What can be done to reduce illegal hunting? An investigation using choice experiments in the Serengeti, Tanzania

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Abstract

Illegal bushmeat hunting is a serious threat to the conservation status of many species in Africa. However, gaps in our understanding of the determinants of bushmeat hunting and consumption remain. In this paper, we use two choice experiments to quantify these determinants. A livelihoods strategy design is used to investigate factors which might reduce participation in illegal bushmeat hunting, whilst a consumption choice experiment investigated the cross-price elasticity of demand for protein substitutes. Results presented here are from two pilot studies, but results from the main surveys will be available in time for the Bioecon meeting in September.

Keywords: illegal hunting, livelihoods, choice experiments, Serengeti, bushmeat.

1. Introduction

Hunting of wildlife is believed to be a key driver of serious population declines and local species extinctions in many parts of the world. Poaching of bushmeat (or wild meat, wild animals killed for food) of certain species is particularly critical in Africa, and especially east Africa, where the link between the decline of wildlife population and hunting has been studied more extensively than in other parts of Africa (see, e.g. Wilkie and Carpenter, 1999; Robinson and Bennett, 2000; Brashares et al., 2001). Recently, a number of studies have expressed concern about the scale of illegal hunting in west Africa and in protected areas such as the Serengeti National Park in Tanzania. The Serengeti ecosystem is one of the oldest on earth and it encompasses the Serengeti National Park itself, the Ngorongoro Conservation Area, Maswa Game Reserve, the Loliondo, Grumeti and Ikorongo Controlled Areas and the Maasai Mara National Reserve in Kenya.

The Serengeti National Park has a long history of wildlife human conflict. Ivory poaching decimated the elephant population until only a few hundred were left in the park, and the thriving rhino population dwindled to just two individuals in the late 1970s. But by the mid 1980's, the improved economic conditions of the park and the country, private donations and international laws (such as the 1989 worldwide Ivory Ban) helped park authorities to regain some control of the park away from the poachers.

However, bushmeat poaching of resident and migratory wildlife, including wildebeest, giraffe, zebras, gazelles, buffalos and impalas continues. Populations of non-target species are also affected because of the use of un-selective methods such as wire snares (Arcese et al., 1995) The estimates of the number of wildebeest killed illegally annually in the Serengeti vary from 40,000 (Mduma, 1996) to 118,000 animals (Campbell and Hofer, 1995), and

concerns have been raised about the sustainability of these practices (Arcese et al., 1995). Previous studies have recognised the need to investigate and understand the determinants of hunting and bushmeat consumption as an essential step to devise more effective policies to reduce unsustainable illegal hunting of wildlife.

Loibooki et al. (2002) interviewed a sample of villagers in the western part to the Serengeti National Park and a sample of arrested hunters in the National Park, and found that participation in illegal hunting was driven by the need of cash income and on wealth, with participation decreasing as number of sheep and goats owned went up. Only one-quarter of their sampled arrested hunters declared that they hunted to obtain food. Access to alternative means of generating income or acquiring protein decreased the likelihood of illegal hunting activities. The sample of arrested hunters was indeed formed by young males with low income and few or no livestock. They also found that community-based conservation programmes put forward by government and agencies as a specific ant-poaching policy did not reduce illegal hunting.

This is not to imply that such projects are not effective under any circumstances. Community-based management programmes are based on the idea that wildlife population depends on the cooperation of the people who live adjacent to wildlife (protected or unprotected) areas, who have to receive tangible benefits from the conservation project (Nielsen, 2006). Johannesen (2005) found that effort in illegal hunting is inversely related to participation in such a conservation programme in Serengeti. Her study found also that the likelihood of poaching decreases as the amount of animals, land for maize and cotton production increases, as well as being related to wildlife-induced damage to crops and domestic animals.

Nielsen (2006) conducted surveys with local hunters in another region in the central part of Tanzania, the Udzungwa Mountains, confirms that illegal hunting is linked to poverty, family size and composition. Knapp (2007) stressed the importance of full-time employment and time use as a very important factor behind illegal activity. Knapp (2007) conducted interviews with poaching and non-poaching households and found, among other things, that none of the poaching households reported having full-time employment, whereas 20% of non-poaching households did have full-time employment.

