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Local People Knowledge on Bushmeat Hunting in the Serengeti Ecosystem: A Case Study of Topi (Damaliscus lunatus)

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Natural Resources Management
Submission date: May 2017
Supervisor: Eivin Røskaft, IBI

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Declaration

I declare to the Norwegian University of Science and Technology (NTNU), that this is my own work. Thus, findings of this work are the result of my field work which I did in the villages bordering eastern and western Serengeti ecosystem and no part of it has been submitted in this university or any university elsewhere, apart from the works of others that I have appropriately acknowledged and referenced.

Damari Samwel Nassary

Dedication

I dedicate this work to my beloved father (Samwel Nassary) and mother (Grace Samwel). Many thanks for your encouragement throughout my life and academic journey. I love you all.

Acknowledgements

First and foremost, my heartfelt thanks to my parents who have always been my hero and motivation in my academic life. I also express my appreciation to my beloved husband, Elirehema Silaa for his love, endurance, support and encouragement while I was away for studies. My sons Brian and Brandon have always been my reasons for working hard during my two years of studies.

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I thank the local leaders from Olosokwan, Soitsambu, Mwabayanda and Robanda villages who kindly contributed their time and expertise to guide me during the field work and the local people who devoted their time to respond to the inquiries.

To reader, please note that the author remains solely responsible for any shortfalls in the structure and content of the work.

Abstract

Illegal harvesting is considered the most significant threat to biodiversity in conservation in Africa. The Serengeti National Park (SENAPA), Tanzania, is facing a similar problem since its establishment in the 1950s. Wildlife populations are being reduced through illegal hunting, causing local extinction of some species in the SENAPA. Illegal hunting is mainly due to poverty as a result of human population increase. Knowledge of wildlife and bush meat hunting among the local communities living in the Serengeti and Busega districts to the west of SENAPA and the Ngorongoro district to the east were examined. Questionnaires were employed to acquire information from 200 randomly selected respondents within four villages bordering the park. Results indicate that communal knowledge of wildlife and bushmeat hunting were significantly affected by gender, tribe and age. Furthermore, tribes living in the western part of the ecosystem and women in general had a more limited knowledge of wildlife. However, older people and those tribes from the western Serengeti reported to consume more topi meat compared to eastern tribes. Most of male respondents from Maasai tribe indicated high percentage on explaining the presence of topi in their area. Methods used to obtain topi meat differs, with tribes living in the western Serengeti ecosystem using more snares while those from eastern part prefer use of bows and arrows. The degree of knowledge on wildlife does not reflect community members' involvement in illegal wildlife use, as most of those with high knowledge on wildlife were from the eastern part where there is limited illegal wildlife hunting. There is a need for improved conservation education programs as well as delivery of alternative sources of protein such as fish, beef, chicken coupled by fair prices that can compete with lower prices of bushmeat. Nonetheless, well-funded anti-poaching patrols may be a more effective way to deter bushmeat hunting.

Keywords: Serengeti ecosystem, bushmeat, wildlife, local knowledge, tribe, gender.

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List of abbreviations

NO	Abbreviation	Meaning
1	TANAPA	Tanzania National Parks
2	SENAPA	Serengeti National Park
3	URT	United Republic of Tanzania
4	TAWIRI	Tanzania Wildlife Research Institute
5	CIMU	Conservation Information and Monitoring Unit
6	LGCA	Loliondo Game Controlled Area
7	IUCN	International Union for Conservation of Nature
8	NCA	Ngorongoro Conservation Area
9	GR	Game reserve
10	PA	Protected area
11	NTNU	Norwegian University of Science and Technology

1.0 Introduction

1.1Background

Wildlife resources play a major role in supporting communities economic livelihood in many biodiversity rich areas of the world (Rao 2002). Across Africa and Asia, many people eat bushmeat for cultural or personal reasons, even when they have easily available alternatives sources of food (Bennett 2002). Consequently, people believe that bushmeat has less fat and greater amount of edible protein per unit of live weight than domestic animals (Ledger et al. 1967). Bushmeat has always provided a secure protein source for rural people of Africa (Ndibalema and Songorwa 2008), and nowadays, illegal off-take of wildlife is still sustaining many of the essential requirements of humans needs (Loibooki et al. 2002, Holmern et al. 2006).

Humans have had tremendous negative effects on ecosystems worldwide; with the use of advanced tools they have affected their natural environment. Recently illegal off-take of wildlife for commercial purposes has accelerated threats to biological diversity, in particular herbivores (Loibooki et al. 2002, Bitanyi et al. 2012). Bushmeat is a source of protein for people's diet and also a source of income to local communities living adjacent to protected areas in many African countries (Mwakatobe et al. 2012). As a result bushmeat hunting is considered as a potential threat to wildlife populations (Ndibalema and Songorwa 2008).

Due to the expanding human pressure within the ecosystem and the continued utilization of bushmeat off take, illegal hunting has been regarded among the most serious threats to wildlife in this ecosystem (Sinclair et al. 2015). According to human population censuses, over the last decade, in all districts surrounding the Serengeti ecosystem on the Tanzanian side, the population has almost doubled (URT 2012). Immigration is thought to be the main accelerator for the growth and caused by utility of fertile lands and potential for illegal harvesting (Loibooki et al. 2002, Sinclair et al. 2015).

Previous studies indicated that hunting was mostly for meat (subsistence), but nowadays it is thought to be for commercial purposes (Stuart et al. 1990, Rentsch and Damon 2013). Generally, bushmeat is cheaper and thought to be more delicious than domestic meat; therefore, it is particularly accessible and in great demand to both poor and middle class households (TRAFFIC 1998). Studies have shown that there is an alarming increase in harvesting rates of less abundant

herbivores such as buffalo (*Syncerus caffer)* (Dublin et al. 1990), giraffe (*Giraffa camelopardalis*), impala (*Aepyceros melampus*), topi (*Damaliscus lunatus*) (Campbell and Borner 1995, Hofer et al. 1996, Holmern et al. 2006) and even the resident wildebeest (*Connochaetes taurinus*) in parts of their ranges. Snaring, which is the most common illegal hunting method, has one of the most severe impacts on wildlife because of its unselective nature, it kills endangered, pregnant or juvenile animals and in most cases leaving them severely wounded but still living (Becker et al. 2013).

Currently, a major problem facing wildlife conservation in SENAPA has been the illegal harvesting of its resident and migratory herbivores (Sinclair et al. 2015). The condition is gradually becoming worse in the western edge of the SENAPA in the districts of Serengeti, Bunda, Magu, Bariadi, Tarime, Maswa and Meatu with very high human population growth rates (URT 2012). Ultimately, the population of resident herbivores has been reduced by illegal harvesting, moreover, the populations of non-targeted species have also been negatively affected by the illegal harvesting because most of the hunters use unselective methods when capturing wildlife (Holmern 2007, Nyahongo 2010). In SENAPA, approximately 82% of the surrounding communities consume bushmeat and 32% are engaged in bushmeat hunting (Loibooki et al. 2002). Bushmeat in some other ecosystems like Katavi (Mgawe et al. 2012) and Udzungwa (Rovero et al. 2010) have been reported to play a great role in the livelihoods of the rural communities surrounding such protected areas. The consumption for wild animal species depends mostly on location, habitat type and availability of the species in the local market (Barnett 2000).

1.2 Justification

Illegal harvesting of bushmeat is a major problem for conservation of wildlife populations in the world. Poaching threatens not only big games, but also local fish and plant populations (Muth and Bowe Jr 1998). Understanding why people poach, prefer or consume bushmeat is critical in order to design appropriate ways to manage wildlife and thus, halt unsustainable exploitation (Bitanyi et al. 2012, Mwakatobe et al. 2012, Rentsch and Damon 2013). Barnett (2000), reported that 34.3% of bush meat traders in the area rely on illegally acquired wild meat as their sole source of income and also that 75% of arrested hunters are hunting for cash or trade (Campbell et al. 2001).

Today in the Serengeti ecosystem, poaching of wildlife species is rampant outside the SENAPA due to seasonal migration of wildebeest, which increases poaching pressures to other species. More information is available in western Serengeti due to presence of villages within the vicinity of protected areas and different forms of protected area management (Kideghesho et al. 2006, Lowassa et al. 2012)

Regarding distribution of this illegal activity, Loibooki et al. (2002) and Holmern et al. (2002) reported that it is concentrated in the western boundary of the ecosystem where human density is high; however, larger parts of the eastern side have been ignored because Maasai tribe have access to bushmeat but they don't use it due to their traditional belief (Ceppi and Nielsen 2014). Because of such differences in illegal hunting among the western and eastern part of the Serengeti ecosystem, little information is available for comparing the severity of illegal hunting and also the population of topi has been in decline over the past years and little information is available on the consumption of this species by local communities. Increased illegal wildlife harvest can cause long term effects on topi as well as negatively change community attitudes with lack of knowledge on conserving such species. This study aims to test if there is any difference in illegal hunting methods, preferences related to over use of resources by people and wildlife knowledge of topi between different ethnic groups in the western and eastern parts of Serengeti ecosystem to acquire better understanding of the conservation challenges facing conservation of this species in the Serengeti ecosystem.

