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Are mammal communities occurring at a regional scale reliably represented in "hub" bushmeat markets? A case study with Bayelsa State (Niger Delta, Nigeria)

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Abstract. Monitoring of bushmeat markets has traditionally been seen as a source of faunistic and ecological data on mammal communities in West Africa. Nonetheless, it is largely unexplored whether datasets coming from monitoring of large "hub" markets in towns can reliably picture the mammal faunas and community compositions at the local level. Here, Swali market in Bayelsa State, Nigeria, that is one of the largest bushmeat markets in the Niger Delta, was monitored for six months in 2013-2014. Data from Swali market were compared with those collected during regular field surveys at five protected forests situated within 15 km radius from the market. A total of 21 mammal species was recorded at Swali versus 29 in the five protected forests. The trade was more intense by wet season. There was a statistically significant linear relationship between mean weight of the sold mammal and its price. A considerable portion of species that occur at the protected forests did not occur in the market samples, including the very rare species and the small-sized species. However, the abundance in the market of the common species was positively related to their apparent field abundance in the forest reserves. Therefore, it is concluded that large-sized bushmeat markets did not depict reliably the whole faunal composition and the community structure of mammals in West Africa, although these types of surveys are sufficient to characterize the abundance distribution of the common species at the regional scale.

Key words: mammalia, hunting, marketing of wildlife, West Africa

Introduction

In many parts of Africa, a sizeable amount of wild animal meat (the so-called "bushmeat") go into the market annually, to support the livelihood of hunters and other indigenous people (e.g. Fa et al. 2000, 2002, 2003, Bakarr et al. 2002). The bushmeat trade has obviously both economic (Davies 2002, Brown & Williams 2003) and conservation (Fa et al. 2005, 2006, Luiselli et al. 2013) implications, and therefore has been a subject of vigorous investigations in the recent years (Fa et al. 2005, 2006, MacDonald et al. 2012, Martin et al. 2012, Obioha et al. 2012).

It has been observed that the increase in bushmeat hunting is a cause of biodiversity loss and decline of wildlife populations throughout Africa (Robinson et al. 1999, Wilkie & Carpenter 1999, Redmond et al. 2006, Mfunda & Roskaft 2010). Nonetheless, noteworthy advances in the knowledge of the distribution of Afrotropical animals, as well as even for description of previously unknown species (especially mammals), are due to inspection and monitoring of bushmeat markets by scientists (Powell & Grubb 2002, Colyn et al. 2010).

In west Africa, commercial hunters provide the harvested animals to the traders, who in turn supply urban markets for profit. Whilst there are myriads of

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small-scale, often temporary, bushmeat markets that trade a small number of individuals mainly at a local scale, there are also several large markets in towns and cities (hereby, the "hub" markets) that represent the main points of sale for a large volume of species extracted from natural areas (Fa et al. 1995, Fa 2000). It is considered that these "hub" markets may offer valuable insights into (i) the supply and demand of bushmeat in human population centres, (ii) the assessment of the effect of hunting on the bushmeat species if data on prey densities are available, and (iii) comprehensive data on the taxonomic composition of mammal communities (e.g. Fa et al. 1995, Angelici et al. 1999, Fa 2000). However, it has never been investigated in detail whether these markets can be really used to have a reliable and comprehensive dataset on local mammal faunas.

Throughout the Niger Delta of southern Nigeria, the bushmeat trade is certainly rampant, and has probably produced considerable negative effects on the local biodiversity (Martin 1983, Okiwelu et al. 2009, Luiselli et al. 2013). In this report, data collected by monitoring a "hub" market (situated in Bayelsa State, Niger Delta of southern Nigeria) were used to compare the diversity and richness of mammal species at the market place with diversity and richness patterns observed in five forest reserves of the same studied region that were subjected to focused researches (Petrozzi et al., unpublished data). By comparing these datasets, it would be possible to infer whether "hub" city markets may be instrumental in determining the relative mammal diversity patterns for the surrounding areas. The a priori expectation was that, if regional mammal diversity is adequately sampled by "hub" markets, then the accurate monitoring of that market should reveal the entire spectrum of species potentially present in the area. Obviously, since small rodents and insectivores are usually uneaten by humans, these species cannot be considered in this kind of comparisons and have been excluded from further analyses.