Most of the studies to date seem to thus suggest a clear link between economic variables such as income and bushmeat prices and poaching in the Serengeti. Cultural motives do not seem as important as in other part of the world. [1] However, the extent and determinants of illegal hunting are still unclear because of lack of accurate data (Knapp et al., 2010). Studies assessing levels of poaching are usually based on four methods: self-assessment of illegal hunting activity; arrest records from anti-poaching units, dietary records to measure the demand of bushmeat, and estimates of species abundance Each one of these methods has its problems. Protein or dietary surveys may be subject to under-reporting and also to limits on the accuracy of the memory of respondents. The use of arrest records to determine the poaching level may tell more about the quality of anti-poaching activity and resources put into it. Finally, self reported levels of poaching coming from household surveys suffer from under-reporting.

In addition to this, problems of endogeneity complicate the identification of relationships between household characteristics and illegal activity. For example, Knapp (2007) offers evidence that considering total household earnings from seasonal and full-time employment,

[1] For an exception, see Kalternborn et al. (2005) that found that the role of hunting in community life extends beyond the food supply and poverty issues.

agriculture, and livestock, poaching households actually earned more income than non-poaching households. However, concluding from this that wealth (or income) is not an important determinant of poaching would be a mistake, as household wealth may be a direct consequence of bushmeat hunting and trade. The conclusion that Knapp is suggesting in his paper – that that the decision to poach may be more an issue of opportunity time rather than household wealth – is still partially affected by this endogeneity bias.

This paper tries to improve upon the existing literature by overcoming the endogeneity issue and assessing the causal effect of economic and social variables on poaching activity using choice experiments. The first choice experiment focussed on the supply-side, the decision to hunt at the household level (this will be referred to as the *bushmeat hunting* choice experiment, more on this later). A second choice experiment tackled the demand side of the problem, the importance of bushmeat price and the degree of substitutability of wildlife food with close substitutes such as fish and chicken (this will be referred to as the *consumption* choice experiment).

2. Methods

2.1. Survey method, sampling and area of study

We conducted our survey in six villages in western Serengeti, located between Serengeti National Park, Lake Victoria and Grumeti Game Reserve. Frankfurt Zoological Society (FZS) and TAWIRI had regularly been conducting surveys in these villages, and enumerators and respondents had built up trust with both organisations. Members of 16 households per village were interviewed by two local enumerators in each village, leading to an overall sample size of n=200. Most enumerators and half of the sample had participated in previous surveys conducted by FZS and TAWIRI and were thus broadly familiar with interviews of

this kind. Half of the respondent households were part of a panel and had previously been selected at random. The remaining households were selected as the nearest neighbours of the households in the existing panel. All enumerators were thoroughly trained in the administration of the choice experiments and conducted several interviews supervised by the team. After a qualitative pre- and a quantitative pilot test of both choice experiments, the enumerators conducted the main survey between December 2010 and February 2011. Choice sets were evenly distributed within each village.

2.2. Bushmeat hunting choice experiment

Choice experiments are a survey-based method. Respondents are presented with a series of alternatives, differing in terms of characteristics (attributes) and their levels, and asked to choose their most preferred. This approach was initially developed by Louviere and Hensher (1982) and Louviere and Woodworth (1983), and is one of the options in a family of empirical stated preference approaches known as choice modelling (for a review, see Hanley et al., 2001). Choice experiments share a common theoretical framework with other environmental valuation approaches in the random utility model (McFadden 1973). According to this framework, the indirect utility function for each respondent i (U_i) can be decomposed into two parts: a deterministic element (V), which is typically specified as a linear index of the attributes (X) of the j different alternatives in the choice set, and a stochastic element (e), which represents unobservable influences on individual choice:

$$U_{ij} = V_{ij}(X_{ij}) + e_{ij} = \beta X_{ij} + e_{ij} \qquad (1)$$

The probability that any particular respondent prefers option “g” (say, “hunting”) in the choice set to any alternative option “h” (say, “not hunting”), can be expressed as the

probability that the utility associated with option “g” exceeds that associated with all other options:

$$P[(U_{ig} > U_{ih})\ \forall h \neq g] = P[(V_{ig} - V_{ih}) > (e_{ih} - e_{ig})]. \qquad (2)$$

