

# Bushmeat hunting by communities adjacent to the Serengeti National Park, Tanzania: the importance of livestock ownership and alternative sources of protein and income

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## SUMMARY

Illegal hunting of resident and migratory herbivores is widespread in the Serengeti National Park, Tanzania. To devise effective strategies to reduce levels of hunting, information is required on why people are involved in illegal hunting and the role of bushmeat in the local economy. Participation in hunting may be influenced by measures of relative wealth, including livestock ownership, means of generating cash income and access to alternative sources of meat. Data came from 300 individuals responding to a questionnaire in 10 villages, from responses by 359 people in 24 group discussions in another 12 villages, and from 552 people arrested and interviewed in the National Park. A smaller proportion of individual respondents (32%) than group respondents (57%) volunteered that they participated in illegal hunting. Most individual and group respondents were subsistence farmers who considered bushmeat to be a source of protein and a means of generating cash income. Three-quarters of those arrested participated in hunting primarily to generate cash income and a quarter claimed that they only hunted to obtain food. Participation in illegal hunting decreased as wealth in terms of the number of sheep and goats owned increased. People with access to alternative means of generating income or acquiring protein were also less likely to be involved in illegal hunting. Arrested respondents were typically young adult males with low incomes and few or no livestock. Illegal hunting was not reduced by participation in community-based conservation programmes. Results suggested that between 52 000 and 60 000 people participated in illegal hunting within protected areas, and that many young men (approximately 5200) derived their primary source of income from hunting.

*Keywords:* bushmeat, illegal hunting, Serengeti ecosystem, livestock, rural economy, National Park

## INTRODUCTION

Illegal hunting of resident and migratory herbivores in the Serengeti National Park, Tanzania, is a major problem for National Park managers (Turner 1987; Arcese *et al.* 1995; Campbell & Hofer 1995). Illegal hunting has reduced populations of resident herbivores (Campbell & Hofer 1995). Possible future overexploitation of large migratory herbivores, particularly wildebeest *Connochaetes taurinus* and zebra *Equus burchelli*, may threaten the integrity of the entire ecosystem (Arcese *et al.* 1995; Campbell & Hofer 1995; McNaughton & Banyikwa 1995; Hofer *et al.* 1996). Because most hunters use an unselective method of capturing wildlife, i.e. wire snares (Turner 1987; Arcese *et al.* 1995), populations of non-target species are also affected negatively (Hofer *et al.* 1993; Arcese *et al.* 1995; Hofer & East 1995). The majority of illegal bushmeat hunting occurs along the western edge of the Serengeti National Park (Arcese *et al.* 1995; Campbell & Hofer 1995; Hofer *et al.* 1996). Approximately 1 million people live along this western edge (i.e. within 45 km of the Park and associated protected areas) and this population is increasing by approximately 2.9% per annum (Campbell & Hofer 1995). Law enforcement patrols attempt to control illegal hunting, but expected economic benefits from the sale of bushmeat are far greater than the costs associated with a low probability of arrest (Hofer *et al.* 2000); illegal hunting is a persistent, widespread problem for Park managers (Turner 1987; Arcese *et al.* 1995; Campbell & Hofer 1995).

To devise more effective strategies to reduce levels of illegal hunting, it is necessary to understand why people hunt, why people consume bushmeat and the importance of bushmeat as a source of income and as a component of the local economy. We interviewed inhabitants of villages close to the National Park (Fig. 1) to investigate possible factors promoting illegal bushmeat hunting. These data were compared with information provided by hunters arrested by law enforcement patrols inside the National Park.

## Study area

Villages close to the western boundary of the National Park formed the focal area for this study (Fig. 1). Agricultural

