The Assessment of elephant poaching in the population of the Selous Game Reserve, Tanzania

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Dedication

This thesis work is dedicated to my late mother Lucia Hussein Chumi for her love, care encouragement and support through the early stage of my life.

Abstract

Elephant poaching is a significant problem in Tanzania and many parts of Africa. This study assess the patterns of elephant poaching for the international ivory trade on the population of the Eastern Selous Game Reserve, Tanzania. Data for assessing the patterns of elephants poaching from 2009 to 2013 were acquired by doing inventory on the demography of poached skulls in the field and assessing confiscated tusks. This is to infer the age and sex of killed elephants; also the season of death were obtained during the field assessment. By combining inferences of age and sex, poaching patterns of African elephants were assessed. Data on the distribution of poached elephants and the effect of poaching on the trophy-quality from tourist hunting were obtained from elephant mortality database of the Selous Game Reserve in the Eastern and North-eastern sectors. The GPS coordinates to determine the distribution of poached elephants were randomly collected by rangers during their daily patrol routine. The poaching patterns in the ESGR were non-selective. The incidences of poaching were higher during the wet season. Hotspots of poaching were identified on the edges of the ESGR. This was attributed by the involvement of local people adjacent the ESGR in poaching activities due to lack of economic opportunities. The patterns of elephant poaching can help to study the impact of poaching on Selous Game Reserve elephant populations. Also, hotspots poaching serve as tool to guide and inform reserve managers involved in wildlife conservation in Tanzania. Improved economic opportunities of local people; enhanced conservation education and research; and improved governance and law enforcement recommended addressing the problem of elephant poaching.

Key words: *Elephant poaching, poaching patterns, Illegal ivory trade and assessment of poaching*

Acknowledgements

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List of abbreviations

AfESG	African Elephant Specialist Group (IUCN/SSC)
ITRG	Ivory Trade Review Group
CITES	Convention for the International Trade in Endangered Species
TRAFFIC	Trade Records Analysis of Fauna and Flora in Commerce
IUCN	International Union for the Conservation of Nature
UNEP	United Nations Environmental Programme
SGR	Selous Game Reserve
ESGR	Eastern Selous Game Reserve
Kg	Kilogram
Ha	Hectares
TAWIRI	Tanzania Wildlife Research Institute
KWS	Kenya Wildlife Service
WD	Wildlife Division
WMA	Wildlife Management Area
UNESCO	United Nations Educational, Scientific, and Cultural Organization
UNEP-WCMC	United Nations Environmental Programme-Wildlife Coservation Monitoring Center
GPS	Global Positioning System

Introduction

Poaching of African elephants (*Loxodanta africana*) for ivory is a major concern throughout Africa. It acts as an immediate threat responsible for the decline of African elephants at alarming rates across many African range countries. This is followed by habitat loss as a threat towards this species in the longer-run (Heltberg, 2001; Milnergulland & Beddington, 1993). Poaching here is defined as illegal killing of elephants for ivory but also for meat (CITES, 2010b; KWS, 2012). Elephant poaching occurs at an alarming rate as a result of high demand for illegal ivory in consuming nations of Asia, particularly China and Thailand. Two principal end-user markets occur, which have rapidly growing economies (Gabriel, Hua, & Wang, 2012; TAWIRI, 2010; UNEP, 2013). This is strongly associated with weak governance and poverty in elephant range countries (CITES, IUCN, & TRAFFIC, 2013).

The African elephant is a crucial 'keystone' species for African savannah and forest ecosystems with significant roles in ecological dynamics and therefore their persistence is important to the conservation of other elements of biodiversity. In tropical forests, elephants play an important ecological role by creating clearings and gaps in the canopy that allow tree regeneration and provide habitats for gap-specialized species (Stephenson, 2007). They also affect the cover and distribution of miombo and acacia woodlands (Mapaure & Campbell, 2002; Stephenson, 2007). Elephants are also important dispersal agents for seeds from a number of tree species (AfESG, 1999; Stephenson, 2007). In savanna ecosystems elephants can maintain species diversity by reducing bush cover and creating an environment favourable to a mix of browsing and grazing animals (Western, 1989). In East Africa, African elephants play a major role in maintaining open grasslands with few trees (Hakansson, 2004). In Tanzania, elephants shape woodland structure of extensive areas such as the Selous Game Reserve, the second largest World Heritage Site (S. Wasser et al., 2010). Elephants act as 'flagship' species, a highly charismatic animal that can serve as a rallying point for conservation, capturing the attention of people from all over the world and generating significant returns from wildlife-based tourism. Thus, it is clear that an African country that can house healthy populations of elephants is likely to preserve many other

species of fauna and flora that share the same habitat (Stephenson, 2007). Moreover, elephants are umbrella species as their conservation depends on large areas of the ecosystems being conserved and protected and therefore serves the objective of wider biodiversity conservation.

The loss or reduction in numbers of elephants can affect the integrity of the ecosystems and their services. For instance, the reduction of elephants in Queen Elizabeth National Park in Uganda from 4000 elephants prior to the 1970s by severe poaching to a few hundred, transformed rapidly the open savannah grassland into dense woodland and thickets caused changes on the other faunal composition (Hakansson, 2004). Also Hluhluwe Game Reserve in South Africa led into increase of bush cover at the expense of grasses (AfESG, 1999).

Poaching has an effect on the population structure of elephants. Elephants are known to have complex social structures. Elephant poaching in particular targets adult animals with the largest tusks, i.e old bulls and matriarch for bigger profits, with important consequences for females and males (Archie & Chiyo, 2012; Gobush, Kerr, & Wasser, 2009). This resulted in the breakdown of social structures among the surviving members of elephant societies (Bradshaw, Schore, Brown, Poole, & Moss, 2005; Nyakaana, Abe, Arctander, & Siegismund, 2001) and thus affects the entire herd's chances of survival. For females, the loss of important social partner may decrease female fitness, which may influence population growth. For males, poaching seems to reduce the age of first reproduction and lead to increased reproductive skew (Ishengoma et al., 2007; Owens & Owens, 2009); which may increase the rate at which the genetic diversity is lost from natural populations (Archie & Chiyo, 2012), such as in Uganda (Nyakaana & Arctander, 1999).

Poaching trend and illegal ivory trade

Historically, for more than ten thousand years, humans have coveted ivory and elephants paid the price (Jackson, 2013). Ivory has played a significant role in the art and culture of many peoples (Moss, 1996). The Romans had wiped out North Africa's population for ivory trade, leading to their extinction by 7th century (Jackson, 2013; Lee & Graham, 2006; Stephenson, 2007). By 1 000 A.D, Islamic states had taken control of the East African ivory trade, while ivory from West

Africa (the 'Ivory coast' was aptly named) made its way across the Saharan desert to the Mediterranean by caravan (Jackson, 2013). In the 15th century, profitable trade with the Middle East, India, China and, subsequently, Europe facilitated the extensive settlement of Swahili ivory and slave traders along the East African coast (Hakansson, 2004). Between 1500 and 1700 A.D. Europe was importing about 100-200 tonnes of ivory per year and by the rate of 19th century, European ivory imports may have been as high as 700 tonnes, representing 60 000 elephants killed per year (Stephenson, 2007). East Africa witnessed that another major peak in ivory demand occurred with the industrialization of Europe and US during the mid-nineteeth century (Hakansson, 2004). In Western and Southern Africa elephant numbers were dramatically reduced in the 18th and 19th century as Europeans settled the continent, expanding the trading routes and increasing the demand for timber and ivory (Stephenson, 2007).

