

Actors' Perceptions of Profitability Along a Bushmeat Commodity Chain in West Africa (Southern Benin)

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Abstract

Background and Research Aims: The bushmeat trade is one of the main drivers of faunal extinction in tropical Africa. We assess the profitability of the bushmeat trade along the commodity chain in southern Benin and study the perceptions of the actors on the profitability of the trade. **Methods:** Data were collected through direct interviews. A total of 120 bushmeat trade actors were interviewed in southern Benin. Economic and financial indicators were estimated and compared using descriptive statistics. Factors affecting the actors' perception of wild animal hunting, trading or supply sustainability were assessed using binary logit. **Results and discussion:** A total of 15 species were traded along the bushmeat commodity chain in southern Benin. During the dry season, hunters' gross product is higher because of greater hunting effort, and traders earn more commercial margin. Throughout the chain of actors, bushmeat trade profitability is seen as positively affected by the number of hunters per household and the availability of large preys (hunters), household size (sellers) and monthly income (consumers); whereas negative factors affecting profitability are distance from hunting sites (hunters), supply issues (sellers) and the cost of the meat (consumers). Both hunters and consumers see hunting and trade regulation measures as negatively impacting bushmeat profitability. **Conclusion and implications for conservation:** The perception of profitability by bushmeat commodity chain actors in southern Benin is conditioned by a set of socio-economic factors that should be considered in national conservation policies and development programs to keep bushmeat hunting profitable and sustainable.

Keywords

hunting, economic flows, bushmeat trade, actors' perceptions, commodity chain, binary logit, West Africa

Keymessage

this study reveals that bushmeat hunting remains an important source of wealth in West Africa despite laws that regulate hunting and the bushmeat trade. Actors' commitment to continue hunting, trading or supplying is conditioned by a set of socio-economic and cultural factors that should be taken into account in conservation actions that aim at mitigating the trade

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Introduction

The illegal wildlife trade is one of the main drivers of species extinction (Morton et al., 2021), with an estimated 100 M organisms globally traded per year (Harfoot et al. 2018; UNODC, 2020; Hughes et al. 2023), representing a yearly value of US\$7-23 billion (Coad et al., 2019). Illegal wildlife trade is related to the commercialization of species protected by law, hunted from protected areas or during non-authorized periods (Hughes et al. 2023). As well as posing threats to public health (Fa et al., 2019), the bushmeat (meat from wild animals) trade seriously threatens biodiversity (Nasi et al., 2011), contributing to wildlife declines with knock-on effects on ecosystem functioning and services (Effiom et al., 2013; Peres et al., 2016). In the tropics, the hunting of wild species for human consumption is a significant contributor to the illegal wildlife trade (Nielsen et al. 2017; Gonçalves et al. 2019; Morton et al., 2021; Hughes et al. 2023).

West and central African rainforests are hotspots of the trade, where bushmeat has traditionally been a vital source of protein and income for rural communities (Chausson et al., 2019; Ingram et al., 2021). In the absence of alternative employment for rural communities, bushmeat provides a direct, open-access source of animal protein and a valuable source of income (Nasi et al. 2008; Mbete et al. 2011). The bushmeat market in Africa represents an important, parallel economy, estimated to generate US\$ 42-205 M in the rainforest zones of West and Central Africa (Davies, 2002). Bushmeat also plays an important role in the wealth of rural communities, contributing to 44.2% of households' food security in Africa (Nielsen et al. 2017). On the other hand, bushmeat offtakes have reached unsustainable rates, with an estimated 5 M tonnes –mostly mammals– harvested from African rainforests annually (van Vliet et al., 2011). This is notably due to booming demography, improvement of hunting techniques, high deforestation rates, and demand from growing urban centres (Bennett et al. 2002). As a consequence, bushmeat has moved from a household-restricted consumption to a selling network activity spread across local, regional and international scales (Schenck et al. 2006; Gonçalves et al. 2019). In Africa, the bushmeat trade also constitutes a refuge source of revenue and meat during difficult or less favourable periods such as economic recession and pandemics (Ordaz-Németh et al. 2017; Tanalgo et al. 2023) or the dry season, when agricultural activities are scarce (Nielsen et al. 2017; Gonçalves et al. 2019).

To what extent rural communities rely on bushmeat as a vital protein supply, and how the lack of availability of such resource may negatively impact food security, remain unclear (Niaky et al. 2014; Lindsey et al. 2013; Knapp et al. 2017). In general, bushmeat consumption –and notably rodents– has been associated with higher status of household food security (Friant et al. 2020), notably in food-insecure developing nations where bushmeat alternatives are limited (Booth et al.

2021). However, on-the-ground studies have shown that harvesting bushmeat was mostly motivated by income generation (Wright & Priston, 2010; Knapp et al. 2017; Tanalgo et al. 2023), and that households showed no particular nutritional reliance on bushmeat species (Albrechtsen et al. 2005). Rather, bushmeat was highlighted as playing a major role in the income of poor rural households (De Merode et al., 2004), suggesting that the bushmeat trade is an important economic stake for rural communities (Kümpel et al., 2010; Knapp et al. 2017).

Although the profitability of the bushmeat trade is generally perceived as high by the communities involved (in terms of returns per unit of effort), there is often a lack of awareness of appropriate wildlife management to ensure the sustainability of such resources (Robinson et al., 2018). In this context, studying the perceptions of the bushmeat chain actors on the motives behind their activities (i.e., profitability) could contribute to establish more efficient management strategies of the bushmeat hunting, which have so far remained globally inefficient (McKenzie-Mohr 2011, Brown et al. 2021).

