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Schoolchildren as informants about bushmeat consumption in Western Serengeti, Tanzania

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Bushmeat contributes to household food security in Western Serengeti, particularly for low-income families who are unable to afford more expensive meat sources. However, as the human population grows, bushmeat demand is increasingly unsustainable. Formulating effective policies to reduce illegal bushmeat hunting in Serengeti National Park (SNP), requires information about the contribution of bushmeat to household meat protein consumption as it varies along a gradient of distance from protected areas and between seasons, which can be difficult to obtain from adults due to the illegal nature of hunting. Data on bushmeat consumption frequencies were collected from 127 class four pupils and compared to that of 150 adults. Data were obtained through interviews conducted in both the dry and wet seasons in October 2017 and April 2018, respectively, in three villages selected based on distance from the boundary of SNP (near, intermediate and far away). Mean reported bushmeat consumption frequencies by both schoolchildren and adults differed significantly between villages declining with distance from SNP. Bushmeat consumption frequencies reported by both groups were significantly higher during the dry season (66%) compared to the wet season (34%). Adults on average reported significantly lower bushmeat consumption frequencies than schoolchildren in both seasons. The results suggest that children are less constrained by the illegal nature of bushmeat hunting and therefore may provide more accurate information about the importance of bushmeat in household consumption than adults. Results also reveal that bushmeat contributes considerably to household meat consumption in villages close to the SNP but not further away. This study provides valuable insights for targeting policies to reduce illegal bushmeat hunting, including through promoting substitute protein sources.

Key words: Consumption frequency, spatial and temporal variations, meat types.

INTRODUCTION

Bushmeat is an important component of household food security in many locations across Sub-Saharan Africa (Lindsey et al., 2013; Nielsen et al., 2017). Bushmeat is particularly important to poor rural households providing protein and essential micronutrients that may otherwise be inaccessible with potentially severe health implications (Fa et al., 2015; Golden et al., 2011). Bushmeat, also called game or wild meat, is defined as meat from non-

domesticated or wild animals hunted, processed and consumed by humans. Bushmeat hunting is considered a significant threat to conservation objectives and depletion of wildlife populations has been tied to high hunting pressure in many locations (Clements et al., 2014; Ripple et al., 2016).

In Tanzania, bushmeat hunting is practised illegally by communities adjacent to protected areas and other wildlife areas since the process of obtaining a hunting licence is economically and practically unfeasible for most local people (Ceppi and Nielsen, 2014; Mfunda and Røskaft, 2010). In Western Serengeti, illegal hunting is an important source of income for primarily young men trading a third of their catch while the rest is consumed in the household (Loibooki et al., 2002). Estimates of the number of households engaged in bushmeat hunting in western Serengeti vary between 8 and 57% of all households (Nuno et al., 2013). About 75% of arrested poachers come from nearby villages, between 0 and 16 km from protected area boundaries, but some live as far away as 45 km (Holmern et al., 2007; Kideghesho, 2010; Loibooki et al., 2002).

Bushmeat is generally much cheaper than domestic animal meat sold at prices between 0.85 and 1.0 US$ per kg (Rentsch and Damon, 2013) while beef, for instance, is sold at prices ranging from 2.7 to 4.7 US$ per kg. With such price difference combined with culturally determined preferences for bushmeat, the reliance of income-poor households on bushmeat for protein seems inevitable (Ndibalema and Songorwa, 2007). However, the sustainability of extraction levels in the Greater Serengeti Ecosystem (GSE) is questionable, and hunting intensity is expected to increase further because of the rising human population in districts adjacent to the protected areas (Holmern et al., 2007; Rogan et al., 2017, Setsaas et al., 2007). Rentsch and Packer (2015), for instance, estimate an annual offtake of 97,796 - 140,615 individual wildebeest and poaching has been identified as the driver of population decline in several species populations (Metzger et al. 2010, Strauss et al. 2015). Depletion of wildlife populations will negatively affect not only rural households directly through their reliance on bushmeat for food and income but also indirectly by reducing tourism income generation, which is an essential source of revenue for Tanzanian's national economy, with trickle-down effects on local communities through various benefit-sharing arrangements and extension services.

A considerable number of studies have attempted to quantify the importance of bushmeat to communities in Western Serengeti (Fischer et al., 2014; Mfunda and Røskaft, 2010). Information about the importance of bushmeat is essential to develop appropriate conservation and development strategies. However, obtaining accurate, reliable data is complicated by the illegal nature of bushmeat hunting, which means that respondents are reluctant to share information for fear of reprisals (Knapp et al., 2010; Nuno et al., 2013). Recent studies have attempted to overcome the reluctance of adults to share information by interviewing children instead (Haule et al., 2002, van Vliet et al. 2015). If following appropriate ethical guidelines aiming to protect respondents, children may be a rich source of information about various questions concerned with household food and nutritional security (Baranowski et al., 2012; McPherson et al., 2000).

