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The pattern and cost of carnivore predation on livestock in maasai homesteads of Amboseli ecosystem, Kenya: Insights from a carnivore compensation programme

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Several papers have been written on the experiences, successes and challenges facing compensation schemes for wildlife, some of whom criticize the strategy while others support it. What is clear among the Maasai is that the burden of conserving wildlife, particularly predators that roam freely on their land and predate upon their livestock, is too great to bear: support in terms of financial compensation and mitigation strategies to reduce socio-economic loss from livestock deaths would help communities tolerate predators, and discourage some among them to kill carnivores in retaliation. Such programs in the Amboseli ecosystem are critical for the long term future of wildlife conservation. The Mbirikani Predator Compensation Fund (MPCF) is such a compensation scheme administered by the Big Life Foundation since 2003. Data from Big Life Foundation's monitoring records of compensation paid between 2008 and 2012 were analyzed in order to establish insights into the pattern and cost of predation in the Amboseli ecosystem. Results show that predation has been increasing with time, especially in recent years and during droughts; it is widespread across the Amboseli Ecosystem, but the frequency and intensity is higher near protected areas. The most common predators in the area studied are hyena, jackal, cheetah, lion and leopard; hyenas are the major predators, targeting all livestock types, while lion primarily target cattle. Between 2008 and 2012, more than KSh28 million was spent on compensation for over 9,000 livestock killed in bomas only. Poor Maasai homestead (*boma*) maintenance encouraged predation further. We recommend the compensation scheme to continue so that it cushions the Maasai from predation costs. Also, current measures of predation prevention such as improved livestock husbandry, construction of predator proof fences, and vigilance at night by the Maasai (especially the morans) should be encouraged, as it is within the MPCF. Benefit systems that complement predator compensation, such as generation of local employment, educational opportunities and involvement in carnivore conservation strategies, will help to conserve predators in the Amboseli ecosystem.

Key words: Amboseli ecosystem, human-carnivore conflict, compensation scheme, cost of conservation.

INTRODUCTION

Lions (*Panthera leo*) and other carnivorous species are in decline throughout most of their range in Africa due to persecution by humans related to depredation of livestock, lack of sufficient natural prey, diseases and destruction of their prime hunting habitats and human encroachment.

There are several mitigation strategies used to minimalize human - carnivore conflicts, but one strategy, compensation, has elucidated much debate on usefulness as well as constraints (Maclennan et al., 2009). Predation on livestock, other than causing general insecurity to human life, leads to huge economic losses, and a heavy conservation cost to local communities, particularly among poor countries. To help mitigate this conflict across a range of social and economic circumstances, livestock compensation schemes have been set up in several countries around the world in order to reduce costs to communities (Montag and Patterson, 2001).

Kenya, Botswana, Malawi and Zimbabwe are examples of the few African countries that have implemented state-run compensation schemes in the last few decades. However, other than government-sponsored compensation schemes, there has been various smaller-scale ‘‘direct incentive’’ schemes which do not necessarily compensate the losses at full market rates, but as “consolation” schemes that aim at increasing local tolerance of large carnivores by the local communities. In the Amboseli Ecosystem, the success of the MPCF has been evaluated (Kenana and Mwinzi, 2010); it was found that there is huge local support for the MPCF program, and that it has led to a much wider tolerance of carnivore costs, with less persecution, leading to an overall increase in carnivore numbers where the compensation scheme has been implemented.

The Amboseli Ecosystem hosts one of the largest remaining free-ranging, contiguous lion populations (IUCN, 2006). The Amboseli Maasai have a long history of lion killing (Western, 1982; Lindsay, 1987). Carnivore killings can either be cultural: when Maasai are coming-of-age ritual that brings prestige to the warrior who first spears the lion (Hazzah et al., 2009); or retaliatory (*Olkiyioi)* killings carried out in retaliation for livestock depredation.

Whilst the majority of lion killings were traditionally due to cultural reasons, most killing today, in the Amboseli and elsewhere in Africa is mainly for protection of life, livestock and in retaliation for losses thereof. If we can deal with compensation aspects to reduce anger and desperation due to predation, it is likely that local communities will tolerate carnivores and allow them to move freely and support minimum viable populations.

Due to the high costs incurred locally from conservation (such as depredation of livestock), and especially where there has not been intervention of compensation schemes and public awareness of the importance of carnivores for the tourism industry and ecology of the area, most Maasai have lost much of their former tolerance of wildlife that allowed them to coexist with large carnivores such as lions, and the availability of cheap and effective poison now gives them the means to eliminate predators. For example, between 1991 and 1994, lions were extirpated from Amboseli National Park, mainly through poisoning, but with time, they gradually recolonized from surrounding communal lands (Hazzah 2009).

In addition, in the early 2000s, conservationists and tourism operators documented unusually high numbers of lions being speared and poisoned on group ranches (communally owned traditional Maasai grazing lands) around Amboseli. In today’s Kenya, wild animals outside of protected areas have minimal positive economic value; they are only an expensive nuisance to the people who lose crops, livestock, and occasionally human life (Hazzah et al., 2009).

The reversal of this unsustainable situation requires poor rural communities, which carry the conservation burden of large carnivores, to be supported through compensation schemes and other benefit mechanisms of ecotourism through national level policy reforms that allow rural people to profit economically from ecotourism or other wildlife-based enterprises (Borgerhoff Mulder and Coppolillo, 2005). For example, properly managed ecotourism investment and activities, with profits transparently distributed to community members, could generate significant income and attendant good will towards wildlife. Kenya does not support trophy hunting for lions and large carnivores due to the potential to abuse the program; it has contributed significantly to declines in carnivore numbers where hunting has been introduced but is uncontrolled, or based on poor understanding of effects on population numbers and structure. Further, a shift towards a decentralized conservation agenda that empowers local communities to conserve wildlife could help address the burden of wildlife property damage to local communities and help turn wildlife conservation from a liability to an asset.

In the Amboseli region, the future of carnivore conservation depends primarily on a better understanding of the nuances of human-carnivore conflict and a concerted effort to address appropriate cultural and community-level institutions, ensuring that economic benefits are provided to local people who engage in conservation activities so that the costs incurred through livestock deaths are reduced. The overall objective of this research is to gain insights from long term monitoring data on human - carnivore conflicts, particularly insights into the pattern and nature of predator attacks to domestic livestock within Maasai homesteads (*bomas*) of two group ranches in the Amboseli region between 2008 and 2012 and to explore the means through which such conflict may be prevented and related costs reduced. Our

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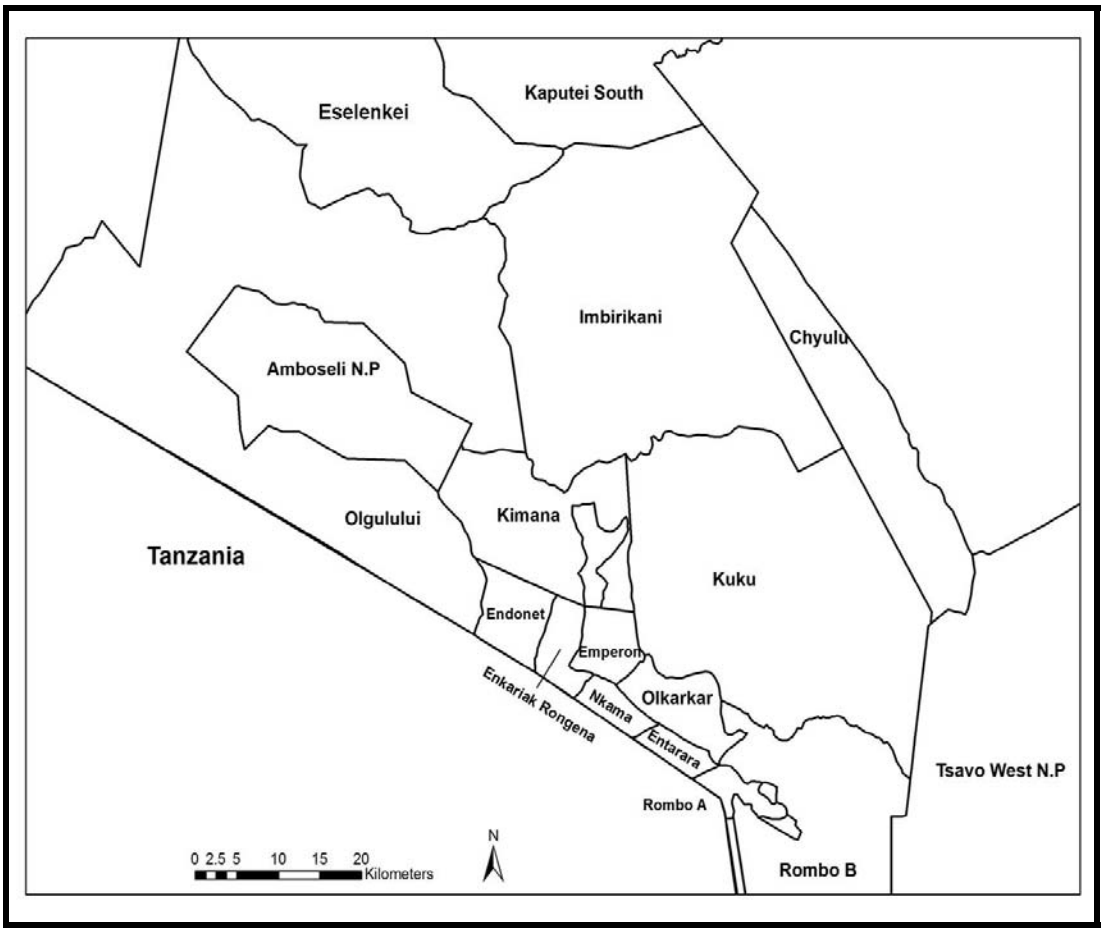

Figure 1. Amboseli and surrounding private and communal Maasai group ranches in Southern Kenya.

synthesis is particularly focused on the costs and pattern of carnivore predation and on the compensation scheme implemented by Big Life Foundation for incidences within bomas only. Insights from this work emphasize the importance of such schemes in contributing to monitoring human-carnivore conflicts, and provide us with assessment of the impact that compensation schemes supporting poor local communities can achieve, and the scale on which they can achieve it, in creating tolerance for large carnivores and giving them a chance for establishing viable populations especially outside the network of protected areas.

MATERIALS AND METHODS

Study site

The Tsavo-Amboseli ecosystem (Figure 1) in Southern Kenya is a major block for wildlife conservation and covers over 6,500 km^2 where large mammal species move freely in an area communally owned by the Maasai (Wishitemi and Okello, 2003). Home to renowned national parks such as Tsavo East and West, Chyulu and Amboseli, the ecosystem comprises an important area for ecotourism which provides a significant source of foreign revenue for Kenya (Okello et al., 2005). Despite being one of Kenya's smallest parks (392 km^2), Amboseli National Park is an extremely popular tourist destination and generates major revenue, while Tsavo (21,812 km^2) comprises the largest protected wildlife area in Kenya. The corridor of land between Tsavo and Amboseli National Parks serves as a wet season dispersal area for many wildlife populations, making it a crucial area for the global conservation of predatory species such as lion, and for East African wildlife conservation in general.

The rangelands in the area include a variety of habitats such as dense and open shrubland, bushland, and woodland, with both riverine and drier regions dominated by *Acacia* species. Soils in this region are classified as volcanic soils which are generally highly saline and alkaline. Whilst soils near water sources can be extremely fertile (Katampoi et al., 1990), in general the land is suitable only for pastoralism and wildlife grazing.

