Research Article

A comparative study on bushmeat consumption patterns in ten tribes in Tanzania

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Abstract
Bushmeat hunting is an important driver of wildlife depletion in Tanzania, but national-wide estimates of its consumption are lacking. We compare bushmeat consumption frequencies and determinants in ten tribes in different ecoregions in Tanzania, four of these within biodiversity hotspots of global conservation importance. Bushmeat consumption is examined in terms of ethnicity, selected indicators of wealth, and distance to and protection level of nearest protected area. Forty six percent of the respondents (n=300) belonging to nine of the ten tribes reported consuming bushmeat during the past 12 months, and 14% admitted that at least one household member hunted illegally. Significant differences in bushmeat consumption frequencies and species consumed were observed among ethnic groups. Regression revealed that the presence of a hunter in the household increased significantly the prevalence of bushmeat consumption, while distance to and protection level of nearest protected area had the most significant negative effect. Anti-poaching patrols are an effective deterrent to illegal bushmeat consumption, whilst access to domestic animal protein and other selected indicators of wealth do not reduce bushmeat consumption. The results emphasise the importance of strengthening anti-poaching services and the integration of cultural differences in preference for bushmeat into policies aimed at reducing bushmeat consumption and conserving wildlife.

Keywords: Bushmeat, Tanzania, ecoregion, biodiversity hotspot, tribe.

Résumé
Un facteur important d'appauvrissement de la faune en Tanzanie est la chasse pour obtenir de la viande de brousse, les estimations concernant sa consommation au niveau national étant cependant insuffisantes. Nous comparons ici la fréquence de cette consommation et examinons ses déterminants dans dix tribus de différentes écorégions de Tanzanie, dont quatre sont des points névralgiques de la biodiversité d'importance mondiale pour la protection de la nature. Ces déterminants sont examinés en fonction de l'appartenance ethnique, de certains indicateurs de richesse ainsi que de la distance à la zone protégée la plus proche et de son niveau de protection. Au total, 46 % des personnes interrogées (n = 300) appartenant à neuf des dix tribus étudiées ont signalé avoir consommé de la viande de brousse au cours des 12 derniers mois et 14 % qu'au moins un membre du ménage avait chassé illégalement. La fréquence de la consommation de viande de brousse et des espèces consommées différait significativement entre les groupes ethniques. Les analyses par régression ont révélé que la présence d'un chasseur dans le ménage avait des effets positifs importants et que la distance à la zone protégée la plus proche et son niveau de protection avaient des effets négatifs importants sur la consommation de viande de brousse. Les patrouilles anti- braconnage semblent donc être un moyen de dissuasion efficace contre la consommation de viande de brousse, tandis que l'accès aux protéines animales domestiques et d'autres indicateurs de richesse ne réduisent pas cette consommation. Ces résultats soulignent l'importance du renforcement des services de lutte anti braconnage et de l'intégration des différences culturelles dans la préférence pour la viande de brousse lors dans la conception des politiques visant à réduire sa consommation et à la conservation de la faune.

Mots-clés: viande de brousse, Tanzanie, hotspot de la biodiversité, tribu.

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Introduction

Restrictive laws on hunting of wildlife for meat and income, later termed bushmeat hunting, were first implemented in Tanzania by the German administration at the beginning of the 20th century. These laws were tightened by the British government in 1918, when a visible reduction of wildlife populations became a concern [1]. Today bushmeat hunting remains a major threat to wildlife in Tanzania's protected areas and wildlife corridors [2, 3]. Bushmeat hunting, along with habitat degradation, fragmentation, and land conversion, has led to depletion of populations and local extinction of some species [2, 4-6].

In Tanzania obtaining a hunting license is economically and practically unfeasible for most local people [7-10]; the majority of bushmeat consumed in the country originates from illegal, unregulated and unreported hunting, although licences are issued for local hunting in Game Reserves (GR), Game Controlled Areas (GCA) and Wildlife Management Areas (WMA). In these protected areas, portions of wildlife can be legally harvested and the meat obtained is allocated to local communities for consumption, although the amount of wild meat produced this way is minimal. Records of allocation of meat among selected villages surrounding the Selous GR and neighbouring WMA in the period from 1998 to 2001 [1], indicate that each village received on average approximately 500 kg/meat/year.

Bushmeat hunting is an important source of protein and income in many rural communities, particularly during the passing of herds of large migratory species [11-13]. Illegal hunting may be the only way for local communities to benefit from adjacent wildlife reserves. According to Mfunda and Røskaft [3], 35% of Ikoma and Natta tribesmen, and 23% of the Ikizu, Sukuma and Taturu tribes in areas surrounding Serengeti, consider hunting an important source of both protein and income. Many tribes believe that wild meat is healthier than domestic meat, increasing the demand for bushmeat [13]. It has been estimated that between 40,000 and 200,000 animals are illegally harvested each year in the Serengeti ecosystem [14, 15]. Extrapolating from these estimates, assuming 20 kg dressed meat per animal sold at a low market price of 2000 TSh/kg, suggests that the value of the bushmeat trade originating in Serengeti is between one and five million US$ per year. With growing demand from the increasing human population in surrounding communities, these numbers are likely to be higher today. In other locations bushmeat hunting is mainly subsistence–oriented, driven by low dietary standards and poverty [4].