1.3 Objectives and hypotheses

The objective of the study was to test local knowledge of bushmeat between different ethnic groups in the eastern and western parts of the Serengeti ecosystem using topi as case study species. In line with this objective, this study is set out to test the hypotheses described below:

1) Maasai and Sonjo tribes in the eastern Serengeti are more knowledgeable and able to identify topi more frequent on a photo card than Ikoma and Sukuma tribes in the western Serengeti (Hypothesis 1). This hypothesis has been supported by other studies that concluded that, different tribes prefer certain bushmeat species of whose identification must be important (Ndibalema and Songorwa 2008, Mfunda and Røskaft 2010, Mwakatobe et al. 2012, Clamsen Mmassy and Røskaft 2013).

2) Several studies have confirmed high levels of illegal off take in western Serengeti by the local tribes in this area (Holmern et al. 2002, Loibooki et al. 2002, Mfunda and Røskaft 2010, TAWIRI 2010). Therefore, I hypothesize that fewer people from the eastern Serengeti (Maasai, Sonjo) have tested topi meat compared to those from the western Serengeti (Ikoma, Sukuma).
3) Lastly, hunters have a variety of methods for the extraction of bushmeat from the wild, including trapping, snaring, netting, use of dogs and shooting (Carpaneto and Fusari 2000, Lowassa et al. 2012, Mwakatobe et al. 2012); with this regard, I hypothesize that hunting methods differ between tribes from eastern and western Serengeti.

2.0 Material and Methods

2.1 Study species

Topi are found in Africa, ranging from Senegal to Somalia and South Africa (IUCN 2016). There is no evidence that an overall decline has reached the 20-30% level over three generations 1988-2008 (20 years) that would justify a near threatened or vulnerable status (IUCN 2008). However, topi is threatened by hunting for meat and grazing competition with cattle. They are estimated to be around 93,000 individuals in Africa with over 90% in areas with reasonably good protection (IUCN 2008). Most remaining populations are known to be or believed to be declining. The topi is a polytypic species with the following subspecies; Korrigum (*D. l. korrigum*); Tiang (*D. l. tiang*); Coastal Topi (*D. l. topi*); Topi (*D. l. jimela*); and Tsessebe (*D. l. lunatus*). They are categorized by IUCN as a Least Concern species (IUCN 2016).

Topi is a medium sized antelope which stands about 1.25m shoulder with long, narrow face and a sloping back. It is sexually dimorphic (male weigh 111-147kg, female weigh 90-130kg). Topi is homeomorphic, i.e., both sexes have lyre shaped/recurved and ridged horns measuring up to 60cm, and the average female body mass weigh 12% less than a male (Ford and Blakeman 1991). The northern sub species is different from the southern, the former inhabit arid areas and have more extensive seasonal movements (Duncan 1975). Topi (Figure 2) is among the Serengeti ecosystem resident ungulates. In this study, topi is used to assess its illegal harvesting status in the Serengeti ecosystem. Being grazers, they prefer open wooded grasslands (Estes 1991). Breeding strategies for topi differs with habitat type with some having permanent male

territories, temporary male territories and some using a mobile lek system (Foley et al. 2014). The topi is gregarious and live in herds of 15 to 20 individuals; however, it can be seen in herds of hundreds. In some areas of the Serengeti ecosystem, the topi has large territories, defended by both sexes. The species are most active in the morning and evening hours. They fall as prey to lions (*Panthera leo*), leopards (*Panthera pardus*), cheetahs (Acinonyx jubatus), spotted hyenas (*Crocuta crocuta*) and African wild dogs (*Lycaon pictus*). Calves are also vulnerable to jackals (*Canis spp.),* servals (*Leptailurus serval*), caracals (*Caracal caracal*), pythons (*Python sebae*) and large eagles (Bro-Jørgensen 2002, URT 2009).

In Tanzania, topi is mainly restricted to the northern and western parts of the country. They are mostly found in the Serengeti ecosystem predominantly the central, northern, south eastern and western sectors of SENAPA. They avoid the short grass-plains in the south. There are few isolated records of their presence in the west of Ngorongoro Conservation Area (NCA), Loliondo Game Controlled Area (LGCA) and Maswa Game Reserve (MGR) (Foley et al. 2014). According to (TAWIRI 2010) census estimates shows that their populations in Serengeti ecosystem have been greatly declining over a period of 19 years (Figure 1), however, according to administrative areas within the ecosystem SENAPA has the highest population size (Table 1).

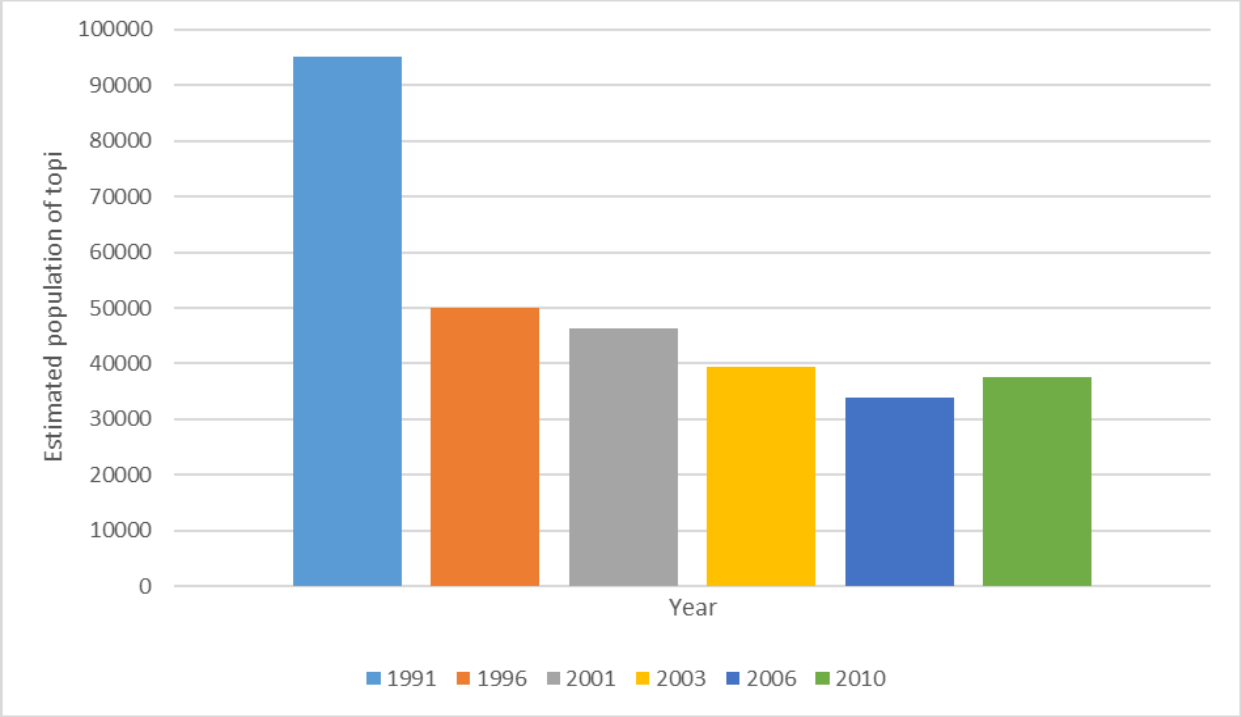

Figure 1: *Topi estimates in Serengeti ecosystem between 1991-2010 (SOURCE: TAWIRI 2010)*

Table 1: *Population estimates of topi in the Serengeti ecosystem according to administrative areas (SOURCE: TAWIRI 2010)*

Year	ADMINISTRATIVE AREAS					
	Serengeti National Park	Ngorongoro Conservation Area	Loliondo Game Controlled Area	Grumeti Game Reserve	Ikorongo Game Reserve	Outside Protected Areas
2001	38554	366	930	11661	249	634
2006	21171	NA	942	3360	1053	7466
2010	35512	NA	1104	510	NA	532

Figure 2: *Group of topi in the Serengeti National Park (Photo: E. Røskaft)*

2.2 Study area description

The study was conducted in the Serengeti ecosystem, in villages bordering western and eastern Serengeti. The Serengeti ecosystem with an area of about 25,000 km^2, is situated between latitudes 1^0 28' and $3^0$17' S and longitudes $33^0$50' and 35^0 20' E (Kideghesho 2006), and is defined by the movement of wildebeest migration (Homewood et al. 2001, Roe et al. 2009). The eastern boundary is formed by the crater highlands and the rift valley. Western Corridor is referred to as an arm stretch west to Lake Victoria. According to Marealle et al. (2010) Isuria escarpments and Loita plains in Kenya forms the northern boundary. The region contains SENAPA, Ngorongoro Conservation Area (NCA), and several game reserves which includes Maswa Game Reserve, Kijereshi Game Reserve, Ikorongo and Grumeti Game Reserves all of which are in Tanzania as well as Maasai Mara National Reserve in Kenya (Kideghesho et al. 2005).