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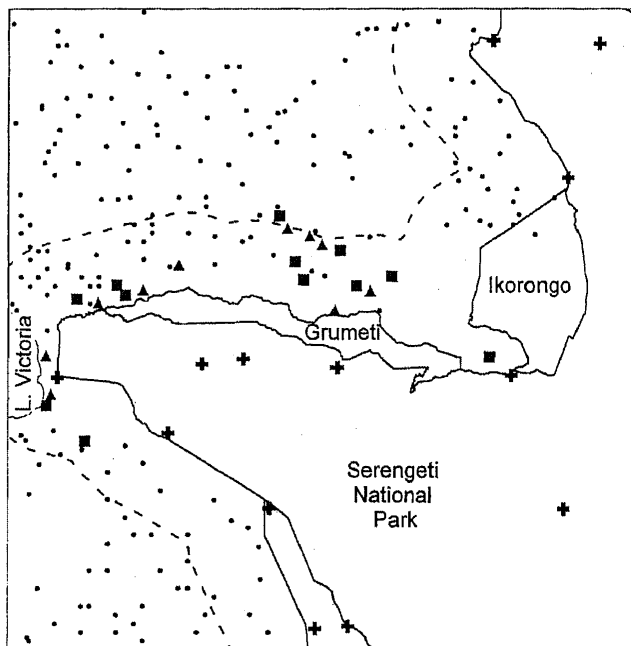


Figure 1 The study area, including the western corridor of the Serengeti National Park, adjacent game reserves, and settlements. '▲' villages selected for individual questionnaires; '■' villages selected for group discussions; '●' remaining village enumeration areas registered at the time of the 1988 National Census (Bureau of Statistics 1992); '✚' ranger posts in the Serengeti National Park. A dashed line shows a 16 km zone adjacent to the protected area.

production was mostly subsistence crops (maize, millet, sorghum and cassava), occasionally cotton, also livestock (cattle, goats, sheep) and poultry. The area cultivated per household was small, typically about 2.5 ha (Loibooki 1997). Villagers close to Lake Victoria may also be involved in commercial fishing, selling fresh fish locally and dried fish to more distant markets. Villages on major all-weather transport routes formed centres for trade and were served by public transport. Villages away from these roads suffered from poor government services, communication and trade (Loibooki 1997).

Wildlife was caught mainly by means of wire snares set in thickets, on game trails and in fences constructed by hunters from thorn bushes (Turner 1987; Arcese *et al.* 1995). Bushmeat offered for sale was typically dried for storage and transport. Porters carry bushmeat from hunter camps inside the National Park to villages (Hofer *et al.* 2000). Dried bushmeat from the Serengeti was not only sold locally, but also transported to more distant markets. Although the majority (75%) of those arrested in the National Park came from villages less than 16 km from the protected area boundary, hunters from villages up to 45 km from this boundary have been apprehended (Hofer *et al.* 1996). A peak in the arrests of bushmeat hunters occurs between August and November (Arcese *et al.* 1995), when large herds of wildebeest and zebra migrate to the western and north-western areas of the National Park (Sinclair & Norton-Griffiths 1979).

Illegal hunting of large resident herbivore populations has proved to be unsustainable in some areas of the National Park (Campbell & Hofer 1995). However, the majority (70%) of the illegal bushmeat harvest is composed of large migratory species, mainly wildebeest and zebra. Estimates of the annual bushmeat harvest vary. Approximately 160 000 migratory and resident animals are illegally hunted in the National Park and associated protected areas, yielding an approximate annual supply of 11 950 tonnes of bushmeat (Hofer *et al.* 1996). Mduma *et al.* (1998) estimated that approximately 40 000 wildebeest are illegally harvested annually, but provided no estimate for the harvest of other resident and migratory species. Due to the growth in the human population close to the Park, the long-term sustainability of the offtake of migratory herbivores is a matter of concern (Arcese *et al.* 1995; McNaughton & Banyikwa 1995; Hofer *et al.* 1996; Mduma *et al.* 1998), as is the high number of non-target species killed as 'bycatch' (Hofer *et al.* 1993, 1996; Arcese *et al.* 1995).

The Community Conservation Services Programme of the Tanzania National Parks that was established in 1994 has promoted conservation education in primary schools and has improved communal facilities in some villages around the Serengeti. The Serengeti Regional Conservation Programme that was established in 1991 under the Tanzania Wildlife Division (Mbanjo *et al.* 1995) has provided 10 villages close to the National Park boundary with low cost legal bushmeat obtained from local game reserves. At this subsidized cost, 1 kg of bushmeat cost the equivalent of US\$ 0.3, compared with 1 kg of cow meat at US\$ 1.2 based on local market prices in 1997 (J. Muya, personal communication 1997). Twelve of 22 (54%) villages involved in the Community Conservation Service Programme, and 7 of 10 (70%) villages within the Serengeti Regional Conservation Programme were situated on all-weather roads in the study area.