Interviewing children may furthermore overcome the challenge of strategic behaviour by respondents about their bushmeat consumption. We, therefore, interviewed standard-four pupils in primary schools as well as adult respondents through interview-based questionnaire surveys to collect information about the frequency of bushmeat consumption at the household level in villages along a gradient of distance from protected areas in Western Serengeti. The multiple objectives include comparing bushmeat consumption frequency in villages along a gradient of distance from protected area boundaries and between seasons. We also compare information reported by schoolchildren to that of adult respondents to assess the accuracy of information provided by the schoolchildren assuming that lower mean bushmeat consumption frequencies reported by adults reflect reluctance to report accurate information. Finally, we evaluate the determinants of bushmeat consumption frequency.

The study had four hypotheses. Hypothesis one postulated that bushmeat consumption frequency is higher during the dry season than the wet season, hypothesis two that bushmeat consumption frequency decrease with increasing distance from protected area boundary, hypothesis three that children report higher bushmeat consumption frequency than adults and hypothesis four that bushmeat consumption frequency is associated with socioeconomic characteristics including household size, age of respondent (adult or child), whether or not the household head held a formal occupation as an indicator of wealth, and the frequency of consumption of other meat types.

Approval to conduct the study was obtained following an ethical evaluation by the National Health Research Ethics Committee under the National Institute for Medical Research (NIMR). An informed consent form was developed, and children, as well as adults, were all verbally explained the objectives of the study and that they could withdraw their participation at any time during the study obtaining children's agreement to participate in the presence of their legal guardian.

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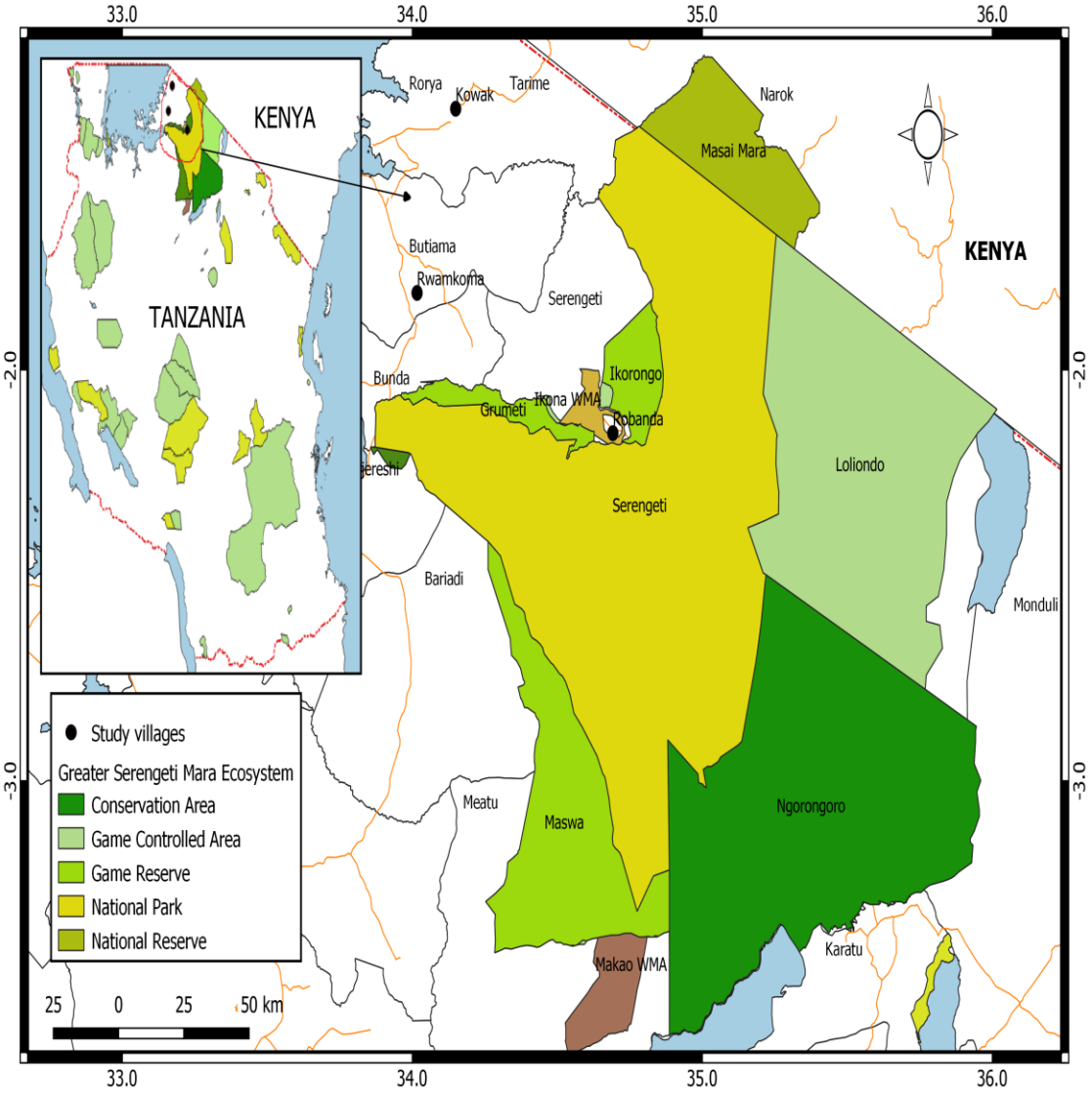

Figure 1. Map of the study area and its location in Tanzania marked with a red circle (in the top left corner). The study villages Robanda, Rwamkoma and Kowak are indicated with black circles and text.