Material and Methods

Study area

The study was carried out in Swali market (4°55′ N, 6°17′ E). Swali market is the main centre for the sales of wildlife killed or captured alive, around Yenagoa and environs (Bayelsa State, Nigeria). Although the amount of traded carcasses in Swali is smaller than in other central markets studied to date (e.g. Kisangani in Congo, Vanvliet et al. 2012 or Malabo in Bioko Island, Fa et al. 2000), this marketplace appeared of special relevance for our study case because (i) it is situated between five forested reserves of the Niger Delta (Fig. 1), (ii) it is anyway larger than most bushmeat markets in the region, and (iii) because it is also used sometimes for sale of remotely captured animals. For instance, we recorded a few bushmeat items belonging to species that do not occur in the Niger Delta, such as the puff adder, *Bitis arietans*.

The study region is characterized by an alternation of flooded swamp forest patches and widely deforested areas, where cropping and forest-derived savannah-like grasslands are prevalent (Niger Delta Environmental Survey 1998). The market is located on the shore of the River Nun. Thus, hunters easily transport their bounties by rivercraft. Swali market is also accessible by good roads, recently constructed by the Bayelsa State government.

Most of the hunters catch the animals from the thick seasonally inundated swamp forests that are situated within 15 km radius from Swali market, i.e. Emeyal, Otuasega, Elebeli, Famgbe, Bebelebiri, Kolo Creek and Ogbia areas (Fig. 1). The importance of this marketplace is widely acknowledged at the local level because hunters prefer selling bushmeat to vendors in Yenagoa than to other locations of the state, because buyers price them better here (Akani et al., unpublished interviews with local hunters).

Fig. 1. Map of the study area, including the forest sources of the bushmeat animals that were traded in the Swali market. Symbols: 1 = Taylor Creek FR, 2 = Upper Orashi FR, 3 = Nun River FR, 4 = Edumanon FR, 5 = Egbedi Creek FR, A = Otuasega, B = Emeyal, C = Kolo Creek, D = Ogbia, E = Bebelebiri, F = Fangbe, G = Elebeli.

Taxonomic notes

We excluded most of the rodents, shrews and fruit bats (*Eidolon helvum*, *Rousettus angolensis*, *Hypsignathus monstrosus*, *Epomophorus anurus*, *Epomophorus gambianus*, and *Epomops franqueti*, see Happold 1987) from our investigations. Nomenclature for mammal species follows Nowak (1999) and Wilson & Reeder (2005). Identification of the recorded individuals was done to the most accurate taxonomic level possible. However, identification of some species remained ambiguous. In this case, either we report the genus name followed by "sp." or present the possible options. For instance, we indicated the genets as *Genetta* sp., with three species occurring in the study area, i.e. *G. cristata*, *G. maculata*, and *G. thierryi* (Powell & van Rompaey 1998). On the other hand, for the geospecies *Galagoides demidovii* (i.e. *demidovii* group according to Grubb et al. 2003), we indicated it as *Galagoides demidovii*/*thomasi*. For the geospecies *Perodicticus potto* (Grubb 2006), we indicated it as *Perodicticus potto*/*edwardsi*.

