The Ecological and Social Aspects of Livestock Predation by Large Carnivores in Pastoral Ranches Adjacent To Maasai Mara National Reserve, Kenya

By

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other university to the best of my knowledge.

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.... 05/06/2010........................

Signature Date

We the undersigned declare that this thesis has been submitted for examination with our approval as the university supervisors

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Dr. NATHAN. N. GICHUKI Date

.... 18/6/2010........................

Dr. J. K. MWORIA Date

DEDICATION

Dedicated to my parents, who though not highly educated, knew education is crucial and took me to school.

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DF	- Degrees of freedom
STD	- Standard deviation
SS	- Sum of squares
Sig	- Significant level
No	- Number
KWS	- Kenya Wildlife Service
MMNR	- Maasai Mara National Reserve
Mm	- Millimetres
Km	- kilometres

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ABSTRACT

All over the world, human-wildlife conflict is an ever increasing problem for many species of wildlife and especially true for large carnivores. They are often killed when threatening humans and their domesticated animals, and since carnivores trophic positions confine them to living at low population densities, their future existence is critically threatened. Research that advances our understanding of predator-livestock interactions is crucial to conflict mitigation and large carnivore conservation. This study was conducted with the aim of (1) determining the large carnivores involved in livestock predation (2) assessing livestock predation intensity and temporal occurrence in the pastoral ranches adjacent to Maasai Mara National reserve, (3) assessing factors that influence livestock predation specifically wild prey density, livestock density, carnivore density and environment.

The study took place in Maasai Mara National Reserve and the adjacent group ranches for duration of eight months. Data was collected via a combination of various methods. Line transects sampling was done to estimate wild prey density and distribution, quadrat sampling to estimate vegetation cover, questionnaires and interviews to estimate livestock/carnivore density in the group ranches, and secondary data retrieved from the Kenya Wildlife Service, human wildlife conflict occurrence book in Narok station.

Results showed that most livestock were attacked and killed during the rainy season (61.2%). Lions (*Panthera leo*), Leopards (*Panthera pardus),* Spotted hyenas (*Crocuta crocuta*) and wild dogs (*Lycaon pictus)* were responsible for 42.9%, 40.8%, 12.2% and 4.1% of the attacks respectively. Leopards (*Panthera pardus*) were identified as the most destructive, having attacked and killed 66% of all livestock during this period. ANOVA results indicated a significant difference ($F_{[3,308]}$ =66.201, $p<0.001$), in grass height between the Reserve and the group

ranches. There was also a significant difference in grass cover between the reserve and the group ranches. There was no significant difference in the number of attacks on livestock (χ^2=4.5; df=2, $p > 0.001$) in all the three group ranches.

During the rainy season most of the native ungulates especially the migratory wildebeests and zebras are in the southern area of Serengeti and this seems to alter the prey availability for resident large carnivores. They hence, turn to livestock predation as the alternative source of food. Also during the rainy season there is a lot of available pasture for the resident ungulates hence less time is spent feeding and more on scanning for possible predators, thereby giving carnivores a more difficult time to hunt.

CHAPTER ONE

INTRODUCTION AND LITERATURE REVIEW

1.1 Introduction

During the recent decades livestock predation by large carnivores has become a major cause of human wildlife conflict globally (Michalski et al., 2006). Reliance of large carnivores on livestock for food has brought them into direct conflict with humans especially in areas where native wildlife intermingle with domesticated stock (Ramakrishnan et al., 1999; Saberwal et al., 1994; Seidensticker et al., 1999). When carnivores attack humans and livestock, campaigns to eradicate them are inevitable (Seidensticker et al., 1999; Woodroffe, 2000). Understanding the circumstances surrounding carnivore attacks on livestock and mitigating against the ensuing conflict is a crucial issue for conserving and managing many apex predators (Frank, 1998).

The economic cost incurred by pastoralists through carnivores predation on their livestock can be substantial (Beier, 1995) and this is also partly responsible for shaping the attitude that pastoralists have towards large carnivores (Vitterso et al., 1999). Identifying the causes and quantifying the level of predation is therefore crucial for large carnivore conservation in any given area (Vitterso et al, 1999). The relative extent of livestock predation varies from area to area (Kaczensky, 1996). Factors such as animal husbandry (Linnel et al., 1999) and wild prey density (Meriggi and lovani, 1996) can help explain part of this variation. Since it is not possible to predict what level of conflict will occur in a given area, it is therefore essential to conduct regional specific surveys of damage. Conserving large carnivores in present day landscapes therefore requires a high level of scientific knowledge (Mech, 1995).

The conservation of large carnivores does not only depend on biological landscape but also the social political landscape (Treves and Karanth, 2003). Changing political attitudes and views of nature have shifted the goals of carnivore management from those based on fear and narrow economic interests to those based on a better understanding of ecosystem function and adaptive management (Treves and Karanth, 2003). Therefore detailed information on the ecology and intensity of predation on livestock is the key to developing strategies for conserving both large carnivores and the wild lands (Polisar et al., 2003).

For any effective conservation of large carnivores to take place, knowledge of a species distribution and status is vital (Linnell et al., 1998; Gese 2001). However, conducting accurate censuses of large carnivores is a very difficult task because of their low densities and cryptic behaviour (Linnell et al., 1998; Gese 2001). The actual size of carnivore populations is very important for determining the appropriate level of protection that a species need, but disagreement about this actual size can also be a source of conflict. Since large carnivores can have very long natal-dispersal distances it is possible for a few young animals to travel widely and create the impression of a far larger population (Swenson et al., 1995). Information on how individual animals move is a vital requirement to fully understand their ecology. The home range size used within given seasons is one of the most basic, but important, parameters on which data is needed, to effectively conserve large carnivore populations (Linnell et al., 1999).

Large carnivores are top predators in their ecosystems and more importantly act as a "top-down" control on populations of their prey in these ecosystems (Reeves et al., 2002). Many are such an important control on their prey that they act as keystone species, and their removal has drastic consequences for the ecosystem (Reeves et al., 2002). The destruction of natural prey in order to support increasing number of domestic livestock has brought many of the big cats into conflict with humans (Michalski et al., 2006). Large carnivores like leopards do not necessarily take advantage of small domestic stock when other food is abundant (Stuart, 1989). However surplus killing (where 10 or many more sheep and goats may be killed in a single incident) is a well-known phenomenon but usually takes place in holding pens or against fence lines (Stuart, 1989).

There is a compelling need to find methods for deterring large carnivores from preying on livestock (Hoogesteijn et al., 1993). Translocation for example has been used to manage individual predators involved in livestock predation as well as elephants when perceived to be problem animals in high conflict areas. This experience has showed promise for more translocations in the future because it delivers a face saving excuse to farmers who otherwise would have illegally killed these problematic animals. However, there are concerns that the survival of translocated carnivores may be limited because of their being territorial and particularly in an ecosystem with a high density of con-specifics, where a translocated animal might not get an opportunity to fit into the social system (Linnell et al., 1999).

1.2 Maasai land ownership and use

1.2.1 Land ownership and the formation of group ranches in Mara ecosystem

Traditionally land was never seen by a Maasai community as a commodity to be traded on, but as a source of pasture, water, medicines and other necessities for their livestock economy and life styles (Alemu, 1999). Land was valued for the services it provided or functions it served the community and this still remain the central part of the social-political organization of the Maasai people. Traditionally, the Maasai community had no centralized government and their political authority was vested in elders who reached decisions by consensus (Alemu, 1999). Their economic style depended on communal systems of land holding that maximized the feeding of the whole community. The tribal elders allocated grazing resources, such as watering points, multipurpose trees and shrubs to various family groups within the clan. The clan elders also regulated the migration patterns of different clans as dictated by the foliage conditions. However, this model ceased to exist when East African governments declared pastoral areas as trust land in mid 1960s.

In 1968, the Kenyan government developed the group ranch model in an attempt to commercialize livestock production (Alemu, 1999). The status of land-ownership was hence changed from trust-lands to group ranches through the land group representative Act, Chapter 287, 1969 of Government of Kenya. The land was adjudicated and registered as freehold, private or group ranches. The Group Representatives Act governed the constitution and administration of groups, while adjudication rights and registration were governed by agricultural legislations. The group elected its members as group representatives, who were registered by the government as trustees. The trustees regulated and controlled land use by members, and also rented the land on behalf of the members. Disputes among group members in relation to land were settled through the regular government court system. During this time, some individual ranches were also created, generally for and by the Maasai elites (Alemu, 1999).

Over time the group ranch model lost favour among members due to corruption and poor management. This prompted the government to sub-divide the group ranches into individual land parcels starting early 1980s. This subdivision greatly restricted the mobility of wildlife and hence resulted in increased human wildlife conflicts in the ecosystem (Sitati, 1997). Consequently, it disturbed the informal user rights of the community to certain resources such as access to certain trees with medicinal value and also led to loss of women rights. Male heads of households and male relatives of women households were allocated exclusive rights of ownership after subdivision. This process therefore expanded and legalised men's access to land while decreasing and informalizing women's rights of ownership and use (Sitati, 1997). A benefit that was derived from privatisation is the elimination of the tragedy of the commons. In the Maasai land, the tragedy of the commons was not so much overexploitation but more of under investment (Sitati, 1997).

1.2.2 Land use change in the Mara ecosystem

The Maasai-Mara ecosystem has undergone considerable changes in terms of land cover, land use and land tenure over the past few decades (Gachugu, 1997). The major land use changes started in the early 1960s. At this time the ecosystem was less populated and the land was exclusively used for nomadic pastoralism, livestock and wildlife grazing. Subsequently, slowly the emigrants from the agricultural communities started entering into the ecosystem. They leased land from the Maasai landowners and slowly human settlements, agriculture and livestock production started expanding (Gachugu. 1997).

Agricultural development, especially land under wheat production, has been rapidly expanding in the Mara ecosystem since 1970s. Figure 1 shows the development of agriculture in Narok district during the period between 1950 and 2005. By the late 1970's most of the northern parts of the ecosystem were under cultivation (Gachugu., 1997). With the leasing of more land by Maasai to commercial wheat farming enterprises, the area under cultivation increased from about 5,000 ha in 1975 to about 50 000 ha in 1995 (a 42.9% increase per annum). The increase in areas under cultivation saw the distance between the farms and the reserve decrease at an alarming rate. The farms were approximately 52 kilometres from the Maasai Mara National Reserve boundary in 1975 and by 1996 the distance had reduced to 17 km (Gachugu., 1997). About 40,000 hectares of wet season wildlife and livestock pasture was lost to agriculture between the year 1975 and 2000 where by majority of the group ranches were subdivided into individual plots (Ottichilo, 2000).

Permanent human settlements also started to increase around the gazetted reserve; hence forming a barrier to free movement of wild animals (Ottichillo, 2000). Many of the former grazing, breeding and watering points for wildlife were converted to crop farms thereby blocking the migratory and movement routes of wildlife (Ottichillo, 2000). The conversion of former wildlife and livestock dry season grazing areas in the ecosystem into agriculture is ongoing and is contributing to illegal grazing of livestock inside Maasai Mara National Reserve.