The unprotected corridor of land between the national parks comprises six group ranches: Kuku, Kimana, Mbirikani, Olgulului-Ololorashi, Eselenkei and Rombo group ranches, all situated in the Oloitokitok Sub County (Figure 1). These group ranches were set up in 1979 to protect the Maasai from losing more land than had already been lost to British colonials and other Kenyan ethnic tribes (Campbell et al., 2000). Kuku Group Ranch covers an area of 960 km^2, Kimana Group Ranch an area of 251 km^2, Olgulului - Ololorashi Group Ranch covers an area of 1,232 km^2, while Mbirikani Group Ranch covers 1,229 km^2. These group ranches

host privately-owned and community wildlife sanctuaries and therefore support the dispersal of wildlife populations between parks as well as supporting large non-migratory populations.

Traditionally, Maasai pastoralist practices have been compatible with wildlife due to large areas of land being available to share between livestock and wildlife, and range similarity in feeding strategies between livestock and most large herbivores. However, the harmony between Maasai pastoralists and wildlife has gradually diminished. The last census estimated the group ranches to have a density of 36 people per km^2 (Republic of Kenya 2001), with the Oloitokitok District having an estimated population growth rate of 5.6% compared to the national average of about 3.6% (Ntiati, 2002); this increasing population has intensified pressure on resources such as land and water (Newmark, 1993). At the same time, there has been a shift in the definition of wealth by the Maasai; originally defined by the number of children and livestock, wealth now depends more on cash and area of private land (Campbell et al., 2000).

These changes increase pressure on group ranches to subdivide their lands from communal to individual ownership. Current government polices provide a framework for this subdivision of land (Graham, 1989; Galaty, 1992); all Maasai group ranches have begun the process, with Kimana already fully subdivided. However, land subdivision results in the Maasai no longer being able to support their large herds of livestock without depletion of land resources. In response, many Maasai are becoming agro-pastoralists (Okello, 2005) despite their traditional belief that to till the land is a curse (Seno and Shaw, 2002). In addition, land tenure policy promoting land subdivision and private ownership has increased the opportunity for migrant farmers to lease subdivided land, hence accelerating agriculture expansion in the area (Okello 2005).

Except in the areas near Kilimanjaro where rain-fed agriculture is possible, almost all agriculture that takes place in the region requires the use of irrigation; this reduces the amount of water available for other land uses such as pastoralism and wildlife grazing (Campbell et al., 2000). In fact, cultivation is considered one of the most serious threats to wildlife conservation in this region (Pickard, 1998; Okello and Kiringe, 2004). The shift from pastoralism to cultivation has also increased conflict between wildlife and communities, through both the reduced ability of wildlife to find natural sources of food (resulting in increased dependence on crops and livestock) and the general damage of property as populations move through settlements. The conflict between humans and species which predate upon livestock is a crucial issue to address in order to sustain carnivore conservation whilst supporting local communities.

The history and process of MPCF predator compensation in the Amboseli ecosystem

The Amboseli-Tsavo Game Scout Association (ATGSA), a privately organized community law enforcement group that collaborates with the Kenya Wildlife Service (KWS) to protect wildlife, began recording the incidents and circumstances of lion killings in the Amboseli region in 2001, providing vital information of imminent regional lion extinction that, in turn, led in 2003 to the establishment of the Mbirikani Predator Compensation Fund (MPCF). MPCF was founded by and is administered through, the Maasailand Preservation Trust (MPT), now re-branded as Big Life Foundation (BLF). The MPCF is funded by private donors and collects long term monitoring data on human - carnivore conflicts and a participatory compensation program to reduce incidences of retaliatory killing of predators when domestic livestock is depredated.

The idea of a compensation fund to protect predators was originally proposed by Maasai community leaders themselves. The specific rules and regulations of MPCF were determined by mutual agreement between the Mbirikani Group Ranch Committee and MPT/BLF and formalized in a legally binding agreement (which, at present, contains 28 separate clauses concerned with verification requirements, benefits to be paid in arrears if no lions are killed, and penalties to be imposed if predators, lions in particular, are killed in violation of MPCF's rules). MPCF's terms and conditions can be re-negotiated annually but BLF reserves the right to terminate the project at any time (Figure 2). All operational costs and 70% of the livestock claims payments are borne by MPCF, while the group ranch covers 30% of the livestock claims payments, this money being earned mainly from bed night conservation fees paid to the community by the local Ol Donyo Lodge.

The predators protected by MPCF include lions, cheetahs (*Acinonyx jubatus*), leopards (*Panthera pardus*), spotted hyenas (*Crocuta crocuta*), jackals (*Canis mesomelas*), and the smaller cats. Cape buffalo (*Syncerus caffer*) and elephants (in collaboration with the Amboseli Trust for Elephants) are also included in the compensation scheme if and when they kill livestock. Maasai livestock species protected by MPCF are cattle, goats, sheep and donkeys.

MPCF has, from the outset, "lagged the market", with payments based on market prices lower than the present reality, although MPCF and the ranch community occasionally revise the values to be paid for each species of livestock protected, based in part on changing market prices. Further reductions in the amount paid by MPCF for a particular claim are based upon whether the depredation was by hyenas, whether a *boma* fence meets minimum standards of protection, and/or whether the head of livestock in question had been lost in the bush and was therefore unprotected altogether. If the predator was a hyena, only 50% of full payment is made; if a *boma* fence (for livestock killed inside a *boma* only) is less than four feet tall and four feet thick, or generally of poor quality, only 30% of full payment is made. If the livestock in question is judged to have been lost in the bush and unattended, only 50% of full payment is made; if a cow is lost in the bush and killed by a hyena, only 25% of full payment is made. If the livestock in question is killed outside the boundaries of the group ranch by more than one kilometer, no payment is made. If the carcass or tracks have been tampered with, or there is no carcass, no payment is made. If the livestock depredated does not belong to a group ranch member, no payment is made. The purpose of these rules is to discourage false claims and to severely punish those livestock owners who practice poor animal husbandry (Richard Bonham and Tom Hill, *personal communication).*

According to the agreement, if a lion is killed in violation of the rules of MPCF, those responsible are arrested and the family of each warrior involved in the killing is fined the value of a cow. At the same time, for the two-month period in which the lion killing took place, all otherwise verified compensation claims payments are rendered null and void for the group ranch members living in the geographic "zone" in which the lion was killed. The stated purpose of MPCF's penalties, according to BLF, is to create peer pressure among families and neighbors in each geographic zone of the group ranch to ensure that all members of the community cease retaliatory lion killing. These penalties have all been successfully imposed.

If an owner is unhappy with a particular verification of depredation on his or her livestock (conducted by the MPCF team of verifying officers, half of whom are not local Maasai), he or she can make a formal complaint to an MPCF Advisory Committee that meets six times a year (on every MPCF payday) which comprisesof one elected male elder from each geographic zone and two women who represent the female population of the community. During these meetings, with the complainant and the verification team in attendance, this committee decides the legitimacy of the complaint and advises MPCF as to whether the payment in dispute needs to be revised or rejected altogether.

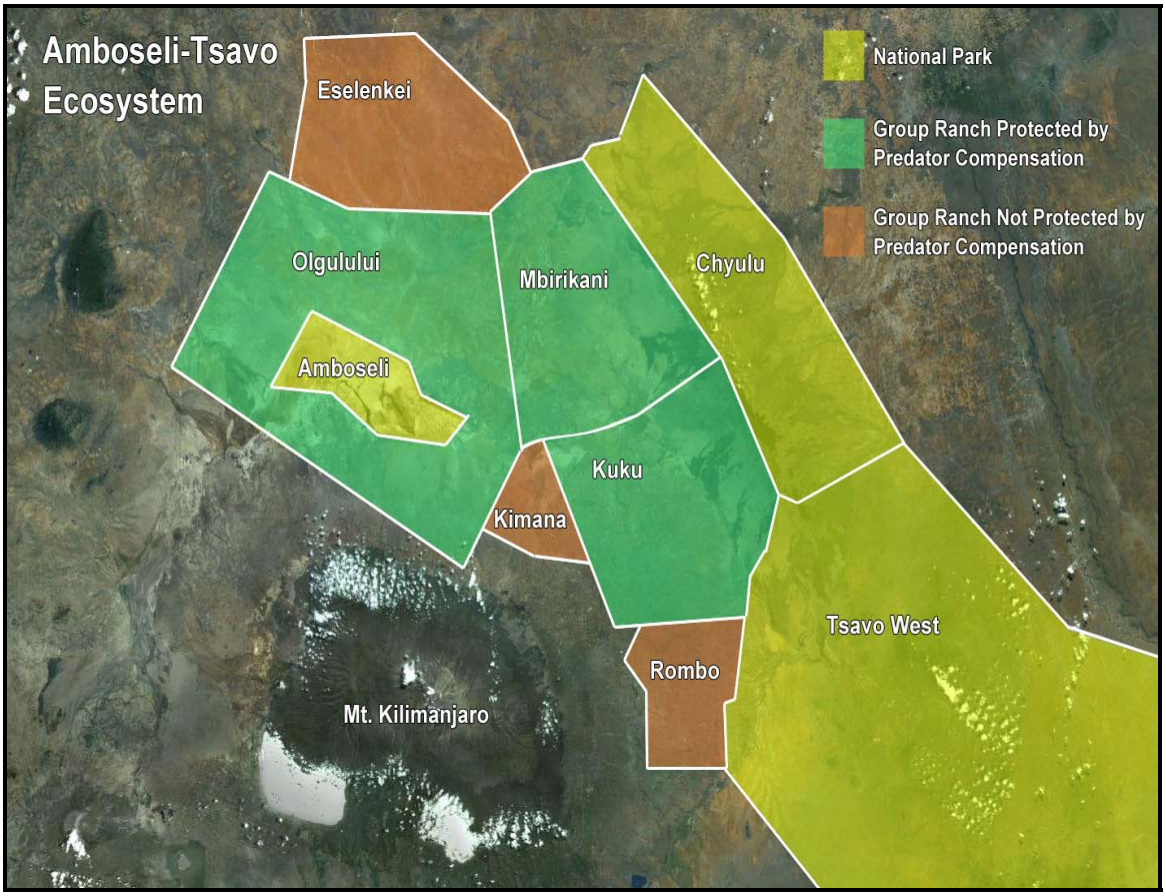

Figure 2. Group ranches where the MPCF is being implemented in the Amboseli Ecosystem.

As a result of the comprehensiveness of the scheme, over the entire history of MPCF, only 42% of full payment (lagging market price) on average has been made per claim (Table 1); therefore, MPCF has been designed from the outset to be a partial consolation fund only, one that rewards good animal husbandry and not one that can be exploited to excess by livestock owners for inordinate benefit (Richard Bonham and Tom Hill, personal communication).

According to data provided by Big Life Foundation, the rate of lion killing on Mbirikani Group Ranch for the 18 months prior to the introduction of MPCF in 2003 was 1.2 lions per month (or approximately 14 lions per year), by both spearing and poisoning. In the 11 years since the introduction of MPCF, a total of just six lions have been recorded killed on Mbirikani in violation of MPCF rules, a reduction in the rate of lion killing, when compared to the 18 months prior, in excess of 95%. The lion population that inhabits Mbirikani Group Ranch has increased significantly during the years MPCF has been in force.