Throughout much of the 20th century the hunting of African elephants for their ivory (Both legal and increasingly illegal) continued to decimate populations across the continent (Stephenson, 2007). The 1970s and 1980s witnessed another period of large–scale, ivory-driven uncontrolled exploitation of elephants particularly in Central and Eastern Africa (Said et al., 1995). The resurge of elephant poaching was due to the influx of automatic weapons into Africa, economic crisis in sub-Saharan Africa and budget cuts. These led to loss of morale and corruption to many wildlife departments in Africa, which in turn led to severe reduction of elephant populations across the continent (AfESG, 1999; Okello et al., 2008). The increase in poaching was also driven by a growing market for ivory goods in the USA, Europe and Japan (TAWIRI, 2010; UNEP, 2013) for piano keys and billiard balls (AfESG, 1999). These mass killings of elephant halved the population from approximately 1.3 million in 1979 to 600 000 in 1989. In East Africa, elephants dramatically declined in response to the poaching during this period, for instance, Uganda's elephant numbers fell from 17 600 to 1 800, Kenya from 130 000 to 19 000 (Douglas-Hamilton, 1987). In Tanzania, the elephant population was also halved from 110 000 to 55 000 during the same period (TAWIRI, 2010).

The sharp decline in the population of elephants prompted the CITES to remove the African elephants from Appendix II (which permits regulated international trade under special conditions) to Appendix I (which prohibits international trade), effectively banning trade in ivory

(Burton, 1999; CITES, 2009). All populations of African elephant have been listed on CITES Appendix I since 1989, except for four national populations that were transferred to Appendix II (Botswana, Namibia and Zimbabwe in 1997, and South Africa in 2000) (CITES et al., 2013). The African elephant is currently listed as vulnerable on the IUCN Red List (CITES et al., 2013).

The effect of the CITES ban on the trade in elephant products including ivory, reduced poaching pressure on many savannah populations. As a result some populations increased, for instance, in Kenya from 19 000 to 29 000 in 2005 (Lee & Graham, 2006) and Tanzania from 55 000 to 110 000 in 2006 (TAWIRI, 2010). During this period, Selous-Mikumi ecosystem elephant population rose from about 22,200 to about 55,000 elephants (Figure 1) (TAWIRI, 2010). In Tanzania, CITES coupled with effective anti-poaching operations, such as *Operation Uhai* in 1990, where the Army and Police Forces collaborated with the Wildlife Department to bring poaching under control, led to an almost complete cessation of the international ivory trade although poaching never stopped completely. This allowed the elephant population in Africa in general, and Tanzania in particular, to recover (TAWIRI, 2010). Other range sates such as the Republic of Congo, Angola, Central African Republic and Zambia continued to lose a significant number of elephants because of civil wars, political instability and corruption in the same period (Blanc et al., 2003; Jackson, 2013).

However, legal sales of 110 tonnes of ivory from Namibia, Botswana, Zimbabwe and South Africa in 1997 and 2008 to Japan approved by CITES fuelled the demand for ivory and made it easier for illegal ivory to enter the market. This was evidenced by a seizure of more than 16 tonnes of illegal ivory in different parts of the world in 2009, which is more than double the amount seized the year before (Bulte, Damania, & Van Kooten, 2007; Gabriel et al., 2012). This also made the proposal submitted by Tanzania and Zambia seeking to down list their elephant populations to Appendix II, and to trade in over 110 tonnes of ivory to be withdrawn by CITES (Gabriel et al., 2012).

In Eastern Africa; African elephant populations which had been recovering for two decades after the heavy poaching of the 1970s and 1980s are now witnessing a resurge of large-scale poaching due to higher market demand in Asia (UNEP, 2013). From 2000 through 2013 the number of

large-scale ivory movements has steadily grown in terms of the number of such shipments and the quantity of ivory illegally traded. Most large consignments of ivory are reaching the Asian markets through the eastern Africa sub-region. This is because Kenya, Uganda and Tanzania accounted for nearly 83 percent of the total volume of ivory seized for which the country of origin or export was known and continue to increase at alarming rates (CITES et al., 2013)

Since 2009, trade routes shifted from West and Central Africa seaports to East Africa, with Tanzania and Kenya as the primary exit points for illegal ivory trade leaving the continent through Indian Ocean ports (Mombasa, Dar es Salaam and Zanzibar). Meanwhile Malaysia, Vietnam and Hong Kong are highly concerned in the trade as the key trade routes and transit with the ivory mostly destined for China, although Thailand is also a destination. But over the last two years, trade routes used by traffickers appear to be shifting as new countries such as Togo and Ivory Coast emerge as exit points in Africa, with Indonesia, Spain, Sri Lanka, Turkey and United Arab Emirates as new transit countries (CITES et al., 2013). Therefore, Tanzania and Kenya are heavily involved in the ivory trade as a source and exit of large-scale ivory than any other country in Africa (CITES et al., 2013; UNEP, 2013). Also this reflects the shifts in poaching patterns from Central and West Africa to Southern and Eastern Africa (CITES et al., 2013). Current poaching trend in Africa remains far too high, and could soon lead into extinction by 2020 (S. K. Wasser et al., 2008), if the present killing rate of 7.4 percent continues, which is higher than the natural population growth rate of not more than 5 percent. But, the situation is particularly acute in Central Africa where the estimated poaching rate is twice the continental average (CITES et al., 2013).

In Selous-Mikumi Ecosystem, the current elephant population show downturn trends in size, as declined from about 50 000 elephants in 2006 to about 39 000 elephants in 2009 (Figure 1) (TAWIRI, 2010). Also, the elephant population has declined from 39 000 in 2009 to 13 000 in 2013 (Figure 1). This trend is due to poaching for ivory to supply the greater market demand of Asia followed by loss of habitat like Kilombero Game controlled area (TAWIRI, 2010, 2014). The current elephant census in Selous-Mikumi ecosystem shows that poaching is the major reason for the decline of elephant population in Tanzania based on the evidences from the carcass-ratio. The study indicated 30 per cent carcass-ratio, which was translated as unnatural