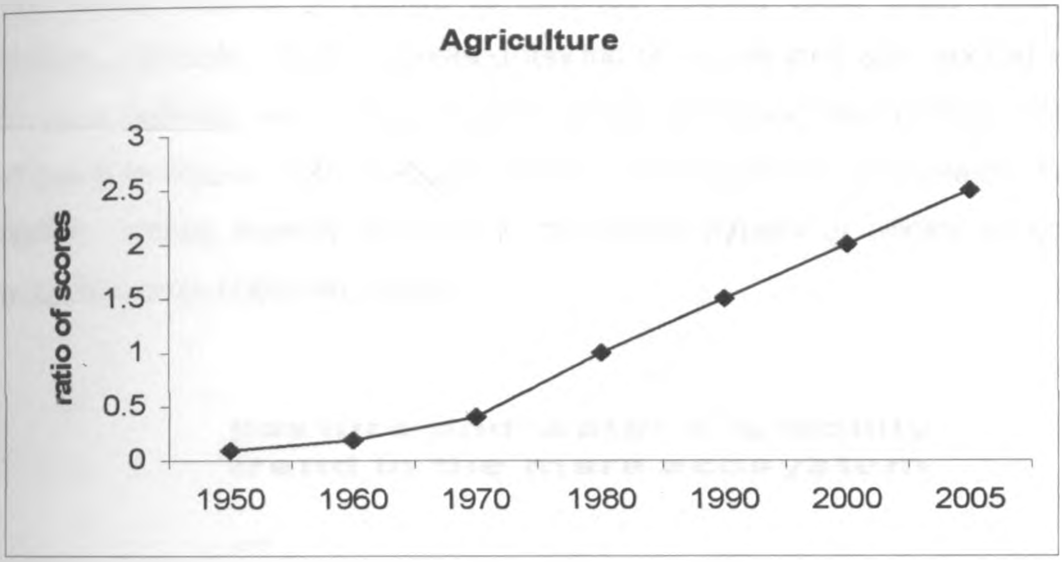

Figure 1: The pattern of Agricultural development in Narok district

(Source: Narok district development plan, and food security assessment report, Narok 2005)

1.2.3 Impact of land use change to wildlife conservation in Mara ecosystem

Whilst grazing land was being converted to agriculture in the 1990s, wildlife populations were also declining in the Mara ecosystem (Ottichilo, 2000). Human populations also increased significantly. An estimated annual human population growth of between 6% and 7.5% which included births and immigration took place in Maasai ecosystem in the 1990s (Gachugu. 1997). This intensified land use (through agriculture and changes in land tenure) thereby putting pressure on the remaining wildlife and livestock grazing pastures. Figure 2 shows the pattern of availability of pasture and water in the Mara ecosystem. As result of variability in pasture and water resources, areas occupied by wildlife and used for semi nomadic pastoralism activities declined rapidly. Migrating herds of wildebeest competed with cattle for grazing lands and some Maasai referred this time of annual migration as the time for cattle famine (Ottichilo, 2000).

The natural instinct of wildlife to continue utilizing these areas resulted to conflicts (Ottichilo, 2000). Increased fencing of private land also blocked wildlife corridors between wet and dry season ranges increasing the conflicts. The area adjacent to Maasai Mara National Reserve also experienced increased human-wildlife conflicts thereby threatening the future viability of wildlife outside the protected areas (Ottichilo, 2000).

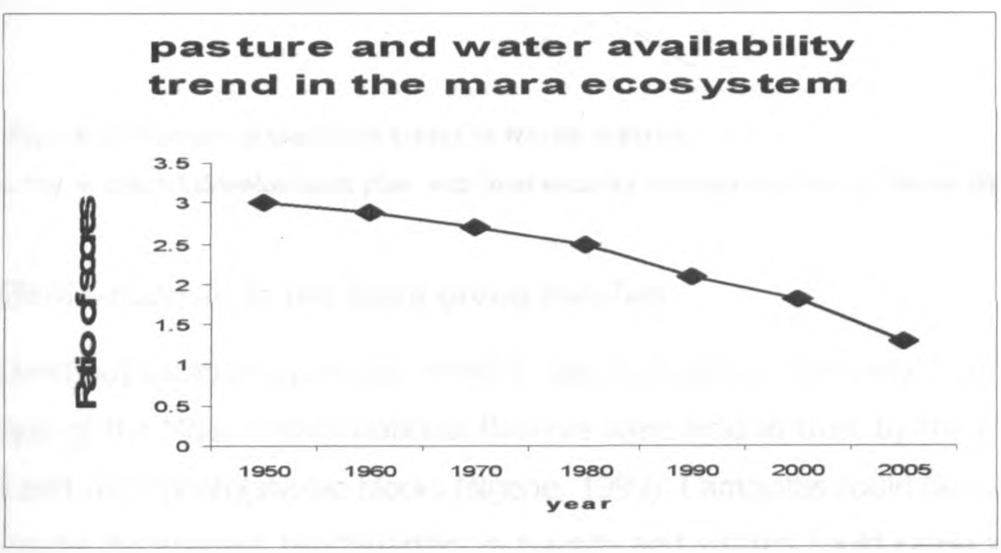

Figure 2: The pattern of pasture and water availability in the Mara ecosystem
(Source: Narok district development plan, and food security assessment report, Narok 2005)

The Maasai in the lower more marginal area in the south of the district moved their animals to the relatively well watered upland areas of Narok in search of better pastures during the dry season (Ngene, 1999). However, such migrations considerably reduced with the subdivision of the group ranches into individual parcels and the conversion of these prime areas to farming and settlements areas in line with the increased human population (Ngene, 1999). The population has been rapidly growing in the Mara ecosystem since 1950s (Figure 3) thereby increasing pressure on natural resources upon which wild animals are also dependent.

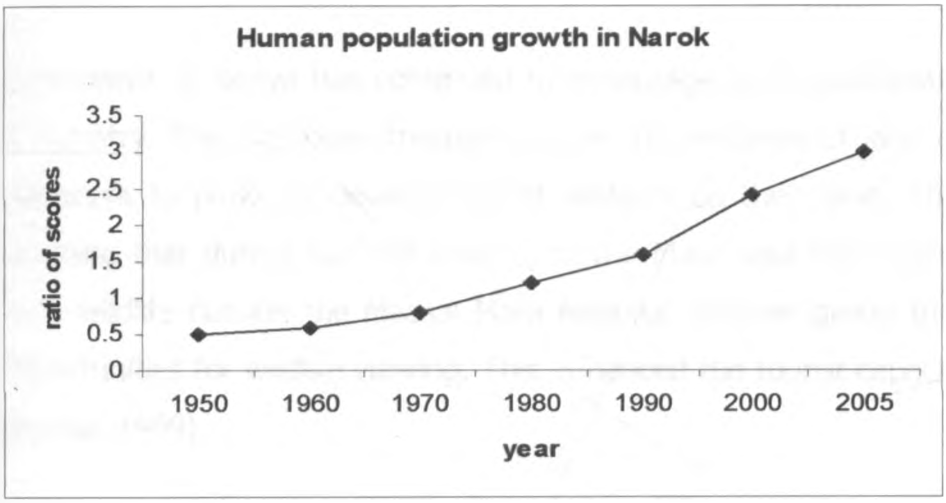

Figure 3: Human population trend in Narok district.

(Source: Narok district development plan, and food security assessment report, Narok 2005)

1.3 Wildlife-tourism in the Mara group ranches

Before land adjudication came into effect in the Mara area in the early 1970^{s}, the surrounds of the Maasai Mara National Reserve were held in trust by the county council and were photographic blocks (Ngene, 1999). Campsites could be booked at the game department headquarters in Nairobi and visitors could camp within these blocks where they liked. With the advent of adjudication, these photographic areas became group ranches with their own title deeds and controlling land owner committees. The ranches sold their hunting rights to various professional hunting firms in Nairobi who operated on quota system and paid all controlled area fees direct to these group ranch bank accounts. When hunting was banned in 1977, the contracts became null and void and many companies closed down (Ngene, 1999).

No single competent stakeholder or authority controlled the area during this period; hence many investment activities were uncoordinated. It is for this reason that in 1978, the Maasai Mara wildlife advisory committee was formed. The committee arranged for the group ranches to draw lease agreements with owners of all the tented camps then (Ngene, 1999).

The government of Kenya has continued to encourage local participation in the wildlife industry. This has been through support of initiatives of land owners in areas adjacent to parks to develop tourist facilities on their land. This started after realizing that during the wet season, in the Mara area for instance, there was more wildlife outside the Maasai Mara National Reserve giving the ranches ideal opportunities for wildlife viewing. This enhanced the tourist capacity for the area (Ngene, 1999).

Most of the group ranches in the Mara area increasingly started embracing eco-tourism as an income generating activity (Ngene, 1999). A number of wildlife associations for example Koiyaki-lemek were established to tap tourist revenues for the community. With increased local participation in wildlife sector, tourism related management issues cropped up in the Mara area. These included; increased tourist pressure, expansion of trading centres in the surroundings of the reserve with unsightly structures, and an entry fee collection system, which was not coordinated among the key stake holders i.e. the wildlife associations and the reserve management (Ngene, 1999).

1.4 Social and economic policies that have influenced policies in the Mara.

The attitude of the Mara community has been influenced by national land use policies that have been changing with time in arid and semi-arid areas of Kenya.

Community conservation has achieved considerable mileage outside the protected areas, while other policies have resulted in negative impacts on conservation. (Table 1) provides a summary of trends in social-economic factors that have influenced land use and other economic activities in the Mara in the last three decades.

Table 1: Social and economic factors influencing policies in group ranches adjacent to Maasai Mara National Reserve

Factors/period	1960s	1970s	1980s to date
Land tenure	Trust land	Group ranches	Individual land holdings/group ranches
Land use	Conservation/ pastoralism	Conservation/ pastoralism and low intensity wheat farming	Conservation/ pastoralism and high intensity wheat and maize farming
Income to the community	High livestock, low agriculture and low tourism	High livestock, low agriculture and low tourism	High livestock, moderate agriculture and high tourism
Livestock production	Transhumant pastoralism	Transhumant pastoralism with some sedentarisation	Restricted transhumant pastoralism and more sedentarisation
Population	Low- no immigration into the area	Increase of immigration of local and international investors.	High increase with immigration and low mortality
Education levels	Low literacy levels	Low literacy levels	Moderate
Cultural changes	Little	Little	Moderate

1.5 Wild animals and livestock population trends in the Mara

1.5.1 Carnivore population status and trends in the Mara ecosystem

In the 1990s; Lions, leopards, spotted hyenas and jackal populations were stable in the Mara ecosystem despite the increased deaths from human related conflicts (Ottichilo, 2000). Lion densities in the Mara ecosystem have been among the highest recorded in Africa (Ogutu and Dublin, 1998). However, they are anomalously lower in the ranches (0.369lion/km^2) than in the reserve (0.460 lions/km^2).

Hyena densities were higher in the pastoral areas (0.561 hyenas/km^2) than in the reserve (0.404 hyenas/km^2). Jackal densities were even both inside and outside the reserve (Ogutu and Dublin, 1998).

Cheetah population has declined significantly. (Burney, 1980) estimated the population of cheetah to be 61 individuals. 22 years later the population of cheetah in the ecosystem was estimated to be 22 individuals, majority of them residing inside the reserve.

1.5.2 Wild herbivore population status and trends in Mara ecosystem

In a period of 20 years, 58% of all non-migratory wildlife species in the Mara ecosystem had declined (Ottichilo, 2000). This decline ranged from 49% in small antelopes such as the Thomson gazelles to 72% in medium antelopes such as the Topi. Some other antelopes had become extinct in the ecosystem (Ottichilo, 2000). Kudus and roan antelopes were found in the ecosystem in large numbers in the late 1970`s but disappeared from the reserve and the adjacent group ranches (Ottichilo, 2000). In individual wildlife species, the decline ranged from 52% in Grant's gazelle to 88% in the warthog (Ottichilo, 2000). Declines of over 70% were recorded in buffaloes, giraffes, elands and waterbucks (Ottichilo, 2000). Only elephant, impala and ostrich had not shown any significant decline or increase. Overall, there had not been any significant difference in decline of all wildlife population sizes inside and outside the reserve, except for Thomson's gazelle and warthog (Ottichilo, 2000). However, the population of elephant had continued to grow due to the international campaign against ivory trade and a stringent management programme. Wildlife biomass had declined by two-thirds in the Mara ecosystem from about 300kg/ km^2 to about 100kg/ km^2 in a period of 25 years (Ottichilo, 2000).