This impressive positive contribution of the compensation scheme was achieved simply at a minimal costing of $10 per person per year (in 2013) when one considers the total cost of MPCF (all claims payments and all administrative, operational, and personnel costs) in relation to the total number of residents of Mbirikani Group Ranch. The approach of the MPCF is similar to an insurance scheme but instead of those covered by the program paying a nominal premium, their "payment" for the protection they receive is made in the form of behavioral change - ceasing the killing of lions and all other predators protected by the scheme, and helping to enforce the rules of MPCF on family members and neighbors.

In 2007 Kuku Group Ranch introduced a highly similar compensation program called *Wildlife Pays* (administered by Maasai Wilderness Conservation Trust); in 2008 Ogulului Group Ranch adopted MPCF with BLF as its administrator. Kenana and Mwinzi (2010) have reported that on this ranch, lion spearing and poisoning declined from 50 lions killed to only 1 lion after compensation was began. Altogether, a one million acre corridor of contiguous group ranch land is now protected by a predator compensation scheme (accounting for all major species of predators and livestock) that connects Amboseli National Park to Tsavo National Parks and the Chyulu Hills National Park, in which more than 40,000 Maasai are resident (Figure 3).

Methods

Here we report on five years of MPCF's long term data collected between 2008-2012 (for Olgulului) and 2010-2012 (for Mbirikani) following the protocols described in the compensation process in this paper. This data was only for predation that occurs inside *bomas* (this accounts for only 20% of the total livestock depredations by carnivores). We therefore clarify that this is only a portion of the compensation paid by MPCF since it also covers livestock depredated outside of bomas.

Long term data used in this work was provided by BLF and consists of records of carnivore attacks on livestock reported by

Table 1. Payment amounts for carnivore predation by the compensation scheme and how payment amounts have changed over the years. The units are in Kenyan Shillings.

Year	Livestock type	No penalties		Lost in the bush		Inadequate boma construction	
		Lion, Cheetah, Leopard	Hyena, Buffalo, Jackal	Lion, Cheetah, Leopard	Hyena, Buffalo, Jackal	Lion, Cheetah, Leopard	Hyena, Buffalo, Jackal
2003-2008	Cow	13,500	6,750	6,750	3,375	4050	2025
	Donkey	6,000	3,000	3,000	1,500	1800	900
	Shoat	2,000	2,000	1,000	1,000	600	600
2008-2010	Cow	14,500	7,250	7,250	3625	4350	2175
	Donkey	6,000	3,000	3,000	1500	1800	900
	Shoat	2,500	2,500	1,250	1250	750	750
2010-2014	Cow	20,000	10,000	10,000	5,000	6,000	3,000
	Donkey	7,000	3,500	3,500	1,750	2,100	1,050
	shoat	3,000	3,000	1,500	1,500	900	900

members of Olgulului from 2008 to 2012, while the data for Mbirikani Group Ranch was available from 2010 to 2012. Only reliable and verified data was used in this analysis and the mentioned years provided the best data for each of the group ranches included in this assessment. This paper considers only the livestock killed and fully compensated for. When incidences of predation are reported, data on the carnivore species, livestock species, location, structural condition of the *boma* (whether well maintained to deter predators or not), date and amount paid off in compensation are recorded in a standardized form. The compensation procedure follows events outlined in the schematic diagram below (Figure 3). Visual assessment of the state of the boma (broken places, age of the fencing materials, types of fencing material and status of poles of the fences) was used to classify bomas as either *well maintained* or *not well maintained*.

Monitoring data collected information on what species of livestock was killed, how many were killed in an attack incidence, which predator species was involved, what was the date of the attack, how much money was compensated based on existing protocol, state of the homestead fence, GPS location, and the name of the area where the attacks took place.

Data was analyzed using normal mathematical procedures of measures of central tendency such as means and dispersion such as standard error (Zar, 1999). Relationships between attributes for count data were analyzed using Chi-square cross-tabulations, while analysis for trends used spearman non - parametric correlation (Zar, 1999). Any significant differences between averages were established using One Way Anova. All tests were deemed significant statistically if the probability of Type 1 error (alpha) was less than 0.05. Tallies and data processing and analysis were completed using Excel Microsoft Spreadsheet 2000 and the SPSS statistical package 2001.

RESULTS

Between 2008 and 2012, a total of 4,660 carnivore predation incidences were reported in Olgulului Group Ranch, involving about 7,491 livestock deaths (an average of 932 incidences per year, involving an average of 1,498 livestock deaths per year). This resulted in a total compensation payment of KSh19, 144, 310 with an average payment of KSh4, 109 per incidence paid out for livestock predation. With regards to Mbirikani Group Ranch, there were 1,785 predation incidences (595 incidences per year, on average) involving 2,740 heads of livestock killed by predators (913 livestock deaths per year, on average). This resulted in a total compensation payment of KSh8, 812,375 with an average payment of KSh4,980 per incidence paid out for livestock predation.

In both Oglulului and Mbirikani, even though predation dropped after the 2009 drought, the general trend in predation claims, predation pressure and accompanying compensation costs showed a generally increasing trend over time. The increase in number of claims in Olgulului (Figure 4) was however not significant ($r = 0.30$, $p = 0.62$), but the increasing trend in livestock claims in Mbirikani (Figure 4) was significant ($r = 0.99$, $p = 0.001$). The increase in the total number of livestock killed by carnivores in Olgulului (Figure 5) was not significant ($r = 0.30$, $p = 0.62$), but the increasing trend in livestock claims in Mbirikani (Figure 4) was significant ($r = 0.99$, $p = 0.001$). Further, the increasing trend in compensation cost (Figure 6) in Olgulului ($r = 0.60$, $p = 0.30$), as well as in Mbirikani ($r = 0.50$, $p = 0.67$) were not significant.

In terms of the number of compensation claims for specific livestock types, goats and sheep (shoats) in both group ranches (Figures 7 and 8) were the animals which compensation claims were mostly demanded, followed by cattle and then donkeys in both Olgulului (Table 2) and Mbirikani group ranches (Table 3). The trend of claims for each livestock types in Olgulului (Figure 7) showed positive (increasing) but insignificant trend in claims for shoats ($r = 0.30$, $p = 0.62$), and donkeys ($r = 0.70$, $p = 0.19$), and negative (declining) but insignificant for cattle

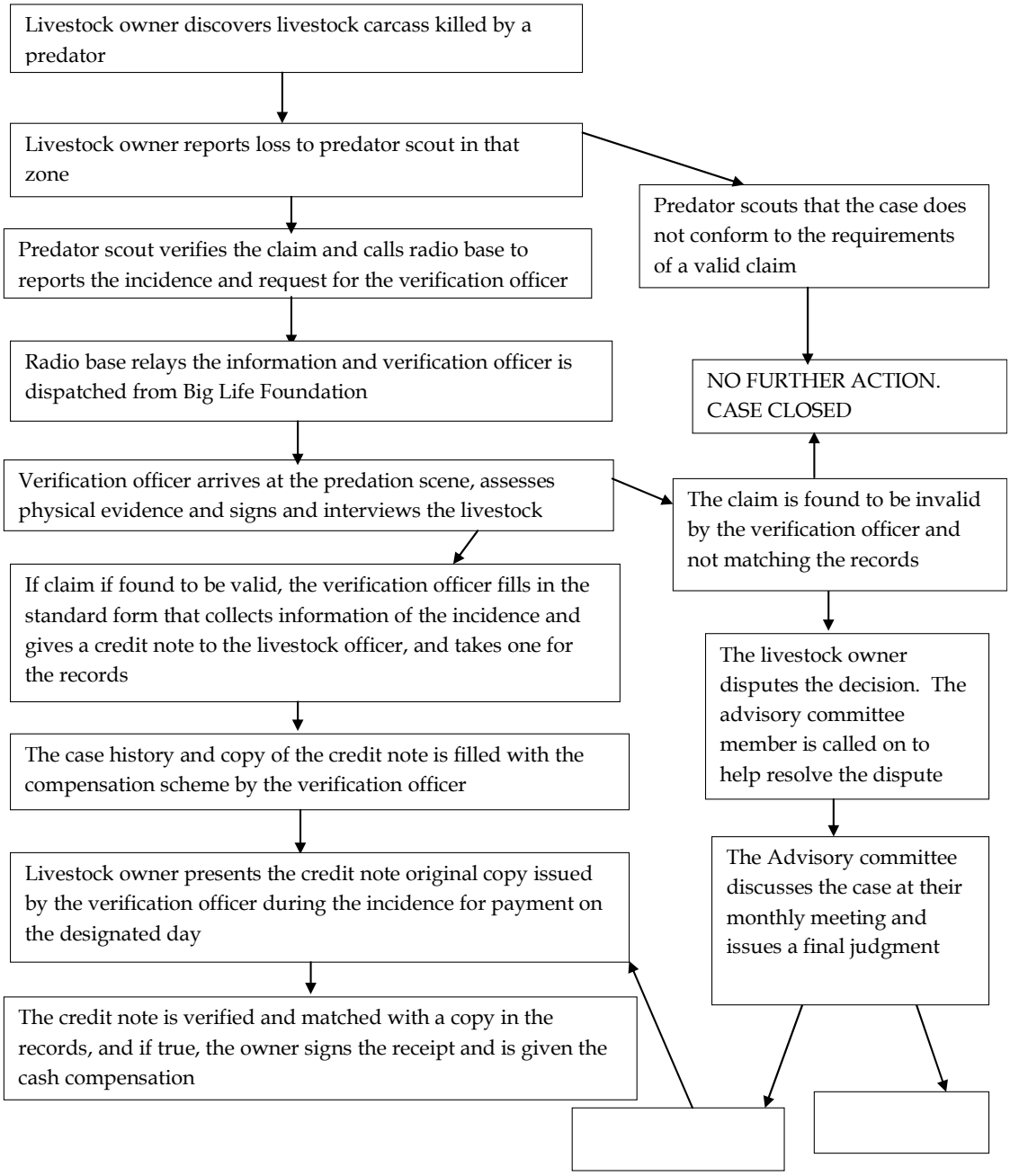

Figure 3. Schematic procedure on MPCF compensation scheme.

claims (r = -0.60, p = 0.29). However, the trend of claims for each livestock types in Mbirikani (Figure 8) showed positive (increasing) and significant trend in claims for shoats (r = 0.99, p = 0.001); but negative (declining) and insignificant for cattle (r = -0.50, p = 0.67), but negative (declining) and significantly for donkeys' (r = -0.99, p = 0.001).