We propose to study the socio-economic factors underpinning the bushmeat trade along the entire commodity chain of the market in Benin (West Africa). Although several recent studies have focused on the socioeconomic determinants of bushmeat hunting and consumption (Drury 2011; Chausson et al. 2019; Akinsorotan et al. 2020), the end point of the market, i.e. commercialization, has remained little studied on these aspects. In southern Benin, bushmeat hunting targets vertebrate populations from the remaining protected forests and small, isolated sacred forests, and thus likely plays a role in the local extinction of game species (Djagoun et al. 2022). Bushmeat is both consumed and sold locally on roads and markets, and distributed to urban, traditional medicine markets, creating a complex network of trading sources and sinks (Djagoun et al. 2013). Although the bushmeat trade in southern Benin is likely to contribute to the food security and income of rural communities (Akinsorotan et al. 2020), its socioeconomic determinants are yet to be properly explored. Our specific objectives are to (i) assess the profitability of the bushmeat trade along the commodity chain by quantifying economic flows among actors, and (ii) delineate the perceptions of the actors themselves on the profitability of the bushmeat trade. On the basis of the socio-economic drivers of the bushmeat trade that we determine, we discuss potential implications in terms of wildlife management and conservation in southern Benin.

Methodology

Study Area

The study was carried out in three major places of the bushmeat trade in southern Benin, including the municipalities of Abomey, Bohicon and Zogbodomey (Figure 1).

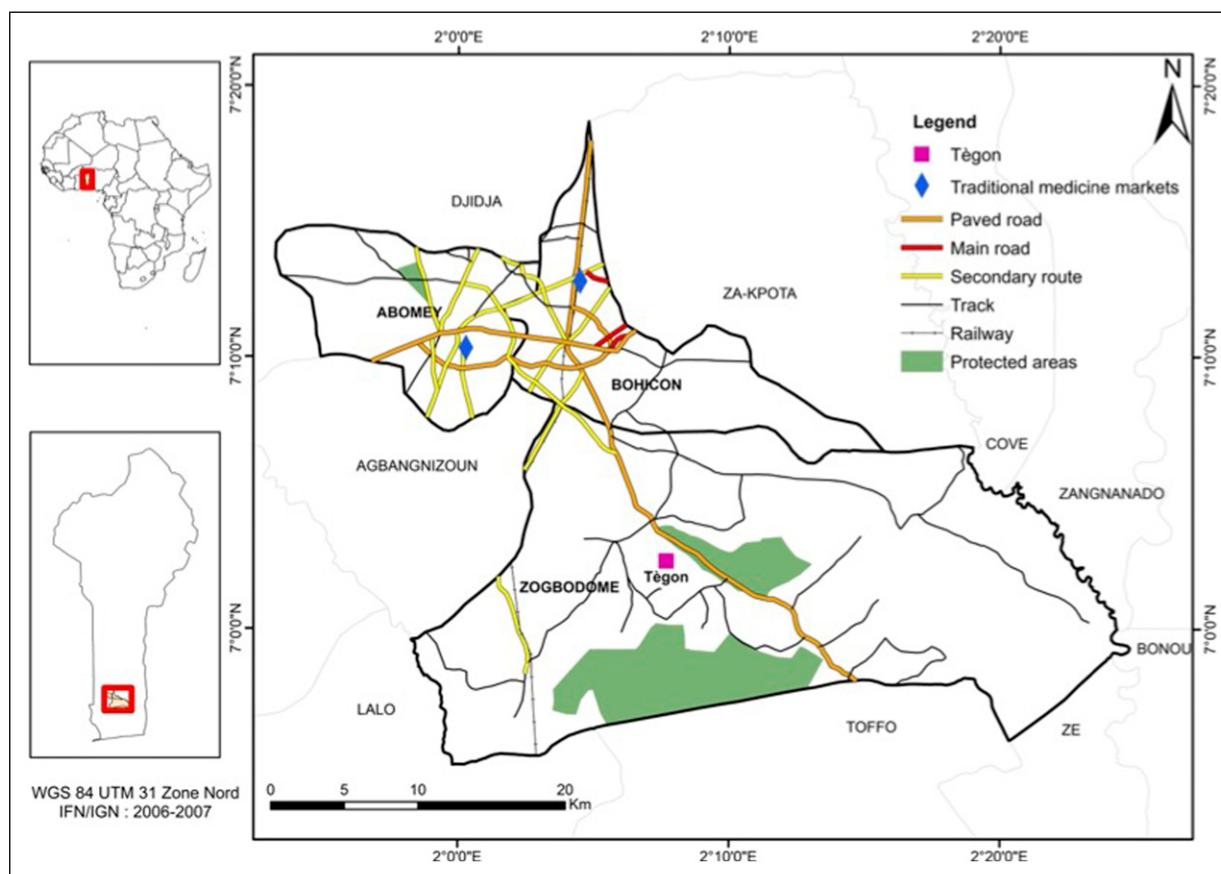


Figure 1. Study area showing the three major places of the bushmeat trade in southern Benin.

The latter is the main supply point for bushmeat in southern Benin (Sogbohossou & Kassa, 2016, Djagoun et al. 2022), where freshly killed animals and smoked meat are sold on stalls for meat consumption along the main road crossing Zogbodomey. Hunting activities feeding this market likely take place in the forest galleries and near or within protected areas that are geographically close, such as the Forêt Classée de la Lama, where large game species such as antelopes (*Tragelaphus spekii*, *T. scriptus*) and wild pigs (*Potamochoerus porcus*) are still recorded (Djagoun et al. 2022). Bohicon is the fourth economic city of Benin. Together with Abomey nearby, they host two of the most important traditional medicine markets from southern Benin. Animals found on these markets are mostly dried or processed specimens sold as pharmacopoeia or fetish items for Vodoun-related practices (Tchiboze & Motte-Florac 2004, Djagoun et al. 2013), but freshly killed or smoked animals can sometimes be present on the stalls (Djagoun et al. 2013; Ayindé Armel Dossou pers. obs.). The bushmeat market of Zogbodomey sells a more restricted range of vertebrate species (mostly mammals) than traditional medicine markets, as the latter has a wider geographic and taxonomic sourcing of animals, including the northern region of Benin and even foreign countries (Djagoun et al. 2013, 2023).

In Benin, bushmeat hunting is a seasonal activity authorized from 1st of December to 30th of June (Law 93-011 of 03 September 1993 – Article 1, regulating nature protection and hunting), roughly corresponding to the dry season. The rest of the year, during the rainy season, hunting is forbidden. Offences to this law are punishable by a fine or imprisonment between two and 12 months. The bushmeat trade is regulated by the decree N°2011-394 of 28 May 2011, fixing the modalities of conservation, development and sustainable management of wildlife and its habitats in the Republic of Benin. Every person holding wild animals and hunting products in transit on the national territory must carry original documents proving the origin of the animals. The absence of these documents results in the seizure of the animals and hunting products, which will be destroyed by the relevant administration. However, in practice, many hunters and bushmeat traders commercialize their products without such documents (Dossou Ayidé, pers. obs.).