1.5.3 Livestock population trends in pastoral ranches adjacent to Maasai Mara National Reserve

In the Mara ecosystem the number of livestock has been growing steadily between 1950 and 2005. The peak of abundance was in the 1990s and there after livestock numbers have been declining sharply (Figure 4). Livestock biomass in group ranches adjacent to Maasai Mara National Reserve had always remained stable at a density of 150kg/km^2, though this fluctuated depending on the yearly changes in rainfall in the region. However, the small stock of sheep and goats had increased significantly in the Mara (Ottichilo, 2000).

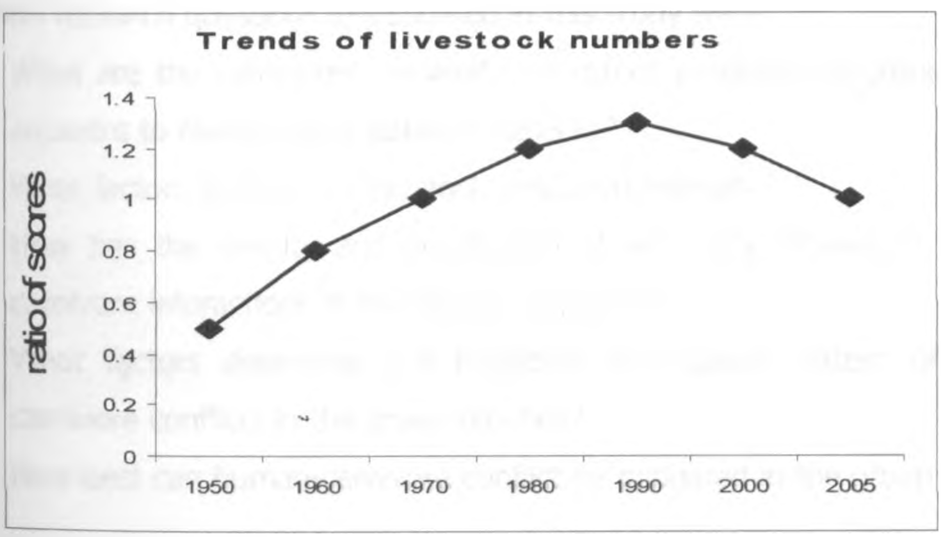

Figure 4: Livestock trend in the Mara ecosystem
(Source: Human-elephant conflicts and land use changes in Narok, KWS report 2007)

1:6. Objective of the study

1:6:1 General objective

This study focused on human carnivore conflict. It aimed to help understand predation patterns associated with carnivore attacks on livestock and to help find solutions for mitigating these attacks so as to promote a stable coexistence between carnivores and people. This broad objective was achieved through the following specific objectives.

1.6.2 Specific objectives

1. To determine the carnivores involved in livestock predation in pastoral ranches adjacent to Maasai Mara National Reserve.
2. To determine predation intensity, spatial and temporal variation of livestock attacks by predators.
3. To assess factors that influence livestock predation; density and distribution of wild herbivores.

1:7 Research questions

The main research questions investigated in this study were:

1. What are the carnivores involved in livestock predation in group ranches adjacent to Maasai Mara National Reserve?
2. What factors determines livestock predation intensity?
3. How has the density and distribution of wild prey influenced human – carnivore interactions in the Mara ecosystem?
4. What factors determine the temporal and spatial pattern of human-carnivore conflicts in the group ranches?
5. How best can human-carnivore conflict be mitigated in the group ranches?

1.8 General hypotheses

In addressing the above specific objectives the following hypotheses were tested.

1. Livestock predation levels are the same in all the group ranches adjacent to Maasai Mara National Reserve.
2. Grass height and grass cover in Maasai Mara National Reserve and the adjacent group ranches are the same.
3. Carnivores attack livestock more when the wild prey is scarce.
4. Vegetation cover influences carnivores attack on livestock.
5. Climatic elements e.g. rainfall influence livestock attacks by carnivores in group ranches adjacent to Maasai Mara National Reserve.

1.8.1 Theoretical frame work

Many visual predators hunt in a frequency-dependent manner, and can actively maintain colour polymorphisms in their prey (Bond and Kamil, 2002). These predators tend to concentrate on common varieties of prey, and to overlook rarer forms even if they are obvious. This type of behaviour is responsible for apostatic selection, and has been interpreted as being due to the formation of "specific searching images". In Maasai Mara National Reserve and the adjacent group ranches wild herbivores have significantly decreased in numbers (Ottichilo, 2000). Livestock numbers have remained stable (probably making them the more common variety) in the group ranches (Ottichilo, 2000). This study therefore hypothesise that predators in the group ranches adjacent to Maasai Mara National Reserve are forming 'search images' for livestock and are slowly overlooking the wild prey even though it is obviously their natural prey.

1.9 Significance of the study

Carnivore populations in Kenya and generally in the rest of the world are on the decline (Frank, 1998). Carnivores are some of the flagship species that attract tourists to the country. Hence, their conservation is of high priority. Results of this study will facilitate a better understanding of the nature and degree of the human-carnivore conflicts in the group ranches adjacent to Maasai Mara National Reserve. This will permit the preparation of a specific conservation and development strategy by relevant organizations in order to meet the needs of the local people and wildlife. The results will also provide appropriate measures to mitigate human-carnivore conflicts in the group ranches.

CHAPTER TWO

STUDY AREA, MATERIALS AND METHODS

2:1 The study area

2:1.1 Size, location and geographical boundaries

This study was conducted in Maasai Mara National Reserve and in three of the adjacent privately owned group ranches namely Koiyaki-lemek, Siana and Olkinyei (Figure 5). The Maasai Mara National Reserve and the above named group ranches are located in the south-west part of Kenya and they cover a total area of 1474 km² (Table 2). Maasai Mara National Reserve and all the surrounding group ranches form the Mara ecosystem. The Mara ecosystem covers an area of approximately 6,096 km² (Norton-Griffiths et al., 1975) and is part of the wider Mara-Serengeti ecosystem with an area of about 25,000 km² that includes Kenya and Tanzania. The group ranches act as dispersal area for the large diversity and concentration of herbivores in the ecosystem.

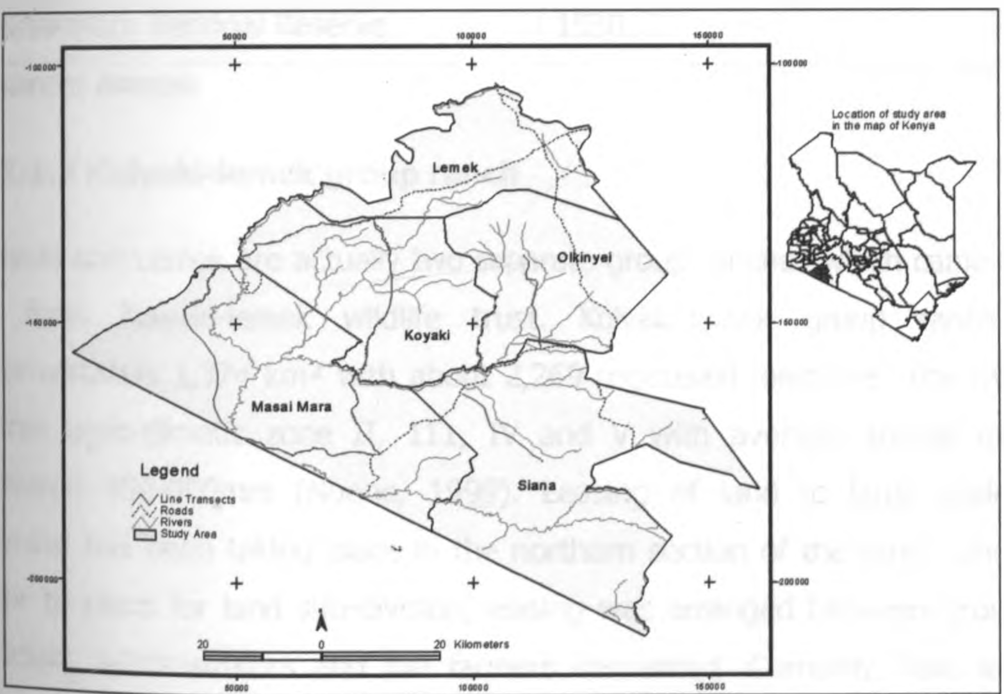

Figure 5: Map of study area showing the Maasai Mara national reserve and three adjacent group ranches

2:1.1.1 The Maasai Mara National Reserve

Maasai Mara National Reserve is approximately 1,530 km^2 and was formally established as a conservation estate by the government of Kenya in 1961. The county council of Narok is entrusted to manage this National Reserve whose land is restricted only to wildlife tourism on behalf of the government of Kenya. Maasai Mara National Reserve lies between 34° 45' and 35° 25' E and 1° 13'- 1° 45' S and has an altitude of 1,500-2170m (Burney, 1980). Maasai Mara National Reserve is probably the most famous and most visited reserve in Kenya (Douglas-Hamilton, 1988).

Table 2: Area covered by various group ranches as compared to MMNR

Group Ranch/National Reserve	Area km^2
Koiyaki-Lemek group ranch	1374
Olkinyei group ranch	788
Siana group ranch	982
Maasai Mara National Reserve	1530

Source: Annon

2:1.1.2 Koiyaki-lemek group ranch

Koiyaki and Lemek are actually two separate group ranches which came together to form Koiyaki-lemek wildlife trust. Koiyaki-lemek group ranch covers approximately 1,374 km^2 with about 2,269 registered members. The ranch falls within agro-climatic zone II, 111, IV and V with average annual rainfall of between 450-900mm (Ngene, 1999). Leasing of land to large scale wheat farming has been taking place in the northern section of the ranch since 1984. Prior to plans for land sub-division, leasing was arranged between group ranch officials, administrators and the farmers concerned. Currently, land leasing is being organised by individual land owners. Traditional pastoralism is the mainstay in lower part of the ranch. Livestock from the upper zone move to the lower zone during the wheat growing season. Wildlife based tourism is practised in the lower zone through the Koiyaki-lemek wildlife trust.

2.1.1.3. Olkinyei group ranch

Olkinyei group ranch covers approximately 788 km^2 with 1,043 registered members. It falls in agro climatic zone IV with annual rainfall of 600 mm. the ranch supports a large number of wild animals and is a breeding ground and migratory route for wildebeest and zebra. The wild animals migrate into the ranch during the long rains and move out during the dry season, after July.

2.1.1.4 Siana group ranch

Siana group ranch falls within the ecological zone IV. It forms part of the dispersal area for wildlife within Maasai Mara National Reserve. The ranch is distinctively marginal for cultivation thus no significant agricultural activities are practised here. Rainfall is low and erratic with an annual mean of 600 mm. long rain come during the march-may period, while the short rains are experienced from October to December. The major economic activity is livestock production. Being in the migratory corridor for wildlife, there is a remarkable interaction between wildlife and livestock as they compete for the same resource. Tourism is being tapped through lease of camping and lodge sites.

2:1.2 Fauna and flora

The Mara ecosystem is an area of undulating grassland savannah intersected by numerous drainage lines and rivers. It is also characterized by twelve different habitat types, the dominant being short and tall grasslands interspersed by acacia woodlands, shrub lands, thicket and riverine forests (Epp and Agatsiva, 1980). The Mara ecosystem supports an extremely high diversity and biomass of large mammals (plate 1 and 2) including a range of ungulate and large carnivore species (Broten and Said, 1995).

Plate 1: A herd of African buffaloes *(syncerus caffer)* in Maasai Mara National Reserve

"Mara" is actually a Maasai word for spotted and it refers to the landscape with patchy distribution of vegetation and herbivores (Costich and Popp 1978). Over a period of time Maasai Mara has undergone some ecological changes. For example in the beginning of the last century there were rinderpest outbreaks which wiped a huge number of grazing animals. The absence of these large numbers of grazers encouraged the regeneration of woody vegetation in Mara. However, over recent decades, Elephant, fire and grazing by wild and domestic herbivores have contributed to the transformation from heavily wooded savannah and bush land to open grassland (Dublin & Douglas-Hamilton, 1987; Dublin et al., 1990). During the dry season (July-October) the reserve is a major concentration area of migratory herbivores including approximately 200,000 zebra and 1.3 million wildebeest, which attract a lot of carnivores and a great deal of tourists.