METHODS

Study area

Serengeti National Park (SNP) (14,763 km^2) is a component of the GSE located between 1°28' to 3°17'S and 33°50' to 35°20'E in Tanzania. In addition to the SNP the GSE also includes, on the western side Ikona wildlife management area (600 km^2), Ikorongo game reserve (563 km^2), Grumeti game reserve (416 km^2), Kijereshi and Maswa game reserves (2,200 km^2) on the southern side, and Ngorongoro conservation area (8,292 km^2) and Loliondo game controlled area (4,000 km^2) on the eastern side. The GSE is a highland savannah region with plains and woodlands at an altitude of 1000 to 1800 m above sea level. The GSE is World Heritage listed and a famous tourist attraction due in part to hosting the last remaining great wildlife migration consisting of wildbeast (*Connochaetes taurus)* and other herbivores. Community land in Western Serengeti acts as a corridor for the migration on its route to the Maasai Mara reserve in Kenya (Loibooki et al., 2002). The migration influences the availability of bushmeat in adjacent communities through illegal hunting (Mwakatobe et al., 2012; Nyahongo et al., 2009).

The study was conducted in three villages (Robanda, Rwamkoma and Kowak) located in Western Serengeti (Figure 1). These villages were purposely selected based on distance from the boundary of SNP. Distances from the centre of the villages to the nearest park boundary are Robanda 3 km, Rwamkoma 27 km and Kowak 58 km. We refer to these villages as close, intermediate and far from the park. The ethnic composition in the villages is diverse including Ikoma, Kurya, Ikizu, Zanaki, Jita and Luo tribes. The human population in the villages close to the park is increasing rapidly at a rate of 3.5% annually (Estes et al., 2012; URT, 2013) and a large proportion of the population subsists on less than 1 US$ per day facing deteriorating well-being due to environmental degradation and lack of economic options (Kideghesho, 2010; Loibooki et al., 2002). The main economic activities are subsistence

farming (maize, cassava, millet and sorghum), pastoralism (cattle, goat and sheep), poultry, hunting, fishing, charcoal making and making local brews (Kideghesho, 2010; Loibooki et al., 2002).

Data collection from schoolchildren

Data were collected through interviews during the dry season in October 2017 and the wet season in April 2018. Collecting information in both the wet and the dry seasons was done in consideration of the high influence of season and the wildlife migration on the availability of bushmeat in the study area (Nyahongo et al., 2009). Interviews were conducted with schoolchildren from primary schools in the study villages. Forty schoolchildren were selected randomly from the standard four classes in each school. This age group represent children between 9 and 12 years, which means that they are old enough to recall and explain what they have consumed (Diep et al., 2015) but too young to have participated in hunting, which may increase awareness about the illegality and possible sanctions for hunting illegally.

On the first day of the data collection in each school, the research team discussed general issues like health, nutrition and biology with the pupils to establish a good rapport with the children. Subsequently, the team implemented a questionnaire enquiring about pupils' household socio-demographic characteristics with the help of the teachers. The questions were explained in plenum and pupils were given time to complete the questionnaire with help from the teacher and researchers. The questionnaire obtained information about the children and their families (age and gender of all household members, and household head occupation), and the composition of meals consumed the day before the interview (breakfast, lunch and dinner). The second day of the study, pupils were asked specifically about types of meat consumed in meals in their household the past 24 hrs. This questionnaire was repeated each day the subsequent four consecutive weeks (information about Saturday and Sundays were recorded on the following Monday) in each season (wet and dry season). The final combined sample contains information about 21,336 meals from a total of 127 pupils from the three villages after attrition.

Data collection from adults

Information about bushmeat consumption frequencies from adults was collected through household questionnaire surveys conducted in the same three villages in the same period as the data collection from schoolchildren, that is, October 2017 and April 2018. Households were selected randomly from the village register through the aid of the Village Executive Officer. The head of the household was interviewed using a questionnaire containing questions about age, gender, education and occupation. In the absence of the household head, the wife (if the household was male headed) or the oldest household member above 18 years of age was interviewed instead. The questionnaire also inquired about the frequency of meat containing meals consumed the week before the interview. A total of 150 respondents in the three study villages were interviewed in both seasons.

Data analysis

The average frequency of consumption (that is, times per week) in each village was calculated for each meat type in each season by dividing the average number of meat meals of each type by the number of days in the recording period. Other meat types were grouped into two main categories; "domestic" for all livestock meat types and "fish" for all species and types of fish including sardines (small dried fish). Comparisons of means were conducted after testing the normality assumption using the Shapiro-Wilkes test. The variation in bushmeat consumption between villages and seasons was analysed using Kruskal-Wallis tests, and the significance of differences was tested using Dunn's post hock test. Wilcoxon tests were used to compare stated bushmeat consumption frequencies between schoolchildren and adults in the same village. As stated bushmeat consumption frequencies for adults was obtained using recall during the first week of the survey in each village we selected the first week of data collected from the children for comparison. This approach was selected in order to minimise bias induced by temporal variations in bushmeat consumption. However, the variation in children's bushmeat consumption frequency between weeks were tested in each season and found no significant difference between the four weeks was found (Kruskal-Wallis test: dry season; $H = 3.18$; $P = 0.364$, and wet season; $H = 1.32$; $P = 0.725$).