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cause of deaths as it is higher to the ratio of 7-8 per cent under natural cause of deaths of elephants (TAWIRI, 2014).
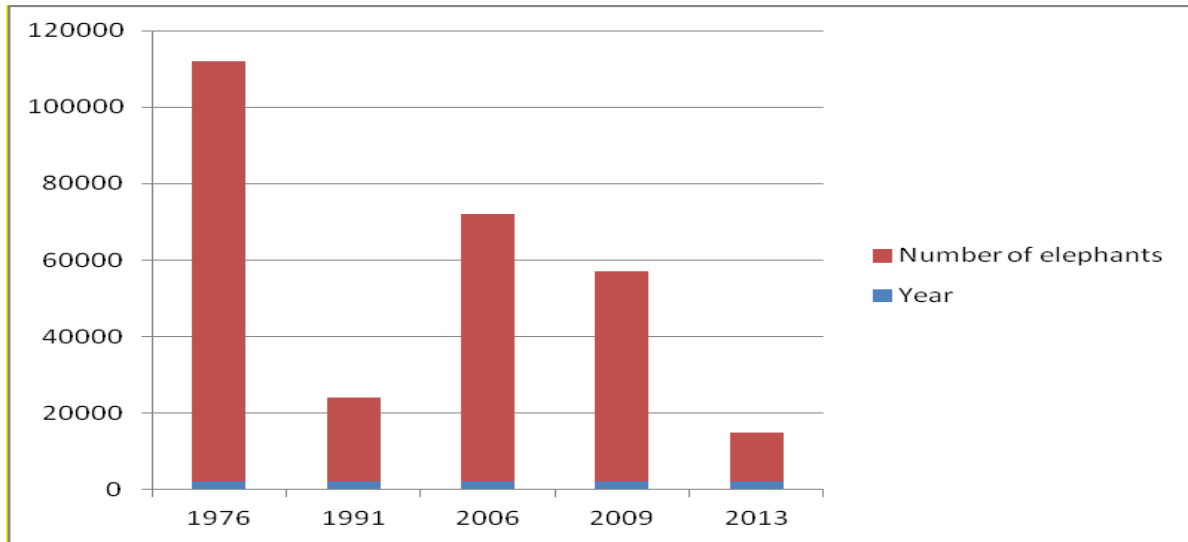
Figure 1: *Trends in Elephant abundance in the Selous-Mikumi Ecosystem 1976-2013* (TAWIRI, 2010, 2014)

Problem statement

Elephant poaching is a very serious threat to the survival of elephants in many range states across (UNEP, 2013). Elephants have been poached to supply ivory for the multimillion-dollar illegal trade that is said to rival drug trafficking (Hakansson, 2004), and this money is often used to finance conflicts (UNEP, 2013). In Tanzania, anecdote reports indicate that 50-60 elephants are currently (2010-2013) illegally killed monthly in the Selous Game Reserve, with more intense poaching in the eastern part of the Reserve. This may be due to the region's proximity and accessibility to the Indian Ocean coastline where tusks may be smuggled out of the country more easily. Such figures are in excessive and raise concern over the sustainability of the population, especially where potential breeding males and females are killed. Also, periodic seizures of illegal tusks of differing sizes and weights within and beyond the reserve suggest that a significant number of individuals of varying ages and sex are killed (WD records). According to the recent elephant census, the elephant population in SGR declined by 66 per cent in 2009

through 2013 due to heavy poaching (TAWIRI, 2014). The current high demand for ivory exceeds what can be supplied sustainably, and demand for illegal ivory must be reduced to prevent the threat to elephant populations (CITES et al., 2013). In order to protect elephants against the current poaching threats, massive investment in skilled personnel, equipment and supplies to enhance effective patrol is required (CITES et al., 2013; Maingi, Mukeka, Kyale, & Muasya, 2012). Also, for effective management and law enforcement, elephant biology, population and demographic trends information are important. This includes information on all causes of mortality such as poaching, natural deaths, tourist hunting and problem animal control (TAWIRI, 2010).

However, wildlife authorities in Tanzania like other countries in sub-Saharan Africa lack adequate manpower with approximately one ranger per 168 km^2 of wildlife reserve (Athuman, 2014, March 12), which is quite wide compared to the international standards of one ranger per 24 km^2 for effective patrolling and policing (Jachmann & Billiouw, 1997). This covers only 24 % of the actual needs (Athuman, 2014, March 12), due to budget constraints (Nahonyo, 2005; TAWIRI, 2010). Also, inadequate information on population and demographic structure of illegally killed elephants such as age and sex of illegally killed elephants makes difficult wildlife managers to make effective decisions on issues such as mitigation measures. Therefore, it is difficult for researchers to model the effect of poaching on the remaining population of elephants (Dublin & Taylor, 1996; TAWIRI, 2010).

Significance of the study

This study will fill the gap existing and knowledge for effective law enforcement and management of elephants in the light of financial constraints. By assessing the spatial distribution of elephant poaching incidences, the hotspot areas of elephant poaching along the distance gradient from the reserve boundary could be identified, which in turn can help guide effective deployment of policing resources. The results will serve as a useful tool to develop short-term and long-term conservation strategies and management programs such as effective anti-poaching patrols in the light of resources constraints. Furthermore, by determining the mortality patterns (i.e age and sex) of elephants in SGR will help other studies to model the

effects of poaching on population dynamics. This study provides the baseline for future demographic and behavioural studies, which will provide a wildlife manager with an understanding of the effects poaching on the behavioural and social organization of SGR population.

In this study, molar evaluation technique was used to infer age and sex at death of elephants by using sixty elephant carcasses obtained in the field. Age and sex could be inferred from confiscated tusk dimensions. These inferences were used to determine the elephant mortality patterns in SGR. Furthermore, ArcGIS 9.20 was used to map the distribution of poaching incidences in the study area. This was used to identify the areas within ESGR that are greater risk to elephant poaching along the distance gradient from the reserve boundary. This information would be useful in guiding the deployment of policing resources in the protected areas and its surroundings, to improve or alter the management actions.

Objective

The study aims to assess the patterns of elephant poaching for the international ivory trade on the population of the Eastern Selous Game Reserve in Tanzania.

Hypotheses

1. Poaching patterns has shifted from selective to non-selective

Traditional poaching: Poaching targeted older elephants especially bulls with tusks weighing six or seven times those of females for bigger profits. This led to skewed sex ratios in elephant populations and disrupted the kin-based association patterns in elephant societies.

Current poaching: Poaching targets all elephant sizes from small to medium-sized tuskers indicating that now adult females and juveniles are also killed. This has been evidenced from current national and international ivory seizures. This may be due to rarity of large-tusked individuals in the wild or non-selectivity on the current poachers due to market demands per kilogram of ivory.

2. Poaching incidences are higher on the edges of the Eastern Selous Game Reserve

The Eastern part of the Selous Game Reserve is bordered by the local communities, who are very poor and depend much on biodiversity for their subsistence needs-both in terms of income and food security. This leads to higher involvement of local communities in commercial poaching of elephants for their livelihoods. Therefore, it is expected that, the edges of the ESGR can be less risky, as the poachers can easily escape from being apprehended by law enforcement officers through partially-protected village lands bordering the reserve. Also, being near to the villages, the reserve can easily be accessed by the local communities, thus higher poaching incidences on the edges of the ESGR.

Methodology

Study species

African elephant (*Loxodonta africana*)

The African elephants are the largest living terrestrial mammals (shoulder height up to 4m; weight up to 7,500 kg). They are they are the only surviving members of the mammalian family Elephantidae in the order of Proboscidae, along with Asian elephants (Stephenson, 2007). Female elephants between 14 and 45 years may give birth to calves approximately every four years. Inter-birth intervals of up to 13 years may occur depending upon habitat conditions and population densities (Poole, 1996). The gestation period is 22 months on average. Under favourable conditions, elephant populations increase at annual rate between 4 and 5 per cent (CITES, 2010a). Although males reach sexual maturity at about 14 years, they are unlikely to compete for mating until the age of 20 years. Elephants are at their most fertile between the ages of 25 and 45. The occurrence of oestrous and conception is significantly higher during and following the wet seasons when females are in good conditions (Poole, 1996). In the absence of human intervention and natural disasters like drought life expectancy is about 50-70 years (Stephenson, 2007).