In order to derive an explicit expression for this probability, it is necessary to make an assumption on the distribution of the error terms (e_{ij}). Econometric models belonging to the family of the limited dependent variable, such as the multinomial logit (or MNL model), can then be applied to estimate the parameters that affect the choice. Estimation results identify characteristics that are statistically significant in the decision making process, controlling for demographic and economic characteristics of respondents (age, gender, education, income, etc.).

In this survey, we asked respondents to choose the most preferred livelihood option among a range of alternatives presented to them. A livelihood option consisted of six factors (the attributes in the choice experiment) that were carefully chosen after a series of focus groups with locals and communities. The options included two related to participation (supply) decisions for illegal bushmeat hunting: the amount of time spend hunting and the chance of being caught whilst hunting illegally. The six attributes along with the levels of each of these factors that we used are the following.

- *Number of cows*. The hypothesis is that a greater number of cows are preferred to smaller (ceteris paribus). The respondents were advised that the cows referred to were all adult, healthy cows. The attribute has four levels: no cows, 1 cow, about 15 cows, about 30 cows.

- *Wage rate*. The respondent was asked to imagine that she or somebody else in the household had a full time job.[2] The hypothesis is that higher wages are preferred to lower wage, ceteris paribus. There are four wage levels, no job, 80,000 TSh per month, 200,000 TSh per month, or 600,000 TSh per month. [3]

- *Access to microcredit.* Microcredit groups are a reality in some of the villages and most of the respondents are familiar with these programmes[4]. Nevertheless each respondent was with the following explanation: "a microcredit group is a group of peers within a village who contribute their own money to a communal bank, and are then allowed to take small loans from this bank to assist with expenses to start a businesses, pay school fees, pay for health care. Loans are all repaid with interest to the village bank, after which time another village member may request a loan. Interest is typically lower than with commercial banks, and all members of the bank are from within the same village." We then asked them to imagine that there could be such a microcredit group in the village that their households could obtain money from. The hypothesis is that the presence of microcredit group has a positive impact on utility.

- *Road to village centre accessible by lorry*. We told the respondent to imagine the existence of a good road between town and the centre of his or her village, so to facilitate the access to markets and the selling of household's produce, if any. The hypothesis is that the road scenario would be preferred to a non-road scenario.

[2] The full-time job was defined in the survey as a job that occupied from Monday to Friday from 8am to 5pm.
[3] The highest level corresponds to the highest salary of a primary teacher in the villages.
[4] Two microcredit groups the Village Community Bank, VICOBA, or the Community Conservation Bank COCOBA, were used as an example.

- *Length of a hunting trip made once a year*. This is the crucial attribute of the choice experiment. The respondent was told the following "Imagine that you or somebody else in your household considered to go bushmeat hunting to sell the meat (not to eat it at home). We are going to show you different options, for example, you (or the other person in your household) could go hunting for 6 months altogether in one year, or 1 week, or not at all. The time we mention here includes all the trips made in one year, whether it's one-night trips or big trips." This attribute has four levels: no hunting, 1 week, 2 months and 6 months. Hunting may be a positive or a negative attribute in the utility function. The amount of time spent hunting increase the risk of being killed by wildlife and the risk of being caught by patrol officers. However, longer hunting sessions imply higher cash income since more animals will be caught and thus more can be sold.

- *Likelihood of being arrested per trip*. This attribute is directly correlated with the previous one.[5] The enumerators read the following text to each respondent "Imagine you or somebody else in your household might be going for a bushmeat hunting trip this year in a group of 10. You or somebody of your group might get arrested. We will show you different likelihoods of being caught (per trip). For example, of the 10 people in this group on your trip, two might be caught, or four." The four levels are: nobody gets caught, one individual out of a group of ten, two individuals out of ten and four out of ten get caught.