The SENAPA is the central part of the Serengeti ecosystem in the northern Tanzanian highlands. In 1951 Serengeti was declared as a national park, and a World Heritage Site in 1981 and it covers an area of 14,763 km^2 (Figure 3). This part of the ecosystem hosts the largest terrestrial mammal migration in the world, which makes it as one of the Seven Natural Wonders of Africa (TANAPA 2013). The Serengeti is also renowned for large-scale herbivore migrations, wildebeest, Thomson's gazelle (Eudorcas thomsonii), zebra (Equus quagga burchellii) and eland (Tragelaphus oryx), as well as for the large populations of resident herbivores (African buffalo, giraffe, Grant's gazelle (Nanger granti), impala, hartebeest (Alcelaphus buselaphus), topi, warthog (Phacochoerus africanus), and waterbuck (Kobus ellipsiprymnus). Considerable populations of large carnivores including lion , leopard, cheetah, and hyenas also roam these areas (Sinclair and Arcese 1995). The Serengeti ecosystem is a highland savannah region with thorn free woodlands and plains from approximately 900–1500 m above sea level.

Climatically, the ecoregion falls within the seasonal tropics. The annual mean rainfall for the ecosystem ranges from 1,050 mm in the northwest to 550 mm in the southeast (Sinclair et al. 2000). The people in this region are agro-pastoralists or pastoralists. The area in the west of SENAPA is populated by various tribes and ethnic groups; the main tribes being Ikoma, Sukuma, Taturu, Issenye, Kurya, Ikizu and Natta. In east of the park the population is dominated

by pastoralists (Maasai, who do not participate in hunting) and farming is very little practiced in this area (Sinclair et al. 2015).

3.0 Data collection

The study was carried out between June and August 2016, which encompasses the end of the wet season and beginning of the long dry season in the Serengeti ecosystem. Both in the eastern and western Serengeti ecosystem local communities were involved. Primary data was obtained through a questionnaire survey in the selected four villages namely; - Soitsambu and Ololosokwan in the east and Robanda and Mwabayanda in the west. The villages were selected with the main criterion being that the village should be located less than ten kilometers from SENAPA boundary and on the notion that people close to it are aware of the illegal events, law enforcement and have direct connection with the investigated species. Moreover, the villages were selected based on the nature of major economic activity of residents in particular villages, those that are pure pastoralists (Maasai) in the eastern Serengeti and those that are agro pastoralist in the western Serengeti. In the east, the majority 87% of the tribes were Maasai, in Robanda 88% were Ikoma and in Mwabayanda 74% were Sukuma, therefore in the further analysis I used tribe as the most important ethnic variable.

Thereafter, face to face interview with both open and close ended questions were used to obtain the required information from the respondents (Appendix I). Purposive sampling (Gandiwa et al. 2014) was employed. Prior to the interview, the main purpose of the study was explained to the village authorities. Permission for conducting interviews was then granted. For this study, the household was regarded as a sampling unit. Respondents above 18 years old were assigned numbers obtained from the village register book. Each number was written on a piece of paper, folded and placed inside a box from which 50 respondents were randomly picked for interview. Any member of the house who was above 18years old or above was interviewed during the survey if the head of the family or wife was not present. The purpose of this was to reduce the biasness in the selection of households and to make sure that the sample was representative (Bryman and Cramer 2002, Wapalila 2008). The interview was conducted under the assistant of local leaders. The respondents (father or mother) were asked to give information about their family background, socio-economic activities, sources of income, knowledge about topi, major source of protein, frequency of eating major protein food, the way they obtained their protein,

whether they have tested topi, availability of topi, methods used to hunt and possession of hunting license (Appendix I).

The information recorded included the socio-demographic variables (tribe, age, gender, education level, occupation and wealth) and the knowledge and utilization of topi as a source of protein, the mechanisms used to obtain it and whether topi are still available in their area. The questionnaires were prepared in English language and thereafter they were translated into Swahili language during interview. Also, the study collected secondary data from published articles and unpublished reports from Park management (SENAPA Law Enforcement Unit), Game reserve management (Grumeti) and Tanzania wildlife research institute in Conservation Information and Monitoring Unit (TAWIRI-CIMU).

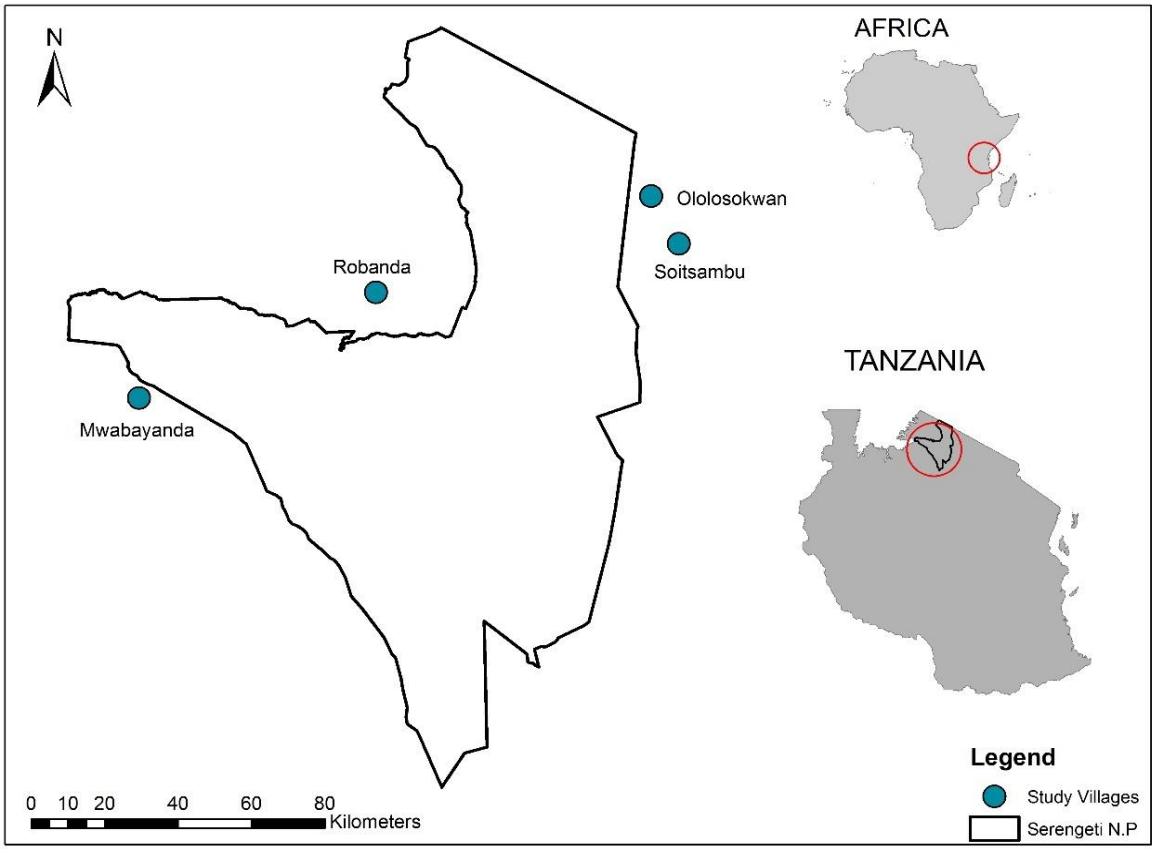

***Figure 3**: Map of Serengeti National Park showing park boundaries and surveyed villages. On the top right corner is the map of Africa with Location of Tanzania and the location of Serengeti National Park in Tanzania at the bottom right corner*

3.1 Data analysis

Statistical analyses were conducted using Statistical Package for Social Sciences (SPSS version 24, Chicago, USA) to analyze the data. Descriptive statistics was used to summarize the questionnaire response data. Since most of the data were categorical, Pearson's chi-square analyses was performed to determine the differences in the independent variables that explain knowledge of the community about topi, consumption and methods used in hunting. Furthermore, logistic and linear regression analyses were used to determine the factor that contributed most to statistical significance in relation to dependent variables such as gender, age, education level, occupation and tribe. All statistical tests were two-tailed and significant level was set at $P < 0.05$.