Research on bushmeat hunting in Tanzania has addressed the impact on wildlife populations [4-6, 16-18], the importance in local economies [3, 4, 9, 19-23] and the effect of ethnicity and culture on consumption patterns [7, 13, 21-25]. The latter has mainly focused geographically on the Serengeti and Katavi ecosystems, and national information on the determinants of bushmeat consumption patterns is not available from Tanzania. Such estimates have been published for other regions of Africa. Estimates of per capita consumption of illegally harvested bushmeat from the Congo Basin, for instance, range from 180

g/person/day in Gabon, to 89 g/person/day in Congo and 26 g/person/day in Cameroon [26]. Similar information is only available from case studies in a few specific locations in Tanzania. Nielsen (2006) [4] estimated an average consumption of 27.4 g/person/day bushmeat per capita per year based on a study of 125 hunting households in the Udzungwa Mountains. In five districts in Western Serengeti per capita bushmeat consumption ranged from 3 to 89 g/person/day, depending on the distance from the national park boundary and wildebeest migration corridors, as well as ethnicity. The influence of ethnicity was also evident in the nature of involvement in hunting, with 91% of arrested hunters from the Kurya tribe only hunting during the wildebeest migration, whilst hunters from the Sukuma tribe hunted all year round [13].

Despite the large amount of bushmeat research undertaken in Tanzania in recent decades, and some studies exploring patterns of consumption among different ethnic groups living in the same ecosystem [22], there is a lack of studies comparing patterns of bushmeat consumption on a national scale. Our study attempts to fill this gap by comparing bushmeat consumption patterns among ten ethnic groups in geographically distinct eco-regions across Tanzania. We thereby provide a more structured overview of this issue than previous case-based surveys in Tanzania have accomplished.

Methods

Study area

The geographical sampling strategy of this study is based on the Ecoregion concept, defined as wide portions of land hosting a particular ensemble of species [27]. The boundaries of the ecoregions are established along the area used by these species prior to human utilization. Of the 17 ecoregions in Tanzania, nine are among the Global 200 ecoregions [28]. The global 200 are ecoregions that, out of the total of 867 ecoregions in the world, have been identified as priority areas for conservation, due to their status on a spectrum ranging from critical, endangered, vulnerable, and relatively stable to intact. Tanzania has the highest number of Global 200 ecoregions found within one country on the African continent. The sampling strategy selected tribes in different ecoregions, in order to include the potential influence of the different ecological properties on the patterns of bushmeat consumption. Ten inhabited ecoregions were selected by overlaying Gulliver's tribal map [28] on the ecoregions world map [29], using GIS software (Quantum GIS 0.9.0.) to produce a geo-referenced link between the distribution of the tribes and the ecoregions. However, the Northern and Southern Inhambane Coastal Forest Mosaic were merged, and only one tribe was selected for these two ecoregions. One target village was selected within the boundaries of each ecoregion based on the following criteria: 1) the villages had to be located in rural districts, not served by electricity and without production plants or industries present in the village area, and 2) the village had to be located within the original area of the distribution of the tribe as determined by Gulliver's map [28] (see Fig. 1).

Four of the selected ecoregions fall within two of the 34 global biodiversity hotspots [30, 31]. Together, these 34 hotspots host 50% of the world's plant species and 42% of all terrestrial vertebrates as endemics, and are characterized by high levels of threat to conservation of biodiversity. The Eastern Afro Montane and the Coastal Forests of Eastern Africa are the relevant Tanzanian hotspots. Of the ten study areas, the Kilombero Valley in the Zambezian flooded grasslands ecoregion is notable for holding 75% of the world's puku (*Kobus vardoni*) population, which is thought to be declining in most of its range (near threatened) [32, 33]. Tamota village is located in the Nguu Mountains within the Eastern Afro Montane biodiversity hotspot and is notable for its intact portion of sub-montane forest, which is generally declining [34]. The villages Mulala and Bujingijira are located in ecoregions within the Eastern Afro Montane biodiversity hotspot on the slopes of Mount Meru and Mount Rungwe respectively. The village of Miembe Saba is within the Eastern African Costal Forest biodiversity hotspot. Finally, the village of Sanjaranda is notable in being centrally located in the Itigi portion of the Itigi-Sumbu thicket, which likely hosts the world's last viable portion of this ecoregion,

considering an estimated 70% loss of the Sumbu thicket in Zambia and its predicted total destruction within the next 20 years [35] (see Appendix 1).