Sampling and Data Collection

Data were collected from May to August 2019. Three groups of actors were investigated from the three market places, including hunters, traders and consumers, through a commodity

chain approach based on hunting, processing, transport, distribution and sale (De Merode & Cowlishaw, 2006; Nielsen et al. 2016). Data collection was based on structured interviews using individual questionnaires (Liu et al. 2016; Boaky et al. 2016). Each group of actors was addressed a specific questionnaire that was pre-tested on a subset of 10 actors before survey start in order to adjust it. Diagnostic investigation techniques such as direct and participant observations were used to collect qualitative data. Interviews were carried out in the actors' local languages (Fon, Maxi and Goun) when respondents did not speak French. Actors who provided incomplete information were systematically removed from the sample set. Some actors objected to participate because they feared reprisals from wildlife resource managers. In total, we sampled 120 actors (40 hunters, 40 traders and 40 consumers) within the study area.

We surveyed hunters who had at least two years of hunting experience and practiced hunting at least, once a week. Hunters were primarily farmers and agriculture was their main economic activity. In the study area, farming is seasonal and based on annual crops (maize, groundnuts, cowpeas, tomatoes, chilies, etc.). Hunting remained peripheral and seasonal, practiced especially during the dry season when agricultural activities are scarce.

The questionnaire addressed to hunters was divided into three core segments. The first and second segments contained general information on the study area and respondents' socio-demographic data. The third segment was used to collect socio-economic variables on hunting activities. Bushmeat traders were identified based on hunters' guidance. Because in most cases, hunters also played the role of traders, we did not identify wholesalers in the study. We only considered retailers as belonging to the trader group. Through the questionnaire addressed to traders, we collected information on the bushmeat supply chain, supply frequency, number of animals sold, pricing, perception of bushmeat availability, species frequently bought, and the perception of variation in species availability based on respondents' experiences. Hunters were also asked about their hunting frequency, the diversity and quantity of game caught per hunting day, and the hunting material used. Consumers were interviewed directly after being observed buying bushmeat on the surveyed marketplaces. In the case of consumers, we also collected data on the frequency with which they buy bushmeat, buying prices, type and quantity of bushmeat most frequently bought, and their perception about the availability of bushmeat.

Data Analysis

Economic Flow Analysis Between Hunters and Bushmeat Traders. The analysis of economic flows was based on hunters' sales, bushmeat traders' sales and consumers' purchases. We considered the different charges (transport and processing costs, processing equipment costs, market taxes) that traders faced doing their activity and the temporal distribution of

bushmeat. Indeed, bushmeat buying and selling prices vary according to their availability. Prices were higher during the non-hunting season in response to supply and demand principles. Economic and financial indicators such as Gross Product in Value (GPV), Gross Margin (GM), Commercial Margin (CM), Added Value (AV) and actors' annual incomes were determined and used for the economic flow analysis (Covey & McGraw, 2014; Adebawale, et al., 2021).

The Gross Product in Value (GPV) is equal to the sum of the sales made by commercial hunters during the season, considering the part consumed by the household and the loss due to unsold meat (eq. 1).

$$GPVi = \sum_{j=1}^m TNSij * Pij \quad (1)$$

with:

GPVi: the hunter (*i*) gross product value calculated in FCFA per season (rainy season vs. dry season according to bushmeat availability; 1 \$ US = 600 FCFA in 2023);

TNSij: the total number of individuals of species *j* trapped and commercialized by hunter *i* during a season (dry or rainy);

Pij: the unit price of species *j* charged by hunter *i* during a season. Since the unit price varies according to factors such as animal weight, sale period and animal sex, average selling price charged by hunter during a season was used.

The Gross Margin (GM) was obtained from the Gross Product Value (GPV) after deduction of the variable costs related to the operating charges for the hunting activities (eq. 2). One of the variable costs considered to compute the gross margin is the transport costs, as those significantly affect hunting activities (Adebawale, et al., 2021). It is estimated as follows:

$$GMi = GPVi - VCi \quad (2)$$

with :

GMi: the Gross Margin computed in FCFA per day for hunter *i*. Computing the gross margin per day allowed us to compare the hunting daily income between seasons (intensive hunting period versus weak hunting period).

GPVi: the Gross Product in Value obtained from bushmeat selling for each hunter *i*

VCi : the variable costs related to the operating charges of hunter *i*.

Hunters' Annual Income (HAI) was estimated based on the gross margins generated during the two hunting periods and fixed costs related to the depreciation charges of the tools used. Annual income was obtained by deducting fixed costs from annual gross margin (equation (3)).

$$HAIi = GMi1 + GMi2 - FCi \quad (3)$$

with

HAIi : Hunter *i* annual income computed in FCFA per year

GMi1 and *GMi2* : the gross margins generated during the intensive and weak hunting periods respectively for hunter *i*.

FCi: the sum of the fixed charges of the hunter *i*.

Fixed charges were obtained considering a linear depreciation of the tools used (guns, traps, machetes, pickaxes, etc.).

The Commercial Margin (CM) was obtained computing the difference between the amounts used to sell and purchase bushmeat (equation 4). Commercial Margin estimation took into account the portion of bushmeat consumed in traders' households and the part lost during processing and storage.

$$CM_i = \sum_{j=1}^m TNS_{ij} (SP_{ij} - PP_{ij}) \quad (4)$$

with

CM_i : the commercial margin of trader i computed in FCFA per hunting season

TNS_{ij} : the total number of individuals of species j bought and sold by trader i during a given season (dry or rainy season as mentioned above).

SP_{ij} : the unit selling price of species j charged by trader i .

PP_{ij} : the unit purchasing price of species j paid by the trader i .