## METHODS

Study villages (Fig. 1) were randomly selected from those within a 16-km zone of the western boundary of the Park, adjacent to the Western Corridor. One group discussion village was later found to be 1 km outside this zone. The study area had a history of involvement in illegal bushmeat hunting (Campbell & Hofer 1995). Information on the total human population, number of cattle, goats or sheep (livestock) and involvement in community programmes were obtained from village records.

Three sets of respondents provided data for this study. 'Individual respondents' (252 male and 48 female) were randomly selected from official lists of village households (30 people each from 10 villages) and provided answers to a standard questionnaire. The names of individual respondents were not recorded. 'Group respondents' included both men and women who provided answers to a standard set of questions posed during 24 group discussions in 12 additional villages. Such meetings are a normal medium for discussing current affairs in Tanzanian villages. Responses to questions

posed at meetings were recorded both in writing and on an audio tape recorder. Individual questionnaires and group discussions were conducted between May and July 1997. Respondents were not asked whether they participated in illegal hunting, but many voluntarily claimed to be involved in illegal hunting. 'Arrested respondents' were 552 people arrested in the National Park between October 1998 and March 2000. Information was obtained from standard questionnaires completed by National Park rangers during interviews. Most of those arrested (403 out of 552) were involved in illegal hunting (i.e. hunters and bushmeat porters). All arrested respondents were male and 99% were subsistence farmers.

Villages with alternative income were those where, in addition to subsistence farming, inhabitants participated in trading or fishing. Trading villages were those served by regional bus services and were either situated on all-weather roads and/or were close to the district capital. Fishing villages were those close to Lake Victoria. A village was classified as an extension village if it had participated in a community conservation programme, and as a non-extension village otherwise. Each village was also classified according to the type of survey (individual questionnaire or group discussion) used in this study.

The average numbers of cattle, goats and sheep per head per village were calculated for each group discussion village as the total number of cattle, goats and sheep owned by all village inhabitants divided by the total population size of the village. For some villages, the number of goats and sheep was unknown, and these villages were excluded from analyses involving these variables. In villages with individual questionnaires, the average numbers of cattle, goats and sheep per head were calculated by dividing the total number of cattle, goats and sheep owned by all individual respondents by the total number of people belonging to the households of all individual respondents. People arrested in the National Park were asked to specify the numbers of livestock they owned.

The validity of the number of livestock per head per village as an indicator of relative wealth of the village was checked against the proportion of individual respondents who owned less than six goats and sheep. The results demonstrated that there was a close match between both measures and thus number of livestock per head can be considered a reliable indicator of relative village wealth (Fig. 2).

Using data from the most recent published Tanzanian National Census conducted in 1988 (Bureau of Statistics 1992) and GIS data with these village locations, the number of people involved in bushmeat hunting was estimated for villages within a 16-km zone to the west of the protected area boundary. Estimates were calculated from the proportion of those that admitted to participating in hunting for each sex and age category within the individual questionnaire sample. 1998 populations were estimated by extrapolation from 1988 census figures using the average annual 1978 to 1988 increase of 2.35% per annum recorded for all village enumeration areas within this 16-km zone. As the young-adult section of