Every respondent was shown six livelihood choice cards such as the one in Figure 1. There were four different questionnaires, as the experimental design used four blocks. The

[5] As it will be specified below, this implies that both in the experimental design and in the econometric analysis the two attributes will be interacted.

combinations of the levels were derived by employing a Bayesian efficient design using the Ngene software.[6]

As shown above, hunting (or better: "time spent hunting") is one of the attributes in the choice experiment. Alternatively, hunting could have been the outcome of choice. First designs of the experiment were indeed more direct, asking respondents to choose between "hunting" versus "not hunting", given different combinations of a similar number of attributes. However, after focus groups and a pilot study on 80-90 individuals, the strategy was changed. The problem was simply that illegal hunting as an outcome totally dominated the attention of the respondents and was effectively seen as a direct question on the amount of illegal hunting the respondents were willing to choose. This being too sensitive an issue (since illegal hunting is punishable) led respondents to protest. A livelihood choice experiment worked much better. And clearly individuals were not afraid to answer. And they did answer to all choice cards presented. More importantly, the livelihood choice experiment design forces respondents to trade the decision and the level of hunting off against other attributes, therefore revealing the weight they attached to illegal hunting and alternative means of earning a livelihood.

2.3. Bushmeat consumption choice experiment

[6] The design was optimized for the d-efficiency of the MNL model, as given the small sample this is the most likely model to be estimated after the pilot is completed to provide priors for the final survey. The target efficiency was calculated for MNL model with 0 priors (weight 33%) and MNL model with all the parameters normally distributed (weight 66%) with priors of means specified as 1/maximum variable value (with the expected sign) and priors of standard deviation specified as 0.5 of the prior of mean. This was in order to assume all variables equally important for respondents and not allow any of the attributes to dominate the others. The utility function included no constants, all the attributes entered linearly, and an interaction term of "length of the hunting trip" and "likelihood of getting caught" was included. For the optimization the SWAP algorithm (reseeding after 100 iterations, with the increment of 100) for the first 4 hours and then switched to the modified Federov algorithm for the remaining Gaussian (abscissas = 3 or 5), Sobol (5000) and Halton (5000) Bayesian random draws were used. The best design of each of this optimization version was evaluated again using the following Gaussian (abscissas = 7), Sobol (50000) and Halton (50000) random draws. The most efficient design was then finally selected.

The bushmeat consumption choice experiment belongs to the family of hypothetical choice experiment in which participants are presented with multiple goods for sale at different prices. Such choice experiments have a long tradition in the marketing literature (see, e.g., Gabor, Granger and Sowter, 1970, Pilon, 1998). Agricultural economists have more recently begun estimating the value of certain private goods using non-hypothetical choice experiments. Maynard et al. (2004) and Corrigan et al. (2010) employed choice experiments that are similar to ours. In Maynard et al. (2004) participants in a hypothetical supermarket can purchase any non-negative quantity of different types of steaks. Participants were presented with just one set of prices and asked to allocate $20 budget across the different types of steaks, with change given in frozen hamburger patties. Our strategy is more similar to the open-ended experiment proposed in Corrigan et al., 2009. In our case respondents have to specify the number of units of bushmeat and number of units of a substitute good at different price levels.

One of the strengths of this experimental design is that it recreates a familiar situation, similar to the one experienced daily in shops, where decisions concern the amount and mix of goods to purchase at different prices. An additional important advantage of our approach is that we can estimate cross-price elasticities since in the choice experiment the prices of bushmeat and substitute good are allowed to vary. For the first time, our choice experiment will identify the degree of substitutability between legal (i.e., fish and chicken) and illegal (i.e., bushmeat) sources of protein without encountering simultaneity or endogeneity bias.