Another indicator is the Added Value (AV) obtained from the Commercial Margin after deduction of Extern Services Charges such as rental fees for sales location and operating charges (transport costs to buy and sell, bushmeat processing and conservation costs) (equation 5).

$$AV_i = CM_i - ESC_i \quad (5)$$

with

AV_i : the added value was computed in FCFA per hunting season for trader i

CM_i : the commercial margin of traders i

ESC_i : the Extern Services Charges of traders i .

Traders Annual Income (TAI) was estimated based on the Added Values (AV) of the two hunting seasons (dry and rainy season) and fixed costs related to the depreciation of the tools used (equation 6).

$$TAI_i = AV_{i1} + AV_{i2} \quad (6)$$

with

TAI_i : the annual income computed in FCFA per year for trader i

AV_{i1} and AV_{i2} : respectively, the added value generated during the intensive and weak hunting periods by traders i .

Analysis of Actors' Perceptions on Bushmeat Hunting, Trading and Supply Viability. We used binary logit regression to assess factors affecting actors' perceptions on bushmeat hunting, trading and supply viability. The explanatory variables included socio-economic, demographic, wealth and other household characteristics that could affect actors' perceptions on bushmeat hunting, trading or supply viability. Explanatory variables likely to affect actors' perceptions were identified through previous studies and included in the different models. Some of these variables are the selling and purchasing prices (McNamara et al. 2016; Wilkie et al. 2016; Liu et al. 2016), hunting area proximity (Allebone-Weber et al., 2011; Lindsey et al. 2011), bushmeat

availability (Lindsey et al. 2011), regulatory measures (Nielsen et al. 2014), consumers' gender (Khongsavanh & Vang, 2020) and buying power (Mbeté et al. 2011; Khongsavanh & Vang, 2020). Other variables of interest were introduced into the models based on field observations and empirical data specific to the study area (Table 1).

Statistical analyses were all performed in the Statistical Package for Social Sciences software (SPSS; Ong & Puteh, 2017).

Results

Socio-Demographic Characteristics of the Actors Involved in the Bushmeat Commodity Chain

All the hunters surveyed were married males and the size of their households varied from 5 to 16 members, with an average of 8.9 (± 2.1). The number of hunters per household varied from 1 to 5 with an average of 2.2 (± 0.9). All hunters had an ascendant (father or grandfather) hunter and the activity was perceived as a family heritage. Christianity and animism were the most practiced religions by 55% and 45% of hunters, respectively. Hunter's age varied from 30 to 60 years with an average of 40.3 (± 6.2). In general, hunters had a low education level with 48% reaching primary education level. The number of years of experience in hunting activities varied from 8 to 40 years with an average of 22.5 (± 6.2). Agriculture was the main activity of hunters (68%), followed by trade (20%), hunting (7%) and crafts (5%).

We identified three categories of traders: primary traders who bought bushmeat directly from hunters, secondary traders who bought products from intermediaries—including primary traders—and sometimes directly from hunters involved in bushmeat processing, and animal carcass traders. Women and men were equally involved in the bushmeat trade. They had on average 20.1 (± 9.7) years of experience in the activity. Their household was constituted of 5.4 (± 1.2) members on average. Traders had a low education level with 43% reaching primary education level. The bushmeat trade was the main activity for 63% of the traders and was dominated by women.

The majority of the bushmeat consumers interviewed were women (63%). Consumers appeared more educated than other the actors as 30% of them reached university degrees. Consumers originated from four main socio-economic groups, including housewives (40%), officials (38%), farmers (17%) and craftsmen (5%). They had in average 5.9 (± 1.4) persons per household and variable monthly income. About 30% of consumers had a monthly income inferior to 50 000 FCFA, 40% earned between 50 000 and 100 000 FCFA, while 30% earned more than 100 000 FCFA. Note that the monthly guaranteed minimum salary in Benin is 52 000 FCFA (86,67 \$US).

Bushmeat Species Diversity

A total of 15 species (10 mammals, three reptiles and two birds; Table 2) were mentioned to be traded along the

Table 1. Variables used to identify the factors determining actors' perceptions on bushmeat hunting, trading and supply viability.

Variables	Modalities	Type of variable	Expected signs
<i>Variables introduced in the first logistic regression model (hunters)</i>			
Age	-	Quantitative variable	-
Years of experience in hunting activities	-	Quantitative variable	±
Household size	-	Quantitative variable	±
Regulatory measures on hunting	0 = no effects I = possible effects	Qualitative variable	-
Number of hunters in household	-	Quantitative variable	+
Distance from hunting site to home	-	Quantitative variable	-
Availability of large bushmeat species	0 = no ; I = yes	Qualitative variable	+
Selling prices	0 = unfavourable ; I = favourable	Qualitative variable	+
Reason for hunting	0 = commercial I = cultural	Qualitative variable	+
<i>Variables introduced into the second logistic regression model (traders)</i>			
Age	-	Quantitative variable	±
Years of experience in bushmeat trading	-	Quantitative variable	±
Sale on credit	0 = no ; I = yes	Qualitative variable	-
Regulatory measures on bushmeat trading	0 = no effects I = possible effects	Qualitative variable	-
Household size	-	Quantitative variable	±
Supply issues	0 = no ; I = yes	Qualitative variable	-
Selling prices	0 = unfavourable ; I = favourable	Qualitative variable	+
Selling frequency	0 = purchase day ; I = sale storage	Qualitative variable	±
Purpose of bushmeat use	0 = consumption I = spiritual practices	Qualitative variable	±
<i>Variables introduced into the third logistic regression model (consumers)</i>			
Gender	0 = male; I = female	Qualitative variable	±
Purchase on credit	0 = no ; I = yes	Quantitative variable	+
Regulatory measures on bushmeat consumption	0 = no effects I = possible effects	Quantitative variable	-
Household size	-	Quantitative variable	+
Buying price	0 = normal; I = high	Quantitative variable	-
Consumption frequency	-	Quantitative variable	+
Monthly income	-	Quantitative variable	+

Table 2. The species commercialized along the bushmeat commodity chain in southern Benin.