3.2 Respondents' demographic information

Of the 200 respondents, majority were males (74.5%). Most of the respondents (41%) were youths, followed by adults (39%) and elders (20%). The tribes of the respondents were the Maasai (43.5%) and Ikoma (22%), Sukuma (20%), Sonjo (2.5%) and others (12%). The main economic activities identified in the study area were pastoralism (44%) and farming (40.5%). Other activities include business and employment (formal/informal sectors) which accounted for 15.5%. About 47% of the respondents had primary school education, 32.0% had secondary education and above while 21.0% had never been to school. Majority of respondents (83%) were born in the same villages whereas 13.0% had migrated in the villages more than 5 years ago looking for farms to cultivate, while 3.0% had been in the villages between two and five years because of employment. Only 1.0% had lived in the villages for less than a year due to being married in the area.

4.0 Results

4.1 Local people knowledge of topi

The Maasai tribe showed statistically significant differences in identifying the topi (93.1%) from the photo card as compared to other tribes ($\chi^2 = 44.99$, df = 4, $P < 0.0001$). Significantly more males than females identified topi correctly from the photo card ($\chi^2 = 12.8$, df = 1, $P < 0.001$). Conversely, age ($P = 0.088$) and education level ($P = 0.898$) had no effect on respondents' ability to identify topi.

A logistic regression analysis with a question on community knowledge on topi identification (yes, no) as the dependent variable and with tribe and gender as independent variables was significant ($r^2 = 0.218$, Wald $\chi^2 = 27.3$ df = 1, $P < 0.001$). Both tribe (Wald $\chi^2 = 19.8$, df = 1, $P < 0.001$) and gender (Wald $\chi^2 = 6.8$, df = 1, $P = 0.009$) were statistically significant demographic independent variables in explaining this variation.

4.2 Local people perception on Topi presence/absence in their areas

Generally, Maasai tribe respondents acknowledge that topi is still present in their area (90.8%) at high rate compared to other tribes ($\chi^2 = 62.7$, df = 8, $P < 0.0001$). Furthermore, statistically significantly more male than female thought that topi's are still present in their vicinity ($\chi^2 = 34.8$, df = 2, $P < 0.001$). Additionally, youth (69.5%) showed statistically significant difference that topi are still present in their areas as compared to elders and old people ($\chi^2 = 18.6$, df = 4, $P = 0.001$). However, education ($P = 0.401$) was not significant.

Using a linear regression model with method enter to the questions with topi availability within their areas as a dependent variable and with tribe, age, and gender as independent variables was statistically significant ($F = 16.924$, df = 3, and $P < 0.0001$, $r^2 = 0.206$). Both gender ($t = -4.853$, $P < 0.001$) and age ($t = -4.189$, $P < 0.001$) were statistically significant demographic independent variables in explaining this variation (Table 2).

Table 2: *A linear regression analysis with availability of topi in their area (yes, no and I don't know) as the dependent variable, and with gender, age and tribe as independent variables*

Dependent variable	**Independent variables**	**Unstandardized Coefficients**			**T =**	**P =**
		B	**Std. Error**	**β**		
Topi availability	Constant	1.675	.138		12.125	.000
	Gender	-.411	.085	-.317	-4.853	.000
	Age	-.205	.049	-.272	-4.189	.000
	Tribe	-.031	.028	-.074	-1.103	.271

$R^2 = 0.194$

4.3. Consumption of topi meat

Statistically significant more people aged above 50 years had consumed topi meat (75.0%) than other age class ($\chi^2 = 29.137$, df = 2, $P < 0.0001$). Furthermore, statistically significant difference was found among tribes; Ikoma (81.8%), Sukuma (55%), Sonjo (40.0%), Maasai (23.0%) and others (54.2) ($\chi^2 = 43.2\%$, df = 4, $P < 0.0001$). Also, education differed statistically significantly where those with primary education (55.9%) had consumed topi meat more than those with no education (32.1%) and with secondary education and above (11.8%). However, gender ($P = 0.29$) was not significant.

A logistic regression analysis with topi meat consumption (yes, no) as the dependent variable and with age, education and tribe as independent variables, proved that both tribe (Wald $\chi^2 = 6.854$ df = 1, $P < 0.009$) and age (Wald $\chi^2 = 14.057$ df = 1, $P < 0.0001$) contributed significantly in explaining this variation.

4.4 Illegal hunting methods

There were statistically significant differences on the used weapons in obtaining topi meat about 63.2% of Maasai claimed that they used arrows. However, Sukuma people (72.5%) claimed to use snares than other tribes in the western parts ($\chi^2 = 94$, df = 16, $P < 0.0001$; Table 3).

Table 3: *Percentages of respondents regarding types of weapons that are used to kill topi with respect to tribes found in Serengeti ecosystem*

Types of weapon	**Respondents percentages (%) shown by different tribes (N=200)**					**Total**
	Maasai	Sukuma	Ikoma	Sonjo	Others	
I don't know	4.60	0.00	0.00	0.00	4.20	2.50
Arrow	63.20	20.00	22.70	80.00	25.00	41.50
Snare	5.70	72.50	65.90	20.00	66.70	40.00
Gun	4.60	7.50	6.80	0.00	4.20	5.50
Others	21.80	0.0	4.50	0.00	0.00	10.50
Total	100.00	100.00	100.00	100.00	100.00	100.00

Also, age differed significantly with those aged above 50 years using more snares (60%) while those aged 19-35 years uses arrow (50%), (χ^2 = 18.8, df = 8, P = 0.016). However, gender (P = 0.19) and education (P = 0.59) were not significant.

A linear regression analysis with type of weapon used to kill topi as the dependent variable with tribe and age as independent variables (Table 4), turned out that no significant contribution to explain the variation was found with respect to tribe (P = 0.35) and age (P = 0.28).

Table 4: *A linear regression analysis with type of weapon used to kill topis as the dependent variable with tribe and age as independent variables*

Dependent variable	**Independent variables**	**Unstandardized Coefficients**			**T =**	**P =**
		B	**Std. Error**	**β**		
Types of weapon	Constant	1.837	0.279		6.576	0
	Tribe	0.071	0.075	0.068	0.946	0.345
	Age	0.205	0.134	0.11	1.532	0.127

R^2= 0.02

Ikoma tribe (43.2%) obtained topi meat by hunting followed by Sonjo (40.0%), Sukuma (22.5%), Maasai (8%), and others (33.3%) (χ^2 = 47.9, df = 8, P < 0.0001). About (26.2%) of males hunted by themselves while only (11.8%) of the females did so (χ^2 = 12.5, df = 2, P = 0.002).

Furthermore, education contributed to the difference where those with primary education (29.8%) obtained topi meat through hunting by themselves followed by those with no education (21.9%) and those with secondary education and above (7.1%) (χ^2 = 11.8, df = 4, P = 0.019). Those aged above 50 years obtained topi meat through hunting by themselves followed by 36-50 year (21.8%), and 19-35 years (13.4%), and this contributed to the significant difference (χ^2 = 31.8, df = 4, P < 0.001).

A linear regression analysis with method used to obtain topi meat as the dependent variable and with gender, tribe, education and age as independent variables, was statistical significant (F = 8.749, df = 4, and P < 0.0001), both age and tribe were statistically significant (Table 5). Gender (P = 0.07) and education (P = 0.86) was not significant.

Table 5: *The results of a linear regression analysis with methods used to obtain topi meat as the dependent variable with gender, tribe, education and age as independent variables*

Dependent variable	**Independent variables**	**Unstandardized Coefficients**			**T =**	**P =**
		B	**Std. Error**	**β**		
Methods used	Constant	-0.408	0.299		-1.364	0.174
	Gender	0.238	0.13	0.125	1.831	0.069
	Tribe	0.084	0.043	0.136	1.955	0.052
	Education	0.015	0.082	0.013	0.181	0.857
	Age	0.336	0.079	0.305	4.238	0.000

R^2= 0.135

4.5 Origin of Poachers

There was a highly significant difference in the mean number of poachers arrested per year covering 12 (2002-2015) years period in the Serengeti ecosystem (ANOVA, F = 42.950, df = 2 & 36, P < 0.0001; Table 6).