In terms of total number of animals killed (animals killed per incidence reported), in Olgulului, shoats (average 1.71 ± 0.05, n = 3633 per incidence) were attacked in significantly higher numbers than other livestock (F = 15.87, df = 2, 4655, P < 0.001), followed by cattle (1.27 ± 0.27, n = 736) and comparatively fewer donkeys (1.13 ± 0.24, n = 289). In Mbirikani, a similar trend was observed, in which the average number of shoats killed (1.56 ± 0.05, n = 1621 per incidence) was also significantly higher (F = 5.22, df = 2, 1618, P = 0.005) than both cattle (1.21 ± 0.36, n = 232 per incidence) and donkeys (1.07 ± 0.05, n = 28 per incidence) (Table 4). These results may be due to either the relative

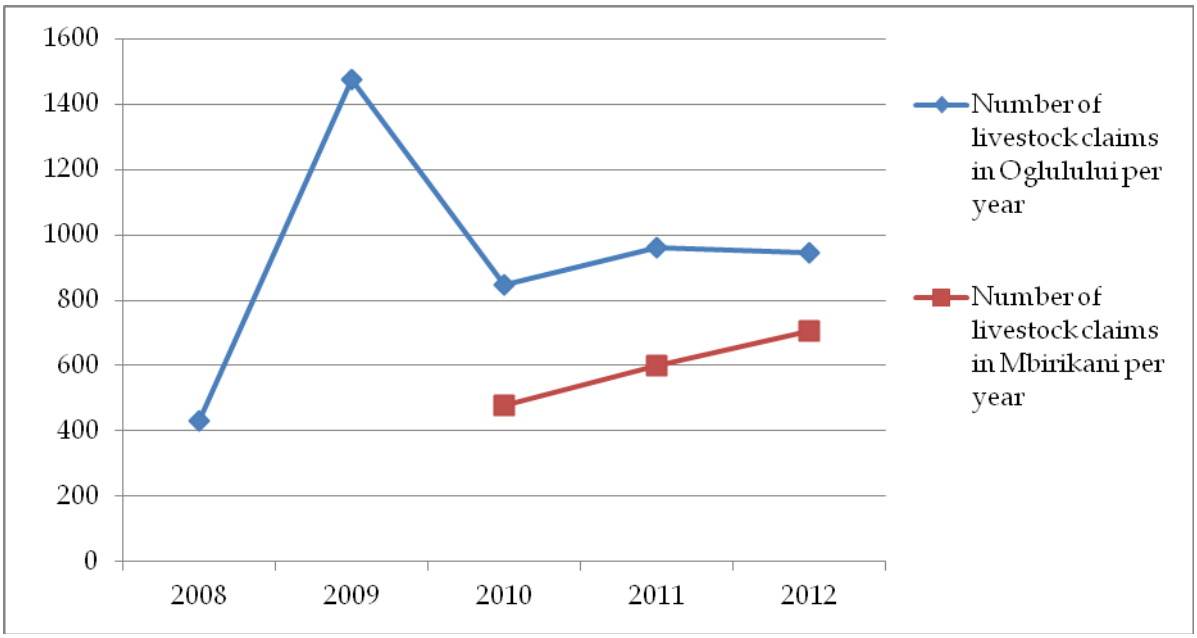

Figure 4. Total number of predation claims in Olgulului and Mbirikani.

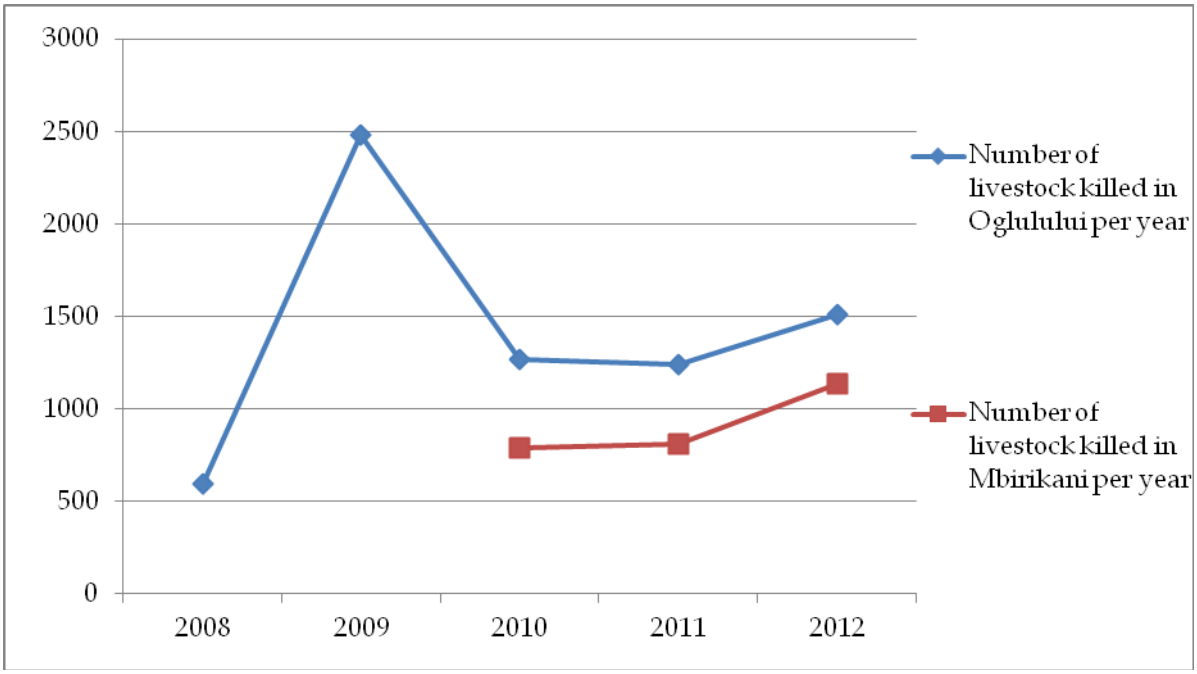

Figure 5. Total number of livestock killed in Olgulului and Mbirikani.

vulnerability of livestock types, preference by individual carnivore types or simply attacks in relation to availability (in numbers) of each livestock type (or a combination of the above).

Trends of the number of livestock killed by carnivores varied over time and between the two group ranches. In Olgulului Group Ranch (Figure 9), the trend in the numbers of shoats ($r = 0.40$, $p = 0.51$) and donkey ($r = 0.10$, $p = 0.87$) killed was positive (increasing) but insignificantly. However, the trend in the number of cattle killed in Olgulului was negative (declining) but insignificant as well ($r = -0.80$, $p = 0.10$). In Mbirikani Group Ranch

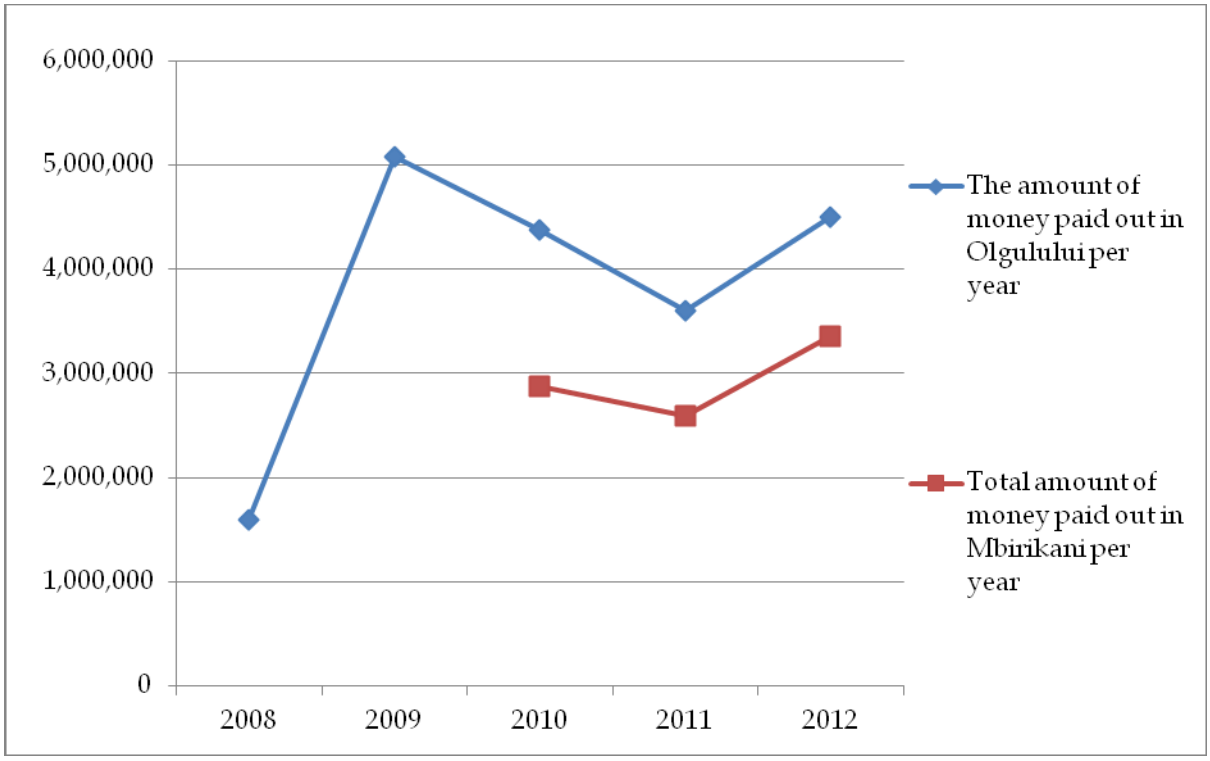

Figure 6. Total compensation payments (KSh) for livestock depredation in Olgulului and Mbirikani.

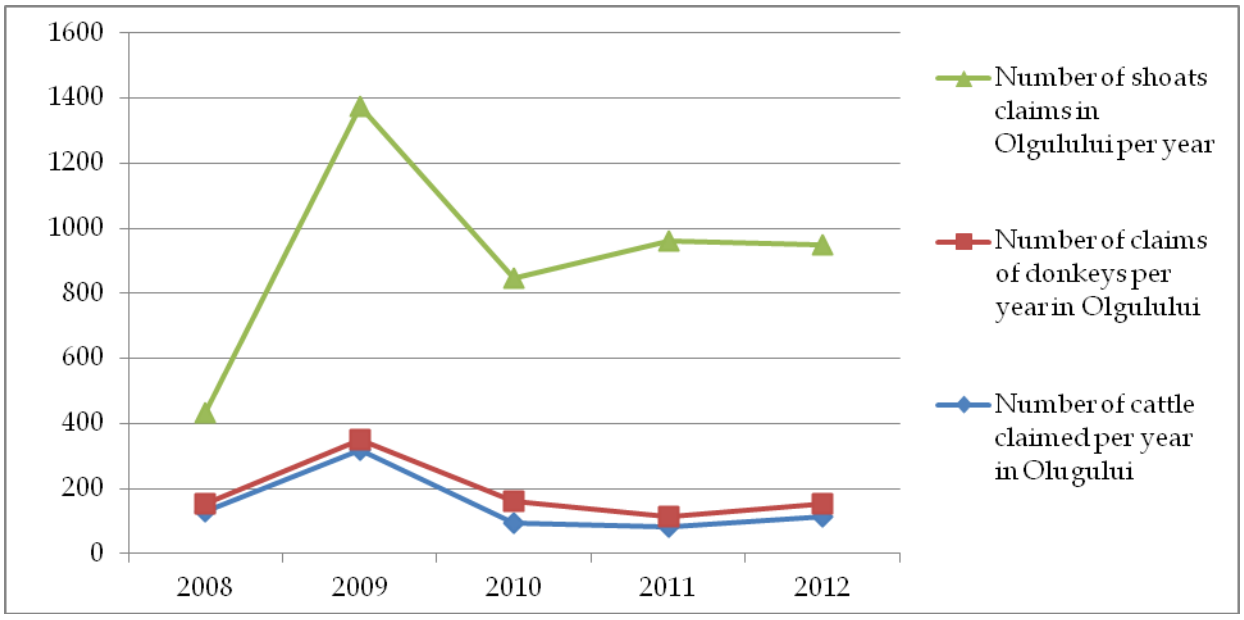

Figure 7. Total number of claims for different livestock types killed by carnivores in Olgulului.

(Figure 10), only the trend in the numbers of shoats killed was positive (increasing) and significant (r = 0.99, p = 0.001).

However, the trend in the number of cattle killed in Mbirikani was negative (declining) but insignificant as well (r = -0.50, p = 0.67), and negative (declining) but significant for donkeys (r = -0.99, p = 0.001).