Class	Order	Family	Species	IUCN Red List
Mammalia	Lagomorpha	Leporidae	<i>Lepus victoriae</i>	LC
		Muridae	<i>Cricetomys gambianus</i>	LC
	Rodentia	Thryonomidae	<i>Thryonomys swinderianus</i>	LC
		Sciuridae	<i>Xerus erythropus</i>	LC
	Artiodactyla	Bovidae	<i>Philantomba walteri</i>	DD
			<i>Tragelaphus scriptus</i>	LC
		Suidae	<i>Potamochoerus porcus</i>	LC
			<i>Erythrocebus patas</i>	NT
	Primates	Cercopithecidae		
	Carnivora	Mustelidae	<i>Hydrictis maculicollis</i>	NT
Reptilia	Squamata	Manidae	<i>Phataginus tricuspis</i>	EN
		Varanidae	<i>Varanus niloticus</i>	LC
		Viperidae	<i>Bitis arietans</i>	LC
Aves	Galliformes	Pythonidae	<i>Python sebae</i>	NT
		Phasianidae	<i>Pternistis bicalcaratus</i>	LC
		Numididae	<i>Guttera verreauxi</i>	LC

Taxonomy follows [Neuenschwander et al. \(2011\)](#)

LC: Least Concern; DD: Data Deficient; NT: Near Threatened; EN: Endangered.

bushmeat commodity chain, of which three are near threatened (*Erythrocebus patas*; *Hydricotis maculicollis*; *Python sebae*) and one is endangered (*Phataginus tricuspis*) according to the IUCN Red List of Threatened Species (<https://www.iucnredlist.org/>).

Commercial Hunting and Bushmeat Traded Profitability

Hunters: Gross Product in Value. Hunters' sales during the high hunting period (dry season) totaled 983 710 FCFA ($\pm 319\,410$) versus 659 115 FCFA ($\pm 240\,090$) during the low hunting period (rainy season). HGP was higher during the dry season ($t = 10.3$; $p < 0.0001$). Mammals contributed the most (76%), followed by reptiles (15%) and birds (9%) (Table 3).

Hunters: Gross Margin and Annual Incomes. The bushmeat sold by hunters allowed them to cover all variable costs, making commercial hunting a profitable and income-generating activity for involved actors. Commercial hunting was more profitable during the dry season ($890\,562 \pm 27\,545$ FCFA) compared to the rainy season ($596\,701 \pm 242\,484$ FCFA) ($t = 9.3$, $p < 0.0001$). Hunters allocated more time to hunting during the dry season (5.4 ± 0.5 days per week) compared to the rainy season (3.1 ± 0.9 days per week). However, GM per hunting days was higher for the rainy season ($8\,668 \pm 4\,066$ FCFA) than the dry season ($6\,774 \pm 2\,562$ FCFA) ($t = 3.3$; $p = 0.002$). Commercial hunters' annual income ranged from 508 096 FCFA to 2 648 398 FCFA with an average of 1 433 551 ($\pm 537\,548.53$).

Bushmeat Traders: Commercial Margins and Annual Incomes. Overall, the Commercial Margin of bushmeat

traders was positive. Commercial Margin was higher during the dry season ($1\,151\,935 \pm 500\,469$ FCFA) than during the rainy season ($646\,900$ FCFA) ($t = 12.8$, $p < 0.0001$). There was no difference in the diversity of species traded between the two hunting seasons (Table 4). However, species contributions to Commercial Margin were variable. Bushmeat traders earned in average 1 418 422 FCFA annual income.

Actors' Perception of Bushmeat Hunting, Trade and Supply Profitability

Factors Influencing Actors' Perception of Bushmeat Hunting Profitability. Of the nine explanatory variables (socio-economic, demographic, wealth and household characteristics) included in the model to explain actors' perception of bushmeat hunting profitability, six were significant at $\alpha = 0.10$ (Table 5). The model was globally robust at 1% significant level. In addition, the Cox and Snell and Nagelkerke R^2 values indicated that the model explained 54% to 71% of the dependent variable variation. The reason which motivates actor for hunting had positive effect on hunters' perception of bushmeat hunting profitability. The same effect was observed concerning availability of large bushmeat species and selling price. Thus, the increase in selling price increases hunters' perception of bushmeat hunting profitability. Opposite to this trend, the distance from hunting site to hunters' home, and the regulatory measures implemented on hunting decrease actors' perception of bushmeat hunting profitability.

Factors Affecting Actors' Perception of Bushmeat Trade Profitability. Table 6 summarizes the results of the second logistic regression of actors' perception of bushmeat trade profitability. The test of model coefficients indicates that the

Table 3. Annual financial value (in FCFA) of species commercialized by hunters according to hunting seasons.

Class	Species	Dry season		Rainy season	
		Financial value	S.D.	Financial value	S.D.
Mammalia	<i>Lepus victoriae</i>	112 013	20 441	85 575	23 292
	<i>Cricetomys gambianus</i>	40 763	13 706	35 025	12 976
	<i>Thryonomys swinderianus</i>	125 190	52 615	93 487	44 519
	<i>Xerus erythropus</i>	50 906	11 190	42 171	11 988
	<i>Philantomba walteri</i>	105 174	41 518	71 727	15 012
	<i>Tragelaphus scriptus</i>	171 250	52 134	196 875	21 786
	<i>Potamochoerus porcus</i>	192 143	26 247	244 286	32 071
	<i>Erythrocebus patas</i>	125 739	59 284	123 261	70 785
	<i>Hydricotis maculicollis</i>	68 100	254 241	50 813	20 924
	<i>Phataginus tricuspis</i>	26 294	4 055	32 143	2 268
	<i>Varanus niloticus</i>	52 629	23 643	39 300	16 322
	<i>Bitis arietans</i>	72 339	27 947	43 985	18 180
	<i>Python sebae</i>	56 327	25 762	38 897	19 972
Aves	<i>Pternistis achantensis</i>	37 028	7 080	29 303	7 729
	<i>Guttera verreauxi</i>	61 982	24 516	52 821	17 303

1 \$US = 600 FCFA.

Table 4. Variation in the commercial margin (in CFA) of traders during the dry and rainy seasons.