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Elephants can feed on variety of plant matter especially fruits, grass, leaves and bark. They can consume up to five percent of their body weight (i.e up to 300kg) per day, although only 40 percent of this food is properly digested (Poole, 1996; Stephenson, 2007). African elephants are amongst the most intelligent mammals in the world and they share a number of behavioural traits with humans, apes and certain dolphin species such as allo-mothering, cooperation, art, play, altruism, use of tools, mimicry, self-awareness, memory and possibly language and compassionate behaviour (Laursen & Bekoff, 1978; Stephenson, 2007).

African elephants belong to the genus of *Loxodonta*, which consists two extant sub-species: the savannah elephant (*Loxodonta africana africana*), and the African forest elephant (*Loxodonta africana cyclotis*) (Stephenson, 2007). The forest elephants can be distinguished from the savannah elephant by their smaller body size, smaller ears and straighter, narrower, downward-pointing tusks (Laursen & Bekoff, 1978; Roca, Georgiadis, Pecon-Slattery, & O'Brien, 2001). Elephants differ slightly in size according to sex, habitat and sub-species. Adult bulls measure from 3.20 m to 4.0 m in shoulder height, and weigh from 4,700 to 6,000 kg. Adult females weigh from 2,100 to 3,200 kg and measure from 2.2 to 2.6 m in shoulder height. Bulls can be distinguished from female by their larger, heavier body, thicker tusks in proportion to length, curved profile of the heads and wider forehead. Also, they have no scrotum, testes are internal. Females are slighter, have an angular profile to the forehead, narrower forehead, slender, pointed tusks, a pair of mammary glands located between their forelegs (Laursen & Bekoff, 1978; Poole, 1996). Also, elephants can be distinguished from other large mammals by having large ears, nose extended into a trunk, and upper incisor teeth that develop into tusks in male and female African elephants (and male Asian elephants) (Stephenson, 2007). African elephant distinguished from Asiatic elephants by its larger ears, higher at the shoulder and usually weighs more, its highest body point is shoulder, and both sexes carry tusks and are swaybacked. In contrast the Asiatic elephant has smaller ears, its highest body point is the head which is twin-domed and dished in the forehead, there is only one finger-like process at the trunk tip, only male generally carry tusks and back is level or convex (Laursen & Bekoff, 1978).

Elephants once inhabited the entire continent, but now are found only in 37 sub-Saharan African countries (CITES et al., 2013). Elephants are found in a broad range of habitat types such as grassy plains, woodlands, deserts, swamps, and bush lands from sea level to high mountain (CITES, 2010a; Stephenson, 2007). Individual home ranges vary from 15 to 3,700 km^2, depending on population habitat (Poole, 1996). If food and water are available, elephant may not venture far, if such resources are scarce, they may make seasonal migrations of several hundred kilometers (CITES, 2010a; Stephenson, 2007). They are grouped as a vulnerable species in the IUCN red list of threatened species (Stephenson, 2007).

African elephants live in a fluid and dynamic social system in which males and females live in separate, but overlapping spheres (Poole, 1996). African elephant societies are arranged around groups of related families and their dependent offspring, usually led by the eldest female (Matriarch). Family unity is defined as the basic social unit of elephant, which consists of an individual female and her dependent offspring (Leggett, Brown, & Ramey, 2011) and may range in size from two to 30 individuals (Poole, 1996). 'Family groups' are related adult females with dependent offspring, who associate (Leggett et al., 2011). Family groups form defensive units and kin-based alliances which have positive impact on the calf survival. Bond groups or kinship groups are made up of several closely related families and may be composed of as many as five families (Poole, 1996). Bond groups are formed when family groups become too large and split along family lines. When bond groups meet elaborate a special greeting ceremony. Families and bond groups that use the same dry season home-range are defined as Clans (Poole, 1996). Usually, males leave these clans when they reach 10-14 years of age (puberty) to live alone or form alliances with other males (Poole, 1996; Stephenson, 2007). Elephants are highly social and tend to aggregate when the resources are plenty and evenly distributed, especially during the rainy season when the resources are plenty. They also tend to aggregate in response to poaching. African elephants are non-territorial, although they do utilize specific home areas during a particular time of the year (Poole, 1996). Elephants communicate within and between social groups through various sounds, scents as well as numerous ear, trunk and body postures. They can communicate one another across large distances of 5-10km, even in thick forest by using sounds of very low frequency beyond the hearing range of humans (Poole, 1996).

Description of the study area

The study was conducted in the Eastern Selous Game Reserve (North-eastern sector, Kingupira in the Coast region and Eastern sector, Miguruwe in Lindi region) administered by Widlife Division of the Ministry of Natural Resources and Tourism, in Tanzania (Figure 2). Kingupira and Miguruwe sectors are among the eight administrative sectors of the Selous Game Reserve (SGR) which is located between at 7° 20'S - 10° 30'S to $36^o00'E$ - $38°40'E$ in Southern-Eastern Tanzania (Ngongolo & Mtoka, 2013; UNEP-WCMC, 2008). The SGR is a UNESCO World Heritage Site since 1982 and the largest protected area in Africa with about 55 000 km^2 (Ngongolo & Mtoka, 2013), which was founded primarily as an elephant reserve (Siege, 2000). The reserve is a part of the Selous ecosystem of over 9 000 000 ha in size, which includes also the adjacent Mikumi National Park (3 000 km^2) and Kilombero Game Controlled Area (6 500 km²), to the West; Udzungwa Mountains National Park (1 900 km^2) to the Northwest and a buffer zone (7 500 km^2). For administrative purpose the reserve is divided into eight sectors namely: North (Matambwe), Northeast (Kingupira), East (Miguruwe), Southeast (Liwale), South (Kalulu), Southwest (Likuyu seka), West (Ilonga) and Northwest (Msolwa) (Ngongolo & Mtoka, 2013). A large area of the reserve is drained by the Rufiji River and tributaries which include the Luwegu, Kilombero, Great Ruaha, Luhombero, Mbarangandu, Matandu, Njenji which are the main permanent streams (UNEP-WCMC, 2008).

SGR borders village lands which are currently managed by a series of Wildlife Management Areas such as Ngarambe-Tapika and Kilwa open area in the Eastern part of the reserve, run by the Widlife Division and the Community Based Conservation Programme. This programme was established to reduce the levels of poaching within the reserve, and to create a buffer zone between it and the villages. Licensed resident and tourist hunting takes place in the village wildlife management areas. With the exception of tourist hunting, photographic tourism and research activities, no human activities are allowed in the SGR. Therefore, all other livelihood activities like farming are concentrated in the adjacent areas. This reserve bisects the traditional lands of the Wangindo tribe of the hunter-gatherers though the infertile land was always thinly settled except in the East. Also, SGR was on the main slave-trading route to the port of Kilwa, was invaded by the Wangoni tribe, and fought over in both the 1906 colonial rebellion and World War I (UNEP-WCMC, 2008).

The reserve experiences a dry sub-humid climate with a wet season from mid-November to mid-May and dry season from June-October. The rainfall ranges from 750 mm in the east to 1 300 mm in the west per year and the average annual range of maximum and minimum temperatures at Kingupira research station on the hotter eastern edge is between 17.9°C and 37.3°C but for the whole Reserve range from 13°C to 41°C, depending on elevation (UNEP-WCMC, 2008).