Sampling protocol

Swali market was surveyed both during the wet season (October 2013 and March 2014) and the dry season (November 2013 to February 2014). In our sampling protocol, a wet season day was not equivalent to a rainy day, as we intended as wet season days also dates with no rain falling. During the 24 weeks of study, the market was visited once every week to list and count the animals landed. Field effort was higher during the dry season (16 versus 8 visits in the wet season). Sampling was carried out only in the morning hours (7.00-11.00 a.m.), when hunters land their bounties and sell them to the bushmeat dealers. Animals killed in the previous night's hunting and animals trapped by snares must be brought to the market in the morning before they begin to putrefy and loose market value. Further information on the bushmeat trade (price of the animal on sale, place of capture, etc.) was acquired through interviews with the dealers and hunters. Overall, a total of 27 different hunters who were regular suppliers of bushmeat to the vendors were recorded, while five were occasional suppliers. The major hunting techniques were reportedly (i) shooting with local dane guns helped by hunt dogs, (ii) trapping with wire snares, and (iii) snap traps. At marketplace, mammals were sold as (i) living animals, (ii) whole carcasses, (iii) butchered parts, and (iv) dried or smoked parts. The condition of all the individuals at the time of examination was always recorded.

In order to explore whether the relative abundance of the various species at Swali market was influenced by their relative field abundance, we established an Abundance Index for all of the species occurring in the forest reserves surrounding Swali, by following Akani et al. (2014, 2015a). This Abundance Index was empirically determined on the basis of our interviews with selected hunters and on the relative number of our field sightings (for details, see Akani et al. 2014, 2015a). We categorized each species' abundance into three groups: very rare (score = 1), uncommon (= 2), and common (= 3). Although we acknowledge that this Abundance Index does not have full scientific support, nonetheless it may give a preliminary indication of the relative abundance of the various species for a region of tropical Africa where there is no data available on the population abundance of most mammal species (Akani et al. 2014, 2015a).

Differences in the frequencies of animals (in terms of both number of individuals and traded biomass) sold in the wet versus dry season were examined by χ^2 test. Relationship between species' relative field abundance and frequency of occurrence at Swali market was analyzed by the Spearman's rank correlation coefficient. Relationship between mean weight of the sold mammal and its price was tested by the Pearson's correlation coefficient. Nonparametric tests were used when variables were not normally distributed. Alpha was set at 5 %. All statistical tests were performed with PAST software.

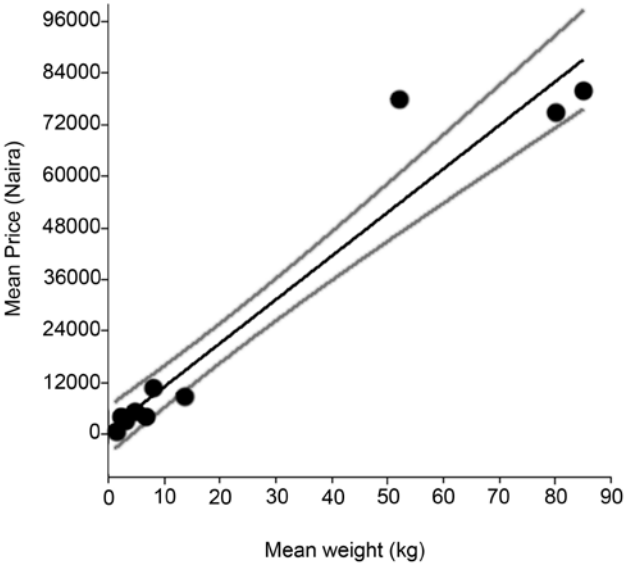

Fig. 2. Relationships (regression line and 95 % Confidence Intervals) between mean weight and mean price for the mammal bushmeat at Swali market.

Table 1. Synopsis of the data on mammals traded in Swali market of Bayelsa State, Nigeria.