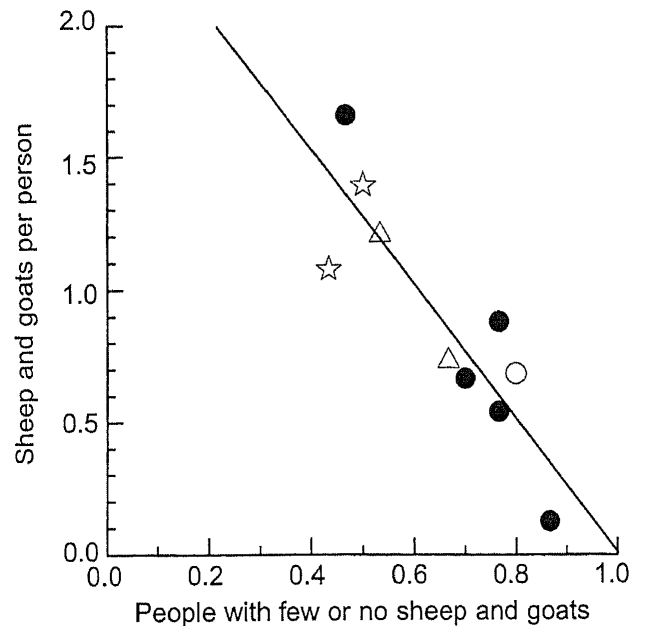


Figure 2 Plot of the number of goats and sheep per head as an indicator of relative wealth per village against the proportion of individual questionnaire respondents who owned either no goats and sheep or only few (up to 5) goats and sheep. ●: villages without community conservation programmes and no access to alternative sources of protein and/or income; ○: villages without community conservation programmes but with access to alternative sources of protein and/or income; △: villages with the Community Conservation Service programme of Tanzanian National Parks and access to alternative sources of protein and/or income; ☆: villages with Community Conservation Service programme of Tanzanian National Parks and Serengeti Regional Conservation Service programme of the Tanzanian Wildlife Division, and access to alternative sources of protein and/or income. Regression equation is  $Y = 2.54 - 2.53 X$ , with  $r^2 = 0.766$ ,  $F_{1,8} = 26.23$ ,  $p = 0.0009$ .

the population is likely to increase at a faster rate than older sections of the population, and as most people involved in illegal hunting were young adults (see Results), the application of a standard rate of increase across the population may provide a conservative estimate.

Data were analysed using Systat (Wilkinson 1999). All statistical tests were two-tailed. Results are reported as means  $\pm$  standard deviations or medians with interquartile ranges, where appropriate.

## RESULTS

### Occupations and sources of income

Ninety-eight per cent of the 300 individual respondents were agriculturalists (54% chiefly subsistence farmers, and 44% chiefly livestock owners) and most (88%) considered agriculture their primary source of income. In addition to agriculture, individual respondents were also engaged in bushmeat hunting (32%), trading (22%), and fishing (17%). Eight per cent of individual respondents considered bushmeat

hunting their primary source of income. Practically all arrested respondents (99%) were subsistence farmers.

Livestock formed a potential source of both protein and income. There was substantial variation among individual respondents in the number of livestock owned (Table 1), and cattle ownership was positively related to ownership of goats and sheep (Spearman's  $\rho = 0.703$ ,  $n = 300$ ,  $p < 0.0001$ ). Depending on size and condition, a cow in the study area was valued at US\$ 45–75, and a goat or a sheep at US\$ 7–15. Thus the approximate monetary value of a median-sized herd (17 animals composed of 46.7% cows and 53.3% goats and sheep; Table 1) was between US\$ 423–735.

Are different types of livestock equally important as sources of protein, income and prestige? Among individual respondents, cattle owners more often considered livestock as a status symbol ( $\chi^2 = 7.90$ ,  $df = 1$ ,  $p < 0.005$ ), as a commercial asset ( $\chi^2 = 6.60$ ,  $df = 1$ ,  $p < 0.01$ ), and as a commodity to be exchanged for a wife ( $\chi^2 = 31.38$ ,  $df = 1$ ,  $p < 0.001$ ) than those that owned only goats and sheep. Goats and sheep were sold or slaughtered to provide meat, but cattle less often.

If the sale of goats and sheep, and/or their meat or hides provided farmers with an income, then their ownership should have been correlated with another measure of relative 'wealth', namely the number of wives. To acquire wives, men were required to present the bride's family with livestock (normally cows). In study villages this bride price ranged between 2 and 16 cows. Due to the custom of paying a bride price for each wife, and the costs associated with rearing children from several wives, the number of wives acquired by a man could be considered an index of wealth and was viewed as such by people in the study villages.

We used a general linear model to simultaneously investigate factors likely to influence the number of wives acquired by male individual respondents. These were: age of male, number of cattle owned, number of goats and sheep owned, level of education, chief source of income and period of residency in a village. Of these, only two factors had a significant effect: age, with older men having more wives ( $F_{1,213} = 4.61$ ,  $p = 0.04$ ), and ownership of goats and sheep, with the number

of wives increasing with the number of goats and sheep owned ( $F_{1,213} = 8.36$ ,  $p = 0.004$ ). The number of cattle owned by a man was not linked to his number of wives, nor was level of education, chief source of income, or period of residency.