Table 6: *Annual mean number of poachers arrested per district*

Numbers of poachers per district				
District	**Area (km2)**	**N-years**	**Mean**	**SD**
Serengeti	10,942	**13**	367	142.8
Bariadi	9,777	**13**	166	82.4
Ngorongoro	13,460	**13**	23	20.3
Total	34,179	**39**	186	171.7

There was no significant correlation between number of arrested poachers and year for each of the districts (Serengeti r = 0.03, NS; Bariadi r = 0.211, NS; Ngorongoro r = -0.031, NS) indicating that poachers were arrested well in the study area over 12 year's period (Figure 4).

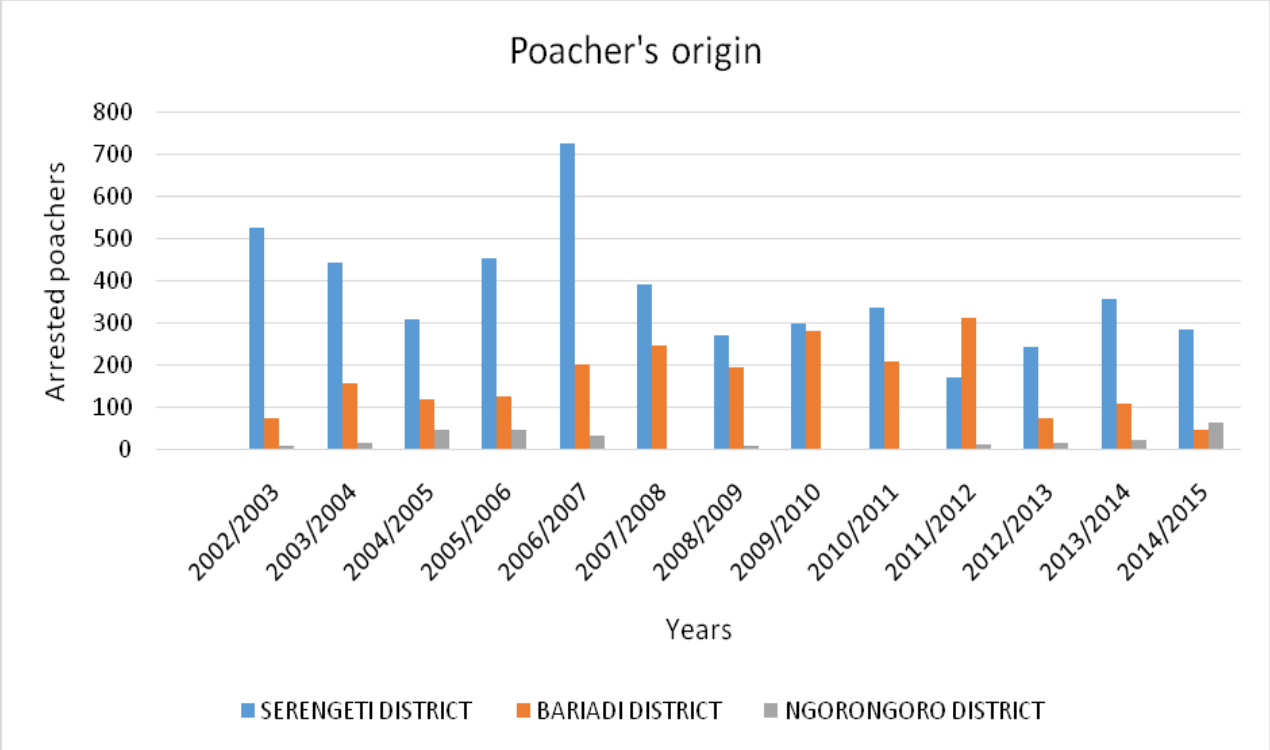

Figure 4: *Number of poachers seized in SENAPA over a period of 12 years and the areas they were arrested; (SOURCE: SENAPA LAW ENFORCEMENT UNIT 2016)*

5.0 Discussion

5.1 Knowledge of topi

The Maasai tribe were more knowledgeable in identifying the topi on a photo card compared to other tribes (Ikoma, Sonjo and Sukuma) residing in the Serengeti ecosystem. Furthermore, males were also more knowledgeable about topi than female respondents. The most probable reason why the Maasai respondents were more knowledgeable is that within the eastern part of the Serengeti ecosystem, the Maasai is more engaged in ecotourism activities, thus they might increase knowledge exchange with tour guides and campsite operators/staff on wildlife utilization. Secondly, the Maasai traditional nomadic lifestyle of using a large area all year round have increased their close contact with different wildlife species, including topi, while grazing their livestock as they mostly live inside the game controlled area. Similarly, Clamsen Mmassy and Røskaft (2013) reported the high wildlife knowledge of the Maasai tribes in the same ecosystem, which concurred this study.

Differences in gender knowledge as found in this study are attributed by cultural norms among the tribes that were interviewed. Both in pastoral or agro-pastoral communities, women are not allowed to give information to strangers in the presence of men, this is the reason why more males responded to the questionnaire as compared to female during the survey, which corroborated to earlier studies (Kaltenborn et al. 2006, Ndibalema and Songorwa 2008, Mwakatobe et al. 2012, Allendorf and Allendorf 2013, Clamsen Mmassy and Røskaft 2013, Nombo et al. 2015, Lyamuya et al. 2016) Division of labour between males and females have been previously reported in activities conducted within the same ecoystem (Mwakatobe et al. 2005).

We suggest that in order to eliminate such gender bias within pastoral and agro-pastoral communities future studies should focus on equal number of respondents between males and females. However, the findings support the hypothesis that the Maasai tribe in the eastern Serengeti are more knowledgeable and able to identify topi more frequent on a photo card than other tribes like Ikoma, and Sukuma in the Serengeti ecosystem.

5.2 Local people perception on topi presence/absence in their areas

Most male respondents acknowledged that topi still are present in their area. The most likely explanation is that males are more engaged in activities such as hunting, charcoal burning, livestock herding and bush meat trade. Such activities increase the contact with wildlife species such as topi. These findings corroborated with previous findings indicating that gender differences exists about knowledge of the presence of different wildlife species in their surroundings (Nyahongo 2007, Gandiwa 2012).

Furthermore, younger people reported that topi are found in larger herds in their area. Young people highly interact with each other within the community, and they are able to travel in longer distances within the pastoral and agro-pastoral community. The youth in the Maasai tribe normally travel over long distance due to cultural movites. Due to this nature of human behavior the results on the presence of topi in their area show that, there is a higher presence of topi in the eastern than in the western Serengeti. However, the result was influenced by gender and age differences in opinions about the presence of topi.

These results are contrary to census data which indicate that more topi were present in the western part of the Serengeti ecosystem (Sinclair 1972, TAWIRI 2010, Goodman 2014). The findings might be a result of the difference in the level of poaching between these two areas, which has also been supported by the study conducted by Loibooki et al. (2002). They documented that illegal hunting is conducted in western Serengeti in order to off-set food shortage and generate cash income. People from this area own less or no livestock and according to Loibooki et al. (2002) involvement in illegal hunting decrease with the increase in number of livestock owned, with those with alternative sources of income being less likely to participate in poaching.

5.3 Consumption of topi meat

The majority of respondents claimed to have consumed topi meat. The elders reported to consume topi meat because they have been living in the area for a long time, and previously resident and commercial game hunting were permitted (Kideghesho et al. 2007). The rate of wild meat consumption as a source of protein was higher in the western Serengeti where Ikoma and Sukuma tribes are residing, than in the eastern Serengeti ecosystem where the Maasai and Sonjo

tribes are found. Several respondents frankly specified that even if social services in the community were greatly enhanced and individuals had improved access to food and cash income, they would still be hunting. The differences in consumption rate are due to differences of culture motives between these tribes, however, although the Maasai tribe has recently started to consume game meat, the other tribes have done so for a long time and developed traditionally motivated preference for game meat as a source of protein. The Maasai tribe might presently be associated with the present day mixed up with other tribes which means that Maasais are learning other means of getting meat. Another reason might be due to the dwindling number of livestock due to overgrazing and drought. This is probably the reason for higher rates of poaching in western than in eastern Serengeti ecosystem.

Along the boundaries of western Serengeti the majority of the local communities are subsistence farmers, many of whom obtain resources such as game meat for household utilization and for sale close or inside the park, firewood, area for grazing and watering livestock especially during the dry season (Sinclair and Arcese 1995, Loibooki et al. 2002). In addition, current alternative sources of income may not be appropriately attractive to compete with the opportunities provided by hunting, in this case, the majority of people in western Serengeti are engaged in illegal harvesting in order to offset food scarcity and generate cash income (Loibooki et al. 2002).