Plate 2: Lions are among the larger predators contributing to human wildlife conflicts especially during the dry season when grass is short and non- livestock herbivores are scarce.

2:1.3 Climate and rainfall

Mara has bimodal rainfall pattern with short rains falling in November- December and long rains falling in March-May. This pattern is influenced by Intertropical convergence zone (ITCZ) which affects the east African region from Zimbabwe, in the south to Sudan in the north (Norton-Griffiths et al., 1975). This band of low pressure fronts follows the north and south movement of the sun with a lag of about 5 weeks. Driven by trade winds which converge in this area from both hemispheres, the system brings rain and cloudy weather. The ITCZ reaches its northern limit in late July and its southern extreme in late January, thus affecting weather pattern in the Mara twice each year.

The Mara region also has a pronounced east-west rainfall gradient with the east side averaging approximately 800mm/year and the west side approximately 1200mm/year (Norton-Griffiths et al., 1975; Epp and Agatsiva, 1980; Stelfox et al., 1986). The west experiences much heavier rainfall because it is influenced by the convergence of the Lake Victoria and Mau range weather systems and locally by the effects of the Siria escarpment. These rainfall gradients result in higher grass productivity on the west side of the Mara River compared to that of the east. Minimum and maximum daily temperatures in the Mara are relatively constant through out the year.

2:1.3.1 Mean monthly rainfall during the study period

The KWS ecological monitoring department has rainfall stations in the Mara ecosystem. These stations have manual rain gauges manned by the KWS rangers and rainfall data is collected on a daily basis. Four of these stations were selected based on their geographical position within the study area, and their mean monthly rainfall for the months of January to August retrieved from the KWS rainfall data base. The mean rainfall of the four stations was then analysed to give a representative mean rainfall for the whole study area. The stations chosen were: Naikara, Lemek and Ewaso-nyiro, (in the group ranches) and Mara KWS research station (in the reserve). During the study period, rainfall data from the four stations was also recorded and the monthly mean for the eight months calculated. The mean rainfall during the study period was then compared with the mean monthly rainfall of the previous years (2001-2007) for the same period (January-August). This was done in order to detect any unusual change in rainfall pattern over years. Only the month of May recorded abnormally lower amount of rainfall compared to the previous years. (Table 3) shows the mean monthly rainfall (January- August) of the Mara ecosystem between the year 2001 and 2008.

Table 3: Mean monthly rainfall (mm) January-August (2001-2008) derived from four KWS stations within the study area.

Year	2001	2002	2003	2004	2005	2006	2007	2008
January	171.925	105.225	89.2	60.2	40.85	38.3	91.55	30.2
February	71.575	30.7	43.675	72.525	21	42.3	133.15	100.875
March	53.925	78.2	65.65	88.275	87	165.3	42.8	150.45
April	126.425	50.7	112.8	106.325	54.475	95.5	68.35	56.125
May	103.1	134.575	191.575	86.875	140.15	53.8	51.8	5.5
June	16	12.375	39.925	8.175	55.3	28.3	88.125	11.75
July	57.025	29.25	8.875	10.55	21.875	38.7	18.25	34.5
August	29.45	14.8	75.725	29.075	68.775	30.7	27.925	45.5

Source: KWS Narok station rainfall data base

2:1.4 Geology and hydrology

Mara River, the largest perennial river in the Serengeti-Mara ecosystem, drains the northern Serengeti and Mara region and flows into Lake Victoria some 100 kilometres to the west. It originates in the Mau ranges (complex) to the north and is fed by several major tributaries along its course. These include the Talek river which rises in the Siana hills and Loita plains, the Olare-Orok and Jagartiek watercourses which drain the Lemek valley to the north and join the Talek river close to its confluence with the Mara river, and the sand river which originates in the Loita hills to the east and joins the Mara along the Kenya-Tanzania border. These rivers usually flow all year round but, in dry years they become a series of small ponds.

The Mara region is an extensive peneplain comprising of metamorphosed pre-Cambrian sediments which have been modified over time by faulting, erosion, and volcanic activity (Williams, 1964). Soils in the area are mainly of volcanic in origin and range from brown, sandy loams to black silt soils. Below this swallow layer of volcanic tuffs lies a basement of gneisses, schists, and quartzites. The most significant relief in the area is the Siria escarpment which forms the western boundary of the Mara and rises 100-300 meters above the plains below. Mean elevation in the Mara is approximately 1600 meters on the plains with the escarpment rising to 1900 meters.

2:2 Materials and methods

2.2.1 Sampling framework

The study area was spatially stratified into two, namely the group ranches and the Maasai Mara National Reserve. In the group ranches random sampling was done to ensure unbiased vegetation sampling sites and selection of respondents for the interview. Open-ended Questionnaires were used to collect data on livestock numbers.

2.2.2 Data collection

2:2:2.1 Estimates of wildlife density and distribution in Maasai Mara and adjacent group ranches

Throughout the study period, the density of all prey animals was estimated on seasonal intervals using predetermined line transects. There were four sampling occasions depending on season. These were January counts which represented the short dry season, the April counts which represented the long rainy season, the June counts which represented the long dry season, before the migration of the wildebeests and zebras from the neighbouring Serengeti National Park in Tanzania and the August counts which represented the long dry season after the arrival of the migrant wildebeest and zebras.

To determine the distribution of wild prey populations, seven transects covering a total of 157 km were driven in four wheel drive vehicle at low speed. This was done in each minor transects once during the four sampling occasions. Transects were chosen on the basis of accessibility and representation. The transects were not of the same length because it was impossible to drive across the landscape and driving in off-road tracks, especially in the protected area, was not permitted. Three of the seven transects were situated inside the reserve and four in the group ranches. The transects in the reserve were noted as Keekorok-talek, Keekorok-mara bridge and Mara bridge-serena and they measured 18 km, 26 km and 28 km respectively. Those in the group ranches were expressed as Talek-aitong, Aitong-mararienda, Nkoilale-siana and Olkinyei and they measured 28 km, 21 km, 18 km and 18 km respectively. Talek-aitong and Aitong-mararienda transects were situated in koiyaki-lemek group ranch, Nkoilale-siana transect was in Siana group ranch and Olkinyei transect occurred in Olkinyei group ranch. Data collection in each transect began at dawn (06.00h), defined as the time which the vehicle lights were not required for driving and stopped at 11.00 hours even though the whole transect had not been completed. 11.00 hours was chosen as the cut of time because this is the time that many ungulates began their midday rest period and hence became more difficult to detect.

During each transect, a record of all species of mammals seen were taken that were larger than 2 kg. Ostrich was also included in the data because it is one of the large herbivore species and form part of the carnivore prey. As soon as the mammal species were sighted, the vehicle was stopped and a record was made of all individuals defined as being within the transect belt i.e. within 200 meters on both sides of the transect. The area of the transect was calculated by multiplying transect width by length and summing them per study site, as described by (Burnham et al., 1980). For each species, density was calculated by adding the total number of individuals seen on a given transect and dividing by the area of the transect.

2:2:2.2. Livestock predation incidents in group ranches

Livestock lost to predators during the study period were reported at the area Kenya Wildlife Service Station and recorded in the Occurrence Book. All the sites of predation were visited with the assistance of the KWS rangers and verification made. Evidence included livestock skulls, hairs, or even unfinished remains and blood. Once verified, the number of livestock lost, type of livestock lost and the carnivore involved was recorded after interviews with the local people and the livestock owner. GPS coordinates were taken together with the date and time of occurrence of the incident. Only verified incidents of livestock predation and those that resulted in livestock loss were analysed in this study. Unreported incidents of livestock predation cannot be ruled out in this study although this was unlikely since pastoralists would require some assistance from KWS.

2:2:2.3. Estimates of livestock densities in the group ranches and the Influence of reserve to livestock distribution

Livestock densities in relation to distances from the reserve were estimated using individual questionnaires and interviews to the local communities. The selection for these interviews was based on certain criteria such as proximity of the interviewees to the transects lines, the presence of livestock holders, the presence of predation incidences, distance of the transect line from the reserve and the administrative boundaries of the group ranches. Interviews were conducted in a friendly way and herders were not given any impression that there was anything to be gained from the information they gave. Questionnaires were designed in a simplistic manner to avoid confusion to the interviews but at the same time extract as much information as needed for the study (see appendix 1).

2:2:2.4. Vegetation sampling and characterization

The environment in which predation occurred was assessed to determine whether livestock predation was in any way influenced by foliage availability. The environment was categorised into two depending on the location: Grasslands in the reserve and grassland in the group ranches. This categorisation was pre-determined after pilot survey showed a significance differences in grass heights and cover between the two locations. Grass cover and grass height were assessed using a 0.25 m^2 quadrat. The quadrat was placed every 2 kilometres along the transects as earlier explained and the height of grass measured using a rule. Grass ocular estimates of basal cover were done using the quadrat. Cover on the ground was also visually estimated and consistency of the estimates pre-tested.

2.2.3 Data organisation and analysis

Descriptive statistics (percentages) were used to analyse some of the survey data. Chi-squire tests were done for both spatial and temporal attacks of livestock while analysis of variance (ANOVA) statistics were used to analyse vegetation variables among the sampling sites. A GPS was used to map the exact locations of predation in UTM co-ordinates and spatial data analyzed using GIS Arc view software.

CHAPTER THREE

RESULTS

3.1 Large carnivores involved in livestock predation in group ranches adjacent to MMNR

Six large carnivores were identified to be present in Maasai Mara National Reserve and the adjacent group ranches. These are: lions, leopards, hyenas, cheetahs, jackals and the wild dogs. However, only four of these were identified to be responsible for the attacks on livestock in this area. They are: lions, leopards, hyenas and wild dogs. This study did not only identify carnivore species responsible for attacks, but also re-established the presence of wild-dogs which were previously assumed to be extinct in the area.

3.1.1 Lions *(Panthera leo)*

Lions have a widespread reputation for livestock killing. Their preference for medium sized ungulates makes them likely predators on livestock of all sizes. In all the three group ranches adjacent to Maasai Mara National Reserve, lions were regularly reported to have killed livestock. Results also show that lions mainly went for cattle and majority of cattle killings was as a result of lions attack.

3.1.2 Leopards *(Panthera pardus)*

Leopards attacked and killed livestock in all the three group ranches. During field interviews most Maasai pastoralists stated that leopard killed the small stock (sheep and goats) in bulk. Report from the KWS human-carnivore conflict occurrence book confirmed that leopard massacred livestock. This was also supported by the Kenya Wildlife Service rangers who set traps, capture and translocate leopards to Maasai Mara National Reserve after their massacre on livestock. Results have also shown leopard to have killed more livestock in the three group ranches than any other carnivore during the study period.

3.1.3 Hyenas *(Crocuta crocuta)*

Hyenas attacked and killed livestock but in smaller numbers when compared to lions and leopards. Results of this study show hyenas attacking livestock only 6 times representing only 12% of the total attacks made by all predators. There was no specific time or season in which hyenas attacked livestock more often. Results show that hyenas attacked and killed livestock twice during the long dry season (June-August), thrice during the long rainy season (March-May) and once during the short dry season (January and February).

3.1.4 Wild dogs (*Lycaon pictus)*

Wild-dogs were only responsible for a minor part of all attacks on livestock during the study period. The low levels of attacks by wild dogs may be attributed to the small population that is currently found in the area. However, the loss incurred by pastoralists as a result of wild dogs attack on livestock cannot be ignored in the area.

3.2 Livestock predation patterns in the group ranches

3.2.1 Livestock predation intensity in the group ranches

Livestock predation focussed on five types of domestic animals: cattle, goats, sheep, donkeys and domestic dogs. A total of 275 heads of livestock were attacked and killed by carnivores between January 2008 and August 2008 after being attacked 49 times (Figure 6). Majority of the attacks took place at night especially where leopard was involved.

