently, the hunting efficiency of shotgun hunters is significantly higher than the efficiency of hunters in other profiles ($p < 0001$). Between the two modern techniques, snare trappers show a lower labour-input and a lower return rate (hunting efficiency) than shotgun hunters.

DISCUSSION

The main finding from our work shows that the current use of shotgun by the Baka seems to relate to the emergence of a specialized and highly efficient type of hunter with a clear market orientation. This finding goes together with two secondary outcomes: contemporary Baka mostly hunt midsize species (small duikers, rodents) and non-traditional hunting techniques, especially shotgun, have a larger impact on game than traditionally used techniques. The progression of the discussion attempts to interpret how the decline in large game population might lead to the expansion of shotgun hunting through different incentives exerted on hunters.

I. Game Composition and Hunting Pressure

Our study on Baka hunting shows a predominance of short hunting events, targeting a low diversity of relatively abundant species such as small duikers, porcupines and rats, and a relatively low share of large game. Those patterns contrast with the historical importance of a hunting strategy based on collective expeditions targeting large mammals (Bahuchet, 1992; Joiris, 1998), but match with recent ecological studies which also show game structure compositions dominated by ungulates, rodents and primates, the three most important taxa for human consumption in the Congo basin (Muchaal & Ngandjui, 1999; Bennett & Robinson, 2000; Fa & Brown, 2009).

Assuming variations in human population densities and resource exploitation between areas, our data provide new insights regarding hunting pressure and local faunal composition. For instance, while the giant pouched rat represents an important part of the catches in our study area, this species is rarely caught by Baka living hundred kilometers to the east (Ngatto-Yokaduma area) (Ichikawa pers. comm. 2014). In the same sense, other species such as medium-sized duikers have been more frequently reported in the Ngatto-Yokaduma area (Hayashi, 2008; Yasuoka, 2014), in a less populated area. Two recent studies have argued that such local variations in game structure are related to the distribution of human activities, and emerging in areas more densely populated by humans and consequently enduring higher levels of hunting pressure (Bobo et al., 2014; Yasuoka et al., 2015). Seen through the lens of these two studies, the preeminence of blue duikers over medium-sized duikers in our data could be interpreted as a side effect of the high human density in the area leading to a replacement, by blue duikers, of medium-sized duikers, which might have been highly targeted and hunted in the past decades. This hypothesis fits with ethnographic information from Baka elders who report that blue duikers live now closer than medium-sized duikers and are easier to hunt than they were in the past.

Our analysis on prey composition also shows a relative absence of large mammals despite cultural diet preferences for such species (for notably hogs and giant pangolin) and social importance of large game hunting (Bahuchet, 1992). We can think of several potential explanations for this finding. First, the decline of local game populations has obviously reduced the encounter rates, implying a higher cost of capture for large mammals. Accessing areas favorable for large game species (like the swampy clearings forests or the remote National Parks) are too costly, in terms of time and money, from permanent settlements. The technology required to capture such game might also be difficult to access (for monetary reasons or closeness with riffle/shotgun owners). Consequently, and as already shown for Neotropical forest (Jerozolimski & Peres, 2003), subsistence hunters might become less selective and progressively change their preference in terms of hunting practices and diet. Second, acquiring, trading and consuming the meat of highly protected species entails legal risks regarding anti-poaching controls that Baka hunters prefer to avoid. It should be noted that our data does not seem affected by the under-reporting bias caused by the fear of the denunciation as it concerned only elephant. Finally, we may also presume that a progressive loss of knowledge or the absence of social-ritual conditions favorable for collective hunts targeting large mammals might also explain the relative absence of large species in the game composition reported.

II. From Spear to Shotgun: Shift in Hunting Techniques

In comparing our data with reports of traditional hunting techniques, we observe a shift in hunting patterns among the Baka: from the traditional use of spear to the prevalence of snare traps and shotgun. These new hunting patterns might correlate with the local decline of some species, notably large mammals. Rarefaction of large species might have implied a loss of cost-effectiveness of the collective hunting expeditions and consequently a larger adaption of individualistic techniques.

This change could also be seen as a cultural adaption to social and spatial changes. Fifty years ago, Althabe (1965) already proposed that the reduction of hunt duration and the focus on small and medium-sized catches by the Baka could relate to sedentarization. As Baka modify their mobility pattern and engage in new economic activities (i.e., agriculture, wage labour), they might see a reduction in the time they can devote to hunting, as well as in the area covered during hunting expeditions. This reduction implies hunting closer to the village, where large game, vulnerable species, and forest specialists might be less abundant now due to past overhunts and habitat modification (Nasi et al., 2011). In parallel, previous studies have shown that few taxa (generally smaller species) may remain unaffected by overhunting or even be enhanced by hunting, as well as tolerant to fragmented habitat (Isaac & Cowlishaw, 2004).