The vegetation in SGR is dominated by deciduous miombo woodland (50%) which provides the chief elephant habitat dominated by *Brachystegia* species 'miombo' which are maintained by fire. This is followed by open savannah wooded grassland (40%) dominated by *Terminalia spinosa*; wetlands (3%) covered by tracts of borassus palm woodland *Borassus aethiopium*; mountains and inselbergs (3%); and riverine ad montane forest (2%). It has more than 20 vegetation types and more than 190 species of trees and shrubs (Ngongolo & Mtoka, 2013; URT, 2012).

The Selous ecosystem has been the core and important stronghold area for elephant conservation in Tanzania for many years in its history. Also, the ecosystem had the largest single population of African elephants in Tanzania and the second largest in Africa, after Botswana (TAWIRI, 2010). But the recent downturn trend of elephant population from 50 000 in 2006 to 13 084 in 2013 mainly due to commercial poaching has deteriorated significantly the conservation outlook of the area with unknown 'knock-on' ecological consequences. This is attributed by lack of sufficient funding (TAWIRI, 2010; UNESCO, 2012; URT, 2013).

The Reserve has a higher density and species diversity than any other miombo woodland area, with over 400 species of animals such as population of elephants and buffalo (*Syncerus caffer)*. The area is famous for wild dogs *(Lycaon pictus)*, lions *(Panthera leo)*, leopards (*Panthera pardus*) and some of the last black rhino (*Diceros birconis*) left in Africa. The reserve has over 350 species of birds. The Mikumi lowlands and mountains and Kilombero wetlands and the Udzungwa Mountains are rich in species such as the Kilombero weaver (*Ploceus burnieri*). The globally threatened wattled crane (*Grus carunculatus*), corncrake (*Crex crex*), and lesser kestrel

(*Falco naumanni*) occur. Reptiles and amphibians are numerous but little studied (UNEP-WCMC, 2008).
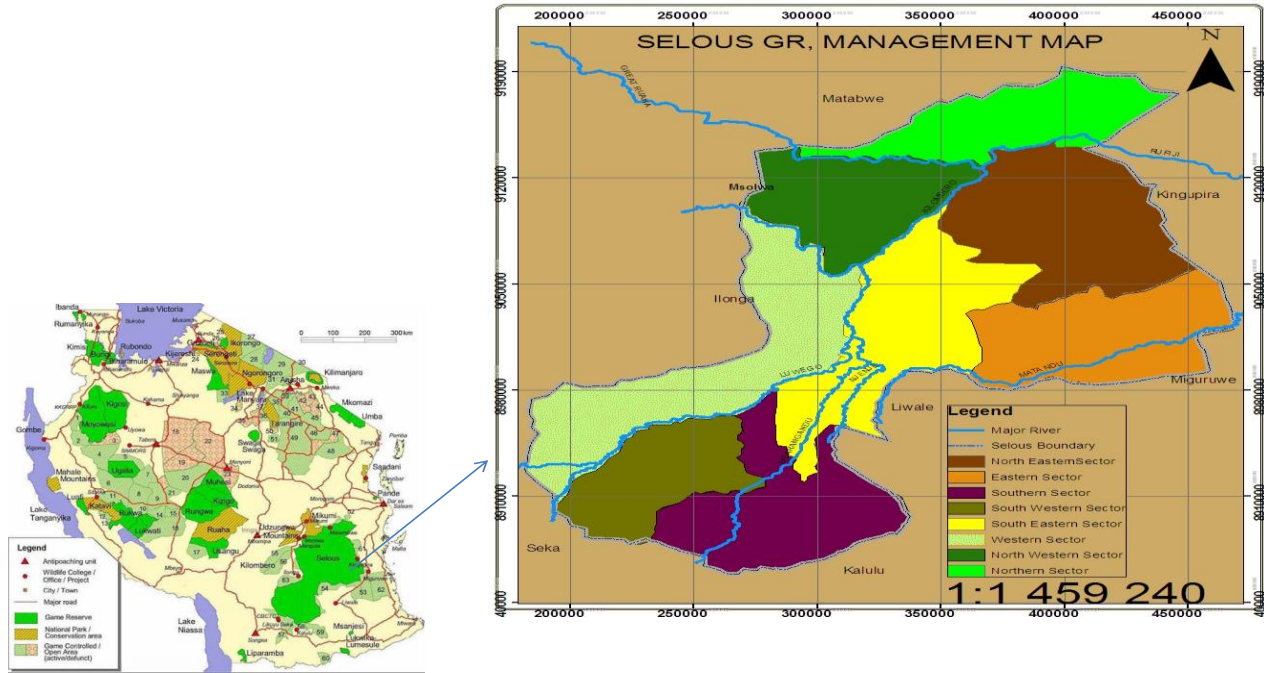
Figure 2 *:Map of protected areas in Tanzania,showing the study area (Selous Game Reserve)*

Types of data

The study uses primary and secondary data. Primary data covers all data that were obtained during my field work. Secondary data were obtained from other research findings related to the poaching of elephants for international ivory trade. Internet and NTNU search engine were used on the related topic.

Data collection techniques

The data were collected from June to August 2013 in Eastern Selous Game Reserve (Kingupira and Miguruwe sector). This was done by inventorizing the demography of illegally killed

elephants through field assessment of skulls and teeth; and assessment of seized ivory tusks to infer age and sex of dead elephants. Also, the GPS coordinates were recorded to determine the hotspots areas of poaching. The following are the procedures:

Field assessment of skulls and teeth

Data on elephant mortality from 2008 to 2013 were obtained from the Selous Game Reserve elephant mortality database (Kingupira and Miguruwe ranger stations' databases), which has been developed over the years following random patrols by rangers. More than 80 locations of elephant kill sites found on the database GPS coordinates were visited randomly by using available roads to search for skull remains. For each skull found, the cause of death was determined whether poaching, natural or tourism. Since my interest was on poaching, therefore the signs of absence of tusks in skull, especially if it looks like the tusks were hacked in a hurry; it was an evidence for the cause of death as poaching for ivory (Moss, 1996). In each skull, the length and width of molars in the lower jaw were carried out to determine the age of individuals at time of death, also from the shape of the head of the skulls the sex of an individuals were determined (Moss, 1996). In this study, sixty skulls were successfully found and their measurements and locations were marked on the data sheet.

Assessment of seized ivory tusks

Consignments of seized tusks that were known (with high degree of certainty) to originate from the eastern Selous population were accessed at Kingupira and Miguruwe Ranger Stations Selous Game Reserve, in July 2013. Each tusk was measured for size (total length and lip line length), weight and lip line circumference in order to infer the age of killed individuals. Also, from the thickness and shape of tusks, the sexes of a killed elephants were determined (Ngure, 1996; Pilgram & Western, 1986). A total of 48 tusks were measured from both Kingupira and Miguruwe ranger stations.

Assessment of ivory from tourist hunting

Data on the size of ivory tusks from July 2008 to August 2013 were obtained from the tourist hunting database at Kingupira ranger station. From the database, a total of 382 ivory tusks found and the weight of each tusk was recorded for studying the effect of poaching on the trophy-quality of ivory.