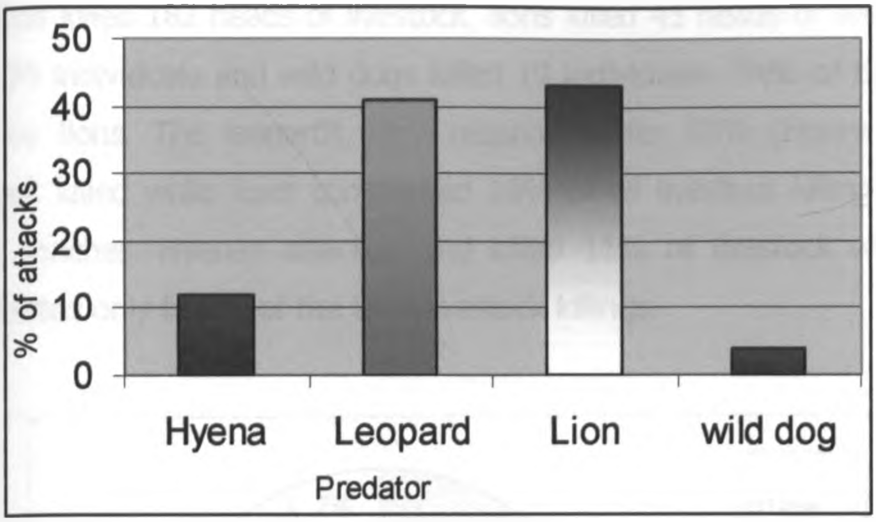

Figure 6: Large carnivore species responsible for attacks on livestock in group ranches adjacent to Maasai Mara National Reserve

Through out the study period, Lions attacked livestock 21 times, followed by leopards 20 times, Hyenas 6 times and wild dogs 2 times (Figure 7). The frequency of attacks on livestock by various predators differed significantly χ^2=22.75, df=3, p<0.001 with lions and leopards attacking livestock more frequently than either the hyenas or the wild dogs (see appendix VI). (Assumption: all livestock predators attack livestock with the same frequency).

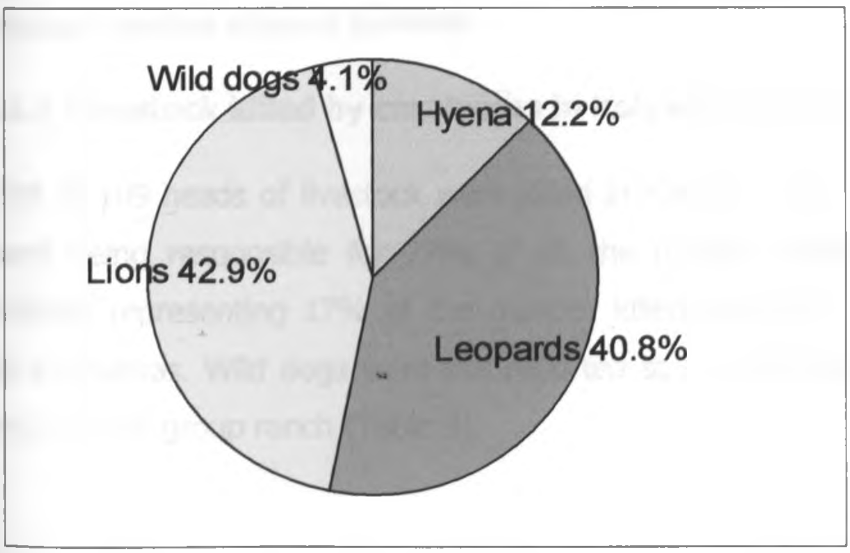

Figure 7: Frequency of attacks on livestock by predator species in the three group ranches

Leopards killed 182 heads of livestock, lions killed 45 heads of livestock, hyenas killed 29 individuals and wild dogs killed 19 individuals. 94% of the cattle killed were by lions. The leopards were responsible for 66% (Figure 8) of all the livestock killed while lions contributed 16% of all livestock killings in the three group ranches. Hyenas attacked and killed 11% of livestock while wild-dogs contributed only to 7% of the total livestock killings.

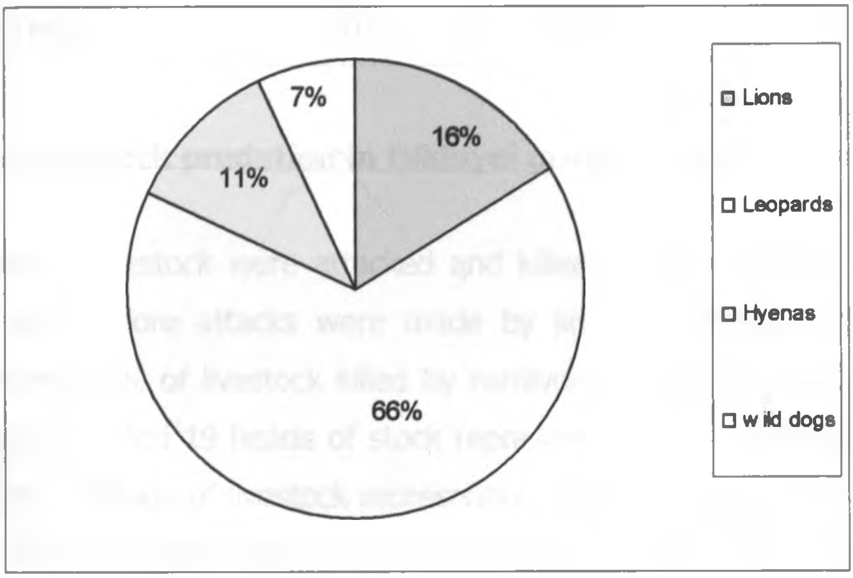

Figure 8: percentage contribution of different predators to livestock predation in the three group ranches adjacent to MMNR

3.2.1.1 Livestock killed by carnivores in Koiyaki-Lemek group ranch

A total of 109 heads of livestock were killed in Koiyaki-lemek group ranch with leopard being responsible for 77% of all the number killed. Lions killed 19 individuals representing 17% of the number killed while 6% of livestock were killed by hyenas. Wild dogs were not reported to having killed any livestock in Koiyaki-Lemek group ranch (Table 4).

Table 4: Carnivores contribution to livestock predation in Koiyaki-Lemek ranch

Predator	Cattle	Dog	Goat	Sheep	Total	%
Leopard	0	7	19	58	84	77
Lion	10	0	9	0	19	17
Hyena	0	0	2	4	6	6
Total	**10**	**7**	**30**	**62**	**109**	**100**

3.2.1.2 Livestock predation in Olkinyei group ranch

61 heads of livestock were attacked and killed by large carnivores in Olkinyei group ranch. More attacks were made by lions which killed 25 heads. This represented 41% of livestock killed by carnivores in this group ranch. Leopards attacked and killed 19 heads of stock representing 31%, while hyenas attacked and killed 17 heads of livestock representing 28%. All cattle were killed by lions. Of the 29 goats killed, 48% were killed by leopard, while hyenas killed 31% of all goats killed by carnivores in this group ranch (Table 5).

Table 5: Carnivores involved in livestock predation in Olkinyei ranch

Predator	Cow	Dog	Goat	Sheep	Total	%
Lion	20	0	5	o	25	41
Leopard	0	0	14	5	19	31
Hyena	0	0	10	7	17	28
Total	20	0	29	12	61	100

3.2.1.3 Livestock lost to predators in Siana group ranch

105 heads of livestock were reported to have been killed by carnivores in Siana group ranch between January and August 2008 (Table 6). 75% of these livestock were killed by leopards and 18% by the wild-dogs. 6% were preyed upon by hyenas and only 1% was due to lions. Goats accounted for 93% of all livestock killed by carnivores in Siana group ranch.

Table 6: Livestock predation in Siana group ranch

Predator involved	Cattle	Dog	Goat	Sheep	Total	%
Hyena	1	0	5	0	**6**	**6**
Leopard	0	1	75	3	**79**	**75**
Lion	1	0	0	0	**1**	**1**
Wild dog	1	0	18	0	**19**	**18**
Total	**3**	**1**	**98**	**3**	**105**	**100**

3.2.2 Temporal and spatial partitioning of livestock attacks in the group ranches

3.2.2.1 Partitioning of livestock attacks by season of the year

Comparing seasons verses livestock attacks, the leopards attacked most during the long dry season 40%, followed by lions 30%, Hyenas 20% and wild dogs 10%. Attacks during the long rainy season were dominated by lions 60%, followed by leopards 27%, hyena 10% and 3% wild dogs.

During the short dry season, attacks were made by only two species of carnivores, leopards 89% and hyenas 11%. Of all attacks made by lions, 85.7% occurred during the long rainy season (Table 7).

Table 7: predator attack on livestock by season

Season	Predator	Number of attacks	Frequency (%)
Long dry season	Leopard	4	40
	Lion	3	30
	Hyena	2	20
	wild dog	1	10
Total		10	100
Long rainy season	Hyena	3	10
	Leopard	8	27
	Lion	18	60
	wild dog	1	3
Total		30	100
Short dry season	Hyena	1	11
	Leopard	8	89
Total		9	100

Generally more attacks on livestock occurred during the long rainy season representing 61.2% of the total attacks, while 20.4% took place during the long dry season and 18.4% during the short dry season (Figure 9). However, of all the livestock killed by carnivores in the three group ranches, 51% were attacked and killed during the long rainy season (March-May), 30% during the long dry season (June-August) and 19% attacked and killed during the short dry season (January-February).

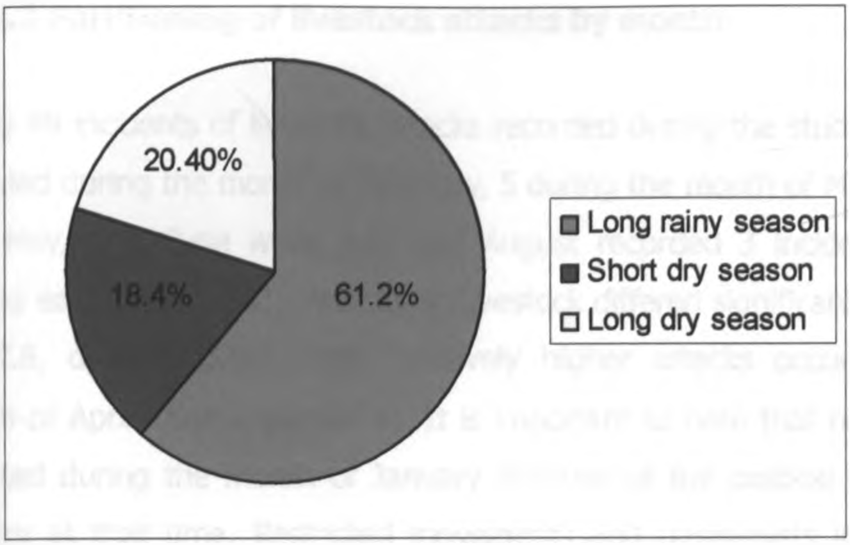

Figure 9: Frequency of livestock attacks by season

139 heads of livestock were killed by carnivores during the long rainy season, 83 during the long dry season and 53 during the short dry season (Table 8). Attacks on livestock differed significantly depending on season χ^2=17.2, df=2, p<0.001 (See appendix III). (Assumption: attacks on livestock and subsequent killing is expected to be equally distributed in all the seasons)

Table 8: Number of livestock killed each season

Seasons	Cattle	Dog	Goat	Sheep	Total	%
Long dry season	3	0	73	7	**83**	**30**
Short dry season	0	7	8	38	**53**	**19**
Long rainy season	30	1	76	32	**139**	**51**
Total	**33**	**8**	**157**	**77**	**275**	**100**

3.2.2.2 Partitioning of livestock attacks by month

Of the 49 incidents of livestock attacks recorded during the study period, 9 were recorded during the month of February, 5 during the month of March, 16 in April, 5 in May, 4 in June while July and August recorded 3 incidents of livestock attacks each (Figure 10). Attacks on livestock differed significantly by the month $\chi^2=27.8$, df=7, $p<0.001$; with relatively higher attacks occurring during the month of April. (See appendix V). It is important to note that no incidents were reported during the month of January because of the political instability in the country at that time. Restricted movements and pastoralists insecurity due to post election violence led to breakdown of communication and therefore predation incidents went unreported during this month. (Assumption: Livestock predation occurrence is expected to be equally distributed in all the months).