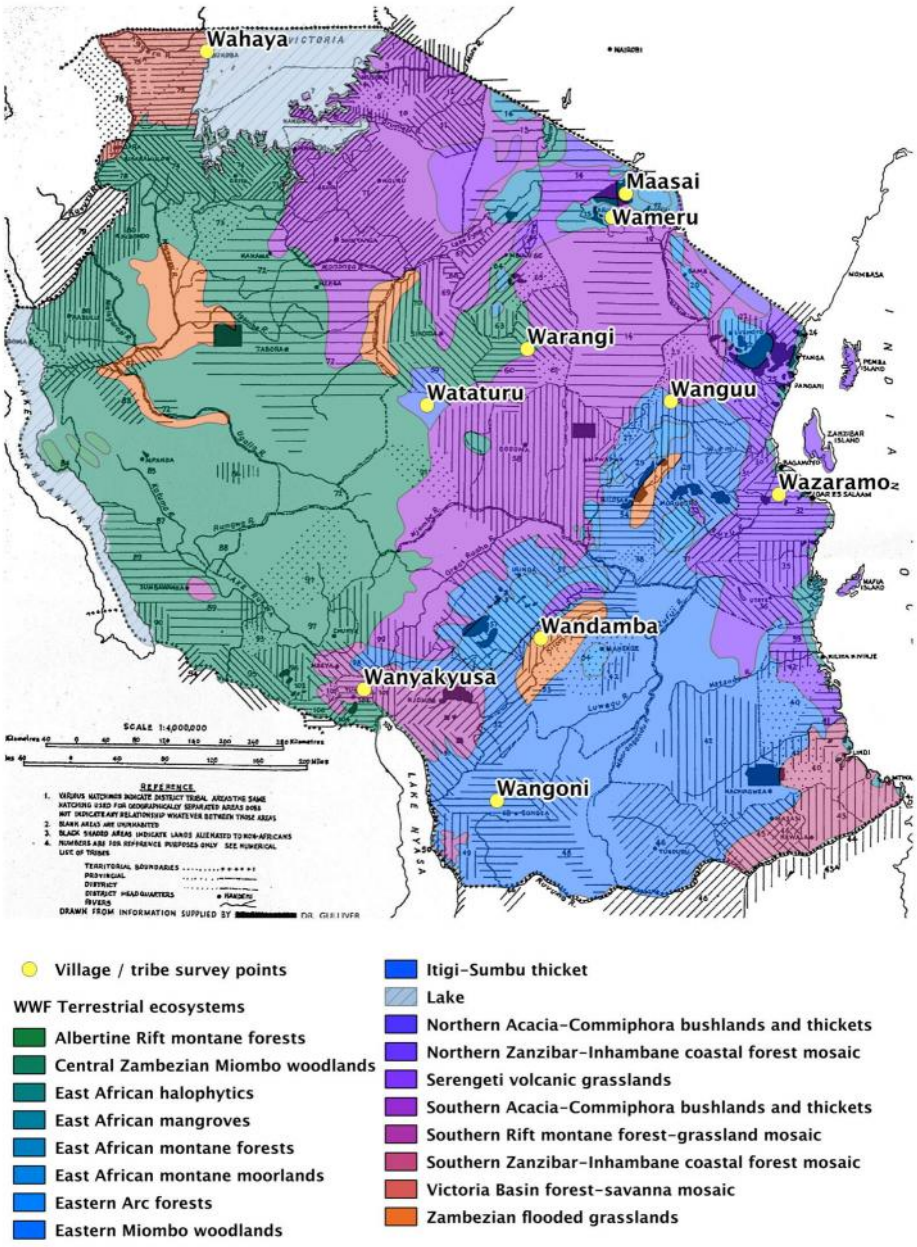

Fig. 1. Ecoregions map of Tanzania (Olson et al. 2001) overlaid by the distribution of different tribes based on Gulliver's (1959) map. The researched communities are indicated in bold.

Data collection

Thirty people from different households in one village in each of the ten ecoregions were interviewed using a structured questionnaire (n=300). In each village, twelve adult women, twelve adult males, and six teenagers between 12 and 17 years were selected from different households for interviews. Prior informed consent to the interview was obtained from every respondent. Information was collected on basic household demographics, assets owned, and bushmeat consumption and hunting. Questions on bushmeat consumption and hunting were posed between other more 'neutral' questions approximately one hour into the interview to avoid creating anxiety. As very few respondents had consumed bushmeat within the past 24 hours, we recorded the frequency of consumption in the following three categories: weekly, monthly and annually. The frequency was noted as: weekly when bushmeat had been part of a meal at least once the previous week; monthly when it had been part of a meal between one and three times the previous month; and annually when it had been consumed at least once the previous 12 months but not every month. A numeric code was attributed to each of these responses (i.e., never=0; annually=1; monthly=12; weekly=52). In Tanzania, meals are commonly shared among all family members, and each respondent's bushmeat consumption frequency was thus assumed to represent the household's. Data on animals consumed were collected by asking respondent to identify bushmeat consumed in the past 12 months to genus and species. Three generic groups were created for birds, antelopes, and other mammals that could not be identified because the respondent was unsure about the specific species or used a local name for which no translation was available. Information on selected assets, including area of land owned, number of domestic animals owned, and construction of main dwelling, was collected as indicators of wealth in these primarily agro-pastoralist-based livelihood strategies (99.3% of the respondents were agro-pastoralists or pastoralists) to explore the effect of wealth as a predictor of bushmeat consumption. All data were collected by SC.

Data analysis

Data analysis was guided by a number of general assumptions about drivers of bushmeat consumption. The assumptions were that the frequency of consuming bushmeat: 1) is determined by the presence of a hunter in the household [2, 13, 24]; 2) is higher in households with lower combined meat weight of domestic animals as a proxy of availability of animal protein; 3) is higher in households with smaller area of land owned, and lower quality of housing as proxies of lower wealth status [3, 25]; 4) is influenced by cultural preferences and taboos reflected in ethnicity [36]; and finally 5) decreases with distance to and increasing protection level of the nearest protected areas [4, 12].

These general assumptions were tested through an ordered logistic regression model according to which the likelihood of the dependent variable, frequency of bushmeat consumption (*F*) in terms of either weekly, monthly or yearly consumption (coded as *i*=1, 2 or 3) is a function of the effect of the following independent variables:

$$\ln\left(\frac{p(s=i)}{p(s=3)}\right)=\ln\left(\frac{p_i}{p_3}\right)= \ _{i,1}+ \ _{i,2}I+ \ _{i,3}Hm+ \ _{i,4}Dw+ \ _{i,5}Ai+ \ _{i,6}Hq+ \ _{i,7}H+ \ _{i,8}D+ \ _{i,9}Pl \qquad (1)$$

where *I* is an ordinal variable representing tribe, *Hm* is the number of household members, *Dw* is the weight of domestic animals owned (in kg) calculated based on livestock equivalents, *A* is the number of acres of agricultural land owned, *Hq* is an ordinal variable representing quality of housing, *H* is a binary variable reflecting whether there is a hunter in the household, *D* is the distance (in km) to the nearest protected area hosting wildlife, and *Pl* is an ordinal variable reflecting increasing level of protection through restrictions on wildlife utilization (i.e. 0=common land, 1=forest reserve, 2=game reserve, 3=national park). Backward elimination was applied to reduce the model until only significant variables were retained. However, basic

statistical comparisons of means were conducted for all variables. Data analysis was conducted in STATA version 11.2 and Statistical Package for Social Sciences version 19.0.