### Sources of protein

Livestock, wild herbivores and fish were the chief sources of meat consumed by individual respondents. Only 51.4% of livestock owners obtained their primary source of meat from the animals they kept, and therefore there was a need to obtain meat from other sources. The majority of individual respondents purchased meat: 92.3% purchased livestock meat, and 82% purchased bushmeat, indicating a large market for both livestock and bushmeat in the study villages. Over a third of individual respondents (39.7%) consumed bushmeat obtained by either family members or themselves, and most (76.3%) claimed that the bushmeat they acquired came from the National Park. Our results suggest that bushmeat is an important source of protein for villagers, as a commodity purchased by a majority of households and a product that can be sold to generate income. Only 39% of those interviewed purchased fish, probably because fish was not readily available in all study villages. Fish was the primary source of protein for only 17.3% of individual respondents.

### Factors influencing participation in bushmeat hunting

Most individual respondents (89.0%) said that people in their area hunted bushmeat, and 31.7% volunteered that they were themselves involved in bushmeat hunting. More men than women admitted to being involved in hunting (36.5% of men, 6.3% of women,  $\chi^2 = 17.06$ ,  $df = 1$ ,  $p < 0.0001$ ). In contrast to individual respondents, significantly more participants of group discussions (56.9%,  $n = 359$ ) said that they were hunters (results of multiple regression model, see below and Table 2), demonstrating that results on sensitive issues, such as illegal activities, can be influenced by survey methods.

**Table 1** Livestock ownership (%) and median herd size (inter-quartile ranges in parenthesis) of those owning livestock, as claimed by individual respondents and by those arrested in the Serengeti National Park for hunting.

	<i>Arrested for hunting</i>		<i>Individual questionnaires in villages</i>					
	<i>% Ownership</i>	<i>Median</i>	<i>Voluntarily admitted hunters</i>		<i>Respondents not admitting to hunting</i>		<i>All responses</i>	
	<i>% Ownership</i>	<i>Median</i>	<i>% Ownership</i>	<i>Median</i>	<i>% Ownership</i>	<i>Median</i>	<i>% Ownership</i>	<i>Median</i>
Cattle	21.5	4 (3–7)	26.3	6 (5–16)	46.3	15 (8–30)	40.0	14 (6–29)
Goats	21.9	5 (3–8)	31.6	7.5 (5–10)	47.8	10 (5–20)	42.7	10 (5–20)
Sheep	10.8	3 (2–5)	11.6	6 (3–10.5)	33.2	6 (4–10)	26.3	6 (3–10)
Total livestock	31.1	8 (3.5–14.5)	36.8	11 (7–21)	61.0	20 (9–45)	53.3	17 (8–41)

**Table 2** The results of a general linear model that simultaneously considered the effects of several factors on  $P_H$ , the proportion of people per village admitting to participating in bushmeat hunting ( $r^2 = 0.944$ ).

Variable	Effect of variable	df	F ratio	p
Access to alternative sources of meat and/or income	$P_H$ was higher if there was no access to alternative sources of meat and/or income	1,8	27.20	0.0008
Survey method (group discussion or individual questionnaire)	$P_H$ was higher in group discussions than individual questionnaires	1,8	17.77	0.0029
Goat and sheep per head	$P_H$ decreased as number of goats and sheep per head increased	1,8	14.00	0.0057
Cattle per head	$P_H$ was not affected by cattle per head	1,8	2.48	0.15
Presence or absence of extension services	$P_H$ was not affected by the presence or absence of extension	1,8	1.37	0.31