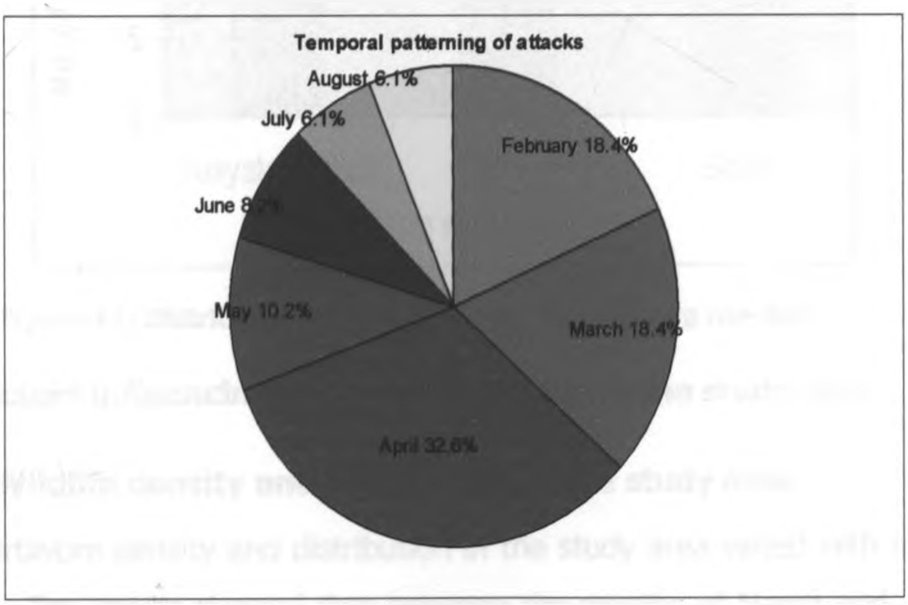

Figure 10: Frequency of livestock attacks by months during the study period

3.2.2.3 Partitioning of livestock attacks by group ranches

Predators attacked livestock 23 times in Koiyaki-Lemek group ranch. In Olkinyei group ranch, the attack on livestock occurred 15 times and 11 times in Siana group ranch (Figure 11). Attacks on livestock did not differ significantly in the three group ranches χ^2=4.5; df=2, p>0.001; (see appendix VII). (Assumption: attack on livestock is uniformly distributed in the three group ranches adjacent to MMNR).

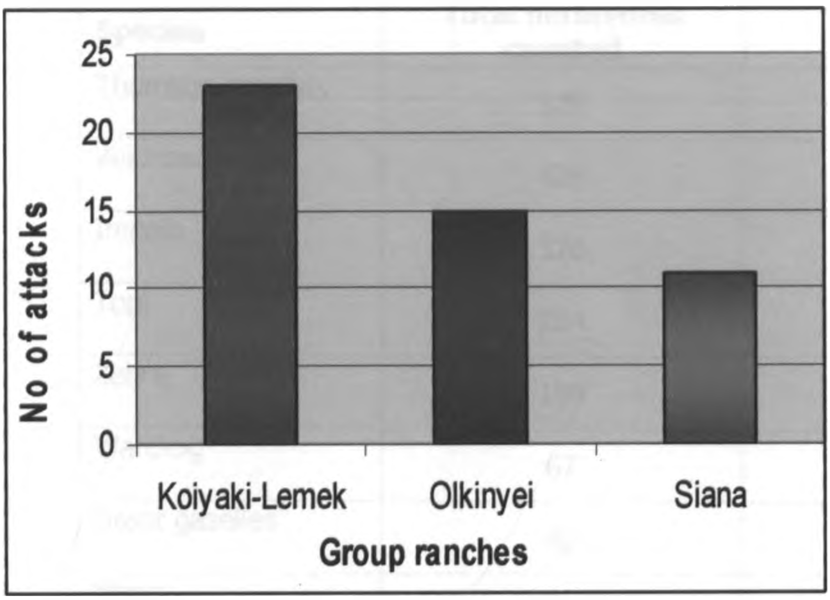

Figure 11: Distribution of livestock attacks by group ranches

3.3 Factors influencing livestock predation in the study area

3.3.1 Wildlife density and distribution in the study area

The herbivore density and distribution in the study area varied with months and season. The results showed that between the months of March and June, more herbivores were found in the group ranches than in the reserve (wet season). From the month of July more herbivores were found in the reserve than in the group ranches.

3.3.1.1 Herbivore numbers and distribution by months during the study period

During the January counts, Thomson gazelle was the most common herbivore species representing 26.88% of the total number of herbivores counted in all ranches (Table 9). Wildebeest followed with 21.77%, impala 19.21% and Topi 12.98%. Other herbivores were present but in small numbers.

Table 9: No. of herbivore species counted in January, 2008

Month	Species	Total herbivores counted	%
January	Thomson gazelle	526	26.88
	Wildebeest	426	21.77
	Impala	376	19.21
	Topi	254	12.98
	Zebra	199	10.33
	Warthog	67	3.42
	Grant gazelles	42	2.53
	Eland	23	1.18
	Ostrich	15	0.77
	Elephant	13	0.66
	Water buck	11	0.56
	Buffaloes	2	0.10
	Dik dik	2	0.10
	Reedbuck	1	0.05
Total		**1,957**	**100**

During the month of April, Thomson gazelle was still the most common herbivore representing 48.31% of all the number of herbivores counted. Zebra was the second common species in the area representing 10.43%, impala 9.31%, wildebeest 9.13% and Topi 8.59% of all individuals counted (Table 10).

Table 10: No. of herbivore species counted in April, 2008

Month	**Herbivore species**	**Total**	**%**
April	Thomson gazelle	815	48.31
	Zebra	176	10.43
	Impala	157	9.31
	Wildebeest	154	9.13
	Topi	145	8.59
	Buffaloes	66	3.91
	Giraffe	59	3.26
	Grant gazelles	40	2.37
	Ostrich	39	2.31
	Warthog	16	0.95
	Hartebeest	14	0.83
	Dik dik	4	0.24
	Elephant	2	0.12
April Total		**1,687**	**100**

The June counts showed wildebeest as the most common species representing 56.59% of the total herbivore numbers in the area at that time. Thomson gazelles were the second most common representing 21.16% and zebra third, representing 17.05% of the total herbivore numbers (Table 11). This is the time when the migrant wildebeest and zebra start arriving in Maasai Mara National Reserve.

Table 11: No. of herbivore species counted in June, 2008

Month	**Herbivore species**	**Total**	**%**
June	Wildebeest	2,960	56.59
	Thomson gazelle	1,107	21.16
	Zebra	892	17.05
	Grant gazelles	91	1.74
	Topi	87	1.66
	Giraffe	32	0.61
	Impala	30	0.57
	Warthog	12	0.23
	Ostrich	7	0.13
	Eland	6	0.11
	Dik dik	4	0.08
	Hartebeest	3	0.06
June Total		**5,231**	**100**

The month of August showed wildebeest being the most abundant herbivore species (Table 12) representing 66.62% of the total herbivores in the study area. Thomson gazelles represented 16.24% and zebras 12.68% of the total herbivores respectively.

Table 12: No. of herbivore species counted in August, 2008

Month	Herbivore species	Total	%
	Wildebeest	4,218	66.62
	Thomson gazelle	1,028	16.24
	Zebra	803	12.68
	Grant gazelles	163	2.57
	Topi	59	0.93
	Impala	28	0.44
	Warthog	24	0.38
	Ostrich	4	0.06
	Eland	3	0.05
	Buffaloes	1	0.02
August Total		**6,331**	**100**

3.3.1.2 Herbivore numbers and distribution in the group ranches and the reserve

The summed totals of herbivore populations from all transects within the group ranches during the four sampling occasions showed wildebeests as the most common herbivore species in the group ranches representing 48.12% of the total herbivores present. Thomson gazelles were the second most abundant representing 33.36% while zebra was third with 7.83% of the total herbivores in the group ranches during the study period (Table 13).

Table 13: summed numbers of herbivores counted in the group ranches during the four counts

Location	Herbivore Species	Species Summed totals	%
Group ranches	Wildebeests	4,105	48.12
	Thomson gazelle	2,846	33.36
	Zebra	668	7.83
	Grant gazelles	310	3.63
	Topi	249	2.92
	Impala	245	2.87
	Giraffe	81	0.95
	Ostrich	11	0.13
	Dik dik	10	0.12
	Buffaloes	3	0.04
	Warthog	3	0.04
Total		**8,531**	**100**

In the reserve, the summed totals of herbivore populations showed wildebeests as the most common herbivore species during the four sampling occasions representing 54.73% of all herbivores counted. Zebra were second in abundance representing 21.00% of the total herbivores counted while Thomson gazelles represented 17.4% (Table 14).

Table 14: Summed numbers of herbivores counted in the reserve.

Location	Herbivore Species	Species Summed totals	%
Reserve	Wildebeests	3,653	54.73
	Zebra	1,402	21.00
	Thomson gazelle	630	17.4
	Impala	346	5.18
	Topi	296	4.43
	Warthog	116	1.74
	Buffaloes	66	1.05
	Ostrich	54	0.81
	Eland	32	0.48
	Grant gazelles	26	3.85
	Hartebeest	17	0.25
	Elephant	15	0.22
	Water buck	11	0.16
	Giraffe	10	0.15
	Reedbuck	1	0.01
Total		**6,675**	**100**

3.3.1.3 Herbivore numbers and distribution in Koiyaki-Lemek group ranch

The summed totals of herbivore species showed wildebeest to be the most common in Koiyaki-Lemek group ranch with a frequency of 52.33%, followed by Thomson gazelle with a frequency of 30.21%. Other common herbivore species in this group ranch includes Zebra 8.12%, Topi 3.52% and Impala 2.61%. (Table 15) shows a summary of herbivore species counted in Koiyaki-Lemek group ranch during the four sampling occasions.

Table 15: distribution of herbivores in Koiyaki-Lemek group ranch

Group ranch	Herbivore species	Species Summed totals	%
Koiyaki-lemek	Wildebeests	3,704	52.33
	Thomson gazelles	2,138	30.21
	Zebra	575	8.12
	Topi	249	3.52
	Impala	186	2.61
	Grant gazelles	129	1.82
	Giraffe	75	1.06
	Dik dik	10	0.14
	Ostrich	6	0.08
	Buffaloes	3	0.04
	Warthog	3	0.04
Total		**7,078**	**100**

3.3.1.4 Herbivore numbers and distribution in Olkinyei group ranch

In Olkinyei group ranch, Thomson gazelles were more common representing 71%, followed by grant gazelles with 19% and wildebeest 8% (Table 16). There was less herbivore diversity in Olkinyei when compared to Koiyaki-Lemek group ranch.

Table 16: distribution of herbivores in Olkinyei group ranch

Group ranch	Herbivore species	Total	%
Olkinyei	Thomson gazelle	652	71
	Grant gazelles	175	19
	Wildebeest	73	8
	Zebra	18	2
	Ostrich	5	1
	Impala	1	0
Total		**924**	**100**

3.3.1.5 Herbivore numbers and distribution in Siana group ranch

Siana group ranch recorded the lowest numbers of herbivores counted during the four sampling occasions. Only six herbivore species were recorded as being found in Siana group ranch. Wildebeest, zebra, impala and Thomson gazelles were the most common representing 62%, 14%, 11%, 11% respectively (Table 17).