As observed in other locations [25], households were unable to quantify the amount of bushmeat consumed. Bushmeat is also often bought sundried or smoked. Estimating the amount of meat consumed from this recall-based survey was therefore considered unfeasible and not attempted.

Results

Hunting, species consumed, and frequencies of consumption

Basic statistics for the interviewed household representatives from each tribe are presented in Table 1. Forty-six percent of the total respondents, belonging to nine of the ten tribes, had consumed bushmeat during the 12 months preceding the survey. Fourteen percent admitted that at least one household member hunted bushmeat illegally. Hunting was heavily gender-biased, performed by males in 91% of cases. However, one female respondent from the Wanguu tribe stated trapping baboon (*Papio cynocephalus*), vervet monkeys (*Cercopithecus aethiops*) and bushpig (*Potamochoerus larvatus*) in order to protect crops, while another woman actively hunted dikdik (*Madoqua* spp.) and hares (*Lepus* spp.) with nets, and in collaboration with other women. A woman from the Warangi tribe also set traps for red-billed quelea (*Quelea quelea*). Similarly to the Wanguu women, this activity responded to the need to protect sorghum and millet fields. Unlike other species, quelea were caged in the traps and consumed days after their capture.

Table 1. Average household characteristics of respondent households. Numbers in brackets are standard deviations.

Tribe	**Livelihood**	**HH members**	**Hunters** (% of sample)	**Bushmeat consumption** (% of sample)	**Livestock equivalent units** (kg/AEU)	**Agricultural land** (acres)	**Housing quality** (rank)
Maasai	Pastoralist	4.1 (1.75)	0	0	1781 (2605)	0.56 (0.57)	1
Wahaya	Agriculturalist	5.3 (2.12)	0	13	61 (84)	0.76 (0.60)	10
Wameru	Agro-pastoralist	5.47 (2.20)	10	20	262 (169)	0.44 (0.35)	8
Wandamba	Agriculturalist	5.83 (2.12)	0	57	17 (40)	0.58 (0.28)	7
Wangoni	Agriculturalist	4.83 (1.90)	0	90	125 (178)	1.58 (0.92)	9
Wanguu	Agriculturalist	5.13 (1.94)	43	97	87 (158)	1.13 (0.95)	2
Wanyakyusa	Agriculturalist	6.1 (2.17)	3	10	65 (75)	0.98 (0.73)	3
Warangi	Agriculturalist	5.83 (2.21)	23	67	400 (635)	1.25 (1.47)	4
Wataturu	Agro-pastoralist	6.0 (2.46)	20	67	1487 (1970)	0.93 (0.67)	5
Wazaramo	Agriculturalist	5.03 (2.25)	10	40	1.25 (1.98)	0.63 (0.61)	6

Twenty-five types of bushmeat were identified to species or genus level (see Appendix 2). Antelope was the most frequently mentioned type of bushmeat consumed, with dikdik (*Sylvicapra* spp.) and duikers (*Cephalophus* spp.) making up the majority of records. This was followed by hare and guinea fowl (*Numida meleagris*). Larger species such as bushbuck and buffalo were consumed by 9.7% and 9.3% of households respectively. Considerable variation was observed in the spatial distribution of consumption of remaining species (see Appendix 2).

The proportion of households containing a hunter differed significantly between tribes (ANOVA f=6.405; P<0.001). A weak significant positive correlation was observed between proportion of households containing a hunter and the average number of species consumed in the community (r=0.290; P<0.001, Pearson's

correlation test). Hence, 43% of the Wanguu households contained a hunter, and this community ranked second in number of different species consumed (see Appendix 2). A strong positive correlation was also observed between presence of hunters in the household and the frequency of consuming bushmeat for this tribe (r=0.617; P<0.001, Pearson's correlation test). The Wanguu, Warangi and Wataturu tribes had the highest proportion of households with a hunter (see Appendix 2). The Wanguu and the Warangi had the highest frequencies of bushmeat consumption (see Table 1). None of the Wangoni and Wandamba respondents admitted to hunting, but a high proportion of these households had consumed bushmeat within the past year (i.e. 90% and 57% respectively). Similarly, only one Wanyakyusa respondent acknowledged that he was hunting, although 10% of the sample in this tribe had consumed bushmeat. None of the Maasai household representatives admitted hunting bushmeat and no records of bushmeat consumption were recorded for this tribe. Also, no Wahaya respondents admitted to hunting, but suggested that the main reason was lack of access to wildlife. The absence of protected wildlife area in Bukoba Rural District or its vicinity may give an explanation to the lack of wildlife.

Correlates of bushmeat consumption frequency

Most explanatory variables in the ordered logit model for bushmeat consumption frequency (equation 1) were insignificant and therefore eliminated from the model. This is likely a result of low sample size in each tribe. As expected, the reduced model revealed that having a hunter in the household had a significant and positive effect on bushmeat consumption frequency (see Table 2). The distance to nearest wildlife area and its protection level (See Appendix 1) had instead a significant and negative effect on the frequency of bushmeat consumption. A multilevel comparison using ANOVA, followed by Bonferroni post hoc test, revealed significant differences in bushmeat consumption frequencies among communities. The frequencies were influenced by the protection level of areas presumably hosting wildlife and found in a radius of 20 km from the respondents (ANOVA f=29.65; P<0.01). Hence bushmeat consumption frequencies increased significantly going from National Park to Game Reserve (P<0.01), from National Park to Forest Reserve (P<0.01), and from Game Reserve to Forest Reserve (P<0.01), but also going from non-protected lands to Forest Reserve (P<0.01) and from non-protected lands to Game Reserve (P<0.01). There was no significant difference (P>0.05) in consumption patterns between sites where the protection level was National Park and non-protected areas, which may reflect that the protection is working and that wildlife is depleted, respectively.