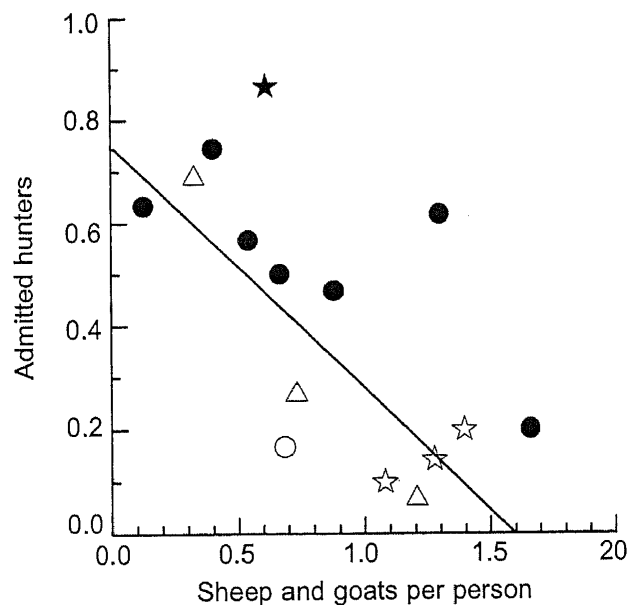
Individual respondents considered that people hunted to obtain food (83.0%), to obtain meat to sell (79.0%), to generate income to pay local taxes (55.3%), and to obtain meat to barter for other items (26.0%). Crop failure (63.3%) and a lack of livestock (45%) were also frequently given as reasons for hunting. The majority of people arrested in the National Park (74.5%) said that they hunted to generate a cash income. A far smaller proportion (24.7%) claimed that they only hunted to obtain food, and only 0.8% claimed to hunt for traditional or cultural reasons.

Both arrested respondents and individual respondents that admitted to hunting were equally unlikely to own livestock ( $\chi^2 = 1.14$ ,  $df = 1$ ,  $p =$  not significant; Table 1). Individual respondents who did not admit to being hunters were more likely to own livestock than individual respondents who admitted to hunting ( $\chi^2 = 12.72$ ,  $df = 1$ ,  $p = 0.0004$ ). Individual respondents that admitted to being involved in hunting on average also owned fewer cattle, sheep and goats, and had smaller herds of livestock than those that did not admit to hunting (Mann-Whitney  $U$  tests: cattle  $U = 7431$ ,  $n_1 = 95$ ,  $n_2 = 205$ ,  $p = 0.0002$ ; sheep plus goats  $U = 7398.5$ ,  $n_1 = 95$ ,  $n_2 = 205$ ,  $p = 0.0003$ ; total livestock  $U = 6972.5$ ,  $n_1 = 95$ ,  $n_2 = 205$ ,  $p = 0.00003$ ; Table 1).

As involvement in hunting provided meat, income, and a commodity that could be bartered, we used a general linear model and data from individual and group respondents to investigate the impact of alternative sources of protein and alternative means of acquiring income on the level of participation in bushmeat hunting. The model considered the proportion of people per village admitting to being involved in hunting in relation to: (1) whether or not the location of the village provided alternative sources of protein and/or income; (2) whether or not the village had extension services; (3) the number of cattle per head; (4) the number of sheep plus goats per head; and (5) the type of data collection (individual questionnaire or group discussions).

A lower proportion of those questioned admitted to involvement in hunting when they lived in a village with alternative sources of protein and/or income (Table 2).

Similarly, the proportion of those that admitted to being involved in hunting decreased as the number of goats and sheep per caput increased (Fig. 3). The model also indicated



**Figure 3** Plot of the proportion of people admitting to participation in bushmeat hunting against the number of goats and sheep per head. ●: villages without community conservation programmes and no access to alternative sources of protein and/or income; ○: villages without community conservation programmes but with access to alternative sources of protein and/or income; △: villages with the Community Conservation Service programme of Tanzanian National Parks and access to alternative sources of protein and/or income; ★: villages with both the Community Conservation Service programme of Tanzanian National Parks and the Serengeti Regional Conservation programme of the Tanzanian Wildlife Division but no access to alternative sources of protein and/or income; ☆: villages with the Community Conservation Service programme of Tanzanian National Parks and Serengeti Regional Conservation Service programme of the Tanzanian Wildlife Division, and access to alternative sources of protein and/or income. Regression equation from general linear model, and hence adjusted for the effects of the other factors in the model (see Table 3), is  $Y = 0.75 - 0.47 X$ .

that a greater proportion of group participants admitted to involvement in hunting than individual respondents. The number of cattle per head was not related to the proportion of people admitting to involvement in hunting, nor was the presence or absence of extension services in a village.