Species traded	Dry season		Rainy season	
	Commercial margins (FCFA)	Sd.	Commercial margins (FCFA)	Sd.
<i>Lepus victoriae</i>	176 800	89 575	108400	71 132
<i>Cricetomys gambianus</i>	35 800	32 608	62240	30 482
<i>Thryonomys swinderianus</i>	130 800	61 701	79 034	23 680
<i>Xerus erythropus</i>	45 043	32 390	30 857	23 666
<i>Philantomba walteri</i>	232 000	132 407	108 857	52 958
<i>Tragelaphus scriptus</i>	148 235	52 468	128 571	22 678
<i>Potamochoerus porcus</i>	151428	106 690	98 400	30 880
<i>Erythrocebus patas</i>	72 857	25 112	58 000	16 841
<i>Hydrictis maculicollis</i>	33750	14 677	10 400	3 662
<i>Phataginus tricuspis</i>	41 333	16 000	39 000	30 000
<i>Varanus niloticus</i>	51 310	40 554	42 000	37 125
<i>Bitis arietans</i>	35 111	26 401	4 889	8 327
<i>Python sebae</i>	22 400	8 919	24 800	9 850
<i>Pternistis achantensis</i>	56 840	17677	36 083	23 680
<i>Guttera verreauxi</i>	132 000	60 041	79 600	37 357

Table 5. Factors influencing actors' perception of bushmeat hunting profitability.

Variables	Coefficient	Standard error	Wald	Significance
Hunter age	0.118	0.217	0298	0.585
Reason for hunting	3.329*	1.940	2.943	0.086
Years' experience in hunting activities	- 0.318	0.211	2.27	0.132
Household size	- 0.001	0.568	0.000	0.998
Number of hunters in the household	3.118**	1.444	4.664	0.031
Availability of large bushmeat species	4.997**	2.23	4.98	0.026
Distance from hunting site	- 0.276**	2.23	4.98	0.021
Selling price	5.205*	2.817	3.415	0.065
Regulatory measures on hunting	- 3.809**	1.809	4.432	0.035
Constant	0.402	8.905	0.002	0.963
-2logvraisemblance = 21.55				
Khi 2 = 31.372				
P = 0.000				
R2 : 0.544 (Cox and Snell) ; 0.714 (Nagelkerke)				

**significant at 5%.

*significant at 10%.

model was statistically significant at 1% level. The Cox and Snell and Nagelkerke R^2 values were respectively 0.52 and 0.70. Household size (positive effect), supply issues and regulatory measures on the bushmeat trade (negative effect) significantly affected actors' perception of bushmeat trade profitability.

Factors Affecting Consumers' Perception of Bushmeat Supply Profitability. As shown in Table 7, the model presented was statistically significant at 1% level of significance and explained 59 to 80% of the variance (Cox and Snell $R^2 = 0.59$; Nagelkerke $R^2 = 0.798$) on consumers' perception of bushmeat supply profitability. Four variables significantly affected consumers' perception: consumers' monthly income

and possibility to purchase on credit influenced positively consumers' perception, while bushmeat buying price and the regulatory measures on their consumption influenced negatively their perception.

Discussion

Characterization of the Commodity Chain

Through this study, we were able to survey the three main categories of actors along the bushmeat commodity chain: hunters, traders and consumers. Hunting in southern Benin appeared anchored as a cultural activity in rural communities; at least one man per household was a hunter and the activity

Table 6. Factors influencing actors' perception of bushmeat trade profitability.

Variables	Coefficient	Standard error	Wald	Significance
Trader age	- 0.128	0.132	0.949	0.330
Years' experience in bushmeat trading	0.097	- 0.131	0.549	0.459
Household size	1.080**	0.552	3.836	0.050
Purpose of bushmeat use	1.093	1.55	0.494	0.482
Selling frequency	- 3.789	2.412	2.467	0.116
Sale on credit	- 0.197	1.342	0.022	0.883
Selling prices	- 1.239	1.399	0.785	0.376
Supply issues	- 3.238**	1.899	2.907	0.039
Regulatory measures on bushmeat trade	- 2.712*	1.41	3.66	0.056
Constant	4.397	4.634	0.900	0.343
- 2logvraisemblance = 24,91				
Khi 2 = 29,63				
P = 0.001				
R2 : 0.523 (Cox and Snell) ; 0.703 (Nagelkerke)				

**significant at 5%.

*significant at 10%.

Table 7. Determinants of consumers' perception of bushmeat consumption viability.

Variables	Coefficient	Standard error	Wald	Significance
Gender	- 0.114	1.259	0.012	0.911
Household size	- 0.196	0.587	- 0.112	0.738
Monthly income	2.37**	1.108	4.583	0.032
Purchase on credit	4,566*	2.455	3.458	0.063
Consumption frequency	3.23	3.13	1.061	0.303
Buying price	- 6,270**	2.551	6.043	0.014
Regulatory measures on bushmeat consumption	- 4.117**	1.862	4.817	0.027
Constant	- 10.239	- 6.874	2.219	0.136
- 2logvraisemblance = 18.68				
Khi 2 = 35.868				
P = 0.000				
R2 : 0.592 (Cox et Snell) ; 0.798 (Nagelkerke)				

**significant at 5%.

*significant at 10%.

was perceived as a family heritage. Therefore, hunting has been an economic and cultural activity transmitted from generation to generation (Morsello et al. 2015; Mmahi & Usman, 2020). In line with cultural transmission and social learning theory developed by MacDonald (2007), in southern Benin one becomes a hunter by accompanying his father during his hunting activities. However, hunting activity remains peripheral and seasonal in the surveyed communities, as the interviewed hunters were primarily farmers who conducted hunting mainly during the dry season because they are occupied with their agricultural activities during the rainy season (Sogbohossou & Kassa 2016).

Bushmeat traders were both men and women and were more professionally specialized than hunters (63% of them had the bushmeat trade as their main activity), showing low education and important seniority in this activity (> 20 years).

We identified three categories of traders; primary, secondary and animal carcass traders. In contrast to other regions in Africa (Tagg et al., 2018, McNamara et al., 2019 in West and Vitekere et al., 2021), in southern Benin we could not identify any wholesalers along the bushmeat commodity chain. Bushmeat is sold directly from hunters to consumers or through a rather simple network of primary and secondary traders. Bushmeat trade occurs along roadsides or in the markets where animal carcasses are mainly sold.