The shift towards shotgun use constitutes one of the main threats for wildlife in Central Africa as it allows an easier access to large animals with critical conservation status (Kümpel et al., 2009). Intensive shotgun use also represents a threat for diurnal monkeys which are likely to decline due to their low intrinsic rates of population growth (Linder & Oates, 2011). In this sense, we noted that the share of monkeys caught is surprisingly high; especially given that the Baka are not traditionally monkey hunters (the only weapon allowing to kill arboreal species being the crossbow, employed in the past by Nzime hunters). The high share of monkeys caught might relate to the increasing importance of shotgun hunting, as 94% of small diurnal monkeys were killed with shotguns, but it might also indicate the decline in large-sized ungulates in the study area, and consequently a change in the preys targeted.

III. Socio-Economic Drivers and the Emergence of Shotgun Hunters

An important result of this work relates to the differences between shotgun hunters compared to hunters falling in other profiles. While snare trappers resemble traditional techniques users in terms of economic features, labour inputs and pressure on wildlife, the profile of a shotgun hunter corresponds to a young male, highly involved in market economy, investing more time for more efficient hunts (bigger prey, more game by trip). Interestingly, and despite its high efficiency, shotgun hunting is regularly used by only a reduced part of the population. In order to discern further dynamics in hunting patterns and sustainability, the potential drivers and the limiting factors of shotgun use among the Baka need to be examined.

Economic incentives:

We might assume that involvement in shotgun hunting is driven by economic incentives in bushmeat commercialization. Damania et al. (2005) have shown that the rise of bushmeat prices might drive a technology shift away from cheaper and less efficient technologies (as snares) to more expensive and more efficient practices, such as shotgun. For the Baka, the involvement in wage labour might increase their capacity to buy cartridges, or eventually their own shotgun, a situation that starts to be observed in the studied area. Surprisingly, economic gains provided by the commercialization of bushmeat do not seem to be linked to higher individual possessions, as we find no significant relation between profile classes and wealth level. In such small-scale societies, the low availability of valuable material items and the fact that not many items are needed for production is a first brake to material accumulation. However, wealth variations exist, although they do not seem related to income level. We might think that the importance of sharing norms play a critical role in the redistribution of monetary gains acquired by hunters making profits. The Baka egalitarian economy is based on the mechanism of demand-sharing (as studied by Peterson, 1993; Ichikawa, 2005). Gains of all kinds are often rapidly distributed within the enlarged family and to anyone who overtly manifest a need. Additionally, the person making the profit endures more frequently pressure from the community aiming to avoid social demarcation and respect the social and political egalitarianism. It is also possible that this form of wealth balancing is linked to the question of social status and prestige that good hunters might seek. Among the Baka,we observed that the acquisition and accumulation of items do not seem to generate prestige. Contrarily, sharing meat appears as an important condition to acquire status. Money from bushmeat commercialization is often rapidly spent in food for the household and for the family-in-law, as well as in cigarettes and alcohol, extensively distributed. Individuals who earn money but rarely shared are badly perceived. It is now an open question to see whether, as the consumption of market goods becomes more general, material wealth might become a source of status for the Baka, as other authors have seen in other societies (von Rueden et al., 2011; Hill & Hurtado, 1996).

Cultural and social incentives:
Hunting in foraging societies often confers a special social status (Wiessner, 1996; von Rueden et al., 2011). Similarly, among the Baka, shotgun hunters are often considered “the best hunters”, as they are perceived as more efficient, being able to kill larger and more culturally significant species (see Reyes-García et al., 2016b). Consequently, prestigious shotgun hunters clearly exercise a powerful fascination over young men and adolescents who seem to neglect traditional weapons. Thus, the emergence of specialized hunters with a higher integration into the local market economy might be seen as a viable and socially recognized alternative livelihood for young Baka. In that sense, they might attempt to be acknowledged by the community through the strong symbolic status of meat, and/ or outside of the community, in terms of friendly and trusting relationships with Nzime or foreigner poachers and meat traders.