	Individuals				
Species	Wet season	Dry season	Total	Mean weight (kg)	% biomass (total = 9345.73)
Cricetomys cfr. *emini*	45	29	74	1.2	0.95
Thryonomys swinderianus	184	112	296	6.65	21.06
Atherurus africanus	27	31	58	2.75	1.71
Philantomba walteri	18	11	29	8	2.48
Tragelaphus scriptus	14	15	29	52	16.14
Tragelaphus spekei	11	17	28	85	25.47
Hymenoschus aquaticus	4	7	11	11.5	1.35
Neotragus batesi	10	3	13	3.75	0.52
Potamochoerus porcus	6	8	14	80	11.98
Viverra civetta	16	11	27	13.5	3.90
Genetta sp.	15	12	27	2.15	0.62
Nandinia binotata	19	10	29	2.6	0.81
Crossarchus platycephalus	28	32	60	3.15	2.02
Aonyx capensis	10	4	14	23	3.45
Uromanis tetradactyla	18	12	30	2.725	0.87
Manis tricuspis	8	5	13	2.3	0.32
Cercopithecus mona	26	22	48	4.5	2.31
Cercopithecus nictitans	13	18	31	5.53	1.83
Cercopithecus spp. (smoked and unidentified)	25	30	55	3.25	1.91
Cercopithecus sclateri	4	2	6	3.5	0.22
Perodicticus potto/*edwardsi*	5	0	5	1.2	0.06

Table 2. Price range of adult mammal carcasses in Swali market of Bayelsa State (as at February 2014).

Species	Sample size	Price range (Naira)	Mean price (Naira)
Tragelaphus spekei	20	75000-86000	80000
Tragelaphus scriptus	16	72000-85000	78000
Potamochoerus porcus	14	72000-80000	75000
Philantomba walteri	10	10000-12000	10780
Thryonomys swinderianus	55	4000-4500	4260
Atherurus africanus	32	3000-4200	4100
Pangolins	15	3500-4400	4000
Cricetomys cfr. *emini*	28	600-1000	850
Viverra civetta	10	8000-10000	8950
Genets	18	3500-4500	4200
Crossarchus platycephalus	15	2800-3200	2970
Cercopithecus spp.	18	4200-5800	5200
Cercopithecus nictitans	22	4000-5800	5000
Cercopithecus mona	10	4200-5500	5000

Table 3. List of the mammal species that although recorded in recent years (2010-2014) in five forest reserves (FRs) of Bayelsa State (Petrozzi et al., unpublished data) were not observed at Swali bushmeat markets. The apparent abundance of these species in the forest reserves is also reported.

Species	Status in the FRs
Arctocebus calabarensis	rare
Cephalophus niger	very rare
Herpestes ichneumon	rare
Funisciurus sp.	common
Galagoides demidovii/thomasi	rare
Pan troglodytes	very rare
Trichechus senegalensis	very rare

Table 4. Comparison between number of traded individuals per species at Swali market and empirical Abundance Index of each species in the five forest reserves surroundings the marketplace. For methodological details, see the text.

Species	No. in Swali	Abundance Index
Cricetomys emini	74	3
Thryonomys swinderianus	296	3
Xerus erythropus	0	3
Funisciurus sp.	0	2
Atherurus africanus	58	3
Philantomba walteri	29	2.2
Cephalophus niger	0	1
Tragelaphus scriptus	29	2
Tragelaphus spekei	28	1
Hyemoschus aquaticus	11	1
Neotragus batesi	13	2
Potamochoerus porcus	14	3
Viverra civetta	27	2
Genetta sp.	27	1
Nandinia binotata	29	1
Herpestes ichneumon	0	1
Crossarchus platycephalus	60	1.8
Aonyx capensis	2	1
Uromanis tetradactyla	30	1
Manis tricuspis	13	1
Galagoides demidovii/thomasi	0	1
Perodicticus potto/edwardsi	5	1
Arctocebus calabarensis	0	1
Cercopithecus mona	48	2
Cercopithecus nictitans	12	1
Cercopithecus sclateri	6	1
Pan troglodytes	0	0.6
Trichechus senegalensis	0	0.6

Results

During the sampling period, a total of 21 mammal species were landed in Swali market for sales (Table 1). However, we were unable to identify genets to species level. Given the considerable species diversity of the genus *Genetta* in the Niger Delta (Powell & van Rompaey 1998), it is possible that more than one species was present in the samples, thus influencing the total number of species detected.