Finally, the determinants of the frequency of bushmeat consumption were evaluated through a Generalised Linear Model (GLM) with logarithmic transformation and standard specification of quasi-Poisson family and a canonical link function. Selection of variables was based on general economic theory and relevant empirical findings (Fischer et al., 2014; Knapp et al., 2010; Nyahongo, 2009). The model tested the influence of distance to protected area boundary (in kilometres), season (wet or dry season), age of respondent (child or adult), household size (number of household members) and occupation of household head (peasant and pastoralist vs employed or managing a small scale business) (Table 1). Evaluation of the model was done using the dispersion parameter and Variance Inflation Factor (VIF). The VIF was calculated to detect and evaluate the presence of multicollinearity. All statistical tests were done in R-Studio (version 1.1.456).

RESULTS

Characteristics of the sample

A total number of 127 class 4 pupils and 150 adults were interviewed in the three villages. The characteristics of villages and the sample in each village are presented in Table 2.

Frequency of bushmeat consumption

Altogether 572 meals contained bushmeat out of 3,623 meat meals recorded in the overall sample from both adults and schoolchildren. In total, bushmeat constituted 15.8% of meat containing meals. The meat of domestic animals constituted 18% while fish was by far the most common source of animal protein at 66.2% of meals containing meat. However, bushmeat consumption differed between villages (Kruskal-Wallis test: $H=454.2$; $P<0.001$) and was consumed very frequently in Robanda the closest villages to SNP at 96.3% of meals, while very little bushmeat was consumed in villages further away (Rwamkoma 1.4% and Kowak 2.3%). More bushmeat was consumed in meals for dinner (57%) than in meals for lunch (43%) and no bushmeat was consumed during breakfast. Bushmeat meals were more frequently consumed during the dry season (66%) than during the wet season (34%). Finally, more fish meals were consumed in Rwamkoma, and Kowak than in Robanda (Figure 3) and

Table 1. Explanatory variables and expected sign of coefficient for variables selected as indicators for testing hypotheses about the determinants of bushmeat consumption frequency in the GSE.

Covariate	Unit	Sign	Hypothesis
Distance	Km	-	Bushmeat consumption frequency is inversely related to distance to the protected area boundary as an indicator of availability and price of bushmeat
Dry season	Dummy variable (Dry season coded as 1 and wet season coded as 0)	+	Bushmeat consumption is higher during the dry season than in the wet season due to the presence of the wildebeest migration in the dry season
Children	Dummy variable (Children coded as 1 and adults coded as 0)	+	Children state higher bushmeat consumption frequency than adults due to lack of concern about reprisal as a consequence of the illegality of bushmeat hunting.
Household size	Number of people	+	Larger households are more efficient in wealth generation and therefore can afford to purchase more bushmeat and allocate household members to hunting
Household head occupation	Dummy variable (Employed or managing small business coded as 1 and peasants and pastoralists coded as 0)	+	Bushmeat consumption frequency is positively associated with formal occupation or running a small scale business as an indicator of wealth
Domestic meat consumption	Frequency	-	Bushmeat consumption frequency is inversely related to domestic meat consumption frequency as an indicator of wealth and fulfilment of protein needs from other ources.
Fish consumption	Frequency	-	Bushmeat consumption frequency is inversely related to fish consumption frequency as an indicator of wealth and fulfilment of protein needs from other sources.

Table 2. Baseline information of the respondents.

Variable		Robanda	Rwamkoma	Kowak
Village characteristics	Total village population	4,735	4,821	4,382
	Number of households	471	802	695
	Distance to PA boundary (Euclidean distance) (km)	3	27	58
Children sample	Children interviewed	46	49	32
	Girls (%)	52.2	57.1	46.9
	Boys (%)	47.8	42.9	53.1
	Age group 9 -12 years (%)	91.3	83.7	90.6
	Age group 13 -14 years (%)	8.7	16.3	9.4
	Household heads occupation	-	-	-
	Peasants (%)	26.1	87.8	87.5
	Agro-pastoralists (%)	32.6	0	0
	Employment and Small scale business (%)	41.3	12.2	12.5
Adult sample	Adults interviewed	**50**	**50**	**50**
	Males (%)	58	46	42
	Females (%)	42	54	58
	Household heads occupation	-	-	-
	Peasants (%)	46	86	64
	Agro-pastoralists (%)	34	14	28
	Employment and Small-scale business (%)	20	0	8