Use of GPS coordinates to obtain distances from the boundary of ESGR

The elephant poaching data obtained from Kingupira and Miguruwe ranger stations databases from 2008 to 2013 were first entered in an Excel spreadsheet with each record having X and Y coordinates (by using Universal Transverse Mercator-UTM), date of mortality and name of locations of poaching. Mapping of the poaching incidences was done by using ArcGIS 9.3 by digitizing the georefered Selous base map whereby the coordinates were added and displayed on the map. Also, the distance from the point of poaching to the nearest Protected area boundaries were obtained for exploring the relationship between elephant poaching incidents and the reserve boundaries.

Sex determination from skulls

The shape of the head was used to differentiate between sexes of elephants. Male has rounded head which is broader between eyes while female has a pointed head which is narrower between eyes (Moss, 1996). This characteristic was used to determine the sex of elephant skulls during the data collection.

Age determination from skull

The age of elephants can be estimated by using measurement of shoulder height, size of the body, hind-footprint length, dung bolus circumference and molar tooth wear and progression

(Ishengoma et al., 2007; Moss, 1996; Rasmussen, Wittemyer, & Douglas-Hamilton, 2005). Each of these techniques has drawbacks. In this study molar evaluation technique was used to estimate the age of elephants at the time of death which is the accurate method for ageing elephants but it is difficult to be applied to free-ranging live animals which makes other less accurate methods to be used (Rasmussen et al., 2005). This was done by observing the stage of molar progression. Elephants develop six molars in each quadrant of their jaws during their life time. Each erupts at a certain age and wears at particular rate. Molar length and width measurements closest to the front of the mouth from lower jaw were taken by using tape measure in order to identify the correct molar number as either M1, M2, M3, M4, M5 or M6. If the molar length measured falls into two molar classes, then the molar width was used to identify the correct molar number. Also, if both molar width and molar length fall between two molar classes, then the molar should belong to the molar class whose maximum width or length dimensions are closest to the measured dimensions (Moss, 1996). The molar appearance, molar loss knowledge (Table 2) and the possible combinations of teeth in wear (Table 3) were used to determine the age of elephant, after assigning the correct molar number by referring to the field notes and photos on skulls/carcasses. For the purpose of analysis, I put the estimated ages into four major categories as following: Calves (0.0-8.0 years); Juveniles (8.0-14.5 years); Sub-adult (14.5-18.5 years); and Adults (>18.5 years).

Table 1: *Molar length and width for molar numbers one through six* (Moss, 1996)

Molar number	Molar length (cm)	Molar width (cm)
M1	1.0-4.0	1.3-2.0
M2	5.0-7.0	2.5-4.0
M3	9.5-14.0	3.9-5.2
M4	13.0-17.5	5.0-6.8
M5	17.5-22.5	5.9-8.5
M6	22.0-31.0	6.4-9.4

Table 2: *The elephant molar teeth appearance and loss: Modified from Dumonceaux (2006) and Moss (1996)*

Molar	Molar appearance (years)	Molar loss (years)
M1	0	2-2.5
M2	0	6-7
M3	1	13-15
M4	6	23-28
M5	18	43-45
M6	30	60-65

Table 3: *Possible combinations of teeth in wear (Haynes, 1991)*

Stage	Description	Laws (1996) years (approx.)
1	**Animals immature, growing rapidly**	
A	None in wear or M1 only	0.0-0.5
B	M1 and M2 in wear	0.5-1.5
C	M1,M2 and M3 in wear	1.5-2.5
D	M2 and M3 in wear	2.5-4.5
E	M3 in wear	4.5-8.0
F	M3 and M4 in wear	8.0-14.5
2	**Animals sexually mature**	
G	M4 in wear	14.5-18.5
H	M4 and M5 in wear	18.5-28.0
I	M5 in wear	28.0-30.0
3	**Animals reaching end of growth**	
J	M5 and M6 in wear	30.0-42.0
4	**Animals passing prime or in old age**	
K	M6 in wear	42.0-60.0

Sex determination from tusk measurements

The sex of elephants were accurately inferred from the shape of their tusks (Pilgram & Western, 1986). Male tusks determined from their thicker for their length and more tapering or conical in shape, while female tusks are more uniform in circumference or cylindrical in shape (Ngure, 1996; Pilgram & Western, 1986). In this study with the help of my field assistants and the ivory handlers at Kingupira and Miguruwe ranger stations, we successfully grouped ivory from poaching into sex categories by using size and shapes of ivory.

Ageing elephants from tusk measurements

Elephants grow throughout their life time (Rasmussen et al., 2005). The size of elephant tusks increases with elephant age, and this makes one to estimate age of elephants from tusk measurements (Ngure, 1996). Practically, the tusk size can only be measured directly for dead, immobilised or tame elephants (Ngure, 1996). According to Pilgram and Western (1986), lip circumference and weight are good estimators of elephant age. The tusk measurements from the seized elephants such as circumference at the lip, lip line length and weight were directly taken from the seized ivory tusks to infer age of dead elephants at Kingupira and Miguruwe. Therefore, weight was used to estimate the age of dead elephants from seized tusks by using a Model for estimating ages of East African elephants from tusk measurements, developed for elephants of all ages (Table 4).

Table4: *Models for estimating ages of East African elephants from tusk measurements, developed for elephants of all ages* (Pilgram & Western, 1986)

Sex	Tusk measure	Model for age
Male	Circumference(c)	exp (-4.25 + 2.12lnc)
	Weight (w)	exp (1.76 + 0.58lnw)
Female	Circumference (c)	exp (-5.24 +2.77lnc)
	Weight (w)	exp (2.25 + 0.72ln w)

Data analysis

The collected raw data were coded and digitized for analyses. Statistical analyses were conducted using Statistical Packages for Social Sciences (SPSS, version 21). Descriptive statistics were used to generate charts, Mean, Standard deviation (SD) and percentages for comparisons purposes. Also one-way analysis of variance (ANOVA) was used to test for differences in the means of the categorical independent variables. Pearson Chi-square Tests were used to test if there was a relationship between two categorical variables (test for the differences in the independent variables) with a significance level of $p < 0.05$.

Results

Inferring age and sex of dead elephants from skulls and confiscated tusks

Sixty elephant skulls were observed successfully within twenty one days in the study area. Of these, age and sex were determined for fifty nine elephant skulls. Overall, sub-adults (39.0 %, n = 23) were the most frequent killed elephants but there was no significant difference between the number of sub-adults and other age categories (Chi-square: $\chi^2 = 7.10$, df = 3, P = 0.69; Table 5). Among the illegally killed elephants, there was no significant difference between frequencies of males and females (Chi-square: $\chi^2 = 0.15$, df = 1, P = 0.696, Table 5). Also, 48 seized tusks were observed for determining age and sex of illegally killed elephants. The results indicated that juveniles (48.9 %, n = 22) were the most frequently killed than other age categories (Chi-square: $\chi^2 = 14.5$, df = 3, P = 0.002; Table 5). Also, there was no significant difference between male and female elephants illegally killed (Chi-square: $\chi^2 = 3.00$, df = 1, P = 0.083; Table 5).