In total, 897 mammal individuals were examined, the great majority of them were already dead at the time of examination. Nonetheless, 12 *Cercopithecus mona*, 2 *Cercopithecus sclateri*, 8 *Cercopithecus nictitans*, and 5 pangolins were alive at the examination time. The landing rate was about 37 mammal carcasses per day of survey. *Thryonomys swinderianus* was the dominant species in the trade, accounting for 33 % of the total carcasses. Other common species were *Cricetomys* cf. *emini*, *Atherurus africanus*, *Crossarchus platycephalus*, antelopes, and monkeys (Table 1).

The collected data suggest a heavier trade during the wet months. Indeed, despite the stronger survey effort performed during the dry season, the numbers of traded carcasses were higher during the wet season at a marginally significant level ($\chi^2 = 30.9$, df = 20, P = 0.0501). In addition, these inter-seasonal differences were highly significant in terms of traded biomass (higher by wet season; $\chi^2 = 393.2$, df = 20, $P < 0.0001$). The highest priced bushmeat were *Tragelaphus spekei*, *T. scriptus*, and *Potamochoerus porcus* (Table 2). There was a statistically significant linear relationship between mean weight of the sold mammal and its economic value ($r = 0.970$, $r^2 = 0.940$, $n = 13$, $P < 0.001$; Fig. 2).

Seven species recently (years 2010-2014) recorded in the forest reserves of Bayelsa State (data in Akani et al. 2014, 2015, Petrozzi et al., unpublished data) were not observed in the marketplace (Table 3). However, there was a significantly positive relationship between species' relative field abundance (Table 4) and its frequency of occurrence at Swali market (Spearman's $r = 0.539$, $P < 0.01$).

Discussion

A total of twenty-nine species of mammals were recorded in five forest reserves situated in the same study region (i.e. Edumanon, Taylor Creek, Egbedi Creek, the River Nun and Upper Orashi Forest Reserves; see Petrozzi et al., unpublished data). The percentage of traded species in Swali market was high (72.4 % of the species that were certainly evidenced

in the same forest region) and thus apparently well representative of the local mammalian diversity. In addition, the positive relationship between species' field abundance and its frequency of occurrence at the marketplace suggests that bushmeat market surveys may be useful to drawn quantitative information on the relative abundances of the various species of tropical forest mammal communities. Nonetheless, our data also revealed that inferences about mammal community structure from bushmeat market surveys may have serious limitations. Indeed, we showed that there are important subsets of the overall community of species that remained unrepresented in the market sample. For instance, all the very rare species (i.e. *Cephalophus niger*, *Trichechus senegalensis*, *Arctocebus calabarensis*, *Pan troglodytes*, Akani et al. 2014, Petrozzi et al., unpublished data) were never observed at the market site during the monitoring period. In addition, many species of smaller size (like squirrels) were also never observed at the market site despite they are common and widespread in the study region (Blench 2007, Akani et al. 2014, 2015a). Community ecology theory does make use of rare species and singletons in many diversity analyses (e.g. Magurran 1988, Gaston 1994, Novotny & Basset 2000, Luiselli 2006). Thus, the biased absence of such community components from bushmeat marketdata certainly introduces limitations in our understanding of tropical forest mammal community structures.

The reasons behind the absence of rare and small-sized species from marketplace are multiple. The absence of small-sized mammal species from bushmeat markets is due to the fact that they are directly consumed by the hunters and/or at the local level of the village as they are not economically viable, and are also hunted by different age groups (e.g. children) (Damania et al. 2005, Kamins et al. 2011). Indeed, rodents (as well as insectivore species and other small-sized animals), which are often consumed by the hunter and his family, hardly appear in the markets and therefore do not appear in the statistics (Colyn et al. 1987, Ntiamoa-Baidu 1997).