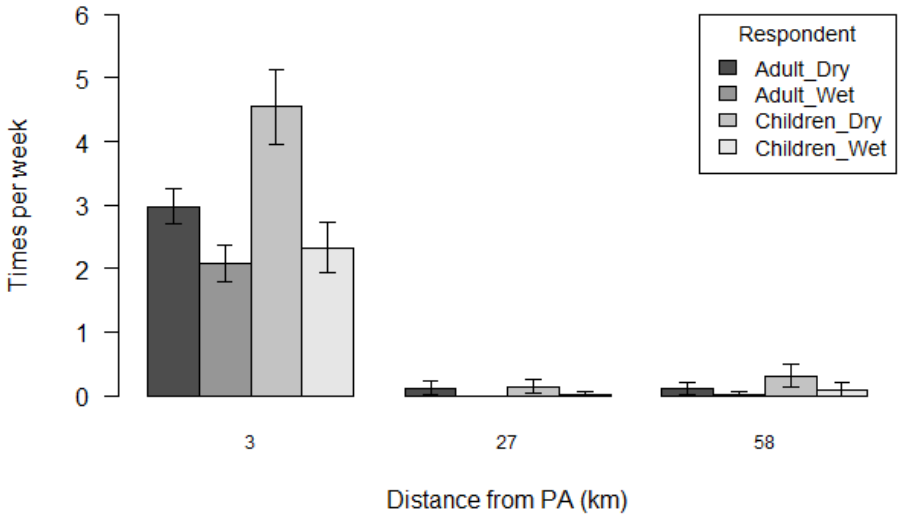

Figure 2. Average number of bushmeat meals consumed per week reported by adults and schoolchildren in the wet and the dry season in Robanda, Rwamkoma and Kowak at increasing distance from the PA boundary.

bushmeat consumption was negatively correlated with fish consumption (Spearman rank correlation test; r=-0.58; P<0.001).

Temporal variation in bushmeat consumption

A combined analysis of data from both adults and schoolchildren shows that, the average number of bushmeat meals per week was significantly higher in the dry season (1.35 ± 0.12) than in the wet season (0.71 ± 0.07), (Figure 2; Wilcoxon test; W=42.50; P=0.018). Furthermore, during the dry season schoolchildren reported a significant higher bushmeat consumption (1.78 ± 0.22) than adult respondents (0.99 ± 0.13); (Wilcoxon test; W=7820.50; P = 0.002). However, during the wet season, the consumption frequencies of adults (0.57 ± 0.08) and schoolchildren (0.87±0.12) were not significantly different (Wilcoxon test; W=8880; P=0.21). In the closest village (Robanda) where bushmeat was most frequently consumed (96.3% of meat containing meals), the consumption frequency was also significantly higher during the dry season than in the wet season (Figure 2) (Wilcoxon test; W=7137.50; P<0.01). Schoolchildren in Robanda (4.54±0.3 and 2.33±0.2, dry and wet season, respectively) reported significantly higher bushmeat consumption than adults (2.98±0.2 and 1.72±0.12, dry and wet season, respectively) in both seasons (Figure 2) (Wilcoxon test; W=3155; P<0.0001).

Spatial variation in bushmeat consumption

Bushmeat consumption was significantly higher in the closest village (Robanda) than in the more distant villages (Rwamkoma and Kowak) (Figure 2) in both seasons (Kruskal-Wallis tests; H=219.88; P<0.001 and H=240.57; P<0.001, in the wet and dry season, respectively). Furthermore, a post hoc Dunn's test shows a significantly higher consumption in Robanda than in Kowak (Z=12.28; P<0.001 and Z=12.89; P<0.001 in the dry and wet season, respectively), as well as in Rwamkoma (Z=13.23; P<0.001 Z=13.79; P<0.001, in the dry and wet season, respectively). However, the bushmeat consumption frequency did not differ significantly between Rwamkoma and Kowak in either season (Z=0.37; P=0.714 and Z=0.28; P=0.78, in the dry and wet season, respectively). In the distant villages, only few respondents both adults and schoolchildren reported bushmeat consumption in their households (Figure 2). Even in the closest village where both adults and students reported bushmeat consumption, schoolchildren reported higher consumption (57.35%) than adults (42.65%).

Spatial variations in the consumption of other meat types

In the dry season, the consumption of other meat types differed significantly between villages (Kruskal-Wallis tests; Domestic meat: H=17.23; P<0.0001 and fish: H=79.041; P<0.001). The average consumption frequency for both domestic meat and fish reported by children were significantly higher than that of adults (Figures 3 and 4) (Domestic meat: W=6302; P<0.001. Fish: W=5395.5; P<0.001) during the dry season.

Moreover, fish consumption also differed significantly

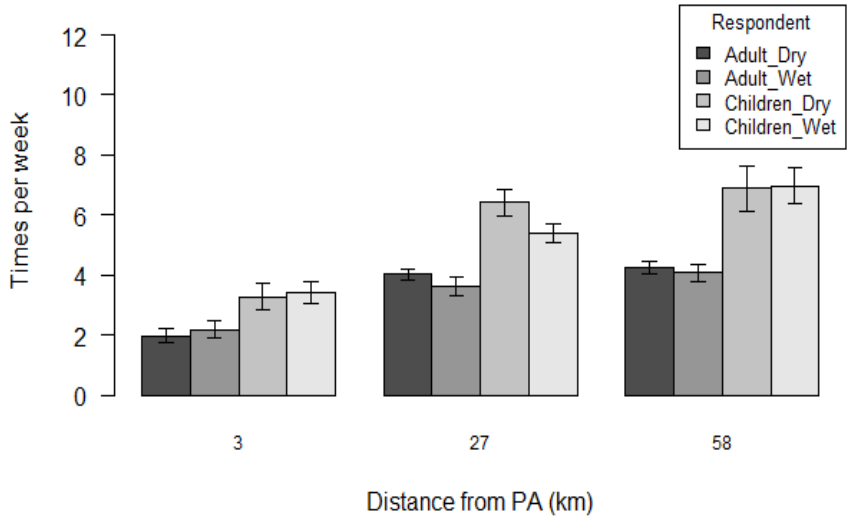

Figure 3. Average number of fish meals consumed per week reported by adults and schoolchildren in the wet and dry season in Robanda, Rwamkoma and Kowak at increasing distance from the PA boundary.