Table 5: *Season, age and sex measurements from elephant skulls and seized tusks for studying patterns of poaching*

					N =	χ² =	P =	Df =
From elephant skulls								
Age categories	Calf	Juvenile	Sub-adult	Adult				
%	15.3	23.7	39.0	22.0	59	7.10	0.69	3
	(n=9)	(n=14)	(n=23)	(n=13)				
Sex	Male			Female	59	0.15	0.7	1
%	51.7			46.7				
	(n=31)			(n=28)				
Season	Wet			Dry	57	32.44	0.000	1
%	83.3			11.7				
	(n=50)			(n=7)				
From seized tusks								
Age categories	Calf	Juvenile	Sub-adult	Adult	48	14.5	0.002	3
%	8.3	45.8	18.8	27.1				
	(n=4)	(n=22)	(n=9)	(n=13)				
Sex	Male			Female	48	3.0	0.083	1
%	62.5			37.5				
	(n=30)			(n=18)				

Seasons of poaching

Elephant poaching was conducted in both wet and dry seasons of the year. The results show that, the frequency of poaching was significantly higher in the wet season than dry season (Chi-square: $\chi^2 = 32.4$, df = 1, P < 0.001; Figure 3, Table 5).
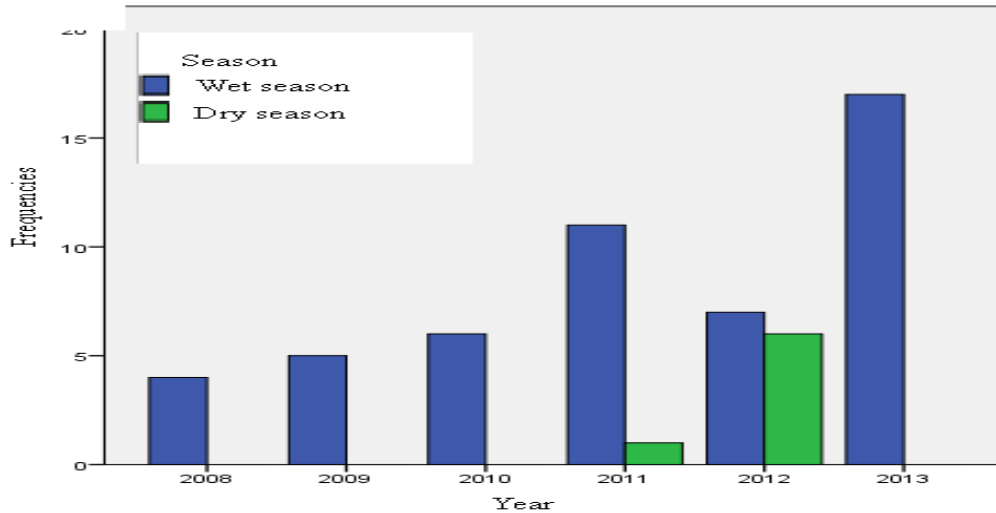
Figure 3*: Seasons of elephant poaching determined from field assessment*

The sizes (weights) of ivory obtained from tourist hunting

The results of this study showed that the number of good trophy-quality (tusks weighing more than 15 kg-minimum trophy weights) obtained from tourist hunting between 2008 and August 2013 was 327 tusks, representing 85.0 percent of the total ivory-trophies. Between the years 2008 through 2013, the mean weight showed a mixed trend from 17.0 kg to 19.1 kg, totaling a mean weight of 18.5 kg. Similarly, the good-quality ivory indicated a mixed trend between 75.0 % and 82.3 % (Table 6).

Table 6: *Measurements of ivory trophy from tourist hunting July 2008-Agust 2013*

Year	Mean (Kg)	N	% of good quality-ivory (>15.0 kg)
2008	17.3	72	75.0
2009	19.3	86	91.9
2010	18.7	73	86.3
2011	18.4	81	85.0
2012	19.1	52	92.3
2013	17.0	18	77.8
Total	18.5	382	85.6

Hotspot poaching areas

More than fifty nine percent (59.7 %, n = 71) of poaching incidents occurred around or close to the boundary of the study area (Northen and Eastern sector Selous Game Reserve). The frequencies of poaching incidences differed significantly along the gradient of the distance from the boundary of the Selous Game Reserve (Pearson Chi-Square: χ^2 = 37.3, df = 2, n = 119, P < 0.001; Table 7).

Table 7: *Frequencies of poaching incidences from the boundary of the Selous Game Reserve*

Distance from the boundary of SGR	Closest (< 20km)	Medium (20 km ≤ 40 km)	Far away (40 km <)	χ^2=	P=	df=
Frequencies	71	22	26	37.33	0.000	2
%	(59.7)	(18.5)	(21.8)			

Discussion

Limitations of the research

Before having the wider discussion of the findings raised by this study, two important limitations should be noted. The first important limitation is the lack of adequate sample of confiscated tusks. This was due to the fact that, only 48 out 120 expected seized tusks were accessible for measurements at Kingupira and Miguruwe ranger stations to infer age and sex of poached elephants. This was also attributed by logistical problems for measuring confiscated tusks at Ivory room in Dar es Salaam, which originated from ESGR in large consignment of tusks weighing more than 90 tonnes, obtained from different sources and origins, as it demanded more time and personnel. Analysis of these data affected age and sex categories inferred from confiscated tusk measurements.

The second potential limitation is that, the study focused on the distribution of poached elephants, the analysis did not attempt to examine other factors such as human and biophysical factors that determine the distribution of poached elephants in ESGR, Tanzania. This would have resulted in a much richer data for effective control of elephants poaching problem. A wider analysis of such factors would have demanded more resources than were available for this study.

Despite all the above limitations or constraints, one of the strength of this study is that it has used elephant carcasses/skulls which include the degree of tooth eruption and wear to infer age, and shape of the skull to infer sex of poached elephants, in most accurate. This study in many ways could be considered as a baseline for similar and more complex research on the issue of poaching in SGR, for there are no other previous studies like this that have looked on patterns of elephant poaching. Also, the constraints explained in this study, gives opportunities for further research on

elephant poaching, to give urgent solutions for the survival of elephant, the largest living terrestrial mammal in Africa.

Patterns of elephant poaching from age and sex of poached elephants

The findings of this study suggest that elephants of all ages and sexes were killed illegally by poachers to supplement the high demand of ivory in the markets. It indicated that the elephants were illegally killed regardless of their sexes and ages. This observation is in agreement with what EIA (2010) illustrated in a similar location. This was also supported by Stiles (2009) in his review who argued that small to average tusks weight were exported from Africa after severe poaching during the 1970s and 1980s. His study indicated that females and juvenile were being targeted by poachers, because few old bulls remained in the wild. The same reason was given by ITRG (1989) on the decline of tusk size exported from Africa. Furthermore, Jackson (2013) reported in Amboseli National Park, killing of matriarchs and their calves at once. CITES et al. (2013), reported massive killings of herds, a large number of elephants which included matriarchs and the accompanied juveniles in Zakouma National Park, Chad. These evidences were contrary to previous studies which reported that elephant poaching was highly selective of individuals, targeting adult animals with the largest tusks that is old bulls for bigger profits compared to cows (Archie & Chiyo, 2012; Gobush et al., 2009; Lemieux & Clarke, 2009). This pattern of poaching resulted in a reduction of elephant population, breakdown of social structures among the surviving members of elephant societies and reduction in the amount of genetic diversity in the surviving populations. My results as well as these reports support the first hypothesis that poaching pattern of elephants has shifted from selective to non-selective.