Table 2. Ordered logit model of bushmeat consumption frequency. First number represents the regression coefficient and numbers in brackets are robust standard error terms.

	Frequency of bushmeat consumption
Hunting household	0. 8815 (0.3804)**
Distance to wildlife area	-0.0150 (0.0030)***
Protection level of wildlife area	-1.3824 (0.1850)***
n	300
Wald chi^2	88.97
Prob > chi^2	0.0000
Pseudo R^2	0.1160
/cut 1	-2.7027 (0.4671)
/cut 2	-1.2257 (0.4274)
/cut 3	0.4691 (0.4601)

*, ** and *** signify statistical significance at 0.1, 0.05 and 0.01 levels, respectively.

A number of other variables provide interesting results on the consumption of bushmeat when analysed individually using basic statistic comparison. Ownership of domestic animals was, for instance, either positively or negatively correlated with frequency of consuming bushmeat, depending on the tribe involved and the type of domestic animal. The two Nilotic pastoralist tribes, the Maasai and Wataturu, inhabit the Tanzanian rangelands, and breed cattle, goats and sheep. The sampled Wataturu are agro-pastoralists that have settled in Sanjaranda village, Manyoni District, in the Itigi Sumbu thicket. Although they rely on similar livelihoods, these two tribes exhibited significant different bushmeat consumption patterns: the Maasai reported no consumption whereas the Wataturu had a median bushmeat consumption frequency of once per year and a median of two species consumed/year (see Fig. 2 and 3). Their relationship with farming also shows some differences. The Wataturu have taken up agriculture the past 25 years, and cultivate intercropped maize, beans and pumpkin (90% of the respondents), with sunflower (50% of the respondents) and sorghum (33% of the respondents) as monoculture. The Maasai respondents farmed less frequently, intercropping maize and beans (67% of the respondents). However, all Maasai respondents involved in agriculture admitted that farming had been completely unsuccessful the previous 6 years. Tribes with accessible sources of animal protein such as poultry and swine (e.g. the Wangoni and the Wandamba), on the other hand, tended to consume bushmeat more often. Overall, weak but significant negative correlations were observed between frequency of bushmeat consumption and ownership of cattle ($r=-0.14$; $P<0.05$) and sheep ($r=-0.13$; $P<0.05$), whereas positive correlations were observed with ownership of pigs ($r=0.18$; $P<0.01$), and chickens ($r=0.16$; $P<0.01$) (Pearson's product moment correlation test).

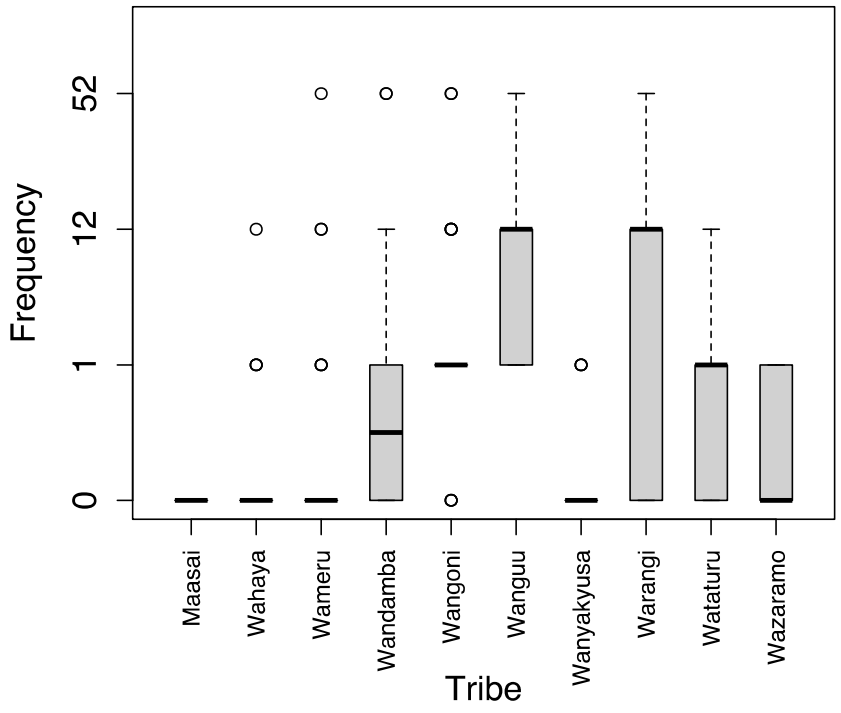

Fig. 2. Summary statistics on frequency of bushmeat consumption the past year in each tribe described in four categories: 0=no consumption, 1=annually, 12=monthly and 52=weekly. Bars = 1.5 x interquartile range. O = above or below 1.5 times the interquartile range.

We found no significant effects in the ordered logit model of the size of agricultural land cultivated, quality of housing, or tribe on bushmeat consumption frequencies. However, traditional beliefs and religious affiliation reflected in tribe have a clear influence on bushmeat consumption and preferences in relation to species consumed. The median of the Wanguu respondents admitted consuming bushmeat at least once per month (Fig. 2, frequency of consumption=12). The Wangoni had the highest median number of species consumed (five species/year) but the median of the frequency of consumption was one (i.e. once per year) (see Fig. 2 and 3), suggesting weaker preference-based procurement and a more opportunistic approach, e.g. eat whatever is available. Typically Islamic tribes such as the Wazaramo, Warangi, and Wanguu abstained from consuming bushpig or warthog because these belong to the 'Suidae' family, forbidden meat by Islamic beliefs. Preferences and attitudes towards bushmeat consumption also differed among pastoralist communities. The Wataturu believed that meat of elephant trunk is the best meat for a man, and although the two most frequently consumed species were bushpig and dikdik, one quarter of the respondents admitted having consumed elephant meat during the previous year. However, effects of difference in species assemblage and wildlife densities cannot be excluded. Hence, for instance, eating cane rat was primarily mentioned by the Wanguu (77% of respondents), residing in forested and wetter areas of the Nguu forests in the Eastern Arc, and the Wandamba (27%) of the Zambezian flooded grasslands, whereas most other tribes did not mention consuming rodents.