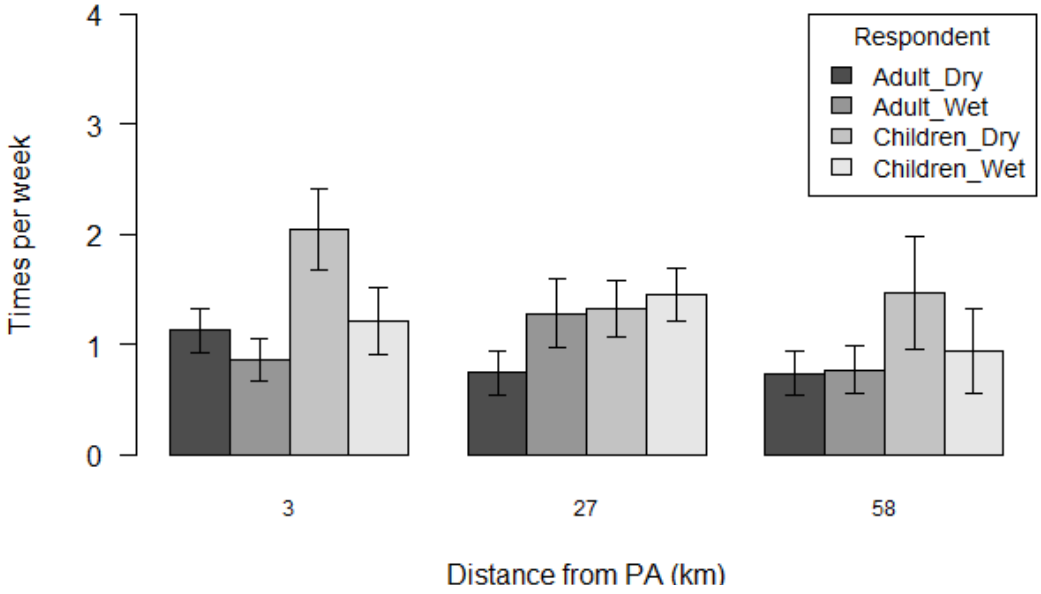

Figure 4. Average number of domestic meat meals consumption per week reported by adults and schoolchildren in the wet and dry season in Robanda, Rwamkoma and Kowak at increasing distance from the PA boundary.

between villages (Figure 3) for adults (Kruskal-Wallis tests; H=32.72; P<0.0001) and schoolchildren (H=60.98; P<0.001) separately. A post hoc Dunn's test shows that both adults and schoolchildren in the closest village Robanda consumed less fish than in Rwamkoma (Adults: Z=4.2; P<0.001. Schoolchildren: Z=6.73; P<0.001) and in Kowak (Adults: Z=5.47; P<0.001. Schoolchildren: Z=6.61; P<0.001). However, fish consumption frequencies in the two more distant villages (that is, Rwamkoma and Kowak) did not differ significantly for either adults (Dunn's tests; Z=1.25; P=0.21) or schoolchildren (Z=0.62; P=0.54).

Furthermore, the consumption of domestic meat differed significantly between villages only for school children

Table 3. Regression coefficients of the quasi-Poisson Generalised Linear Model predicting logarithmic transformed bushmeat consumption frequency from socioeconomic variables, consumption of other meat types, distance to protected area boundary, season and respondent group.

Variable	Estimate	SE	T	P
Intercept	1.58589	0.14036	11.299	<0.001
Respondent (Children = 1 and adults = 0)	0.65730	0.07050	9.323	<0.001
Household heads occupation (employment/business income = 1 and peasants/pastoralists = 0)	0.06196	0.07680	-0.807	0.420
Household size (smaller families < 7 people and large families ≥ 7 people)	0.02402	0.01629	1.475	0.141
Domestic meat consumption frequency (times/week)	-0.20436	0.02974	-6.871	<0.001
Fish consumption frequency (times/week)	-0.14485	0.02462	-5.884	<0.001
Season (dry season = 1 and wet season = 0)	0.76243	0.07215	10.567	<0.001
Distance (27 km)	-4.06938	0.28980	-14.042	<0.001
Distance (58 km)	-3.29956	0.23122	-14.270	<0.001

Model properties: Observations, 554; Respondents, 277; Dispersion parameter, 0.63.

(Kruskal-Wallis tests; H=10.45; P=0.005) but not adults (H=5.65; P=0.056). Schoolchildren in Robanda reported higher domestic meat consumption than schoolchildren in Rwamkoma (Dunn's tests; Z=2.87; P=0.012) and Kowak (Z=2.64; P=0.017) while the difference between Rwamkoma and in Kowak were not significant (Z=0.081; P=0.94).

