PATTERNS AND ECONOMIC IMPACTS OF LIVESTOCK PREDATION IN RURAL COMMUNITIES BORDERING MAKGADIKGADI PANS NATIONAL PARK IN BOTSWANA

By

Leonard Mogopodi Dikobe

Submitted as the dissertation component
in partial fulfilment of the
requirements for the degree of
Master of Science
in the
School of Environment and Development,
University of Natal

Pietermaritzburg
1997

ABSTRACT

Continuing interaction between livestock and wild carnivores characterises many of Northern Botswana's rural agricultural settlements bordering national parks and game reserves. In two study areas (Khumaga and Gweta, bordering Makgadikgadi Pans National Park), spatial, temporal and prey-type patterns of livestock predation were assessed. Cattle, goats, horses, donkeys and sheep were the key livestock types. Lion, leopard, cheetah, wild dog, black-backed jackal, spotted hyena and the Nile crocodile (occurring only in Khumaga) were the key predators. Oral interviews with farmers in these villages provided insights into the patterns and impacts of livestock predation on rural economies.

Khumaga's livestock predation scenario is dominated by lion predation on cattle, goats and donkeys, leopard predation on small stock and calves, and crocodile on goats. Wet season predation rates were higher than dry seasons', except for spotted hyena, black-backed jackal and leopard. Leopard and black-backed jackal are dominant small stock predators in Gweta. lion are the main cattle and donkey predators (though at lower frequencies). Dry season predation rates are higher. Farmers who own more livestock appear to lose more

ABSTRACT

Continuing interaction between livestock and wild carnivores characterises many of Northern Botswana's rural agricultural settlements bordering national parks and game reserves. In two study areas (Khumaga and Gweta, bordering Makgadikgadi Pans National Park), spatial, temporal and prey-type patterns of livestock predation were assessed. Cattle, goats, horses, donkeys and sheep were the key livestock types. Lion, leopard, cheetah, wild dog, black-backed jackal, spotted hyena and the Nile crocodile (occurring only in Khumaga) were the key predators. Oral interviews with farmers in these villages provided insights into the patterns and impacts of livestock predation on rural economies.

Khumaga's livestock predation scenario is dominated by lion predation on cattle, goats and donkeys, leopard predation on small stock and calves, and crocodile on goats. Wet season predation rates were higher than dry seasons', except for spotted hyena, black-backed jackal and leopard. Leopard and black-backed jackal are dominant small stock predators in Gweta. lion are the main cattle and donkey predators (though at lower frequencies). Dry season predation rates are higher. Farmers who own more livestock appear to lose more cattle than those who own few. Gweta contrasts with Khumaga, having livestock predation highest during dry seasons, less reduction in livestock sales and a lower value of pending compensation claims. These predation patterns synchronise with movements of zebra and wildebeest to and from the Boteti river.

Losses of livestock affect the utility derived from livestock and monetary gains from direct sales. Costs due to loss of biodiversity, though not quantified, add to those borne by the State through predator control. Both the State and the farmers loose. These losses reduce the incentives of the latter to conserve species that contribute reduction in their returns. The issue of State expenditure on predator control illustrates the possible need for re-direction of such funds into farmer-based predator control, much as an integral part of the current southern African trend of community-based natural resource management.

Key words: livestock predation, predator control, economics, conservation, Botswana.

PREFACE

The survey work described in this dissertation was carried out in Khumaga and Gweta villages in Botswana, under the auspices of the Department of Wildlife and National Parks, from September 1996 to January 1997 under the supervision of Dr Richard H. V. Bell (based in Botswana) and Dr Mark A. G. Darroch (based in Pietermaritzburg - Republic of South Africa).

Background knowledge of most aspects of rural pastoral farming systems and predator control, owing to the author's childhood exposure to typical rural African life and professional exposure to wildlife conservation and resource-use issues, has been put to use in this study. The study represents original work by the author and has not otherwise been submitted in any form for any degree or diploma to any University. Where use has been made of the work of others, it is fully acknowledged in the text.