Of particular note is the year 2009 and 2010 because

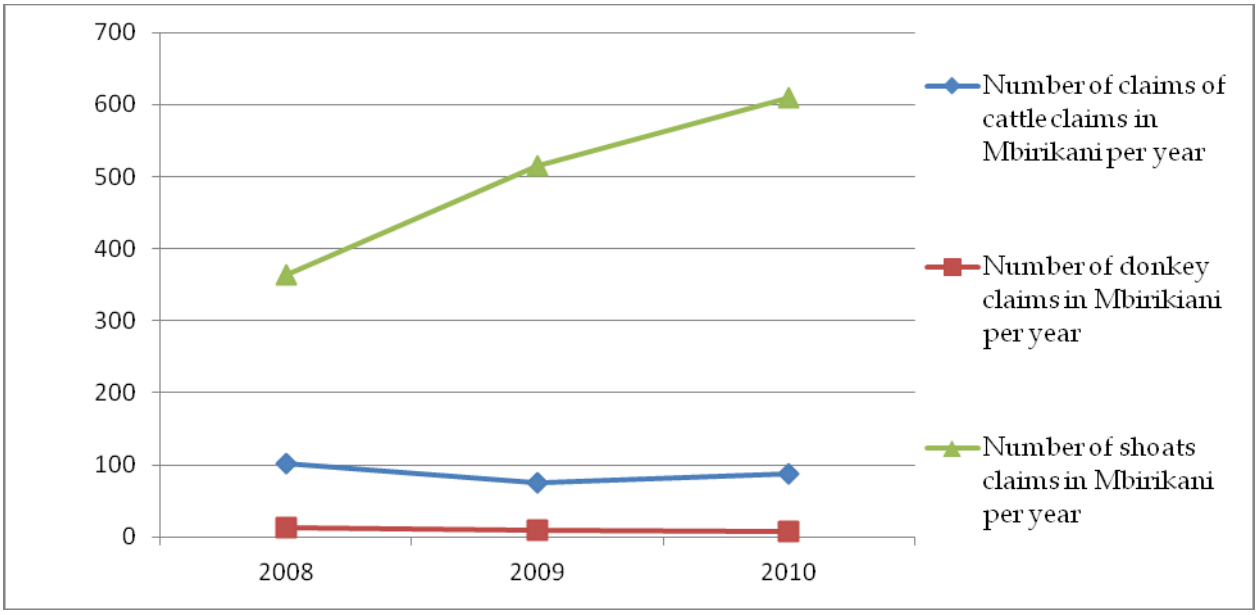

Figure 8. Total number of claims for different livestock types killed by carnivores in Mbirikani.

Table 2. The average amount of money and claims per livestock type killed by carnivores in Olgulului Group Ranch between 2008 and 2012.

Species	Livestock total	Number of claims	Average Mean ± SE	Total number of animals killed
Cattle	6,938,975	736	9,441 ± 319.22	934
Donkey	930,390	289	3,219 ± 175.84	326
Sheep and goats	11,274,945	3,635	3,102 ± 62.24	6,230

Table 3. The average amount of money and claims per livestock type killed by carnivores in Mbirikani Group Ranch between 2010 and 2012.

Species	Total cost (Ksh) spend	Number of claims	Number of animals killed	Average mean ± SE
Cattle	3,263,125	266	325	6190 ± 178.68
Donkey	149,100	30	32	4,468 ± 678.08
Shoats	5,400,150	1,489	2,383	45131 ± 136.88

Table 4. Portion of claims and expenditure for each carnivore type in Olgulului Group Ranch.

Carnivore	Number of claims Incidences	Total animals killed by predator	Total paid (KSh) over 5 years	Average cost per claim (mean, SE)
Lion	637	855	5,836,900	9,163.11 ± 372.89
Leopard	99	122	362,250	3,659.65 ± 382.93
Jackal	856	950	1,904,950	2,225.41 ± 38.60
Hyena	2,366	4714	9,046,510	3,825.16 ± 95.16
Cheetah	696	845	1,953,450	2,802.65 ± 83.61
Buffalo	5	5	40,250	4,106.01± 78.49

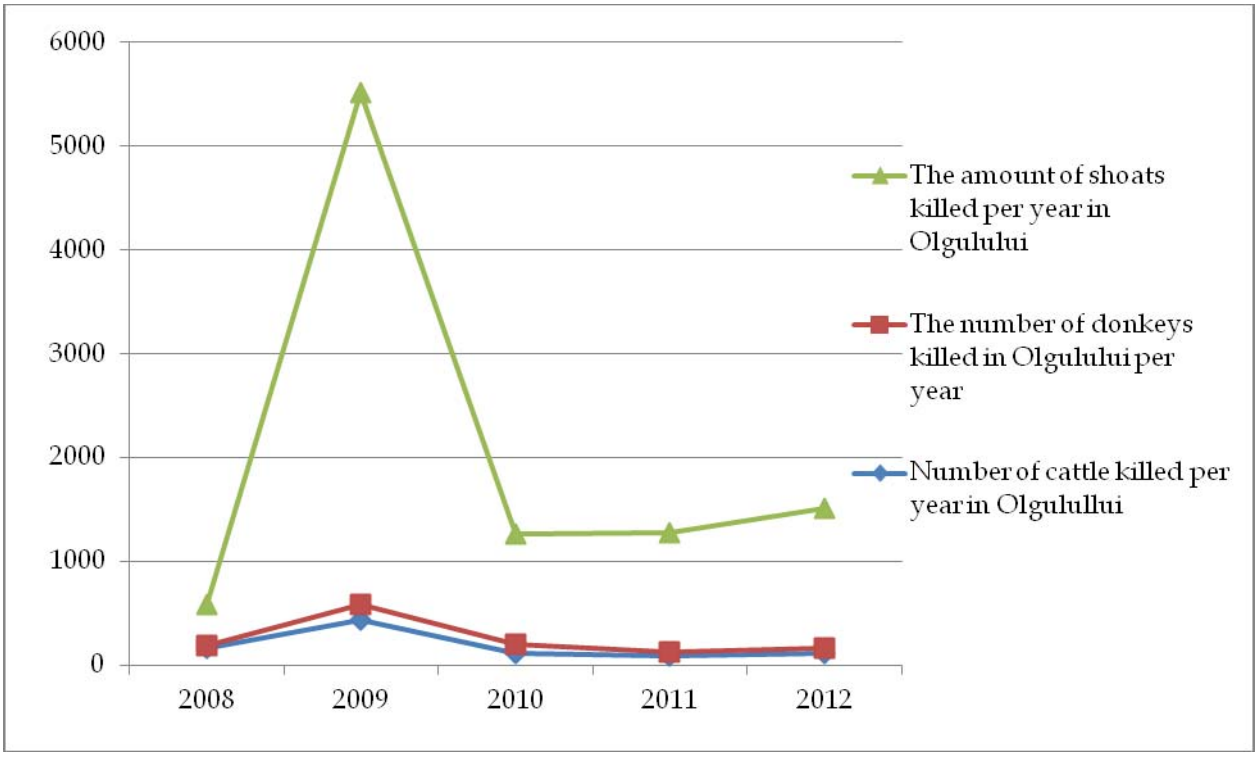

Figure 9. Total numbers of various livestock types killed by carnivores in Olgulului.

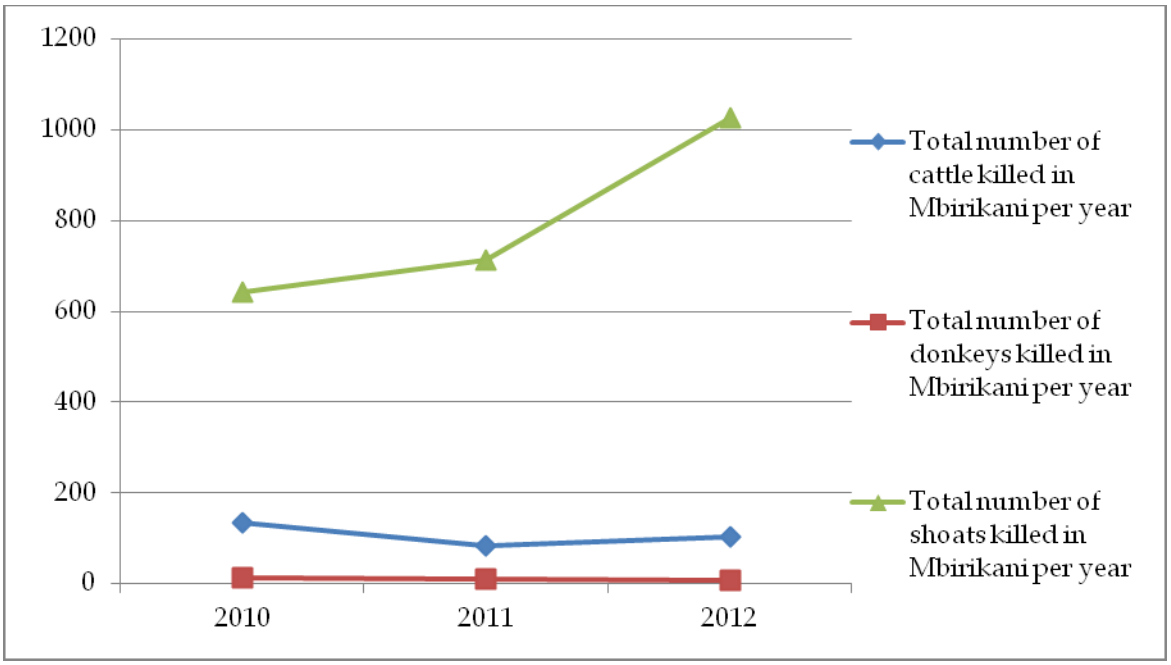

Figure 10. Total numbers of various livestock types killed by carnivores in Mbirikani.

there was a severe drought in Kenya that led to the decline or migration of most typical natural prey species, thus increasing predator dependence on livestock. Accordingly, for Olgulului most incidences occurred in 2009/2010. The total cost in compensation varied, being dependent not only on the frequency of attacks, but on

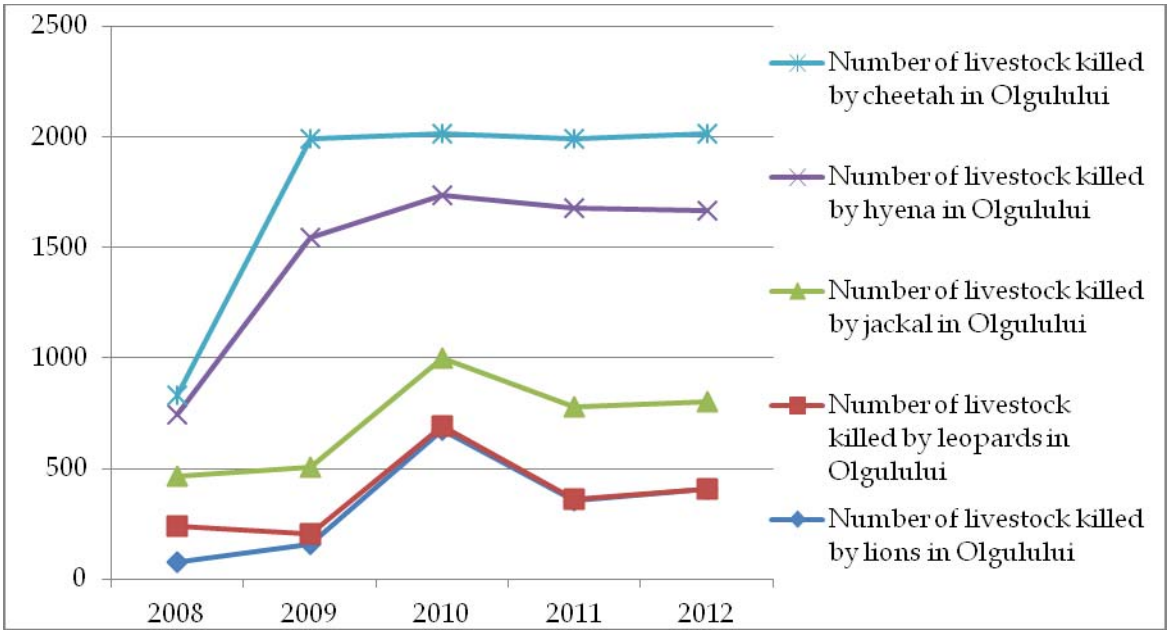

Figure 11. Predation intensity and trends for Olgulului Group Ranch.