The consumption frequency of other meat types reported by both children and adults also varied significantly between villages during the wet season (Figures 3 and 4). The consumption frequency of fish was significantly higher in the more distant villages for both adults (Kruskal-Wallis tests; H=42.18; P<0.0001) and schoolchildren (H=68.47; P<0.001) during the wet season. Furthermore, a post hoc Dunn's test shows that fish consumption reported by schoolchildren differed significantly between the three villages (Robanda vs Rwamkoma: Z=5.58; P<0.001. Robanda vs Kowak: Z=7.99; P<0.001. Rwamkoma vs Kowak: Z=3.06; P<0.002). However, fish consumption reported by adults was lower in Robanda than in Rwamkoma (Dunn's tests; Z=4.46; P<0.001) and Kowak (Z=6.32; P<0.001), while consumption frequencies in Rwamkoma and Kowak did not differ statistically (Z=1.85; P=0.06).

The variation in the consumption of domestic meat were statistically different between villages only for schoolchildren (Kruskal-Wallis tests; H=8.86, P=0.012) and H=5.26, P=0.072 for schoolchildren and adults respectively). The differences were significant only between Rwamkoma and Kowak (Dunn's tests; Z=2.97; P=0.009) but not between Robanda and Rwamkoma (Z=1.49; P=0.135) or Robanda and Kowak (Z=1.60; P=0.22).

Predictors of bushmeat consumption frequency

The GLM reveal that reported bushmeat consumption frequency is associated with the respondent category being positive and significantly associated with children as informers. The frequency of bushmeat consumption is also significantly associated with the frequency of consumption of other meat types decreasing when the consumption frequency of domestic meat and fish increases. Other significant factors include a positive association with dry season and a negative association with distance from the PA boundary. Hence, bushmeat is more frequently consumed in the dry season but less frequently consumed as distance to the PA boundary increases. Other socioeconomic factors such as household size and occupation were not significantly associated with bushmeat consumption frequency (Table 3). The average VIF was 1.11 indicating that multicollinearity is negligible and the dispersion parameter was 0.63 indicating that the model has no sign of overdispersion which can leads to type I error.

DISCUSSION

Hypothesis 1: Bushmeat consumption frequency is higher during the dry season than the wet season

The first hypothesis was supported by the study findings. The assumption was that bushmeat is consumed more frequently during the dry season than the wet season. Both schoolchildren and adult respondents stated consuming bushmeat more frequently during the dry season than the wet season. The explanation for this differnece likely includes the migration of wildebeests and other herbivores which increase their range searching for food and water during the dry season (Holmern et al., 2006; Holmern et al., 2007). Variation in resources availability influenced by seasonal changes is the main reason for the animal migration (Sinclair et al., 2015) and they often move outside protected areas during this

migration. During the dry season, the animals experience food and water shortage and therefore expand their range searching for drinking water and green pasture. This provides the opportunity for hunters to access the animals and therefore increases the availability of bushmeat for household consumption in adjacent villages (Rentsch and Packer, 2015).

Previous studies have also found that illegal hunting is mostly practised during the dry season with high peaks from August to November, following the migration routes of wildebeest and zebra (Loibooki et al., 2002). The high rate of illegal hunting is also facilitated by the increased openness and right weather conditions during the dry season as well as lack of farming activities which occurs mostly in the wet season. The large harvest of wildebeest is associated with their abundance (Holmern et al., 2006) and migration behaviour, both of which make them more available compared to other herbivores (Sinclair et al., 2015). The consumption of bushmeat was low during the wet season which is mainly due to the low availability of migratory herbivores. During this time, the resident herbivores are the primary source of bushmeat (Rentsch et al., 2015). Also, people were busy with farming activities and therefore had less surplus labour to invest in bushmeat hunting (personal communication, April 26, 2018). This also explains why both children and adults consume domestic meat more frequently during the wet season in Robanda. However, the consumption of other meat types particularly fish was also low in the wet season which may be attributed to poor infrastructure and roads being inaccessible during heavy rain hindering the transportation of fish, including sardines (Nyahongo et al., 2009). Furthermore, during the wet season households experience low income since it is not yet harvest time which is the main source of cash income for most people in the area (personal communication, April 30, 2018).

Hypothesis 2: Bushmeat consumption frequency decrease with increasing distance from protected area boundary

Bushmeat was consumed more frequently by both adults and children in the closest village compared to the intermediate and the distant villages. In Western Serengeti, bushmeat is consumed regularly by 45 to 60% of households according to a recent study (Rentsch and Packer, 2015). In the closest village, Robanda households consumed bushmeat on average five times per week in the dry season and two times per week in the wet season (Figure 2). Previous studies conducted in villages adjacent to the western part of the Serengeti ecosystem have also found that closer villages consume more bushmeat than distant villages (Fischer et al., 2014; Nyahongo et al., 2009). This indicates that adjacent communities relies more on bushmeat as a source of meat protein which may offset some of the disadvantages of limited land for expansion and high rates of crop damage and livestock depredation experienced by people living adjacent to wildlife areas (Bitanyi et al., 2012; Galvin et al., 2008).