ACKNOWLEDGEMENTS

I wish to thank, sincerely, the Department of Wildlife & National Parks (DWNP) Directorate, especially the former Director, Mr Samuel Rathedi for allowing this study to be conducted in Botswana, and the current Directorate, in particular Sedia Modise and Joseph Matlhare, for continuing with Rathedi's support. Also within DWNP, sincere gratitude is owed to Jan Broekhuis for spending his time in organising the digital mapping data and sending it from Botswana to South Africa for my use. I also wish to thank the field staff of DWNP with whom I worked during the hottest times of the Northern Botswana summer, in particular Ontlametse Semele (my field assistant) and Goitseone Lebonetse (my boss) both for having strongly vested interests in the success of this project.

I thank greatly, the farmers of Khumaga and Gweta villages, and their respective chiefs for so enthusiastically making themselves part of this study. My special gratitude goes to the late Chief Ngande Kgama of Khumaga who even during the last days of his life continued to contribute towards this study - may his soul rest in peace.

To my field supervisor, Richard Bell; for his instrumental guidance during the initial stages of the project and for even committing his personal resources to ensure the success of this project; to my University supervisor, Mark Darroch; there can also never be enough gratitude for the time spent reading through the numerous drafts and helping to build the frame of this work and its arguments - I sincerely thank them all. I also thank Susan Brittain for her review of the statistical sections of the Results and Discussion chapter and Botshabelo Othusitse for his meaningful contribution in the review stages of this work.

Behind all the urge and motivation for success lies my mother, Babui and the rest of my family, together with my fiancee, Kelebogile. They have borne intensive pain due to my continued absence and have still remained forever loving and supportive. I thank them all!

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

ADMADE	Administrative Management Design for Game Management Programme
BLDC	Botswana Livestock Development Corporation
BMC	Botswana Meat Commission
BOPHA	Botswana Outfitters and Professional Hunters Association
BWTI	Botswana Wildlife Training Institute
CAMPFIRE	Communal Areas Management Programme for Indigenous Resources
CBNRM	Community-Based Natural Resources Management
CBPP	Contagious Bovine Pleuro-Pneumonia
CHA	Controlled Hunting Area
CNP	Chobe National Park
DWNP	Department of Wildlife and National Parks
GNRT	Gwezotshaa Natural Resources Trust
GoB	Government of Botswana
IRR	Internal Rate of Return
KNP	Kruger National Park
LIFE	Living In a Finite Environment
LIRDP	Luangwa Integrated Resource Development Project
MGR	Moremi Game Reserve
MPNP	Makgadikgadi Pans National Park
NGO	Non Government Organisation
NRMP	Natural Resource Management Programme
PAC	Problem Animal Control
RAD	Remote Area Dweller
RALE	Representative and Accountable Legal Entity
SCP	Selous Conservation Programme
TGLP	Tribal Grazing Land Policy
WCNP	Wildlife Conservation and National Parks
WMA	Wildlife Management Areas
WTP	Willingness To Pay
ZWP	Zambia Wetlands Project

GLOSSARY

- Names of languages (of mostly Southern African origin) are written with prefixes such as "se" which denotes their being names of languages, or "ba" to denote a group of a particular language speakers followed by a root for the name of a language. The prefix may change depending on the language group to be either "*se-*", "*chi-*", "*ki-*", or "*isi-*" (for language names) and "*ba-*", "*ha-*", "*ama-*", etc. (for a group of people speaking a particular language).
- Words of San Origin have been written using notation adopted from Nguni languages so as to allow most readers to refer to the extensive literature on Nguni language and pronunciations with ease.
- Names of predator species central to this study have been used in singular form to include plural, and hence they act as collective nouns. This has been considered relevant to the study since none of the animals are discussed as individual entities, but rather collectively, as a species.

The following are English words and phrases used in the text which have other more common uses or are of *SeTswana* language such that the author feels the use of an English substitute would compromise the meaning.