Table 17: Numbers and distribution of herbivores in Siana group ranch

Group ranch	Herbivore species	Species Summed totals
Siana	Wildebeest	328
	Zebra	75
	Impala	58
	Thomson gazelle	56
	Giraffe	6
	Grant gazelles	6
Total		**529**

3.3.2 Vegetation characteristics in the study area

3.3.2.1 Grass height characteristics in the study area

Grass was tallest in the reserve with a mean of 61.162 cm, followed by Koiyaki-lemek with mean grass height of 16.947cm, and then Siana with mean height of 14.7cm and the shortest grass was in Olkinyei mean height of 9.65 cm (see table 18). Grass was not of the same species which could explain some of the differences in height but was mostly dominated by *Themeda triandra* species.

Table 18: Average grass height in all the sampling blocks

Dependent Variable: Grass height				
			95% Confidence Interval	
Sampling area	Mean	Std. Error	Lower Bound	Upper Bound
Reserve	61.162	2.355	56.528	65.797
Koiyaki-lemek	16.947	2.81	11.418	22.476
Siana	14.7	4.531	5.785	23.615
Olkinyei	9.65	6.407	-2.958	22.258

Differences in grass heights were tested using one-way ANOVA. The results showed a significant difference ($F_{[3,308]}$=66.201, $p<0.001$) in grass heights between the Reserve and the group ranches (see figure 12 and table 19). However, the grass height in the group ranches showed no significance difference.

Table 19: ANOVA table for grass heights in all the areas

Source of variation	Df	Sum of Squares	Mean Square	F	Sig.
Treatment	3	163067.732	54355.911	66.201	0.000***
Error	308	252890.017	821.071		
Total	311	415957.749			

Siana and Olkinyei ranches supported a high density of sheep and cattle apart from being drier. Hence, grass was continually grazed and kept at low level. There were also many patches of open ground without cover of grass or other herbs (Plate 3).

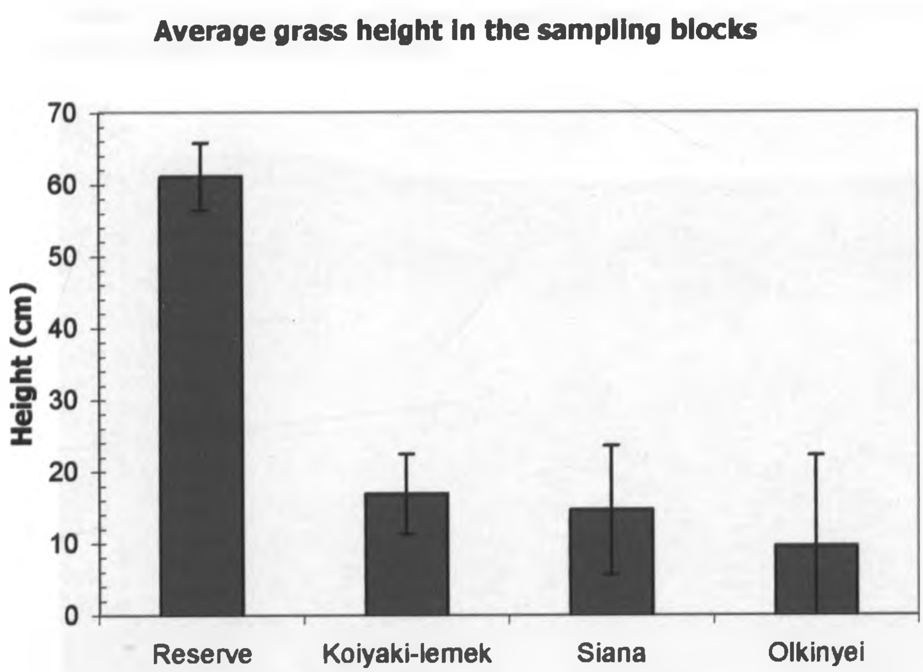

Figure 12: Mean (±SD) Grass height in the four sampling blocks

Plate 3: Short grass and bare ground in over grazed pasture in Koiyaki group ranch in Narok district

Plate 4: Tall grass in the Maasai Mara National Reserve serving as abundant food for grazing wild herbivores and providing cover to predators.

3.3.2.2 Grass cover characteristics in the study area

More grass cover was observed inside the National Reserve: mean 87.64%. It was followed by Koiyaki-lemek with an average cover of 42.64%, then Siana group ranch 41.05% and finally Olkinyei with average grass cover of 40.75% (Table 20).

Table 20: Average grass cover in all the sampling blocks

Dependent Variable: Grass cover				
	Mean	Std. Error	95% Confidence interval	
TYPE			Lower Bound	Upper Bound
Reserve	87.64	1.68	84.33	90.94
Koiyaki-lemek	42.08	2	38.13	46.02
Siana	41.05	3.23	34.69	47.41
Olkinyei	40.75	4.57	31.75	49.75

ANOVA statistics were also used to test for differences in arcsine transformed grass cover. The results showed that there was a significant difference for cover with the reserve having the highest while the ranches showed no significance difference (Figure 13).

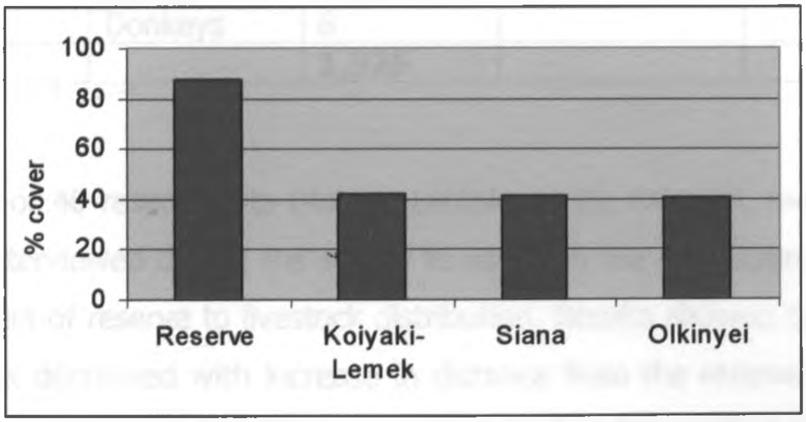

Figure 13: Average % grass cover in MMNR and three ranches outside the reserve

3.3.3. Livestock numbers and distribution in the group ranches

Table 21: Number and distribution of livestock in the group ranches

Group ranch	Livestock species	Total number of livestock counted	Transect name	Approximate distance of transect line from the reserve in km
Koiyaki-lemek	Cattle	9,265	Talek/aitong	5 km
	Goats	1,082		
	sheep	4,312		
	Donkeys	4		
Total		**14,663**		
Koiyaki-Lemek	Cattle	4,405	Aitong-mararienda	15 km
	Goats	812		
	sheep	2,289		
	Donkeys	56		
Total		**7,562**		
Siana	Cattle	4,090	Nkoilale-siana	20 km
	Goats	738		
	sheep	1,625		
	Donkeys	17		
Total		**6,470**		
Olkinyei	Cattle	494	Olkinyei	50 km
	Goats	360		
	sheep	1,075		
	Donkeys	6		
Total		**1,925**		

A total of 40 respondents (Koiyaki-Lemek, n=20; Olkinyei, n=10; Siana, n=10) were interviewed during the survey to establish the distribution of livestock and the effect of reserve to livestock distribution. Results showed that the number of livestock decreased with increase in distance from the reserve (Figure 14). This can be attributed to fact that most of the land in the north is already subdivided into individual patches and leased to wheat farmers forcing the pastoralist from the north of the district to move their animals to the non-subdivided and relatively greener areas in the south in search of better pastures. Some livestock owners grazed their livestock in the reserve due to laxity of rangers or collusion with them. Koiyaki-lemek group ranch was closer to the reserve and recorded more livestock numbers per household than Olkinyei.

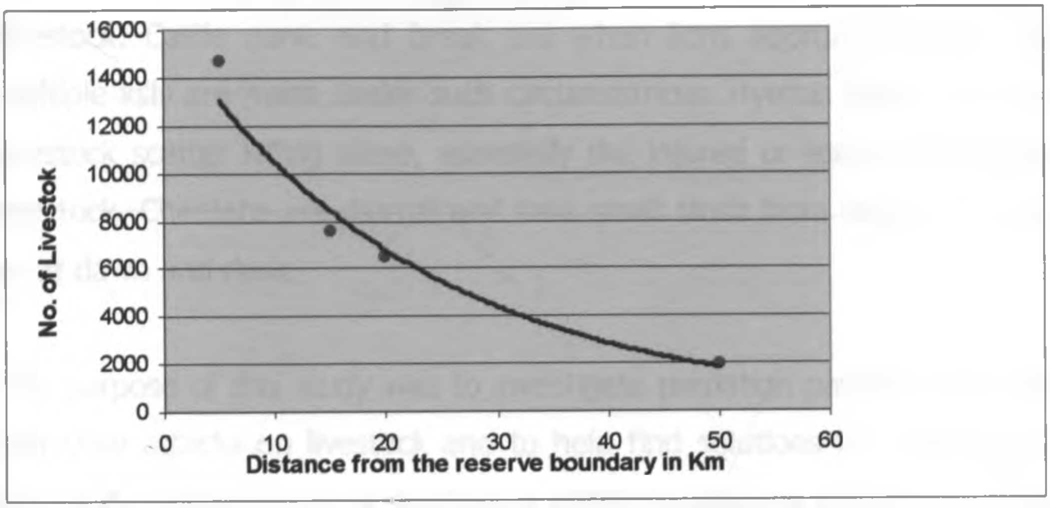

Figure 14: Influence of reserve to livestock distribution

CHAPTER FOUR

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

4.1 Introduction

Different species of predators attack livestock in different ways. Lions, leopards and hyenas will invade 'bomas' at night. Lions and leopards leap over while hyenas crawl through 'bomas'. When confined in 'bomas', predators can kill many livestock. Cattle panic and break out when lions approach 'bomas' at night. Multiple kills are made under such circumstances. Hyenas take advantage when livestock scatter killing some, especially the injured or scavenging on the dead livestock. Cheetahs are diurnal and take small stock from herds in the day light or at dawn and dusk.

The purpose of this study was to investigate predation patterns associated with carnivore attacks on livestock and to help find solutions for mitigating human-carnivore conflicts so as to promote a stable coexistence between carnivores and pastoralists. The objectives of this study were to find out the carnivores involved in livestock predation in the group ranches adjacent to Maasai Mara National Reserve, their predation patterns and to assess the ecological factors that influence carnivore attacks on livestock in the group ranches.

4.1.1 Pattern of livestock predation in group ranches adjacent to Maasai Mara National Reserve

The attacks analysed here represent incidents in which large carnivores attacked and killed livestock. Some attacks resulted in livestock injuries but these were not presented in this thesis. Most attacks on livestock occurred during the long rainy season 61.2% in contrast to prior studies by Karani (1994) and Rudnai (1979), in central and western Kenya respectively that claimed carnivores raided livestock more frequently during the dry season. The annual movements of native ungulates especially the migratory wildebeests and zebras that arrive in the area during the dry season seem to alter the prey availability for resident large predators during the rainy season long after they have left.

Since, during the rainy season there is a lot of available pasture (grass is tallest) it is possible that the resident ungulates spend less time feeding and more time scanning for possible predators hence, making it very difficult for carnivores to search, find and handle. Carnivores are therefore, prompted to turn to livestock since, they are the alternative source of food.

The results showed that more attacks on livestock occurred when wild prey was limited supporting studies by (Singh and Kamboj, 1996) who showed that large predators are likely to attack livestock when wild prey is inaccessible. They also indicated that availability of native prey may be governed by annual cycles or when their populations have been exterminated by humans.