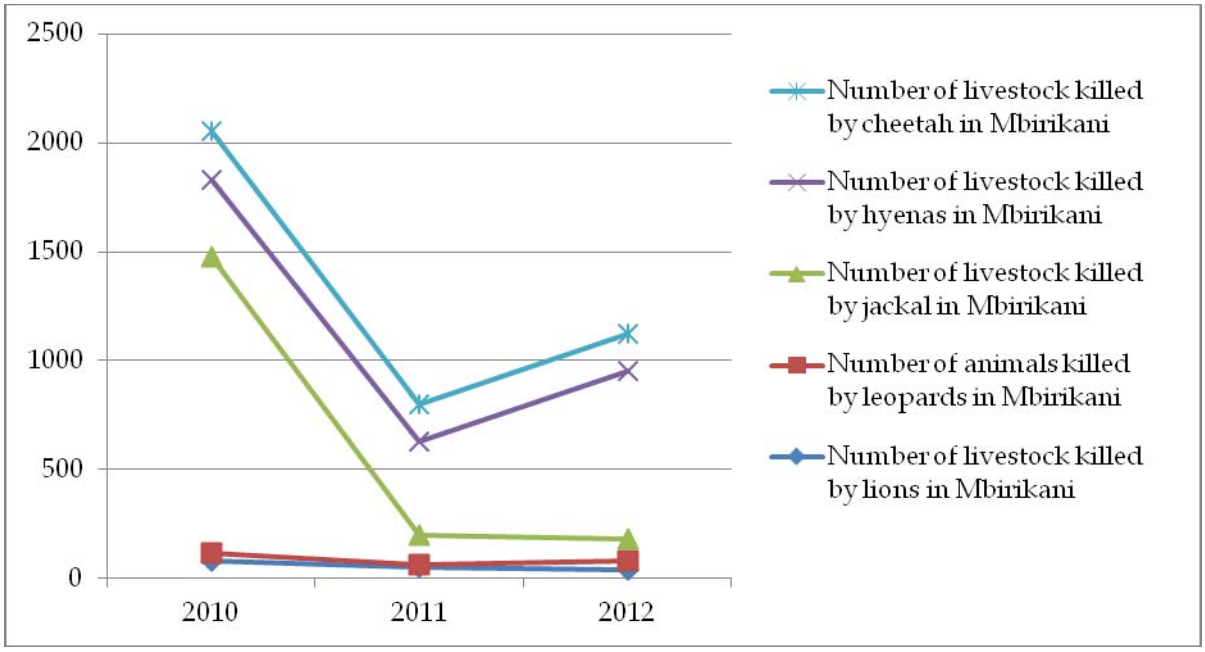

Figure 12. Predation intensity and trends in Mbirikani Group Ranch.

the number of animals killed and livestock type most targeted). It also depended on direct proximity to the conservation area. Olgulului / Ololorashi Group Ranch surrounds over 90% of Amboseli National Park perimeter and therefore predation frequency and pressure is generally high for all carnivore predation cases.

In terms of carnivores most involved in predation incidences (Figures 11 and 12) and associated compensation costs (Figures 13 and 14), hyena was the most problematic predator, followed by jackal, cheetah, lion and leopard (Tables 4 and 5), with some deaths by buffalo attacks. In Olgulului, the most common predators were hyena, jackal, cheetah and lion; however, in terms of total compensation cost, whilst the hyena caused the

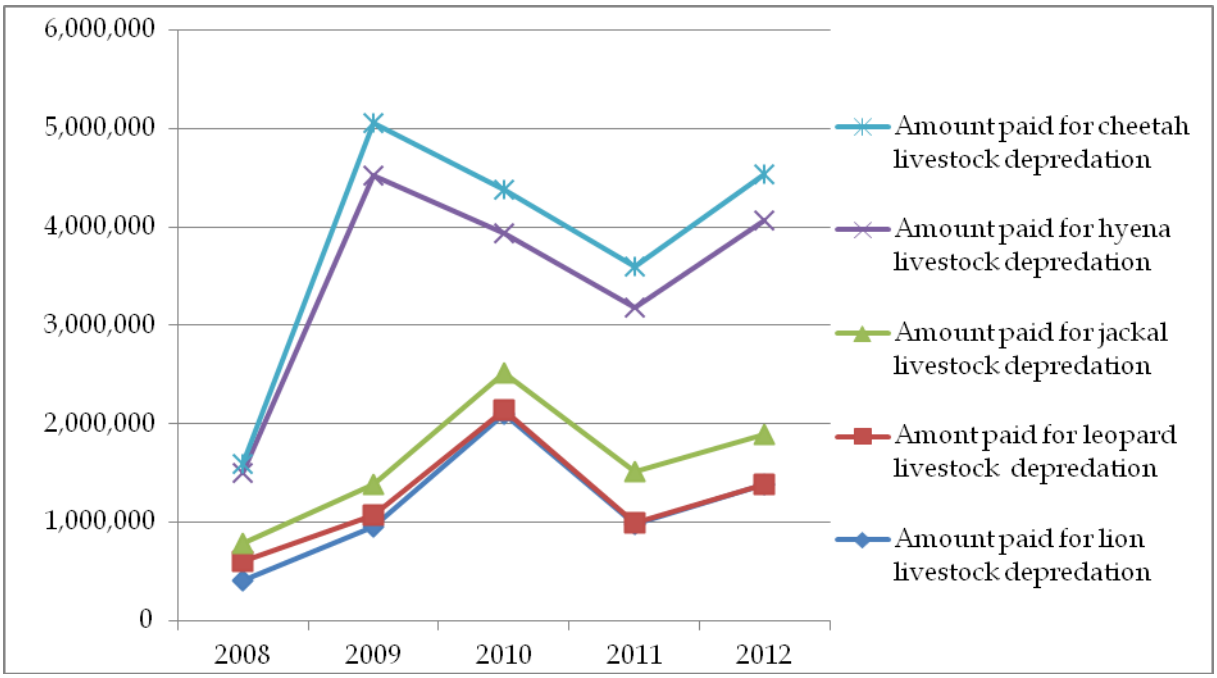

Figure 13. Predation trend and cost for Olgulului Group Ranch.

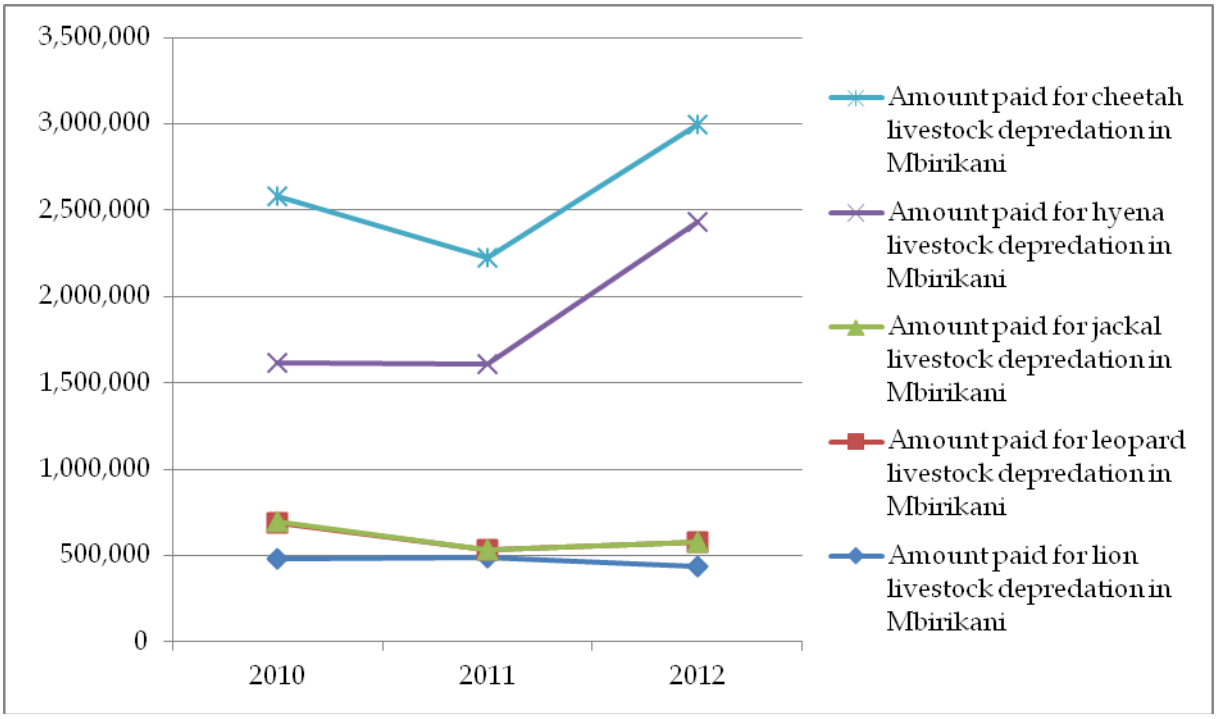

Figure 14. Predation trend and cost for Mbirikani Group Ranch.

greatest costs, this was followed by lion, cheetah, and finally jackal (Table 4). Similarly, in Mbirikani, the three main predators (in terms of both numbers of incidences and total number of livestock killed) were hyena, cheetah and jackal, whilst greatest contributions to compensation costs were due to the hyena, cheetah and lion (Table 5).

Trends in carnivore predation frequency were variable among the carnivore species and between the two group

Table 5. Portion of claims and expenditure for each carnivore type in Mbirikani Group Ranch.