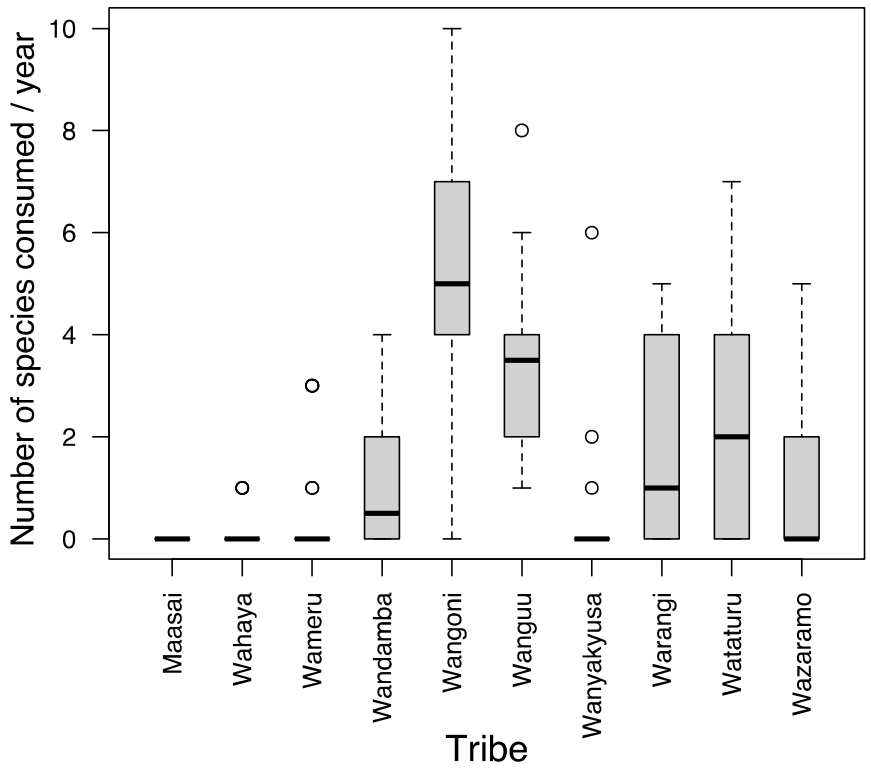

Fig. 3. Summary statistics on number of species consumed the past year by each tribe. Bars = 1.5 x interquartile range. For this chart all outliers (O) are households consuming a number of species above 1.5 times the interquartile range.

Discussion

Prevalence of bushmeat consumption

The results of this study show that hunting and bushmeat consumption is widespread in most tribes and Ecoregions throughout Tanzania. However, we find considerable variation in the prevalence of both aspects among ethnic groups. A number of different factors have been suggested as drivers of hunting and bushmeat consumption in Tanzania [7, 13, 23, 37-40]. Knapp [41] stresses that even though illegal hunters are commonly conceived as poor farmers, with low level of education and few alternative livelihoods options, hunting may also be driven by a desire to improve skills, identity formation, opposition to authorities, boredom, and thrill seeking. In this study we found an equally complex set of variables influencing bushmeat consumption.

Protected area status

The frequency of consuming bushmeat naturally depends on the availability of bushmeat, whether in the market or in adjacent wildlife areas. We found consumption to increase with the presence of a hunter in the household and decrease with increasing distance to, and active protection of, protected areas (See Appendix 1), indicating that bushmeat is predominantly locally generated rather than coming from distant wildlife resources through commercial trade [23]. However, there were examples of tribes where a large proportion of the sample consumed bushmeat although none of the households hunted bushmeat (i.e. the Wangoni and Wandamba). This may be explained by underreporting, but more likely reflects a vibrant local bushmeat trade by specialised actor groups. Evidence from the Kilombero Valley of the Wandamba reveals a commodity chain with well-defined actor groups supplying national markets as well as markets in neighbouring countries [38, 42]. Also, some of the species consumed by some tribes (Wangoni, Wandamba, Wataturu, Wanguu and Wazaramo), such as buffalo, elephant and hippopotamus, require specialised skills, indicating organised hunting and bushmeat trade. For example, elephant meat was sold twice during five days of monitoring the trade at the Catholic Mission of Peramiho village in the Wangoni area, and buffalo meat was available on a daily basis at the Songea market. The Wangoni was the ethnic group where the greatest proportion of the households consumed bushmeat and where the highest number of consumed species was recorded. This level of bushmeat consumption may be facilitated by proximity to the wildlife rich Selous Game Reserve and to the Selous-Niassa ecological corridor [2], as well as the distance from institutions appointed to enforce wildlife management regulations.