We could not identify any socio-economic trends in consumers, as observed elsewhere in Africa (Carla et al., 2015, Olmedo et al. 2022, Nguyen et al. 2022), although the majority of clients were women. Both in rural and urban areas, women are generally in charge of the household diet (Dell et al. 2020), probably explaining why they were the most represented consumers (buyers) in southern Benin. The

lack of socio-economic trends in consumers could be explained by the straightforward availability of the bushmeat in the study area (see [Chausson et al., 2019](#)), although the sampling method -targeting bushmeat selling sites- may also reduce the variability of bushmeat consumers under study.

We could identify 15 species of vertebrates that were frequently traded as bushmeat throughout the year, including mammals (rodents, hares, antelopes and wild pigs, primates, carnivores, pangolins), reptiles (snakes) and birds (wild fowls). Our results are in line with previous market surveys in southern Benin, emphasizing the preponderance of mammals on the bushmeat stalls ([Codjia et al. 2004](#), [Assogbadjo et al. 2005](#), [Djagoun & Gaubert, 2009](#), [Djagoun et al. 2018, 2023](#)). In West Africa, mammals are the most traded vertebrate class and are the main contributors to hunters' gross products and margins ([Fa et al. 2006](#); [Petrozzi et al. 2016](#)), which might also apply in southern Benin.

Economic Flows Along the Bushmeat Commodity Chain

Hunting and bushmeat trade offer significant compensation to hunters and sellers involved in the bushmeat commodity chain in southern Benin. Independently of the season, sellers have higher marketing margins compared to hunters, in line with previous studies elsewhere in Africa ([Tagg et al. 2018](#); [Jones et al. 2019](#)). Such higher margins could be explained by the added value made by sellers through the selling of their products on a diversified network of markets, implying higher demand. Hunters generally sell their products "field edge" and therefore have less opportunity to increase their selling prices given the low diversity of buyers and reduced selling network. This situation can have a cascading effect as it forces hunters to increase the quantity of collected bushmeat, potentially leading to game overexploitation ([de Mello et al. 2020](#)).

The commercial hunting margin estimated in this study (1,487,263 FCFA/year) is almost equal to that of [Layade et al. \(2021\)](#) in Nigeria (1,394,771 FCFA/year), and was greater than estimates from central Africa (Democratic Republic of Congo; 210 960 FCFA/year ; [Van Vliet et al. 2019](#)) and remain very important considering Benin Gross Domestic Product per capita in 2022 (753,366 FCFA/year; [World Bank Group, 2024](#)). Difference observed could be explained by a greater demand in southern Benin related to the co-occurrence of two different markets (bushmeat and traditional medicine markets; [Djagoun et al. 2013](#)) in conjunction with the rarefaction of western African fauna due to intense deforestation and hunting ([Taylor et al. 2015](#)). Indeed, the low hunting margins estimated by [Van Vliet et al. \(2019\)](#) in Congo are to be related to the context of the study site, involving less hunting activities.

Despite national legislation prohibiting hunting during most of the rainy season (from 1st July to 30th November), hunting activities were conducted throughout the year. The regular hunting season (dry season) was the most profitable for both

hunters and sellers. Although hunters' gross margins per hunting days was higher during the rainy season, hunters earn their most important margins during the dry season because of greater hunting effort and higher catches. Our results are in contradiction with [Van Vliet et al. \(2019\)](#) and [Sackey et al. \(2023\)](#), who showed that bushmeat actors earn their most important margins during rainy seasons respectively in Ghana (West Africa) and Congo (central Africa). In southern Benin, most hunters are primarily farmers and are more committed to farm activities during the rainy season, contributing to the lower game numbers collected during that period.

The monetary values of game species varied between seasons. Overall, values were lower during the rainy season, except for the bushbuck (*T. scriptus*) and the red river hog (*P. porcus*), which seemed to act as "financial refuges" for hunters through their higher prices in the rainy season compared to the dry season. Previously in Nigeria, [Akani et al. \(2015\)](#) showed that the bushbuck and red river hog were sold at the highest prices on the bushmeat market. Red river hogs in Benin are highly prized because of their meat ([Codjia & Assogbadjo, 2004](#)), whereas bushbuck skins are valued both for their meat and ornamental or religious purposes ([Tawo et al. 2016](#); [Wahab et al. 2021](#)).

In the case of sellers, seasonal trends were similar except for the Gambian rat (*C. gambianus*), which played the role of financial refuge during the rainy season. The Gambian rat is one of the commonest species on sellers' stalls during the rainy season, probably because of their high reproductive rate and their commensalism ([Dounias, 2010](#)). Moreover, their sociality with human and the shift towards trapping strategies during the rainy season –because of reduced hunting time– make their hunting efficient ([Okiwelu et al. 2009](#)).

Although hunting was a secondary activity for most of the hunters, commercialization of the bushmeat products allowed covering all costs related to hunting. Hunting equipment is the main charge supported by hunters (no hunting permit needed), sometimes reaching high costs despite artisanal manufacturing as in the case of guns ([McNamara et al. 2016](#)). Moreover, game hunting supports other incidental charges such as gasoil for moving to hunting sites, motorbike maintenance, dog feeding, etc. The awareness by rural households of the considerable incomes achievable through hunting, notably during the rainy season when hunting is prohibited, is likely an economic factor promoting illegal hunting in southern Benin together with the continuous selling of bushmeat throughout the year. Indeed, considering the income generated by traders after deducting all costs, the bushmeat trade in southern Benin can be seen as a very profitable business in which actors are committed to a long-term career (70% of the sellers had the bushmeat trade as a main activity).

Actors' Perceptions on the Profitability of the Bushmeat Trade

Both hunters and traders from southern Benin underlined the profitability of the bushmeat commodity chain, in line with

the general profitability pattern observed elsewhere in tropical Africa (Van Vliet et al. 2019; Layade et al. 2021; Wahab et al. 2021). The number of hunters per household was significantly affecting the positive perception of profitability. Indeed, greater numbers per household increase hunting power and knowledge sharing, leading to higher hunting efficiency and benefits (Knapp et al. 2017; Nunes et al. 2020). In this context, the presence of young hunters in the household was seen as an opportunity for senior hunters to have assistants during their activities, whom could be trained and help bring the hunted animals to the household or markets.