The majority of individual respondents had received either no education or only primary school education. This was true for those that claimed to be involved in hunting (94.7%,  $n = 90$ ) and those that did not (92.2%,  $n = 189$ ). Admitted hunters were younger (mean age  $36.0 \pm 11.1$  years,  $n = 86$ ) than respondents that did not admit to hunting (mean age  $44.8 \pm 15.5$  years,  $n = 194$ ;  $U = 5491$ ,  $n_1 = 86$ ,  $n_2 = 194$ ,  $p = 0.00001$ ). The average age of the sample of those arrested due to their participation in hunting activities (mean age  $31.5 \pm 12.7$  years,  $n = 396$ ) was less than that of admitted hunters among individual respondents ( $U = 21368$ ,  $n_1 = 86$ ,  $n_2 = 396$ ,  $p = 0.0002$ ).

### Numbers involved in hunting

Based on the proportion of individual respondents admitting to participation in bushmeat hunting (36.5%), the total number of people involved in bushmeat hunting from villages within 16 km of the protected area boundary was estimated to be 52 928 (Table 3), including 48 436 men and 4492 women. Those claiming to hunt were likely to include both hunters and porters who transported bushmeat from the National Park. This may be an underestimate, since approximately 12% of hunters and porters arrested in the National Park (1989 to 1993 data, Campbell & Hofer 1995) came from

villages located between 16 and 45 km from the protected area boundary. Including these additional people would boost the total number involved in illegal hunting to approximately 60 000. When a similar estimate was made based on the proportion of group respondents that admitted to participation in hunting (56.9%), the estimated numbers involved in hunting increased to approximately 90 000 people. This figure is likely to be an overestimate (see discussion).

Eight per cent of individual respondents (see above) considered bushmeat hunting their primary source of income. As the majority of these hunters are likely to be young adult males (15–35 years old age category,  $n = 65\ 824$ ; Table 3), then an estimated 5266 young men within a 16 km zone to the west of the protected areas of the Serengeti ecosystem derive their primary source of income from bushmeat.

### DISCUSSION

This study focused on subsistence farming communities close to the western boundary of the Serengeti National Park, where a large proportion of the meat consumed was illegal bushmeat obtained from the National Park and associated protected areas (Fig. 1). Bushmeat was the most important means for generating cash income after agriculture, and an estimated 5266 young-adult males living close to the western boundary of the National Park may have derived their primary source of income from illegal hunting. Income derived from bushmeat was also viewed as an important means to pay government taxes and local development levies.

**Table 3** 1988 National Census figures (Bureau of Statistics 1992), extrapolated population estimates for 1998 and estimated numbers of people involved in bushmeat hunting within a 16 km zone to the west of the protected areas in the Serengeti ecosystem based on the results of individual household questionnaires.

Sex	Age group	1988 population	1998 estimate	Hunters in sample (%)	Number of hunters estimated for 1998
Males	0–4	34 019	42 929	0	0
	5–9	31 059	39 194	0	0
	10–14	26 686	33 675	0	0
	15–24	32 533	41 054	58.82	24 147
	25–34	19 629	24 770	50.72	12 563
	35–44	12 549	15 836	39.58	6267
	45–54	9057	11 429	31.58	3609
	55–64	6382	8054	13.16	1059
	65+	7530	9502	8.33	791
Females	0–4	34 861	43 991	0	0
	5–9	31 067	39 204	0	0
	10–14	26 650	33 630	0	0
	15–24	39 681	50 074	0	0
	25–34	24 797	31 292	8.33	2606
	35–44	14 949	18 864	10	1886
	45–54	9934	12 536	0	0
	55–64	6390	8064	0	0
	65+	7278	9184	0	0
Total		375 051	473 282		52 928

These results suggest that bushmeat constituted an important element in the local economy.

People arrested for hunting activities (hunters and porters) and individual respondents that claimed to be hunters were typically poor young-adult males that owned few or no livestock, indicating that individual respondents who voluntarily claimed to be hunters were a representative sample of the segment of the population that participated in illegal hunting. In contrast, individual respondents who did not claim to be involved in hunting were generally older and owned larger herds of livestock (Table 1). The numbers of goats and sheep owned was more important than the number of cattle for an understanding of the role of bushmeat hunting in the economy of local communities.