Carnivore	Number of animals killed	Number of claims	Total Ksh paid	Average per claim ± SE
Lion	201	138	1,678,850	12,137 ± 920
Leopard	89	68	404,000	5,941 ± 609
Jackal	324	297	745,000	2,534 ± 66
Hyena	1559	844	3,848,875	4,609 ± 176
Cheetah	566	437	2,138,750	4,928 ± 237
Buffalo	1	1	900	-

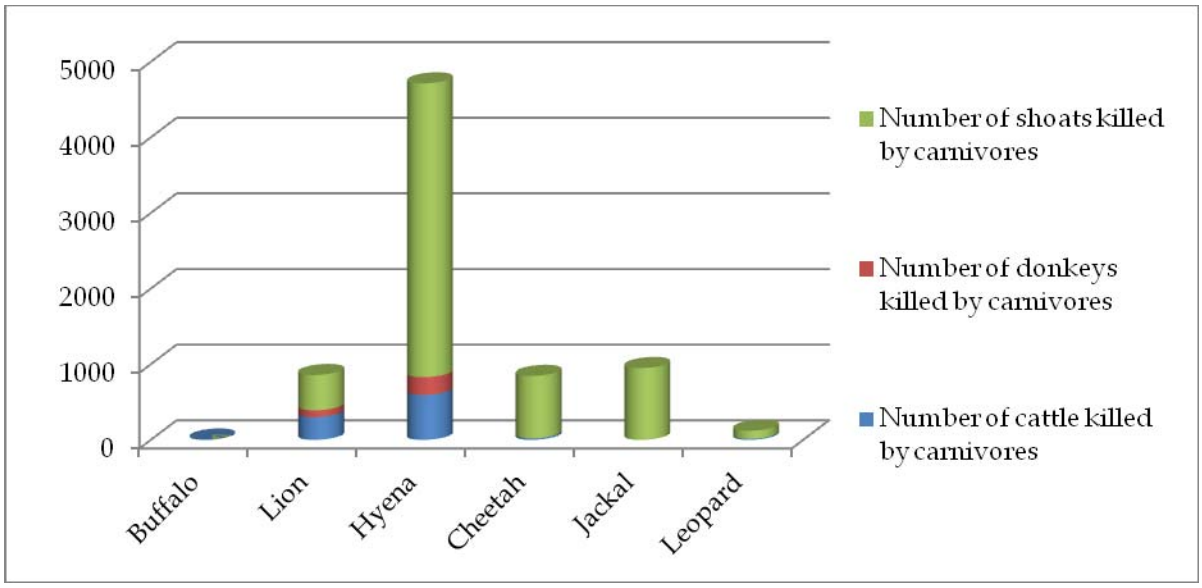

Figure 15. Number of livestock killed by various carnivores in Olgulului Group Ranch.

ranches. In Olgulului, incidences (and number of livestock killed) involving hyena, lion and jackal have generally increased, while those involving cheetah have remained stable and those involving leopard appear to have declined. Furthermore, it is evident that predation rates regarding jackal, hyena and cheetah were higher than for other carnivores during the drought period of 2009/2010 in Olgulului (Figure 11). In Mbirikani, however, lion, leopard, jackal and cheetah did not show a clear trend over time, with both incidences and number of livestock killed over time remaining variable (Figure 12). However, incidences and total livestock killed by hyena and cheetah seemed to increase with time in Mbirikani Group Ranch (Figure 10). Furthermore, the cheetah was involved in a relatively higher number of incidences and number of livestock killed during the drought period of 2009/2010 (although the same general trend with hyena) compared to other carnivores in Olgulului Group Ranch.

In terms of relationships between most vulnerable livestock species (regarding both incidences and number of livestock killed) and carnivore type, it appears that, in general, large predators such as lion and hyena consumed across livestock types, while relatively smaller and more specialized predators such as jackal and leopard targeted relatively small sized livestock prey only (Figures 15 and 16). This prey preference is evident in both Olgulului. Carnivore species preference seemed to also be influenced by livestock type and size, with relatively larger carnivores (lion and hyena) taking larger sized domestic prey (cattle and donkeys) while smaller sized carnivores (including jackals) targeted relatively smaller domestic prey types (χ^2 = 732.26, df = 10, P < 0.001). This prey preference was also similar in Mbirikani where predators seemed also to have prey preference (χ^2 = 311.88, df = 10, P < 0.001). Nevertheless, the cheetah seemed to prey upon both cattle and shoats; in Mbirikani, they prey exclusively on shoats in Olgulului. Since sometimes carnivore predation can be opportunistic, the general observation was that even though larger carnivores tended to attack large livestock frequently, smaller livestock prey such as shoats were attacked by all carnivore species, including large sized carnivores (lions and hyena).

In term of hotspots for human-carnivore conflicts, these

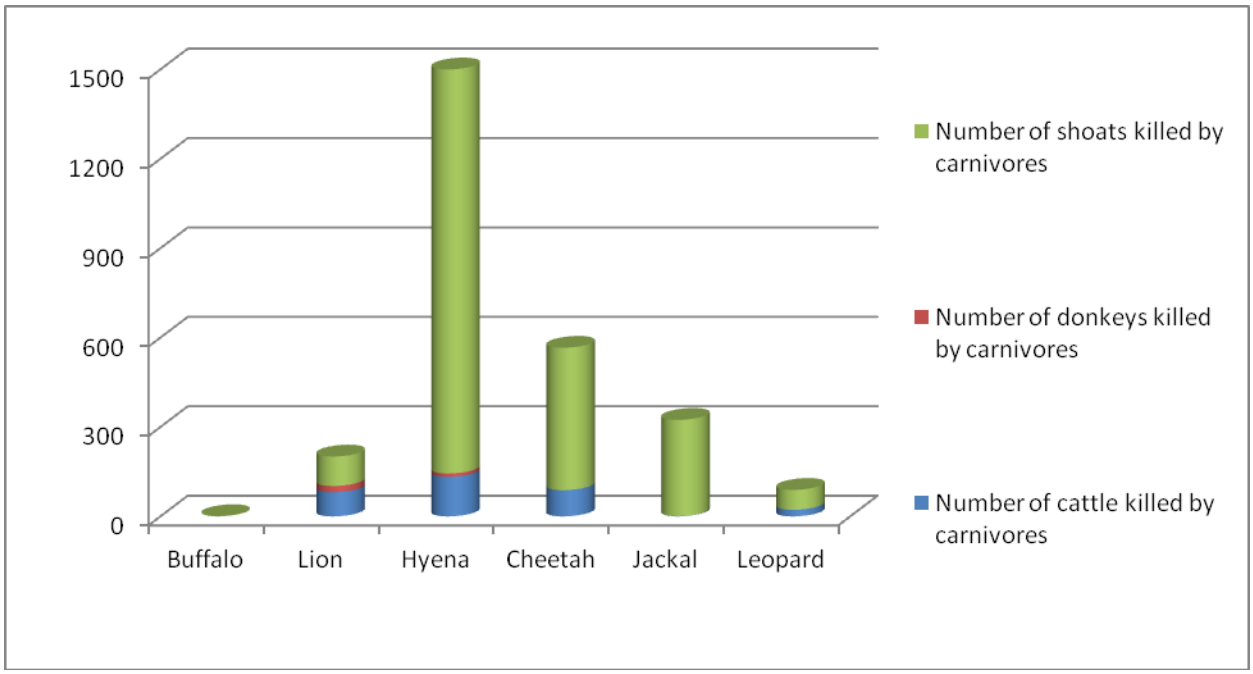

Figure 16. Number of livestock killed by various carnivores in Mbirikani Group Ranch.

are widely distributed in the Amboseli Ecosystem, with the greatest hotspots being in Olgulului / Ololorashi relative to Mbirikani Group Ranch. Most of these hotspots are relatively close to a national park, in isolated rangeland or near wildlife sanctuaries/conservancies.

The condition of the Maasai boma seemed to influence the frequency and intensity of attacks (in terms of number of animals killed), which supports the MPCF regulation of paying just 30% of the agreed rate if the boma is in disrepair compared to 100% compensation rate if the boma is well kept. In Olgulului, badly maintained bomas had a higher average number of livestock killed (average killed per incidence 1.91 ± 0.07, n = 2507) with significantly higher numbers killed ($F = 170.85$, df = 2, 4655, $P < 0.001$), compared to relatively well maintained ones (1.22 ± 0.07, n = 96) and well maintained bomas (1.25 ± 0.02, n = 2055).

Further, in Olgulului Group Ranch, livestock depredation was highly dependent on boma condition ($\chi^2 = 127.65$, df = 4, $P < 0.001$), with more predation taking place in poorly maintained bomas than in well maintained ones. This was also similar in Mbirikani Group Ranch, where more predation occurred in poorly maintained Maasai bomas ($\chi^2 = 95.38$, df = 4, $P < 0.001$) compared to moderately or well-maintained ones.

DISCUSSION

Carnivore conflicts are higher among the communities adjacent to protected areas than those that are far off. The results of this study show that Olgulului which surrounds over 90% of the perimeter of Amboseli National Park, consistently suffered a greater frequency and intensity of carnivore attacks to livestock compared to Mbirikani. This is expected as carnivores venture out of the safety of protected areas into neighboring dispersal areas first and will attack livestock that is grazing or in poorly protected Maasai homestead. Costs are likely to be very high if carnivore attacks to lost livestock or those in grazing fields are incorporated in the total cost assessments. It is therefore important to prioritize the communities adjacent to protected areas and wildlife sanctuaries for compensation, since they bear the greatest loss and cost of conservation from dispersing carnivores from core protected areas (Western, 1975, 1982; Galaty, 1992; Pickard, 1998; Seno and Shaw, 2002). These communities should also be prioritized for any other benefits or innovations aimed at reducing carnivore predation or human-carnivore conflicts in general. They should also be targets for awareness and education aimed at increasing the harmonious coexistence of communities and wildlife.

From MPCF records, Maclennan et al. (2009) concluded that, in descending order of importance, spotted hyena, lion, and cheetah and or leopards caused the greatest number of cattle losses. Our analysis has confirmed that the hyena still leads in frequency and intensity of predation; however, our data suggests that jackals are the next greatest predators, followed by cheetah, lion and leopard. The differences may be due to the fact that our data only considered predation in bomas

while his may have considered predation in the bomas and in the field as well. In terms of cost, the greatest amount of compensation was paid out for predation by hyena, followed by cheetah and lion. Hazzah (2009) noted that, compared to other large carnivores, lions are relatively insignificant as livestock predators and so the intense resentment of lions expressed by 25% of respondents suggest that conflict is rooted in perceptions rather than actual losses, possibly influenced by vulnerability linked to land use changes, displacement, and the imposition of conservation measures (Lindsay, 1987; Adams and McShane, 1996). However, this analysis shows that lions can be significant predators to livestock and, since they target cattle, which are highly priced both economically and socially, such incidents can cause more intense retaliation reactions than other carnivores (Dickman, 2005; Bagchi and Mishra, 2006). Lions are also more vulnerable to retaliatory poisoning because they often return to carcasses. Hazzah et al. (2009) noted that lions are most vulnerable because they are the easiest carnivore to kill using traditional methods (spearing), while leopard, hyena, and cheetah are much more difficult to track and kill; furthermore, spearing a lion has traditionally provided immense prestige within Maasai society (Hazzah, 2009).

In terms of compensation costs and carnivore attack incidences, shoats were the most affected by predation, followed by cattle and donkeys. There could be several explanations for this. First, shoats constitute the greatest number of individuals of these livestock, followed by cattle and finally donkeys. If the rate of carnivore attack is based on relative abundance and frequency of encounter, it therefore makes sense that attacks on shoats will follow the pattern seen (Holmern et al., 2007). Another possible explanation is the abundance of the carnivore types and their hunting strategy. Hyena appears to be the most abundant carnivore in the ecosystem (Kenana, personal communication) and because of its hunting strategy and its physical strength, it can easily take both small prey (shoats) and larger prey (cattle and donkeys) (Kissui, 2008). Therefore attacks by hyena are likely to depend on which livestock type is more readily available (Holekamp et al., 1997). Conversely, other smaller predators such as jackals, cheetah and leopard are likely to prefer smaller livestock prey than larger types, with their ability to overcome prey being the main influence on which livestock type they attack. These two reasons could explain the relatively higher rates of predation on shoats than on cattle and donkeys. Lions, on the other hand, may optimize their foraging reward by choosing bigger livestock prey such as cattle. Indeed lion attacks of cattle and donkeys are relatively higher than those by other carnivores (except hyena).