The results also reveal that the protection level of the nearest protected area generally reduces the frequency of bushmeat consumption regardless of distance (i.e. there were no significant interactions). This indicates that greater protection status, when associated with increased enforcement activity, reduces bushmeat consumption. Hence, if bushmeat consumption is a proxy of hunting pressure, then hunting is lower in areas adjacent to National Parks that have anti-poaching patrols than in areas with less enforcement [22]. However, effects of differences in wildlife density, species ensemble and habitat characteristics were not explicitly included in the analysis and could have an effect on the interpretation of the results. For example, the Itigi thicket hosts a rich ensemble of mammal species, and the structure of the intertwined and impenetrable vegetation makes it virtually impossible for Wataturu hunters from the village of Sanjaranda to get caught hunting within or near the Muhesi Game Reserve. In comparison, bushmeat consumption frequencies were low among the Wahaya from the Victoria Basin forest savannah mosaic. This appears to be a result of lack of wildlife in the general area, rather than an effect of protection status, as the location is more than 100 km from Rumanyika Game Reserve. This community furthermore lives 8 km circa from Lake Victoria, where both fresh and dry freshwater fish are easily accessible, indicating a possible effect determined by the availability of protein-rich animal foods. On the other hand, the Warangi respondents of Iyole village in the Central Miombo Woodland, farther away from protected areas, consumed bushmeat once a month but only from a few species (median=1 species) (see Figure 2, Figure 3, and Appendix 2).

Wealth and domestic animals

Contrary to the findings of a number of case-based, location-specific studies [3, 25, 43], we found no significant effect of household size, size of farmed land or quality of housing as indicators of wealth in the model on bushmeat consumption frequency. This suggests that other factors, as discussed above, are more important in determining the prevalence of bushmeat consumption on the national scale. However, we did find differences related to number and type of domestic animals owned. Contrary to what we expected, but similar to findings in Katavi ecosystem [23], greater availability of chickens and pigs was associated with higher bushmeat consumption, despite chicken and pigs often being promoted to increase protein availability and reduce dependence on bushmeat [44], and pigs being suggested as an indicator of wealth [45]. On the other hand, greater availability of goats and sheep was negatively related with bushmeat consumption. The pastoralist Maasai are known to eradicate wildlife to protect grazing areas [46] and have been found to hunt smaller antelopes in Western Serengeti [3] but in this study no bushmeat consumption was recorded. This discrepancy may reflect the presence of well-organised privately funded rangers in the nearby Ndarakwai Private Conservancy, or a lack of bushmeat suppliers due to the severe post-drought stress that forced adult men to migrate in search for good pasture in distant locations. The other Nilotic agro-pastoralist tribe, the Wataturu of the Itigi Thicket, whose livelihoods are similarly centred on livestock keeping, supplemented by farming income, indicated that bushmeat is not only a culturally acceptable food but also that some types of bushmeat have great cultural value. This includes the trunk of elephants, which is believed to increase male virility. These results indicate that the often-suggested strategy of increasing livestock production to reduce the demand for bushmeat may be too simplistic.

Additional aspects and limitations

In Tanzania there are 120 tribes, and although our study targets only ten tribes, a fraction of the large cultural melting pot in the country, the selected tribes are representative of different ecological and farming systems, religious affiliations, and a diversity of livelihood strategies. These include Bantu mountain farmers from different ecoregions (Wameru, Wanguu, Wanyakyusa), subsistence farmers applying slash-and-burn strategies (Wangoni, Warangi), coastal systems (Wazaramo), Nilotic livestock keepers (Maasai) and more settled Nilotic agro-pastoralists (Wataturu), farmers around Lake Victoria relying on banana farming (Wahaya), and commercial rice farmers from the Kilombero Valley (Wandamba). Each of these groups is adapted to differing rainfall and soil fertility patterns and local biological diversity, and have varying cultural traditions and coping mechanisms that make comparisons among them relevant for a national overview of bushmeat consumption.

This study is based on data collected directly from people about their use of an illegal resource. We therefore cannot exclude the occurrence of under-reporting. However, by focusing primarily on the consumption of bushmeat and not the act of hunting, we reduced the sensitivity of the subject, and interviewees generally spoke freely. In fact males aged 14-18 often readily admitted to hunting and spoke about hunting activities with a certain sense of pride, whereas adults and elders were more reserved. This suggests that including more teenaged men in studies of bushmeat hunting may provide better insight into the prevalence of hunting and number of animals caught. Their more relaxed attitude may be attributed to less awareness of consequences of rule breaking and less fear of prosecution. By contrast, elder people in locations adjacent to National Parks were well aware and terrified of being caught with bushmeat by park authorities. These qualitative observations also suggest that further education of young people on the importance of wildlife conservation, and of adhering to rules and regulations, may have a positive impact on illegal harvesting of wildlife.

We made no attempt to quantify the amount of bushmeat consumed, as we found that most households were unable to provide reliable estimates. In addition, some bushmeat was bought sundried or smoked, and

in other cases it was fresh, and we cannot exclude that some species consumed may have been misidentified by respondents, as also noted by Mwakatobe [36].

Implications for conservation

This study constitutes the first national level insight on the prevalence of bushmeat consumption in Tanzania and provides useful suggestions for selecting conservation strategies. We find that bushmeat consumption is influenced in complex ways by: distance to protected areas and their protection level; whether or not there is a hunter in the household; ownership of domestic animals; and ethnicity. On a positive note, results indicate that the extensive efforts of Tanzania National Parks authority seem to work as a deterrent to bushmeat hunting, as reflected in very low rates of bushmeat consumption among the Wameru and Wanyakyusa communities located along the boundaries of the Arusha and Kitulo National Parks respectively. Also, the absence of hunters and lack of bushmeat consumption among the Maasai living on the boundary of a private and well protected wildlife reserve lend credibility to the efficacy of law enforcement, although cultural aspects cannot be ruled out.

Overall, the results suggest that well-funded anti-poaching patrols may be a more effective way to deter bushmeat hunting than efforts to increase domestic animal production, an often proposed strategy to reduce dependence on bushmeat consumption. Preference for bushmeat over domestic sources of animal protein may furthermore be a product of cultural traits, in that tribes with very similar livelihoods have different frequency and conceptions of bushmeat consumption. Hence, cultural traits should be accounted for when designing mitigation policies and strategies for wildlife conservation.