In eastern Serengeti, there were a small number of respondents who admitted to have been consuming topi meat. However, it is known that the majority of respondents in eastern Serengeti are Maasai and it has been documented by Campbell and Hofer (1995) that, the pastoralist Maasai residing in the eastern Serengeti rely solely on the livestock and they don't consume wild animal meat. Due to the close co-existence of Maasai and other ethnicities in this part of Tanzania, it may be suspected that, Maasai are exposed to different lifestyles and habits (including bushmeat consumption) and partly give up their traditional behaviors. Overall, this suggests that pastoralist ethnicities (such as Sukuma and Maasai), previously thought not to be involved in bushmeat activities, are now at least in some areas of Tanzania involved in bushmeat activities (Kiffner et al. 2015). Rusch et al. (2005) reported an extreme decline of topi population in Serengeti, with the population of other herbivores, this has also been evidenced by the TAWIRI census data trend over a period of 19 years (Figure 1). This situation is alarming and

have risen up a concern that the topi is the mainly targeted species by illegal hunters and exploited at an unsustainable level.

In addition, the data obtained from the Law Enforcement Unit in Serengeti National Park showed that over a period of 12 years there has been a higher number of poachers confiscated from the western than in the eastern Serengeti. This may be due to presence of villages close to park boundary as well as recent human population increase in western Serengeti which demand more game meat. Furthermore, this can be contributed to easy access of widlife resources as suggested by Holmern (2007). A study by Mfunda and Røskaft (2010), documented that nearly 40% of illegal harvesting practices in the Serengeti ecosystem is reported to be conducted by the people from the Ikoma tribe in western Serengeti, which support my findings. Other studies have also documented that illegal hunting are important activities to the communities living around Serengeti's western Corridor (Hofer et al. 2000, Loibooki et al. 2002). The rate of illegal hunting in Serengeti vary among villages as it is in other parts of Africa and it is independent of consumers' preferences of species (Ndibalema and Songorwa 2008). These evidences suggested that bushmeat hunting is a significant contributing factor to local diets and economies in the western Serengeti ecoystem. These findings and other previous studies support that fewer people from the eastern Serengeti (Maasai, Sonjo) have tested topi meat compared to those from the western Serengeti (Ikoma, Sukuma) and it supports the hypothesis number two.

5.4 Illegal hunting methods

Snare setting for game meat hunting including topi, was the most common method used in western Serengeti. The snares where easily obtained from different sources including old car tires which were easy accessed by the local communities. This finding is also supported by the previous studies (Campbell and Hofer 1995, Kaltenborn et al. 2005). Furthermore, other methods such as the use of bows and arrows, and pitfall traps have been reported in earlier studies (Sinclair and Arcese 1995). The use of these methods is intensely entrenched in the culture of the Ikoma and Kuria tribes, and is closely related with wildebeest annual migration season (Rentsch and Damon 2013). Illegal hunting is an alarming threat to the Serengeti ecosystem, it is not only an important delicacy or economic activity for communities, but also a potential threat to wildlife populations (Dublin et al. 1990). The extensive household survey conducted in the western and

eastern parts of Serengeti ecosystem clearly indicate that, bushmeat consumption is widespread among the local people in the western Serengeti; this conforms to previous studies (Campbell and Hofer 1995, Sinclair and Arcese 1995, Hofer et al. 1996, Loibooki et al. 2002, Kaltenborn et al. 2005, Knapp et al. 2010, Mfunda and Røskaft 2010).

According to the government of Tanzania regulations, both land and wildlife are state possessed, and thus the issuing of hunting permits are given by the government. The lawful hunting is based on a quota system whereby the blocks are set annually (Baldus and Cauldwell 2004). Both legal hunters which includes tourists and local hunters (recently residential hunting has been banned) are all permitted to hunt only and only if they possess valid licenses given by the Wildlife Division (URT 2009). Since the majority of the local people cannot afford to fulfill the needed requirements (licensing fees, legal possession of firearm) and by the present ban, they continue shift into illegal hunting practices.

Regrettably, communities surrounding areas rich of wildlife prefer using of traditional weapons to conduct illegal hunting (Kaltenborn et al. 2006) where up to 75% of meat protein is derived from wildlife in some African countries. In the Serengeti ecosystem, there is widespread illegal hunting (Knapp 2007). Villages in the western Serengeti seem to rely on illegal hunting as majority of them do not have hunting license. The easy catch-ability method such as pitfall traps have been widely practiced by the households because it has little or no cost. The use of snare is unselective and can injure or kill many wildlife species. On the eastern side Maasai uses spears mostly in their hunting endeavors and this support the hypothesis that hunting methods do differ between these two areas.

6.0 Conclusion and management implication

This study uncovers understanding on wildlife knowledge and consumption of bushmeat between western and eastern part of Serengeti ecosystem in Tanzania. The eastern Serengeti tribes are more knowledgeable on wildlife when compared to their counterpart. This is mainly due to their co-existence with wildlife for quite some time, having regular contact with wildlife on grazing grounds as well as good numbers of the same on their areas compared to other tribes where different land use practices have degraded natural habitats. The majority of illegal bushmeat hunting occurs along the western edge of the SENAPA (Campbell and Hofer 1995, Sinclair and Arcese 1995, Hofer et al. 1996). To conclude with, there is higher illegal bushmeat consumption for the tribes living in the western Serengeti than those in the eastern Serengeti, this is evident from the results as bushmeat was more consumed by the western tribes (Ikoma and Sukuma) than the eastern Serengeti tribes.

Measures to reduce/lower down illegal bushmeat off-take in western Serengeti, it is recommended that, there should be an alternative source of protein such as fish, beef, chicken coupled by fair prices that can compete with lower prices of bushmeat. Nonetheless, well-funded anti-poaching patrols may be a more effective way to deter bushmeat hunting. Preference for bushmeat over domestic sources of animal protein may furthermore be a product of cultural motive, in western Serengeti tribes with very similar livelihoods has different frequency and conceptions of bushmeat consumption. Hence, cultural motives should be accounted for when designing mitigation policies and strategies for wildlife conservation. Establishment of wildlife information centres in the village or at ward level might also be helpful in enhancing knowledge skills and increasing conservation awareness. Also, establishment of small village community banks will possibly reduce level of poverty and reduce dependence on hunting activities.

7.0 Reference

Allendorf, T. D., and K. Allendorf. 2013. Gender and attitudes toward protected areas in Myanmar. Society & Natural Resources **26**:962-976.

Baldus, R. D., and A. E. Cauldwell. 2004. Tourist hunting and it's role in development of Wildlife Management Areas in Tanzania. Wildlife Division, Dar es Salam.

Barnett, R. 2000. Food for thought: the utilization of wild meat in eastern and southern Africa. Traffic East/Southern Africa.

Becker, M., R. McRobb, F. Watson, E. Droge, B. Kanyembo, J. Murdoch, and C. Kakumbi. 2013. Evaluating wire-snare poaching trends and the impacts of by-catch on elephants and large carnivores. Biological Conservation **158**:26-36.

Bennett, E. L. 2002. Is there a link between wild meat and food security? Conservation Biology **16**:590-592.

Bitanyi, S., M. Nesje, L. J. Kusiluka, S. W. Chenyambuga, and B. P. Kaltenborn. 2012. Awareness and perceptions of local people about wildlife hunting in western Serengeti communities. Tropical Conservation Science **5**:208-224.

Bro-Jørgensen, J. 2002. Overt female mate competition and preference for central males in a lekking antelope. 0027-8424, Regent's Park, London NW1 4RY, United Kingdom.

Bryman, A., and D. Cramer. 2002. Quantitative data analysis with SPSS release 8 for Windows: a guide for social scientists. Routledge.

Campbell, K., and M. Borner. 1995. Population trends and distribution of Serengeti herbivores: implications for management. Pages 117-145 Serengeti II: dynamics, management, and conservation of an ecosystem. A. R. E Sinclair & Peter Arcese, The University of Chicago Press, Ltd., London.

Campbell, K., and H. Hofer. 1995. People and wildlife: spatial dynamics and zones of interaction. Pages 534-570 Serengeti II: dynamics, management, and conservation of an ecosystem. A. R. E Sinclair & Peter Arcese, The University of Chicago Press, Ltd., London.

Campbell, K. L. I., V. Nelson, and M. Loibooki. 2001. Sustainable Use of Wild Land Resources: Ecological, Economic and Social Interactions. Main Report. Natural Resources Institute,

University of Greenwich, Department of International Development, London., Natural Resources Institute, Chatham Kent, UK.

Carpaneto, G. M., and A. Fusari. 2000. Subsistence hunting and bushmeat exploitation in central-western Tanzania. Biodiversity & Conservation **9**:1571-1585.