Three features of this design are crucial in order to achieve a successful experiment. The first concerns the choice of substitute goods. We have decided to have two experiments administered, one in which participants have to choose among 1 “live adult healthy” chicken

and 1 piece of dried bushmeat, and the other one in which they have to choose between 1 piece of dried bushmeat and 1 piece of good quality fish. Bushmeat is bought at black markets in pieces. We have used a piece of paper to show how big the piece of bushmeat we were referring to was. The second concerns the price levels. The range of prices was based upon previous research in the area after focus groups and discussions in the villages regarding realistic intervals. The price levels for 1 piece of bushmeat consisted of: TSh500, TSh1,500, TSh3,000 and TSh4,500; the price levels for 1 piece of good quality fish was TSh1,000, TSh3,000, TSh5,000 and TSh7,000; whilst chicken had four price levels: Tsh6,000; Tsh9,000; Tsh12,000 and Tsh15,000. The third crucial aspect regards controlling hypothetical bias arising in such experiments. The questionnaire reminded the participant to think about their budget constraints and that it was perfectly fine if they were not willing to buy any quantity. Figure 2 shows a sample of the choice card used for the consumption choice experiment. This was obtained using a factorial design with 12 rows and 2 blocks.

Because participants can request any non-negative quantity at a given price level, we are able to estimate individual's demand curve using fixed effects and random effects count models to account for the count nature of the data, its panel structure and over-dispersion common in this type of study.

3. Preliminary Results

The results reported here comes from the pilot studies run in December 2010. These will be updated with the results coming from the main surveys, which were completed in Spring 2011. We are currently validating the data from both the bushmeat hunting and consumption choice experiments. Results from these two datasets will be presented in the paper in

September. Meanwhile, Table 1 shows the preliminary results of the hunting choice experiment from a basic MNL model.

Table 1- Hunting choice experiment

	Coefficient	Standard Error
Number of cows	.03923***	.01078
Wage per month	.19396**	.08010
Access to microcredit	.58260**	.28881
Access to markets	.09085	.27840
Likelihood of being arrested	-3.52691***	1.34681
Time spent hunting	.00667	.01772
Likelihood of being arrested X time spent hunting	.05498	.08991
N	76	
Pseudo R-squared	0.18	

Note: ***, **, * significance at 1%, 5%, 10% level, respectively.

The likelihood of being arrested is the only negative attribute in the participant's utility function, as expected. Time spent hunting and the interaction term are the only attribute that are not statistically significant, although they are positive. This model is based upon 76 observations and therefore the lack of significance of time spent hunting may be driven by multicollinearity (since the presence of the interaction terms may inflate the standard errors). If we interpret the coefficient as weight in the utility function, these preliminary results suggest that access to microcredit is a powerful tool in conservation management, more so than the ability to earn a wage in outside employment.

The preliminary results from a variety of panel count models of the consumption choice experiment are illustrated in the following Tables. These models contrast fish and bushmeat only.

Table 2 – Fixed effects Poisson models

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Bushmeat price	-0.558***	-0.558***	-0.558***	-0.739***	-0.705***	-0.743***
	(0.136)	(0.136)	(0.136)	(0.173)	(0.160)	(0.174)
Fish price	0.073**	0.073**	0.073**	0.068*	0.067*	0.066*
	(0.034)	(0.034)	(0.034)	(0.035)	(0.035)	(0.035)
(Bp) x (bushmeat favourite)				0.470**		0.213
				(0.220)		(0.327)
(Bp) x (more than 1kg)					0.597**	0.421
					(0.238)	(0.353)
Observations	97	97	97	97	97	97
Number of id	14	14	14	14	14	14
AIC	225.76	225.76	225.76	223.35	222.22	223.82

Table 3 Random effects Poisson models

VARIABLES	(1) bq	(2) bq	(3) bq	(4) bq	(5) bq	(6) bq
Bushmeat price	-0.558***	-0.558***	-0.558***	-0.739***	-0.705***	-0.743***
	(0.136)	(0.136)	(0.136)	(0.173)	(0.160)	(0.174)
Fish price	0.074**	0.074**	0.074**	0.069**	0.068*	0.067*
	(0.034)	(0.034)	(0.034)	(0.035)	(0.035)	(0.035)
favourite==bushmeat	0.656		0.299	0.175		0.096
	(0.723)		(0.856)	(0.758)		(0.913)
bushmeatathome== more than 1kg		1.088	0.827		0.436	0.344
		(1.155)	(1.377)		(1.189)	(1.430)
(Bp) x (bushmeat favourite)				0.472**		0.216
				(0.220)		(0.327)
(Bp) x (more than 1kg)					0.598**	0.420
					(0.238)	(0.353)
Observations	131	131	131	131	131	131
Number of id	19	19	19	19	19	19
No overdispersion	75.51***	69.52***	68.31***	75.20***	69.30***	68.02***
AIC	352.83	352.58	354.46	350.38	349.01	352.47