Concerning rare species, in theory it is possible that some species are not hunted because they are taboo (e.g. Oates et al. 2004, Baker et al. 2009) or because they are protected/forbidden to hunt in Nigeria and thus can be sold, but hidden (Oates 1999). However, several species, that officially are protected by Nigerian federal laws on Act 11, Schedule I (i.e. *Atherurus africanus*, *Tragelaphus spekei*, *Hyemoschus aquaticus*, *Neotragus batesi*, *Aonyx capensis*, *Manis tricuspis*, *Uromanis tetradactyla*) or Schedule II (i.e. *Genetta* sp., *Nandinia binotata*, *Viverra civetta*, and all *Cercopithecus* species), were regularly traded, thus showing that this type of legal impediment did not work to diminish the trade. Local taboos were also unlikely to affect the trade at Swali market, because this marketplace collated animals from a suite of different forest sites where hunting was performed by different ethnic groups.

The present study also revealed a higher trade by the wet season (more evident in terms of traded biomass than in terms of number of carcasses offered for sale). This result is in agreement with bushmeat market data for reptiles (Akani et al. 2015b). However, in reptiles it has been demonstrated a considerable intensification of above-ground activity (and hence of the encounter probability with hunters) during the rainy months (Akani et al. 2010, 2013), whereas the same inter-seasonal differences in phenology have, to our knowledge, never been reported for Niger Delta mammals. On the contrary, it has been reported that hunting was lower during rainy days, which occur generally in the wet season (e.g. Anadu et al. 1998, Wright & Priston 2010), because (i) of lower/more concentrated activities in mammals around water bodies (thus facilitating hunters, Bifarin et al. 2008) and (ii) agriculture cycle (Wright & Priston 2010). Therefore, our data suggest that the best hunting days were the dry days (and nights) within the wet season period.

In terms of economic value, the given data showed that the size of the traded animal determined for a great deal its price. Indeed, regardless of the type of traded animal, body weight predicted linearly (r^2 = 0.940) the economic value of its carcass. This result is in disagreement with Ntiamoa-Baidou (1997). In the bushmeat trade in Kantamanto market, Accra (Ghana), this author recorded a considerable interspecific variation in the average price/kg of the traded animals (see tables 3.7 and 3.8 in Ntiamoa-Baidou 1997). It is not known what may be the reasons behind these observed differences, but since we lack in our sample set the intermediary sized species (between 15 and 50 kg), our graphic (Fig. 2) is stretched between the two extremes, and this fact may have in part biased our conclusions.

Concerning the traded species, at Swali market there was an almost identical number of traded *Tragelaphus scriptus* and *Tragelaphus spekei*. Okiwelu et al. (2009) stated that the former species was recently replaced in the bushmeat market trade by the latter species, whereas it was dominant few decades before. Interestingly, clear dominance of *Tragelaphus scriptus* versus *Tragelaphus spekei* was also found by

Angelici et al. (1999) in 1996-1997, thus independently confirming the "historical" observations by Okiwelu et al. (2009). It seems therefore demonstrated that these two species are really experiencing an inverse trend of occurrence in bushmeat markets. It is possible that this inversion of trends may depend on a progressive increased scarcity of *Tragelaphus scriptus* in the wild in the Niger Delta (at least in human-altered habitats), thus forcing hunters to enter deep inside the swamp forest places (typical habitat type for *Tragelaphus spekei*, see Antelope Specialist Group 2008) in order to hunt efficiently for antelopes. A deeper penetration of hunters inside mature forests was also seen in Gabon (Steel 1994).

Overall, the results of the present study suggest that central ("hub") bushmeat markets could not depict reliably the whole faunal composition and the community structure of mammals in West Africa, although the common species can be adequately sampled, even with quantitative estimates of their relative abundance mirroring true wild abundances. Thus, careful field surveys remain essential in order to establish the presence/absence, and obviously also the relative abundance, of a considerable portion of the mammal fauna of West African tropical forests.

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