Ceppi, S. L., and M. R. Nielsen. 2014. A comparative study on bushmeat consumption patterns in ten tribes in Tanzania. Tropical Conservation Science **7**:272-287.

Clamsen Mmassy, E., and E. Røskaft. 2013. Knowledge of birds of conservation interest among the people living close to protected areas in Serengeti, Northern Tanzania. International Journal of Biodiversity Science, Ecosystem Services & Management **9**:114-122.

Dublin, H. T., A. Sinclair, S. Boutin, E. Anderson, M. Jago, and P. Arcese. 1990. Does competition regulate ungulate populations? Further evidence from Serengeti, Tanzania. Oecologia **82**:283-288.

Duncan, P. 1975. Topi and their food supply. University of Nairobi, Nairobi.

Estes, R. 1991. The behavior guide to African mammals. University of California Press Berkeley.

Foley, C., L. Foley, A. Lobora, D. De Luca, M. Msuha, T. R. Davenport, and S. M. Durant. 2014. A Field Guide to the Larger Mammals of Tanzania. Princeton University Press.

Ford, A. B., and S. Blakeman. 1991. Horn and body measurements of topi in relation to a variable mating system. African Journal of Ecology **29**:37-42.

Gandiwa, E. 2012. Local knowledge and perceptions of animal population abundances by communities adjacent to the northern Gonarezhou National Park, Zimbabwe. Tropical Conservation Science **5**:255-269.

Gandiwa, E., P. Zisadza-Gandiwa, N. Muboko, E. Libombo, C. Mashapa, and R. Gwazani. 2014. Local people's knowledge and perceptions of wildlife conservation in Southeastern Zimbabwe. Journal of Environmental Protection **5**:475.

Goodman, P. S. 2014. Large herbivore population estimates for the Grumeti Reserves – August 2014. Grumeti Game Reserve, Grumeti Fund, Sasakwa, Serengeti District, Tanzania.

Hofer, H., K. L. Campbell, M. L. East, and S. A. Huish. 1996. The impact of game meat hunting on target and non-target species in the Serengeti. Pages 117-146 The exploitation of mammal populations. Springer.

Hofer, H., K. L. Campbell, M. L. East, and S. A. Huishi. 2000. Modeling the spatial distribution of the economic costs and benefits of illegal game meat hunting in the Serengeti. Natural Resource Modeling **13**:151-177.

Holmern, T. 2007. Bushmeat hunting in the western Serengeti: Implications for community-based conservation. Norwegian University of Science and Technology, Norway.

Holmern, T., S. Mkama, J. Muya, and E. Røskaft. 2006. Intraspecific prey choice of bushmeat hunters outside the Serengeti National Park, Tanzania: a preliminary analysis. African Zoology **41**:81-87.

Holmern, T., E. Røskaft, J. Mbaruka, S. Y. Mkama, and J. Muya. 2002. Uneconomical game cropping in a community-based conservation project outside the Serengeti National Park, Tanzania. Oryx **36**:364-372.

Homewood, K., E. F. Lambin, E. Coast, A. Kariuki, I. Kikula, J. Kivelia, M. Said, S. Serneels, and M. Thompson. 2001. Long-term changes in Serengeti-Mara wildebeest and land cover: pastoralism, population, or policies? Proceedings of the National Academy of Sciences **98**:12544-12549.

IUCN. 2008. SCC Antelope Specialist Group. Damaliscus lunatus jimela. The IUCN Red List of Threatened Species 2008: e.T6241A12591307.

IUCN. 2016. IUCN SSC Antelope Specialist Group. Damaliscus lunatus. The IUCN Red List of Threatened Species 2016: e.T6235A50185422. http://dx.doi.org/10.2305/IUCN.UK.2016-2.RLTS.T6235A50185422.en. Downloaded on 11 March 2017.

Kaltenborn, B. P., T. Bjerke, J. W. Nyahongo, and D. R. Williams. 2006. Animal preferences and acceptability of wildlife management actions around Serengeti National Park, Tanzania. Biodiversity and Conservation **15**:4633-4649.

Kaltenborn, B. P., J. W. Nyahongo, and K. M. Tingstad. 2005. The nature of hunting around the western corridor of Serengeti National Park, Tanzania. European Journal of Wildlife Research **51**:213-222.

Kideghesho, J. R. 2006. Wildlife conservation and local land use conflicts in Western Serengeti, Tanzania. Norwegian University of Science and Technology, Norway.

Kideghesho, J. R., J. W. Nyahongo, S. N. Hassan, T. C. Tarimo, and N. E. Mbije. 2006. Factors and ecological impacts of wildlife habitat destruction in the Serengeti ecosystem in

northern Tanzania. African Journal of Environmental Assessment and Management **11**:17-32.

Kideghesho, J. R., E. Røskaft, and B. P. Kaltenborn. 2007. Factors influencing conservation attitudes of local people in Western Serengeti, Tanzania. Biodiversity and Conservation **16**:2213-2230.

Kideghesho, J. R., E. Røskaft, B. P. Kaltenborn, and T. M. Tarimo. 2005. 'Serengeti shall not die': Can the ambition be sustained? The International Journal of Biodiversity Science and Management **1**:150-166.

Kiffner, C., L. Peters, A. Stroming, and J. Kioko. 2015. Bushmeat consumption in the Tarangire-Manyara ecosystem, Tanzania. Tropical Conservation Science **8**:318-332.

Knapp, E. J. 2007. Who poaches? Household economies of illegal hunters in Western Serengeti, Tanzania. Human Dimensions of Wildlife:195 - 196.

Knapp, E. J., D. Rentsch, J. Schmitt, C. Lewis, and S. Polasky. 2010. A tale of three villages: choosing an effective method for assessing poaching levels in western Serengeti, Tanzania. Oryx **44**:178-184.

Ledger, H., R. Sachs, and N. Smith. 1967. Wildlife and food production. World Rev. Anim. Prod **3**:13-36.

Loibooki, M., H. Hofer, K. L. Campbell, and M. L. East. 2002. Bushmeat hunting by communities adjacent to the Serengeti National Park, Tanzania: the importance of livestock ownership and alternative sources of protein and income. Environmental Conservation **29**:391-398.

Lowassa, A., D. Tadie, and A. Fischer. 2012. On the role of women in bushmeat hunting–Insights from Tanzania and Ethiopia. Journal of Rural Studies **28**:622-630.

Lyamuya, R. D., E. H. Masenga, R. D. Fyumagwa, M. N. Mwita, and E. Røskaft. 2016. Pastoralist herding efficiency in dealing with carnivore-livestock conflicts in the eastern Serengeti, Tanzania. International Journal of Biodiversity Science, Ecosystem Services & Management **12**:202-211.

Marealle, W. N., F. Fossøy, T. Holmern, B. G. Stokke, and E. Røskaft. 2010. Does illegal hunting skew Serengeti wildlife sex ratios? Wildlife Biology **16**:419-429.

Mfunda, I. M., and E. Røskaft. 2010. Bushmeat hunting in Serengeti, Tanzania: an important economic activity to local people. International Journal of Biodiversity and Conservation **2**:263-272.

Mgawe, P., M. B. Mulder, T. Caro, A. Martin, and C. Kiffner. 2012. Factors affecting bushmeat consumption in the Katavi-Rukwa ecosystem of Tanzania. Tropical Conservation Science **5**:446-462.

Muth, R. M., and J. F. Bowe Jr. 1998. Illegal harvest of renewable natural resources in North America: Toward a typology of the motivations for poaching. Society & Natural Resources **11**:9-24.

Mwakatobe, A., A. Lowassa, and J. Keyyu. 2005. THE IMPACT OF FUEL WOOD AND POLES EXTRACTION ON VEGETATION IN VILLAGES IN WESTERN SERENGETI. Page 265 *in* Proceedings of the Fifth TAWIRI Scientific Conference: 1-3 December 2005, Impala Hotel, Arusha, Tanzania. Tanzania Wildlife Research Institute, Arusha.

Mwakatobe, A., E. Roslash, and J. Nyahongo. 2012. Bushmeat and food security: Species preference of sundried bushmeat in communities in the Serengeti-Mara ecosystem, Tanzania. International Journal of Biodiversity and Conservation **4**:548-559.

Ndibalema, V. G., and A. N. Songorwa. 2008. Illegal meat hunting in Serengeti: dynamics in consumption and preferences. African Journal of Ecology **46**:311-319.

Nombo, C. I., S. J. Kabote, D. P. Mamiro, G. Synnevåg, A. Z. Mattee, J. K. Urassa, and L. Matata. 2015. Adaptation to Climate Change: Changing Gender Relations in the Meatu and Iramba Districts in Tanzania. Pages 587-599 Sustainable Intensification to Advance Food Security and Enhance Climate Resilience in Africa. Springer.