Table 4 – Random effects negative binomial models

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Bushmeat price	-0.561***	-0.551***	-0.549***	-0.752***	-0.704***	-0.754***
	(0.159)	(0.155)	(0.158)	(0.199)	(0.175)	(0.199)
Fish price	0.069*	0.072*	0.071*	0.066*	0.067*	0.065*
	(0.040)	(0.039)	(0.040)	(0.039)	(0.038)	(0.039)
favourite==bushmeat	1.083		0.760	0.577		0.430
	(0.747)		(0.864)	(0.812)		(0.954)
bushmeatathome==more than 1kg		1.350	0.768		0.810	0.517
		(1.136)	(1.315)		(1.234)	(1.424)
(Bp) x (bushmeat favourite)				0.475*		0.243
				(0.244)		(0.341)
(Bp) x (more than 1kg)					0.597**	0.402
					(0.251)	(0.362)
Observations	131	131	131	131	131	131
Number of id	19	19	19	19	19	19
AIC	352.53	353.03	354.17	350.97	350.21	353.06

These models show that bushmeat price and fish price have an effect on the quantity of bushmeat purchased and that this effect is robust under several specifications of the count model, different panel structures and with varying approaches to over-dispersion. However, the effect of fish price on the decision of buying bushmeat is relatively small. The cross-price elasticity varies from 0.06 to 0.5 and it increases as bushmeat price increases, as expected. The preliminary results would suggest that the introduction of sustainable fish farm or ponds would reduce the amount of bushmeat consumed only if bushmeat prices are higher than the Tsh4,000, which seems to be higher than the average current price.

Conclusion

Illegal hunting of bushmeat is an important threat to the conservation status of many species in Africa. We employ the choice experiment method to investigate the effects of changing decision variables on both the hunting and consumption of bushmeat. For hunting, we avoid asking households to directly reveal whether they are engaged in illegal hunting, and instead ask them to choose between different livelihood strategies, including bushmeat hunting. Early results show that changes in the probability of being caught matter, but reductions in hunting would also result from either increasing waged employment in villages or increasing agricultural wealth (as measured by numbers of cattle). In terms of consumption choices, higher prices of bushmeat or lower prices of a substitute in consumption – chicken or fish – would also reduce bushmeat consumption, although the cross-price elasticity of demand for bushmeat with respect to fish seems rather low in absolute terms. Data available from the main surveys will enable us to provide a greater wealth of detail on these relationships at the conference in September.

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Figure 1 Example of choice card

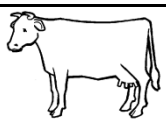
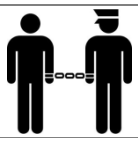
		A	B	C
Number of cows		0	30	1
Wage per month		600,000 TSh	No job	80,000 TSh
Access to microcredit		Yes	Yes	No
Access to markets		Yes	No	Yes
Likelihood of being arrested		0	2/10	4/10
Time spent hunting per year		**1 week**	**2 months**	**6 months**
Which one would you choose?		[ ]	[ ]	[ ]

Figure 2 - Consumption choice experiment

	Desired number of pieces of bushmeat	Desired number of chicken
1 piece of bushmeat **TSh 1500** 1 chicken **TSh 12000**		
1 piece of bushmeat **TSh 1500** 1 chicken **TSh 6000**		
1 piece of bushmeat **TSh 4500** 1 chicken **TSh 12000**		
1 piece of bushmeat **TSh 4500** 1 chicken **TSh 6000**		
1 piece of bushmeat **TSh 1500** 1 chicken **TSh 15000**		
1 piece of bushmeat **TSh 500** 1 chicken **TSh 12000**		