Seasons of poaching

Our findings of this study show that poaching takes place throughout the year, but the incidences of poaching was significantly higher in the wet season than during the dry season. This was due to the fact that large areas of the reserve could not be easily accessed by vehicles as most of the roads are seasonal and cut off by flooding rivers in the rainy season. This tends to be difficult in transporting rangers for patrol to distant and remote areas. Hence, only few easily accessible

areas of the reserve which are frequently patrolled are leaving more room for poachers to roam around in the reserve. Similar reasons have also been reported by others from different places that the peak poaching is during the wet season (Maingi et al., 2012; Nahonyo, 2005). Also, high poaching during the rainy season was attributed by closing of tourist operations such as tourist hunting, which could make the poachers enter the reserve without being noticed easily (EIA, 2010). The effort of combating poaching during the wet season was also undermined by poor visibility due to thick vegetation, which might make the ability to sight poachers in the wild more difficult (Nahonyo, 2005).

Hotspot poaching area

Poaching activity is expected to be intense where elephants are most abundant and where transportation of the poached ivory directly to the ivory traders or through middlemen is easiest. This is because it provides the poacher with the highest return on effort. Also, elephant poaching is expected to be tempered by the poacher's fear of detection by game rangers and law enforcement (Maingi et al., 2012). My findings support the second hypothesis which states that poaching incidences are higher on the edges of the Eastern part of the Selous Game Reserve between 2009 and 2013. Since, poaching is mostly done during the rainy season Mid-November to May; the edges of the reserve are easily accessed by the poachers, who usually travel on foot. Also, the edges of the reserve are less risky to poachers in the same season due to the fact that the reserve is bordered by open areas (Ngarambe-Tapika and Kilwa Open areas) which are poorly protected by the local communities, which again are poorly patrolled by village game scouts because of insufficient funding (CITES, 2010b). Thus, Open areas (Village wildlife management areas), can be used by the poachers as refuge areas and safe route to the reserve. One other study in Tanzania (Kioko, Zink, Sawdy, & Kiffner, 2013) has found that poaching incidences of elephants increased from the core protected areas towards the partially protected areas such as ranches and community areas. Maingi et al. (2012) reported that hotspots of elephant poaching were mostly located along the edges of the Tsavo Conservation Area in Southern-Eastern Kenya, between 1990 and 2009, indicating higher involvement of local people in poaching as porters and guides to the foreign poachers due to lack of economic opportunities to the local people. This supports the findings as most poaching incidents in ESGR between 2009

and 2013 occurred along the edges of the reserve. According to the EIA (2010), poachers sometimes come from outside the villages nearby the SGR but usually employ villagers to act as guides inside the reserve, paying them a little amount of money per trip. Some groups of poachers reportedly enter the SGR for a period of up to two weeks and kill as many as 10 elephants each trip. The poached ivory is then hidden, buried at remote locations on the edge of the reserve until it is sold to traders mostly from Dar es Salaam. The transactions usually take place in the villages surrounding the reserve that have become known hotspots for ivory trading. They include Mloka, North of the SGR; Chumo in the center of the reserve, Liwale in Southern Tanzania. Also, the town of Somanga is a key transit point on the road from Lindi in Southern Tanzania to the coast. Moreover, transactions sometimes are carried out in the town of Ikwiriri, a key transit point on the road to Dar es Salaam. UNEP (2013) argued that poverty facilitates the ability of profit-seeking criminal groups to recruit local hunters who know the terrain, and to corrupt poorly remunerated enforcement authorities. Poachers are well-known in the communities neighbouring the SGR (Jackson, 2013).

The effect of poaching on the trophy-quality of ivory from tourist hunting

The mean weight of ivory from tourist hunting was 18.48 kg, and the mean weight between years from 2008 and 2013 was in a mixed trend, which did not show a decline in quality of the trophy. This is because sport hunting of elephant trophies is regulated by minimum trophy size (15kg and 150cm per tusk), and numbers killed (CITES, 2010b). Thus, the effect of poaching on the size of ivory obtained from tourist hunting could not be found. However, poaching can not only reduce the sustainability of these legal offtakes, it can potentially have a substantial negative impacts on the population of Selous-Mikumi ecosystem as a whole (CITES, 2010b). (CITES, 2010b), reported a loss of trophy-quality males from illegal killing estimating a net loss of around 11,255 elephants a year between 2006 and 2009 in Selous Game Reserve.

Conclusion and Recommendations

Conclusion

Elephant poaching threatens the survival of elephant to most of the protected areas in Tanzania especially Selous Game Reserve. Research findings show that elephants are illegally killed regardless of their sexes and ages in the reserve. This supports the first hypothesis which states that poaching pattern of elephants has shifted from selective to non-selective. The incidences of poaching were higher during the wet than dry season. Also, the research findings identified the edges of the Eastern Selous Game Reserve as hotspot area of poaching. This supports the second hypothesis which states that poaching incidences are higher on the edges of the reserve between 2009 and 2013. Poaching had no effect on the quality-trophy of the ivory obtained from tourist hunting because sport hunting of elephant trophies is regulated by trophy size (weight of ivory) and the number of elephant killed. However, poaching can have a substantial impact on the population of the Selous-Mikumi ecosystem as a whole.

Recommendations

Improving economic opportunities of local people

The government and its conservation agencies should make enough efforts towards improving the economic opportunities of the people, which would reduce poverty. Reducing poverty in the local communities bordering the ESGR would help reduce elephant poaching. Among these efforts, would be high commitment in the government and its wildlife authority in supporting Wildlife Management Areas (WMAs) financially and technically to undertake adequate security of elephants. This would lead to the sustainability of WMA projects around the SGR, hence supporting conservation and local communities economically. Also, government should support environmental-friendly small projects in the communities based on low interest loans. These projects should be owned by the community themselves so that they can afford to repay the

loans. This will impart the community with the sense of projects-ownership and responsibility for running the projects as they will all benefit. These projects can also create employment for the poorest members of the local communities as an alternative source of revenue to meet their basic needs, thus minimizing dependency on the natural resources.

Enhance community conservation education and research

Conservation related education is very important as a long-term approach in tackling the poaching problem. This will create awareness within local communities, especially the young people from nursery school on the mitigation measures to loss of biodiversity including loss of elephants. Also education can also include the value and importance of conserving biodiversity like elephants. This will ensure sustainability of the biodiversity including different species of wildlife, because the young people will be the conservationists and guardian of tomorrow. Also, research on finding the reasons for local communities' involvement to elephant poaching and alternative livelihood strategies with minimal impacts to wildlife, would be important for controlling and reversing the poaching problems. Moreover, further research on the impact of elephant poaching to the remaining population of SGR is recommended.

Improving governance and law enforcement

Governance is the most important national-level factor of elephant poaching. The consequences of poor governance are likely to manifest themselves throughout the ivory supply chain, facilitating the movement of illegal ivory from the site way to the point of export. Poor governance prevents the improvement of the human condition, driving the rural poor to poaching for sustenance, which in turn provides incentives for underpaid and demotivated officials to facilitate, and benefit from, the movement of illegal ivory. Therefore, governance should be improved to address the problem of elephant poaching. Moreover, wildlife management authority should ensure that, SGR receive adequate patrolling. Also, the law enforcement staff should be well housed, equipped, well trained and led, and adequately remunerated.

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