On a village level, the proportion of admitted hunters per village decreased as individual wealth in terms of livestock per caput increased, and as access to alternative sources of protein and income generation became available. This emphasizes the economic importance of bushmeat to disadvantaged farmers, and the lack of alternative means of generating income in the area. If community-based conservation projects aim to reduce illegal hunting and managers want to distribute benefits to those villages most involved in illegal hunting, numbers of livestock per caput, particularly sheep and goats, may provide a useful indicator of illegal hunting levels.

Reduced participation in bushmeat hunting by villages situated on all-weather communication routes and near the district capital was linked to increased opportunities to generate income through trade. Commercial fishing provided both income and protein to villagers near Lake Victoria, and was also linked to a decrease in bushmeat hunting.

Our results suggest that, all else being equal, there was no difference in the proportion of people admitting to being involved in bushmeat hunting between villages with and without community conservation programmes. As community programmes were mostly located in villages along all-weather trading routes, such programmes were established in villages with a low probability of extensive involvement in bushmeat hunting. Such conservation programmes may therefore be more effective in decreasing illegal hunting if they were established in villages situated on minor roads and where farmers own few or no livestock.

Hunting activities are mostly undertaken by men (Arcese *et al.* 1995; Hofer *et al.* 1996), and all of those arrested for hunting inside the National Park were male. However, some women also considered themselves to be hunters. Indeed, 13 of 14 women participating in an all-women discussion group claimed to be involved in hunting. Some women carry dried meat from hunting camps inside the National Park to local villages and it is likely that porters (including women) described themselves as hunters. Women may also be involved in trading dried bushmeat. However, if women are indeed actively hunting, this would be a change in traditional gender roles.

Levels of education within the study area were low, due to

inadequate primary school facilities, a lack of secondary schools and vocational training colleges, the inability of parents to support their children beyond primary education, and the importance of children as a source of labour in agricultural communities. The improvement of education in the region, particularly the establishment of vocational training opportunities, might, by increasing the potential for alternative sources of income, decrease the dependence of subsistence farmers on cash income from the sale of bushmeat.

#### Bushmeat hunting: how general a phenomenon?

Amongst individual respondents, 31.7% voluntarily admitted to being hunters. If their villages form a representative sample of those in the 16 km zone along the western boundary of the protected areas, then approximately 60 000 people may be involved in hunting activities inside the protected areas. This may be a conservative estimate, because individual respondents were not directly asked if they participated in illegal hunting, and some may have decided not to mention their involvement in illegal activities. It is also possible that some individual respondents overemphasized their involvement in hunting, but possible reasons for doing so are less obvious.

More group respondents (56.9%) than individual respondents (31.7%) claimed to be hunters, demonstrating that results can be influenced by the survey methods that are applied. It is possible that the figure for group respondents is inflated, since it may include those who, in the social situation of a group discussion, claim to be hunters but have little to do with hunting in reality. Yet the figure for group respondents is in the same range as that recorded by Barnett (2000) who reported that 54% of households surveyed in Meatu District (south-west of Serengeti National Park and outside of the current survey area) included hunters.

Not all of the 60 000 people estimated to participate in hunting necessarily conducted hunting trips every year. However, many hunters operate multiple hunting trips per year, as hunters arrested inside the National Park admitted to  $3.7 \pm 0.3$  (range 1–36,  $n = 233$  hunters) hunting trips per year (Hofer *et al.* 1996). As only approximately 500 hunters and porters are arrested by anti-poaching patrols within the National Park annually (i.e. less than 1%), anti-poaching patrols are unlikely to represent a significant deterrent to hunters. A model of the economic costs (including arrest) and benefits of illegal hunting in the Serengeti produced the same conclusion (Hofer *et al.* 2000). Thus current benefits of illegal hunting substantially exceed the small expected cost based on the low chance of arrest at present levels of law enforcement. Increased law enforcement might increase the cost of arrest, but is also likely to escalate conflict between the National Park and local communities.

The relationship between small stock ownership (goats and sheep) and reduced hunting levels demonstrated by this study suggests that measures targeted towards improving

small livestock development, especially among the poorest farmers with few or no livestock, are likely to result in reduced bushmeat hunting. Development measures that diversify sources of income and reduce poverty among subsistence farmers are similarly likely to result in a reduction in illegal bushmeat trade.

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