Furthermore, the closest villages consume more bushmeat than distant villages because it is easy for illegal hunters to access the animals (Holmern et al., 2002). Consuming bushmeat is a part of the culture of most ethnic groups especially those who live close to wildlife areas in Western Serengeti (Knapp et al., 2017). Since bushmeat consumption is a tradition and has cultural values (Kideghesho, 2008), these people tend to use any means to obtain bushmeat for their households especially the Ikoma (Mfunda and Røskaft, 2010). Even during the wet season where the availability of migratory herbivores is low, they hunt resident herbivores (Rentsch et al., 2015) despite the difficulties associated with hunting in the wet season. The distant villages were obtaining bushmeat from hunters through the bushmeat trade (Mwakatobe et al., 2012). However, the recent increased focus on law enforcement has increased the likelihood of being fined for trading bushmeat and also increased the penalty. Perhaps, as a result, the frequency of bushmeat consumption in the distant villages Kowak and Rwamkoma was found to below. Hence, the results support Hypothesis 2.

Hypothesis 3: Children report higher bushmeat consumption frequency than adults

Contrary to schoolchildren, adults reported very low consumption frequency in the intermediate and distant village. In the closest village Robanda, both schoolchildren and adult respondents reported higher bushmeat consumption than in distant villages. Despite similar trends in consumption frequencies, schoolchildren reported significantly higher bushmeat consumption than adult respondents in both seasons (Figure 2). Similar differences were observed for other meat types suggesting that children generally report higher consumption frequencies than adults. Depending on responsibilities household heads may fail to recall the details of the meals consumed in the household. Most households were headed by men who typically are less involved in food preparation compared to women and children and therefore may be less inclined to recall the particular meat type although they eat the same.

Another explanation may stem from the difference between the surveys. Adults were asked to recall their meat consumption over the duration of a week introducing recall bias. Schoolchildren, on the other hand, were asked to recall their meat consumption within only the past 24 hours (except for the weekend) and may have been more engaged in the exercise being unaccustomed to this level of attention. Previous studies of illegal bushmeat hunting in the Serengeti have also noticed that adult respondents provide less information through questionnaire surveys compared to other methods(Rentsch et al., 2015). It is commonly observed

that adult respondents behave strategically and may provide less or incorrect information about their activities and income for fear of reprisal or to escape taxation (van Vliet et al., 2015). Some people may also exaggerate their need for assistance to be considered for assistance from the government or NGOs. However, there appears to be no logical reason why schoolchildren should exaggerate the frequency of bushmeat consumption and consumption of other meat types in their household. Hence, the results support Hypothesis 3 and suggest that children may provide more accurate information about household bushmeat consumption than adults.

Hypothesis 4: Bushmeat consumption frequency is associated with socioeconomic and other characteristics

As expected, the model revealed that bushmeat consumption frequency was significantly associated with respondent group, season and distance to the protected area boundary. Also, the consumption of domestic animal meat and fish significantly influenced the frequency of bushmeat consumption. However, contrary to expectations household size had no significant influence on bushmeat consumption suggesting that large and small households are equally reliant on bushmeat. Similarly, the occupation of the household head, whether or not he or she held employment or managed a small-scale business as an indicator of wealth had no significant influence on bushmeat consumption frequency. The majority of people in Western Serengeti depends on small-scale agriculture and has been characterised as poor (Loibooki et al., 2002). This implies that bushmeat is more important for poor households whose economy depends on small scale agriculture than the relatively fewer people who depend on employment and small-scale business.

Fish typically sardines (small sun-dried fish) were consumed more frequently than the other meat protein types in both seasons. Although sardines were consumed in the village closest to the protected area boundary where the availability of bushmeat is high, its consumption increased with distance to the boundary. Sardines were consumed frequently in villages far from the PAs, where bushmeat is less available and expensive. However, the more distant villages are also located relatively closer to Lake Victoria which is the main source of fish in the region. Sardines were the most affordable meat protein source in the area where many people are poor, and alternatives such as domestic meat and other fish are relatively expensive (Kiffner et al., 2015, Ndibalema and Songorwa, 2007). The consumption of domestic meat did not vary significantly with distance from the protected area boundary for either school children or adults. Domestic animal meat is the most expensive of the types of meat accessed. Furthermore, there were no sign of butchers selling beef but only rather few groceries selling roasted goat meat with beer, which usually is considered a luxury good.

Conclusion

The results reveal that bushmeat is an important source of meat protein and hence food securities particularly to households in villages close to protected areas and in the dry season. Enhancing the production and increasing the availability of cheap alternative sources of meat protein is recommended in order to reduce dependence on bushmeat. An increase in fish production can help to reduce the dependence on bushmeat (Brashares et al., 2004). Sardines may be the most appropriate alternative meat type because it can be obtained from nearby Lake Victoria. The results hence suggest subsidising an increase in the availability of sardines in villages located close to wildlife areas although concerns has been raised about the impact on fish stocks (Rentsch and Damon, 2013). Alternatively, the feasibility of fish farms should be tested with the help from the local government in order to increase the supply of fish near villages like Robanda that are far from Lake Victoria. The study also suggests that the use of schoolchildren at the age of 9 to 12 as informers can generate information on bushmeat consumption that may be more reliable than information obtained from adults. This may be the result of this age group not yet being cognisant about the illegality of bushmeat hunting and therefore less likely to respond strategically than adults.

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CONFLICT OF INTERESTS

The authors declare that there is no conflict of interests regarding the publication of this paper.

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