Limiting factors:
However, access to shotgun by the Baka is limited by strong social and economic factors. The cost of a firearm is often too high for the Baka, the small number of shotgun possessed by them in the area consists on damaged, and often dangerous, firearms obtained through local partners in exchange of work in elephant hunting or in cacao plantations. Then, most Baka hunters remain highly dependent on non-Baka people for the use of shotguns, which they typically borrow in exchange of money or meat. In addition to this dependence, multiple barriers to adopting gun hunting are mentioned by the Baka: fear of anti-poaching controls (using shotgun without permit being forbidden by the hunting regulations), fear of conflicts with the lender (dishonesty, lack of trust), physical risks (accidents with old weapons), and lack of skills and experience. Those limiting factors are evidently a significant trait to consider in the needed differentiation between Baka hunters and non-Baka hunters in terms of their pressure on local wildlife.

CONCLUSION

Our study shows the relevance of studying hunting practices in terms of economic, social and technical individual variations. Among the Baka, snare trappers and traditional hunters have a relatively low hunting efficiency, which might result in low impacts on wildlife. On the other side, shotgun hunters, encouraged by external economic incentives that drive them to provide bushmeat for the illegal trade, have a higher hunting efficiency for which they are potentially more harmful for local wildlife. Neither shotgun nor wire snare are new hunting techniques for the Baka, although their relative generalization and their interlocking with the booming bushmeat trade is. However, the changes in hunting patterns have to be perceived as part of a cultural adaptation of the Baka communities, a perpetual recomposing including new technical and economic stakes rather than a break and a discontinuity in the evolution of Baka culture, as already proposed by Leclerc (2012) for the case of agriculture. As commercial hunting is spreading extensively in the Congo Basin it is legitimate to ask how new practices, concerns and individual status are integrated within the society without bringing deep changes in the social organization.

Moreover, while our study focused on intracultural variations, the complexity of economic and symbolic relations between ethnic groups in the study area also needs to be taken into account in further studies. Such distinctions might imply strong variations in the hunting patterns and pressures as a recent study highlights the importance of differentiate “pygmy” and “non-pygmy” groups in their hunting pressure and species targeted (Fa et al., 2016). While some conservation policies in the Congo Basin have been drawing attention towards subsistence hunting, it would be much more important to focus on the differentiated impact of the various techniques used and how they relate to different levels of market integration. Understanding local perceptions of hunting and individual variations in uses of resources might allow improving efforts for sustainable hunting practices.

NOTE

(1) In absence of the direct recording the actual weight of each animal, these results might be biased as they are based on secondary literature not taking into account the local variations that might exist for the same species. Thus, some weights might be underestimated and other overestimated.

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Citations of the literature in the main text should be made with the author's surname and the year of publication:

... (Nishida & Kawanaka, 1972; Itani, 1980; 1994)

Fossey (1979) pictured them ....

For more than two authors, use the first author's name plus "et al.":

Furuichi et al. (1982) set forth ....

Refer to pages for direct quotations, after a colon following the year:

Leech (1957: 119-120) stated that ....

... (Pruit, 1960: 19).

The references at the end of the paper should list all works referred to in the text and only those, in alphabetical order of the author surnames. Do not abbreviate journal names. Do not indent the reference entries, although they will be indented in the final print. Below are some examples:

Hoff, M.P., R.D. Nadler & T.L. Maple 1981. The development of infant play in a captive group of lowland gorilla (*Gorilla gorilla gorilla*). *American Journal of Primatology*, 1: 65-72.

Lee, R.B. 1965. What hunters do for a living, or how to make out on scarce resources. In (R.B. Lee & I. DeVore, eds.) *Man the Hunter*, pp. 30-48. Aldine, Chicago.

Turnbull, C. 1965. *Wayward Servants: The Two Worlds of the African Pygmies*. Natural History Press, New York.

Uehara, S. 1981. The social unit of wild chimpanzees: A reconsideration based on the diachronic data accumulated at Kasoje in the Mahale Mountains, Tanzania. (in Japanese with English abstract). *Africa Kenkyu*, 20: 15-32.

Idrees, A.A. 1986. *Ganigan War 1881-2: The Kyadya Reaction to the Political and Economic Domination of Bida in the Middle Niger*. Paper presented at the 31st Annual Congress of the Historical Society of Nigeria, May 18-24, 1986. Ife, Nigeria.

AFlora Committee 1998. *AFlora on the Web: The Database of Traditional Plant Utilization in Africa*. Online. http://130.54.103.36/aflora.nsf (Accessed June 13, 2002).

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