Nyahongo, J. W. 2007. Depredation of livestock by wild carnivores and illegal utilization of natural resources by humans in the western Serengeti, Tanzania. Fakultet for naturvitenskap og teknologi.

Nyahongo, J. W. 2010. The source–sink concept in the conservation of African ungulates: importance and impact of bush meat utilisation from Serengeti, Tanzania, and other protected areas in Africa. Conservation of Natural Resources. Some African and Asian Examples (eds EJ Gereta & E. Røskaft):237-254.

Rao, M. 2002. Wild-meat use, food security, livelihoods, and conservation. Conservation Biology **16**:580-583.

Rentsch, D., and A. Damon. 2013. Prices, poaching, and protein alternatives: An analysis of bushmeat consumption around Serengeti National Park, Tanzania. Ecological Economics **91**:1-9.

Roe, D., F. Nelson, and C. Sandbrook. 2009. Community management of natural resources in Africa: Impacts, experiences and future directions. IIED.

Rovero, F., A. Mtui, A. Kitegile, M. R. Nielsen, and T. Jones. 2010. Uzungwa Scarp Forest Reserve in Crisis.

Rusch, G., S. Stokke, E. Røskaft, G. Mwakalebe, H. Wiik, J. M. Arnemo, and R. Lyamuya. 2005. Human-wildlife interactions in western Serengeti, Tanzania. Effects of land management on migratory routes and mammal population densities. NINA rapport.

Sinclair, A. 1972. Long term monitoring of mammal populations in the Serengeti: census of non-migratory ungulates, 1971. African Journal of Ecology **10**:287-297.

Sinclair, A., S. A. Mduma, and P. Arcese. 2000. What determines phenology and synchrony of ungulate breeding in Serengeti? Ecology **81**:2100-2111.

Sinclair, A. R. E., and P. Arcese. 1995. Serengeti II: dynamics, management, and conservation of an ecosystem. A. R. E Sinclair & Peter Arcese, University of Chicago Press.

Sinclair, A. R. E., A. Dobson, Simon A.R. Mduma, and K. L. Metzger. 2015. Shaping the Serengeti Ecoystem. Pages 11-32 *in* A. R. E. Sinclair, K. L. Metzger, S. A. R. Mduma, and J. M. Fryxell, editors. Serengeti IV: Sustaining Biodiversity in a Coupled Human-Natural System. The University of Chicago Press, Chicago and London.

Stuart, S. N., R. J. Adams, and M. Jenkins. 1990. Biodiversity in sub-Saharan Africa and its islands: conservation, management, and sustainable use. IUCN.

TANAPA. 2013. Natural Wonders Awards 2012. Tanzania National Parks (TANAPA), Serengeti and Kilimanjaro National Parks, Arusha.

TAWIRI. 2010. Tanzania Wildlife Research Institute, Aerial Census in the Serengeti Ecosystem. Tanzania Wildlife Research Institute, Arusha.

TRAFFIC, E. 1998. Food for thought: The utilization of wild meat in Eastern and Southern Africa.

URT. 2009. The Wildlife Conservation Act. 0027-8424, Ministry of Natural Resources and Tourism, Dar es Salaam.

URT. 2012. Population and housing cencus. Population distribution by administrative areas. Natural Bureau Statistics. Ministry of Finance and Empowerment, Dar es Salaam.

Wapalila, G. J. 2008. Protected areas, local people livelihoods and conflicts: a case study of Mikumi National Park in Tanzania. Forest Policy and Economics **21**:1-126.

8.0 Appendix (Questionnaire used)

Household questionnaire

General description

ID……. Date…../…../…..... G.P.S……/…….

Village Name……

District……. Ward……

Respondent particulars

Gender; male female □Age……. Tribe……

Level of education, No education□ Primary□ Secondary □

Head of HH……., How many people in HH a) Adults……. b) Children…….

1. How long have you stayed in this village a) I was born here □ b) Less than a year □ c) 2-5 years d) 5 years and above □

2. If, immigrated what is the reason.....?

3. What are your socioeconomic activities?

a) Farming crops b) Employment c) Fishing d) Business d) Pastoralist e) Other……...

4. Monthly income (Tsh)

a) < 50,000 b) 51,000- 100,000 c) 101,000- 200,000 d) > 201,000

4. How much do you consume in your household per month?

1) < 50,000 b) 51,000- 100,000 c) 101,000- 200,000 d) > 201,000

Ungulate utilization

1. Can you mention five types of ungulates.....?

2. Mention type of ungulates crossing your village.....?

3. What kind of damage do they pose.....?

4. What method or techniques do you use to avoid damage.....?

5. Do you know this species (photo of Topi)? Yes □ No

6. If yes, when was the last time to see them.....?

a) A week ago, b) A month ago c) Less than a year d) More than a year

7. At the time when you saw them, how many were they?.....

8. In what season/month of the year do they prefer to cross through the village.....?

9. What is your main source of protein?

a) Beef b) Chicken c) Fish d) Wildmeat

10. How often do you consume meat in a week?

a) Less than once a week b) once in a week b) 2-3 times c) Every day

11. How many kilograms of meat does your family consume in a meal?

a) Less than 1 Kg b) 1-5 kg c) More than 5kg

12. Have you ever tasted Topi? Yes □ No □

13. If yes how did you get it? a) Hunted yourself b) Bought it c) other ……

14. If you hunted yourself, did you have?

a) Permits b) No permit c) Other…….

15. What was your last time you ate topi.....?

16. Do you know which type of weapons that are used to kill them…….……?

17. Do you think topis are still available in your area? Yes No

18. If no what is the reason why those animals have disappeared in your area?

a). Not available free space for animals b) Habitat destroyed c) Overhuntedd) others specify……

19. If your crops are damaged/livestock depredated, what measures do you normally take?

a) Fencing b) Employing guide c) Poisoning d) Shooting whenever encounter them in your farm e) Reporting to the district wildlife officials f) Others specify please……...

20. What is the most important wild animal causing loss of crops/livestock.....?

21. Is there a market for Topi meat? Yes □ no □. If yes, how much you pay per kg/topi meat…….....?

22. If you hunt them, do you normally seek for hunting license? Yes No

General description

ID……. Date…../…../…..... G.P.S……/…….

Village Name……

District……. Ward……

Respondent particulars

Gender; male female □Age……. Tribe……

Level of education, No education□ Primary□ Secondary □

Head of HH……., How many people in HH a) Adults……. b) Children…….

1. How long have you stayed in this village a) I was born here □ b) Less than a year □ c) 2-5 years d) 5 years and above □

2. If, immigrated what is the reason.....?

3. What are your socioeconomic activities?

a) Farming crops b) Employment c) Fishing d) Business d) Pastoralist e) Other……...

4. Monthly income (Tsh)

a) < 50,000 b) 51,000- 100,000 c) 101,000- 200,000 d) > 201,000

5How much do you consume in your household per month?

a) < 50,000 b) 51,000- 100,000 c) 101,000- 200,000 d) > 201,000

Ungulate utilization

1. Can you mention five types of ungulates.....?

2. Mention type of ungulates crossing your village…….?

3. What kind of damage do they pose…….?

4. What method or techniques do you use to avoid damage……...?

5. Do you know this species (photo of topi)? Yes □ No □

6. If yes, when was the last time to see them.....?

a) A week ago, b) A month ago c) Less than a year d) More than a year

7. At the time when you saw them, how many were they?.....

8. In what season/month of the year do they prefer to cross through the village.....?

9. What is your main source of protein?

a) Beef b) Chicken c) Fish d) Wildmeat

10. How often do you consume meat in a week?

a) Less than once a week b) once in a week b) 2-3 times c) Every day

11. How many kilograms of meat does your family consume in a meal?

a) Less than 1 Kg b) 1-5 kg c) More than 5kg

12. Have you ever tasted Topi? Yes □ No □

13. If yes how did you get it? a) Hunted yourself b) Bought it c) other ……

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15. What was your last time you ate topi.....?

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17. Do you think topis are still available in your area? Yes No

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a). Not available free space for animals b) Habitat destroyed c) Overhuntedd) others specify…….

19. If your crops are damaged/livestock depredated, what measures do you normally take?

a) Fencing b) Employing guide c) Poisoning d) Shooting whenever encounter them in your farm e) Reporting to the district wildlife officials f) Others specify please…….....

20. What is the most important wild animal causing loss of crops/livestock.....?

21. Is there a market for Topi meat? Yes □ no □. If yes, how much you pay per kg/topi meat…….....?

22. If you hunt them, do you normally seek for hunting license? Yes No

THANK YOU