Leopard was singled out as the one carnivore that killed most heads of livestock (66%) although it attacked less (40.8%) as compared to lions (42.9%). At one incident it was reported to have killed a massive 36 goats. Similar studies by (Stuart, 1989), showed that surplus killings by leopard especially in holding pens or against fence lines is a well known phenomenon.

Livestock killing by the predators was obviously biased by body size. Leopards, hyenas and wild dogs attacked smaller livestock and specifically went for goats and sheep. However there is an incident in which a cow was killed by hyenas and another by wild dogs. Lions went for larger prey and 94% (31 out of 33) of cows killed, were by the lions. An efficient predator will accept all potential prey encountered when food is scarce or un-predictable but will exercise greater selectivity when food is common and adequate (Emlen, 1966; MacArthur and Pianka, 1966; Sunquist and Sunquist, 1989). Previous studies have looked at prey preference of large carnivores as a function of prey size (Karanth and

Sunquist, 1995). These studies compared their observations in light of foraging theory (Stephens and Krebs, 1987), where the most profitable prey is that measured by the ratio of energy gain to prey-handling time. Thus in my case cows would appear to be the most profitable prey large enough to provide full meal and small enough not to cause major harm to lions. Consequently leopards prey typically range in weight from a few 100 g (e.g. rodents) to over 100 kg, with preferred weight being between 20 and 50 kg (Schaller, 1972). (Schaller, 1972), also observed that leopards preferentially kill prey in the 20 ± 70 kg weight class. Goats and sheep range in this weight class and hence provide the most profitable prey for leopards.

Previous studies on stalking predators, cheetahs and lions have shown that hunting success tends to be lower in areas with little cover, when the prey group is more vigilant, or when hunts are initiated further from the prey (Elliot et al., 1977; Van Orsdal, 1984; FitzGibbon and Fanshawe, 1988). Interviews with the local community also reviewed that more livestock were killed in bushy areas than in the plains. This study therefore, confirms that more attacks are likely to occur in areas where a predator can approach its prey with minimal chances of being detected.

4.1.2 Causes of livestock predation in the group ranch adjacent to Maasai Mara National Reserve

4.1.2.1 Land use and land tenure policy

The ever changing land use policy within the Mara ecosystem is a major set back towards carnivore conservation in the area. The greatest weakness of the group ranch arrangement has been in its administration (Sitati, 1997). The original believe that a select group of individuals could hold rights of land and manage communal resources for the benefit of the community, has proved futile. Self interest, lack of integrity, political interests, lack of knowledge of procedures and guidelines and lack of adequate checks and balances has resulted to almost all of the group ranches being subdivided or seeking subdivision (Sitati, 1997). This has in turn led to fragmentation of the hunting ranges for carnivores and consequently increasing carnivore-livestock interactions.

4.1.2.2 Livestock predation mitigation measures employed by the Maasai community

This study noted that three types of measures against livestock predation are widely practiced by the Maasai community. These include the construction of thorn enclosures (bomas), use of dogs to warn pastoralists of any approaching carnivore and direct anti-predator mechanism which involves active defence of livestock in times of the attack. The first measure involves keeping livestock confined at night in bomas. The bomas are made of branches of many traditionally preferred tree species with strong thorns. However, these branches must be within that vicinity. This method is not highly effective since, in many cases livestock break away from the bomas when they smell an approaching predator. A suggestion is made for construction of better livestock holding structures e.g. the use of wire mesh which is predator proof and also cannot be broken by scared but enclosed livestock.

4.2 Conclusion

Lions, leopards, hyenas and wild dogs are the carnivores involved in livestock predation in group ranches adjacent to Maasai Mara National Reserve. The kind of livestock selected by various carnivores varies with the species. Sheep and goats are mainly killed by leopard.

Large carnivores' attacks on livestock in group ranches adjacent to Maasai Mara National Reserve are at the highest during the wet season. During this season, many large ungulates which form the food source for large carnivores are widely dispersed due to plenty of foliage available and probably due to possibility of many watering points that may be in the area. The wild prey may also be very health because of the plenty foliage available hence, It is possible that they spend more time scanning for possible predators than searching for food. Since alert and strong prey are hard to hunt, the carnivores may be prompted to attack livestock more during this wet season.

During the dry season migrating herds of zebra and wildebeest are in the Maasai Mara and the adjacent group ranches providing easy food for the resident carnivores. At this time carnivores direct less attention towards livestock because of the possible resistance and counter attack by the herders. It is therefore prudent to suggest that carnivores only target livestock when the natural prey is inaccessible.

4.3 Recommendations

4.3.1 Measures towards reducing livestock predation in group ranches adjacent to Maasai Mara National Reserve

4.3.1.1 Livestock husbandry

Livestock husbandry has a clear effect on rates of livestock predation and hence on the numbers of predators killed in revenge. Cattle, goats, sheep and donkeys experienced the lowest predation rates when attentively herded by day and enclosed in traditional corrals (bomas) by night. Construction of the "boma", the presence of watchdogs, and high levels of human activity around the "boma" are all associated with lower losses to predators.

4.3.1.2 Managing of problematic carnivores by Kenya wildlife service personnel

Targeted lethal control may under some circumstances, have an important role to play in carnivore conservation. Use of Poison is a serious and indiscriminate threat to all species that scavenge. Many commercially available cattle dips, insecticides and seed dressings are used as poisons against large carnivores by local communities. This toxin has been banned in several other countries because of its effects on wildlife, and a similar ban in Kenya. This study suggests that control of problematic carnivores must only be performed by the KWS personnel and the ban of non-conspecific methods like poisoning should never be lifted.

4.3.1.3. Compensation for livestock lost to predators

The idea of compensation/consolation scheme for carnivore conservation has emerged in many areas of Kenya. Before this scheme is established it should however, be established whether these compensation programme will really help large carnivore species in conflict with humans. It should also be established if conservationists are armed with adequate information to apply these programme effectively. Establishment of well-trained, efficient, responsive Problem Animal Control Teams within KWS would be an important step in providing such means for local communities. Such teams should also have an important educational responsibility, teaching local communities about better livestock husbandry practices and other measures that would reduce the vulnerability of livestock to predation.

4.3.1.4 Community participation and eco-tourism

Mechanisms for local people to benefit from large carnivores outside protected areas should be developed. The negative impact of large carnivores on human livelihoods may be reduced if a complementary approach is found to offset those losses by providing alternative income sources. One such existing alternative source of income to communities affected is ecotourism. This involves not only encouraging ecotourism initiatives and conserving carnivore populations but also developing new approaches to make carnivores more visible and accessible to tourists outside protected areas.

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APPENDICES

APPENDIX 1

Survey Questionnaires on livestock predation by large carnivores in group ranches adjacent to Maasai Mara National Reserve

Instructions to Respondents: 1. please fill the responses in the spaces provided and tick where appropriate.

Section A: General Information

1. (a) Name of respondent ....Date .... Age...............

(b) Residential pastoral area (0). Koiyaki (1) Siana, (2) Lemek (3) Olkinyei

2 What is your main source of your livelihood?..................................

3 (a). Do you own livestock? (0) Yes (1) No

(b). which livestock species do you own and how many per species? (0) Cattle........ (1) Goats (2) Sheep........ (3) Donkeys........ (4) Others specify).............................

Section B: Human-predator Conflict

(4) a) Have your livestock ever been attacked by wild carnivores? (0). Yes (1) No

(b) If yes, how many this year?

1. Bull..........................
2. Cow..........................
3. Heifer.......................
4. Calf ....
5. Goats.........................
6. Sheep.......................
7. Donkey ....

(c) Which species of predators attack in order of frequency?

1)..

2)..

3)..

4)..

(d) How much was the loss? (In Ksh)... ....

e) Which season do they mostly attack? (0) wet (1) dry

f) What time of the day do they usually attack? (0) Day (1) Night (2) Both

5 (a) if predators have been involved in attacking your livestock; (please Fill in the following tables)

Number of livestock lost to predators per house hold (manyatta)

Species	Number of Animals lost	Unit value of each animal	Total value of animals lost
Bull			
Cow			
Heifer			
Calf			
Goat			
Sheep			
Donkey			
Kids /lambs			

Predator species involved in livestock predation

Livestock killed in attack	Lions	Hyenas	Cheetahs	Leopards	Wild dogs	Unit value
Bull						
Cow						
Heifer						
Calf						
Sheep						

Goat						
Donkeys						
Kids /lambs						
Unit value						

6 (a) Do you know of predators that have been killed by people or by KWS for attacking livestock? (0) Yes (1) No

(b) If yes, please provide the following information.

Predator species	Number	Place of killing	Predator species
Lions			
Hyenas			
Cheetahs			
Leopards			
Wild dogs			
Others specify			

Section C: predators' abundance and distribution in the study area

7 (a) in your opinion, how many large carnivores do we have in this area?

1. Lions.............................
2. Hyenas............................
3. Cheetahs...........................
4. Leopards.........................
5. Wild dogs.........................
6. Others specify.....................

APPENDIX 11

Analysis of variance table for number of attacks on livestock in the three group ranches

Sources of variation	df	Sum of Squares (ss)	Mean Square(variance)	F(variance ratio)	Significance
Group ranches (fixed factors)	2	0.841	0.421	1.475	0.239
Experimental Error	46	13.118	0.285		
Total	48	13.959			

The results showed a significance difference at 5% significance level.

APPENDIX 111

Season	Observed	Expected	$(o-e)^2/e$
Long rainy season	10	16.3	2.4
Long dry season	30	16.3	11.5
Short dry season	9	16.3	3.3
		$X^2=\Sigma(o-e)^2/e = 17.2$	
		Df=2	

Chi-square table for season's attacks on livestock

Appendix IV

Seasons	Observed	Expected	$(o\text{-}e)^2/e$
Long dry season	83	91.6	0.8
Short dry season	53	91.6	16.2
Long rainy season	139	91.6	24.5
		$X^2=\Sigma(o\text{-}e)^2/e = 41.5$	
		Df=2	

Chi-square table for season's heads of livestock lost to predators

Appendix V

Month	Observed	Expected	$(o-e)^2/e$
January	0	6.1	6.1
February	9	6.1	1.3
March	5	6.1	0.2
April	16	6.1	16.1
May	5	6.1	0.2
June	4	6.1	0.7
July	3	6.1	1.6
August	3	6.1	1.6
		$X^2=\Sigma(o-e)^2/e = 27.8$	
		Df=7	

Chi-square table for monthly attacks on livestock

Appendix VI

predator	Observed	Expected	$(o-e)^2/e$
Lions	21	12.25	6.25
Leopards	20	12.25	4.9
Hyenas	6	12.25	3.1
Wild dogs	2	12.25	8.5
		$X^2=\sum(o-e)^2/e = 22.75$	
		Df=3	

Chi-square table for predators' frequency attack on livestock

Appendix VII

Group ranch	Observed	Expected	$(o-e)^2/e$
Koiyaki-lemek	23	16.3	2.7
Olkinyei	15	16.3	0.1
Siana	11	16.3	1.7
		$X^2=\Sigma(o-e)^2/e = 4.5$	
		Df=2	

Chi-square table for frequency of attacks on livestock in the group ranches

Appendix VIII

Dependent Variable: Grass height				
			95% Confidence Interval	
Sampling area	Mean	Std. Error	Lower Bound	Upper Bound
Reserve	61.162	2.355	56.528	65.797
Koiyaki-lemek	16.947	2.81	11.418	22.476
Siana	14.7	4.531	5.785	23.615
Olkinyei	9.65	6.407	-2.958	22.258

ANOVA table for grass height in all the sampling blocks

Appendix IX

Tests of Between-Subjects Effects						
Dependent Variable: Cover						
Source of variation	Df	Sum of Squares	Mean Square	F	Sig.	Conclusion
Treatment	3	2822.7	940.888	2.251	0.082ns	Accept the null hypothesis (Ho)
Error	308	128751.3	418.024			Not significant at the 5% significance level
Total	311	131574				

ANOVA table for grass cover in the sampling blocks