General predation in the group ranches appears to be increasing. This may be due to increasing carnivore and/or livestock numbers, thus increasing the rate of encounter which can lead to an attack. Indeed, the number of carnivores in the Amboseli ecosystem is increasing (Kenana, KWS; and Hazzah and Dolrenry at Lion Guardians, personal communication). It is therefore likely that an increasing predator population will not only predate on a higher number of natural prey, but a higher number of domestic prey as well (Patterson et al., 2004). Although no scientific studies have been done to show relative carnivore preference for livestock over natural prey once they begin taking livestock, a several predation cases in the region (in BLF's experience) have shown that once a carnivore begins to attack livestock, it may develop a preference for this meat over that of wild prey, since it is easier to kill and may have more tender meat, and may become a frequent predator of livestock. This may also become magnified in times of drought when there are lower numbers of natural prey, or at times when natural prey migrates beyond predator ranges, leaving livestock prey to become the primary target (Lindsay, 1987; Treves and Karanth, 2003; Treves et al., 2006). Indeed, the results show a clear indication that predation of livestock was greatest in the year 2009 when there was a general drought that reduced natural carnivore prey.

Another reason for increased livestock depredation may be continued human encroachment onto carnivore habitat. When numbers of livestock have increased in the Amboseli ecosystem, group ranch pasture (now declining in quantity and quality) has not been sufficient to sustain Maasai livestock. Encroachment into national parks (Tsavo and Amboseli) then becomes inevitable, especially during droughts, and lead to increased carnivore attacks, especially on stray livestock or those without a Maasai herder present (Hazzah et al., 2013;, IUCN, 2006; Saberwal et al., 1994; Krebs, 1999). Furthermore, increased livestock numbers necessitate larger and therefore less well maintained livestock sheds in bomas due to congestion and wear and tear of thorny fences. Natural thorny fence deterioration, especially in wet and damp seasons, increases fence decay and its inefficiency as a barrier (Kiringe and Okello, 2005), therefore increasing the likelihood of a successful attack by a predator.

The results clearly showed that bomas which were well maintained had reduced incidences of carnivore attacks compared with those that were poorly maintained. This emphasizes the need for proper boma fencing and strengthened security measures (such as additional night vigilance) as a deterrent to livestock predation (Okello et al., in press).

Responsible herding (by more experienced members of the community in addition to minors) and minimizing loss of livestock during grazing is also critical (Ogada et al., 2003). Tracing straying livestock and proper boma maintenance as well as support for the construction of predator proof bomas (carried out by Big Life Foundation, African Wildlife Foundation, African Conservation Centre,

Lion Guardians and other conservation organizations in the ecosystem) complements the compensation scheme and should be strengthened as a strategy to prevent predator attacks and reduce the number of incidents requiring compensation.

It is difficult to ascertain from the Maasai people whether or not the numbers of their livestock is increasing over time. Such an issue is sensitive, since it is a matter of individual wealth. However, personal observation estimates that recent droughts, especially that of 2009, reduced Maasai livestock numbers by over 60%. It is likely that livestock numbers are now recovering, hence the increase in predation.

Furthermore, land uses in the greater Amboseli ecosystem are changing fast, with increasing cultivation and urbanization coupled with high human immigration and birth rates, leading to diminishing space for livestock grazing (Woodroffe, 2000; Galaty, 1992; Okello et al., 2005; Campbell et al., 2000). This in turn leads to the confinement of grazing in areas where encounters with carnivores become high, hence increasing predation rates.

There are three possible interventions, in our view, that provide hope for carnivores in the Amboseli area: 1) the implementation of compensation schemes that help the Maasai to bear the costs of living with wildlife (such as BLF's compensation scheme studied here); 2) the empowerment of the Maasai to take simple and effective measures that reduce predation incidences on their livestock, such as the construction of predator proof bomas; and 3) the implementation of initiatives that diversify means for sharing benefits of wildlife across local communities, such as through employment in tourism or wildlife protection.

The strategy with the widest local appeal and support, one that has the greatest impact in reducing human-carnivore conflict and which covers the greatest number of people will make the greatest contribution to carnivore conservation. The compensation scheme as implemented now in Mbirikani is the most valuable, based on these criteria and on local opinions (Kenana and Mwinzi, 2010). These strategies, supported by KWS animal control units, should help to reduce human-carnivore conflicts and thus increase the tolerance of the Maasai in sharing resources with wildlife, ultimately serving to increase the number of key carnivores in the Tsavo-Amboseli Ecosystem (Hazzah et al., 2009; Maclennan et al., 2009).

Previous work on this compensation scheme and other aspects of its performance has been assessed and reported by Hazzah et al. (2009) and Maclennan et al. (2009). This paper chose to focus on insights obtained from the pattern of predation and the costs incurred, since in poverty stricken rural areas, costs of wildlife become crucial to both conservation and local development. The amount of money paid to community members after verification and appropriate relevant animal husbandry penalties in the two group ranches was close to KSh28 million for over 9,000 livestock killed over the duration. Since this covers just a small area of the ecosystem, considering only reported cases, this suggests a very high cost to the local communities. It also depends on significant funds to be provided by the organization, and without proper fundraising and support by government and other stakeholders in conservation, this critical program cannot be guaranteed (Nyhus et al., 2003, 2005). From discussions with communities bearing this cost, retaliation and killing of carnivore rates will be very high in the absence of such schemes, leading to concerns of carnivore extinction in the Amboseli ecosystem, raised by *National Geographic* (2008).

In a study by Hazzah et al. (2009) of the compensation scheme, the majority of the respondents had been compensated for their livestock losses, but only about half of those compensated approved of the program (Hazzah, 2006). However, a study by Kenana and Mwinzi (2010) showed that the scheme in Mbirikani had resounding successes whereby both the community and wildlife benefited through easing of economic loss, fostering positive attitudes towards wildlife and reduced carnivore mortalities. They further noted that on support structures and its operationalization platform, the compensation schemes had great successes of between 60% and 90% achievement of indicators. Program execution and administration was also very successful, as was the attainment of the objective of the MPCF. Their results further showed that whereas the success of the program has traditionally been viewed from a relatively narrow angle, as to whether there is reduction in carnivore mortalities or not, there are a number of subtle but nonetheless important successes of the scheme that enhance wildlife conservation. These successes include the reduction in hostility between community and conservationists; increased community policing on illegal activities against conservation; and positive attitudes of local community towards conservation (Kenana and Mwinzi, 2010).

This synthesis considers just a small portion of the overall cost of conservation of carnivores to the community, including just livestock death inside bomas. It does not consider injured animals or those killed during grazing, or those lost and eventually killed by carnivores. There have been many papers written to support or oppose compensation of local communities from wildlife damage (Nyhus et al., 2003, 2005; Bulte and Rondeau, 2005; Frank, 1998; Holmern et al., 2007; Maclennan et al., 2009; Hazzah et al., 2009; IUCN, 2006; Kissui, 2008; Linnell et al., 1999; Mishra et al., 2003; Montag and Patterson, 2001; Naughton-Treves et al., 2003; Wagner et al., 1997); however, without any other benefit system such as from ecotourism or private wildlife sanctuaries on their land, bearing the cost of conservation by the community without significant benefits (Ferrao and Kiss, 2000; Norton-Griffiths and Southey, 1995) and without

government and other stakeholder support is difficult on the ground (Galaty 1992). Understanding that conservation has a cost to local communities, and having government, conservationists and researchers appreciate this cost is critical to the survival of carnivores in poor countries in Africa (National Geographic, 2003; Dickson, 2005; Ginsberg et al., 1990; Hunter et al., 2007; Marker et al., 2003; Mishira. 1997; Myers, 1975). It is also important that conservationists, researchers and government take action to relieve the plight of local communities that live side by side with wildlife in order to contain the escalating negative attitudes caused by ever-increasing human-wildlife conflict (Treves and Naughton-Treves, 1999; Patterson et al., 2004; Ogada et al., 2003; Woodroffe and Frank, 2005).

Critics of compensation schemes often argue that that compensation in whatever form is neither an effective nor sustainable tool for conservation (Naughton-Treves et al., 2003). In the case of the MPCF, however, where compensation can be well below even half of livestock market value, in terms of impact and scale it is the most appreciated mitigation strategy among the Maasai, which inherently increases its sustainability. Local communities cannot be expected to appreciate the scientific and aesthetic benefits of wildlife when they are struggling with the very basics of life. Additional costs to their life and property from carnivores makes basic survival much more difficult, and violates their human right to own property and lead a peaceful life. In western countries where economic livelihoods and opportunities are greater, tolerance for wildlife in the midst of costs of conservation can be enabled. Loss of livestock, and of human life, among poor communities in Africa is a major cause for persistent negative attitudes and conflicts with wildlife, leading to widespread wildlife mortality. Compensation, when well managed and operated (such as that of Mbirikani) and when conducted alongside other benefits and awareness programs, simply helps lighten the burden, without encouraging immoral behavior, since it only pays a fraction of the total market value of the lost livestock. The change in attitudes of the Maasai and tolerance of carnivores in the Amboseli as measured by reduced retaliatory killing and a rising number of carnivores (Kenana and Mwinzi, 2010) is testament to the fact that compensation can be a highly effective conflict mitigation strategy, especially in poor rural communities in Africa.

We also see an enhanced role of adult male Maasai and morans in this respect by helping guard livestock at night. As noted by Maclennan et al. (2009), compensation should not become a source of income for the Maasai, or compensation for sick and dying livestock exposed to predation. Effective animal husbandry, establishing carnivore proof bomas, increasing home vigilance against predators at night and ensuring other forms of benefits from presence of carnivores (such as establishment of wildlife sanctuaries) and appropriately zoned land use practices should help prevent livestock predation, thereby reducing the need for compensation; these practices should be encouraged on a larger scale.

If inadequate livestock management practices were effectively rewarded through compensation payments, the impact of the compensation scheme would be reduced. Overcoming these issues is a challenge in such a support system, but can be managed well with community goodwill and good structures in place (Maclennan et al., 2009; Hazzah et al., 2009). In order to ensure that the Maasai understand that compensation is one of the last resorts to help them live side by side with wildlife, BLF also promotes prevention strategies such as employing local game scouts to reduce human-wildlife conflict and encouraging improved livestock husbandry. The verification system and penalties imposed for poor husbandry practices under MPCF ensure that Maasai are encouraged to take every action possible to prevent predation of their livestock, and perverse incentives for poor animal husbandry are limited (Maclennan et al., 2009). This is further helped by the fact that the Maasai are generally not willing to devalue their animals just for compensation, and take every measure possible to keep their livestock alive, rather than leave a sick animal out for carnivores.

Finally, since funding for compensation schemes does not flow continuously and may not always be available, we suggest that accompanying disincentives, such as rigorous law enforcement and prosecution, would help to reduce retaliatory lion-killing, also suggested by Hazzah (2006). Losses to depredation can be substantial for individuals, and some people may continue to harbor negative attitudes towards carnivores despite compensation schemes, due to general insecurity and other concerns they may have. This is also because compensation schemes cannot pay for all livestock losses in all conceivable circumstances.

Despite this, there has been a 90% decrease in the number of lions killed annually in the Amboseli ecosystem where compensation schemes exist, with numbers of lions (and of other carnivores) now increasing (Kenana, personal communication). This may be due to a combination of factors, such as the appre-ciation of the MPCF efforts; the Maasai's embrace of privately owned wildlife sanctuaries in the area; education and awareness; increased employment opportunities offered by BLF; the activities of other conservation orga-nizations operating in the ecosystem, such as African Wildlife Foundation, Lion Guardians, Amboseli Trust for Elephants, The School for Field Studies, African Conservation Centre and the Amboseli-Tsavo Game Scout Association.

Conflict of Interest

The author(s) have not declared any conflict of interest.

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