Similarly, the traders' household size had a positive effect on their commitment to continue trade activities. The unpaid family workforce allows larger traders' families to minimize operational costs and generate more profit (Cowlshaw et al. 2004). In southern Benin, traders with large households had less bushmeat processing difficulties and could multiply the number of selling sites (e.g., markets, road sides and consumers' homes).

Hunters also related profitability with large game species and good selling prices, larger species being sold at higher prices (Gonedélé-Bi et al. 2022). The largest and most profitable species hunted were the bushbuck, Walter's duiker and red river hog, all of which are relatively frequent on the bushmeat stalls of the subregion, including southern Benin (Codjia and Assogbadjo, 2004; Okiwelou et al. 2009; Akani et al. 2015; Wahab et al. 2021). However, population status and the sustainability of their trade remain unassessed in the study zone, so the long-term profitability of hunting the largest game species is uncertain.

One of the two main factors negatively associated with profitability along the bushmeat commodity chain, including consumers, was regulatory measures taken by administrative authorities such as hunting ban and market controls. Such measures, when implemented, can be a powerful tool to mitigate the bushmeat trade activity and limit vocations towards game hunting and commercialization (Nielsen et al. 2014). Further investigations will have to be conducted to decipher whether it is the negative perception of potential regulatory measures or the measures *per se* (or both) that were expressed by the surveyed actors.

Supply difficulties were the second main factor identified by hunters and traders as negatively acting on the bushmeat trade profitability in southern Benin. For hunters, supply issues translated into long distances from hunting areas. Indeed, the proximity of hunting sites allows hunters to minimize transport costs and the risk of being caught by authorities during the hunting ban period. In southern Benin like in other places from tropical Africa, it is likely that hunting for subsistence and local trade activities mostly occur near villages and according to game abundance (Lindsey et al., 2011), especially since hunters are generally poorly equipped and also need to take care of their crops (Fargeot, 2005). Traders were sensitive to a lack or low supply of

bushmeat from suppliers (hunters and sometimes intermediaries), restricted bushmeat supply promoting competition among traders (Brugiere et al., 2009; Nyaki et al. 2014; Nielsen et al. 2014).

Because they motivate the demand for bushmeat, consumers represent a critical point of entry in the bushmeat commodity chain. However, they remain a category of actors difficult to apprehend given the large socio-economic spectrum they represent (Van Vliet et al. 2011; Chausson et al. 2019). In southern Benin, monthly income, and the possibility of buying by credit had a positive influence on the perception of bushmeat profitability, whereas selling prices had the opposite effect. Our results support the dichotomic view on bushmeat consumers, distinguishing a wealthy group with the means to buy the game for which they have a strong preference *versus* a group –mostly rural– with no viable alternative than bushmeat to access mammalian animal proteins (and as such, price sensitive and less selective in terms of game species) (Wilkie et al. 2005; Van Vliet et al. 2011; Liu et al. 2016; Wilkie et al. 2016).

Implications for Wildlife Conservation

Our study showed that hunting in rural communities from southern Benin was a household-based, culturally-anchored and profitable activity on which households strongly rely (Codjia & Assogbadjo, 2004; Luz et al. 2015; Van Vliet et al. 2015; Sogbohossou & Kassa 2016; Wilkie et al. 2016). Because hunting is a local activity, we posit that hunting by rural communities in southern Benin will mainly affect wildlife close to villages. Nevertheless, since villages are present within protected areas (e.g., Forêt Classée de la Lama), a negative impact of hunting on both human commensal and forest species, the latter being generally of higher conservation concern, is anticipated.

Poaching Activities Occurring During the Hunting Ban Period. Poaching activities occurring during the hunting ban period contribute to the unsustainable exploitation of wildlife and the local extinction of the largest, most prized species from southern Benin, as observed in other parts of tropical Africa (Harrison et al. 2016; Rogan et al. 2017; Rija et al. 2020; Gonedélé-Bi et al. 2022). Indeed, according to the actors' perception of hunting profitability, the availability of larger species (duikers, for example) has a positive influence on the hunters' decision to continue their activities, as observed in other study systems (Tieguhong and Zwolinski 2009; Chabi-Boni et al., 2018). Therefore, we recommend that ecological surveys are urgently conducted on the most hunted species in order to assess their population status and establish a scientifically-sound management strategy where vulnerable and exploitable species would be differentiated. For example, the development of such a strategy will help people to appreciate the impact of hunting on *Lepus victoriae* and *Hydrictis maculicollis* in different way.

Our study highlighted that profitability was perceived by all the actors along the bushmeat commodity chain, including hunters, traders and consumers, and was anchored into local livelihood and culture. The significant incomes generated along the chain and the cultural aspects related to hunting in southern Benin make the question of mitigating and regulating the bushmeat trade complex. For instance, community perception of hunting as a cultural heritage was one of the most important reasons for illegal hunting. Although law enforcement might be efficient in regulating the trade (Lindsey et al., 2013; Ripple et al. 2016; Antunes et al. 2019; Chausson et al. 2019; El Bizri et al. 2020; Rijja et al. 2020), its implementation remains costly for most African states submitted to a political will challenged by global state corruption (Bennett 2015; Wyatt et al. 2018; Chausson et al. 2019). Incentives for alternative sources of animal proteins (e.g., cane rat farming, cultivation of indigenous leguminous plants) and professional retraining, better hunting practices and self-participatory involvement of local communities in game management could also be an option (Lindsey et al. 2011; Lindsey et al. 2013; Nyaki et al. 2014; Ripple et al. 2016; Nielsen et al. 2017; Chausson et al. 2019; McNamara et al. 2019; Van Vliet et al. 2019). However, these require upstream socio-economic and cultural changes not achievable in a short timeframe and disruption-prone to the slightest risk, be it environmental, economic or socio-political, given the significant source of fallback income and food security the bushmeat represents (Kümpel et al. 2010). Bushmeat commodity chain actors' commitment to continue hunting and trade in southern Benin is conditioned by a set of socio-economic and cultural factors (cultural motivations and perceptions) that need to be considered in national conservation policies and development programs to keep bushmeat hunting profitable and make it sustainable in the long term.

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