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Appendix 1. Description of surveyed locations and distance and level of enforcement of wildlife regulations in nearest protected area.

Ecoregion [26]	Tribe	Village, District	UTM	Altitude (m a.s.l.)	Date	Nearest wildlife area within 20 km radius and its protection level
Southern Acacia-Commiphora bushlands and thickets	Maasai	Miti Mirefu, Siha	37M 0277998; 9667708	1306	Sep-2009	Ndarakwai Private Conservancy, adequate antipoaching effort.
Victoria basin forest-savanna mosaic	Wahaya	Igombe, Bukoba	36 M 0367362; 9860534	1294	Feb-2009	None.
East African Montane Forest	Wameru	Mulala, Meru	37M 0258452, 9633700	1635	Jan-2009	Arusha National Park Highest level of protection.
Zambezian flooded grasslands	Wandamba	Chita, Kilombero	36L 0824202; 9057056	318	Sep-2007	Kilombero Game Controlled Area – Medium Level of protection. organised rangers patrolling.
Eastern Miombo woodlands	Wangoni	Mdunduaro/Litapwa si, Songea Rural	36L 0762687; 8835494/ 36 L 0776384; 8813570	986/1030	Apr-2008	Selous/Niassa corridor, residential and tourism hunting allowed, insufficient number of rangers/km^2.
Eastern Arc Forest	Wanguu	Tamota, Kilindi	37M 0339589; 9381990	730	Jan-2008	Kilindi Forest – Low level of protection, utilisation of renewable resources allowed, no organised patrolling
Southern Rift Montane forest-grasslands mosaic	Wanyakyusa	Bujingijira, Tukuyu	36 L 0582839; 8988590	1606	Nov-2007	Kitulo National Park. Highest level of protection
Central Zambezian Miombo woodlands	Warangi	Iyoli, Kondoa	36 M 0724025; 9659838	1175	Nov-2009	None
Itigi-Sumbu Thicket	Wataturu	Sanjaranda, Manyoni	36 M 0669891; 9376904	1289	Dec-2007	Muhesi Game Reserve - residential and tourism hunting allowed, lack of rangers/km^2
Southern Zanzibar Inhambane Coastal Forest Mosaic	Wazaramo	Miembe Saba, Kibaha	37 M 0487818; 9255122	173	Mar-2008	None

Appendix 2. Different species consumed during the previous 12 months by proportion (as %) of households in each tribe (Maa=Maasai; Hay=Wahaya; Mer=Wameru; Nda=Wandamba; Ngo=Wangoni; Ngu=Wanguu; Nya=Wanyakyusa; Ran=Warangi; Tat=Wataturu; Zar=Wazaramo).

Tribe/Species	**Latin**	**Maa**	**Hay**	**Mer**	**Nda**	**Ngo**	**Ngu**	**Nya**	**Ran**	**Tat**	**Zar**
Antelope, any	*N/A*	0	0	3	0	13	10	0	0	0	10
Mammal, any	*N/A*	0	0	10	0	43	0	3	3	7	0
Birds, any	*N/A*	0	0	7	0	0	0	0	13	17	0
Bohor reedbuck	*Redunca redunca*	0	0	0	0	0	23	0	0	0	0
Buffalo	*Syncerus caffer*	0	0	0	50	20	10	0	0	0	13
Bushbuck	*Tragelaphus scriptus*	0	0	0	0	17	53	0	0	0	27
Bushpig	*Potamochoerus larvatus*	0	3	0	3	3	3	3	3	37	0
Cane rat	*Thryonomys swindernianus*	0	0	0	0	27	77	0	0	0	7
Dikdik, Kirk's	*Madoqua kirkii*	0	0	7	0	0	13	7	60	50	23
Dove spp.	*N/A*	0	0	0	0	3	0	0	10	7	0
Duiker, Abbot's	*Cephalophus spadix*	0	0	0	0	0	0	3	0	0	0
Duiker, red forest	*Cephalophus natalensis*	0	0	0	0	33	77	0	0	0	0
Duiker, spp.	*N/A*	0	3	0	0	0	17	7	17	10	0
Elephant	*Loxodonta africana*	0	0	0	10	47	0	0	0	23	0
Francolin spp.	*N/A*	0	0	0	0	33	0	0	13	13	0
Helmeted/crested guinea fowl	*Numida meleagris/Guttera pucherani*	0	0	0	0	40	10	0	30	20	0
Hare	*Lepus capensis*	0	7	7	0	53	0	0	10	10	13
Hippopotamus	*Hippopotamus amphibius*	0	0	0	20	17	0	0	0	0	7
Impala	*Aepyceros melampus*	0	0	3	0	7	0	0	17	0	3
Kudu, Greater	*Tragelaphus strepsiceros*	0	0	0	0	0	0	0	3	23	0
Porcupine	*Hystrix cristata/Hystrix africaeaustralis*	0	0	10	0	0	27	3	0	3	0
Puku	*Kobus vardonii*	0	0	0	43	0	0	0	0	0	0
Quail spp.	*N/A*	0	0	0	0	0	0	0	0	7	0
Quelea	*N/A*	0	0	0	0	0	0	0	7	0	0
Sable antelope	*Hippotragus niger*	0	0	0	0	0	13	0	0	0	0
Tree hyrax	*Dendrohyrax arboreus*	0	0	0	0	0	3	3	0	0	0
Warthog	*Phacochoerus africanus*	0	0	0	3	23	0	0	0	0	0
Zebra	*Equus quagga*	0	0	0	0	0	0	0	0	0	3