Cattle-post:	An area set aside for raising livestock (predominantly cattle), usually a part of communal grazing land. Such areas are allocated by a Tribal Land Board in accordance with the Tribal Land Act[33]. No strict boundaries exist except for the kraals - by virtue of their physical existence. Only the eight kilometre radius is used for allocation of boreholes but is not applied to grazing arrangements.
Dry season	Periods from 1 April of any one year to 31 October of the same year.
Endowment	Number of livestock (by type) kept at any one cattle-post. At times several relatives keep livestock at one cattle-post,

	especially women to benefit from the livestock care provided by male herders.
Incentives	Any inducement which is specifically intended to motivate the pursuance of a particular behaviour considered desirable, as in the case of natural resource management (adopted from McNeely[81]).
Kgotla	Refers to both an institution and a place in SeTswana culture. As an institution, *Kgotla* is the decision-making body at village level. As a place, it serves to accommodate a wide range of fora from conflict resolution to information dissemination and duty allocation to military regiments and working groups. The headman (or chief in tribal capitals) is the leader of the *Kgotla* though he may delegate elder members to preside over other matters.
Mafisa	A system of cattle lending in traditional *SeTswana* culture where the owner gives out cattle to individuals with smaller numbers or no cattle at all. The individuals benefit by using them for draught power and milk. Decisions as to their sale and slaughtering are made by the owner while location and grazing access rights are arranged by the recipient.
Matimela	Refers, in general context, to lost property in *SeTswana* but is used (in a personified form) to specifically refer to a state-run programme in Botswana whereby livestock whose owner(s) cannot be traced are kept in holdings maintained and administered by government. A daily rate equivalent to US$ 0.28 is charged to the owner unless the livestock stays for up to one year in which case they will be sold by public auction.
Perverse Incentives	Used in natural resource conservation to mean those incentives which favour a value system not shared by the author.
Problem Animal	A term used in the context of subsistence pastoral farming in Africa to refer to species of potentially dangerous wild animals that cause damage to livestock, crops, property and human life.

Remote-Area Dwellers	Inhabitants of parts of Botswana that are, to date, not part of the main stream of the economy due to their geographical location, life style (nomadic, with different social structure), and/or immediate dependence on indigenous food sources and hunting.
Wet season	Periods from 1 November of any one year to 31 March of the following year.

INTRODUCTION

Predators, Livestock and Humans

In Africa, mammalian predators that have continued to challenge human and livestock safety are lion (*Panthera leo*), leopard (*Panthera pardus*), cheetah (*Acinonyx jubatus*), wild dog (*Lycaon pictus*), hyena (*Crocuta crocuta*), and jackal (*Canis mesomelas*)[1]. Nile crocodile (*Crocodylus niloticus*), though reptilian, also feature significantly as predators. The rarity of python (*Python sebae natalensis*) is a possible reason for their less threatening position as livestock predators. All these predators have posed threats to pastoral farming of camels, cattle, horses, donkeys, goats and sheep. Conservation efforts of today are continuously having to face the realities of legitimate claims and complaints against raids by these wild predators on herbivores from neighbouring human communities. States that make efforts to reduce losses incurred by farmers are likely to find the financial implication of such exercises overwhelming in terms of institutional costs of compensation, actual compensation monies and capital costs of controlling predators. The relationship between different degrees of these Problem Animal Control (PAC) efforts and the extent of damage by problem animals is still not established as positive. Bell[2] found no reduction of crop damage by elephants in Malawi at various levels of PAC effort other than family protection and electric fencing. Relationships between the different predators and livestock types, their spatial and temporal patterns are also yet to be understood. Such an understanding could guide PAC efforts in terms of when to act, how to act and the form of government intervention to take to mitigate the different problems associated with the interaction of predators and livestock. Before defining the aims and objectives of this study, an outline is presented of the past experiences with predator-livestock interactions in Botswana.

History of Predator Control in Botswana

In Botswana, control of predators by farmers dates back to the evolution of pastoralism between A.D. 350 and A.D. 600[3,4]. At that time, iron-headed spears were the best form of weaponry by which to kill feline and canine predators that preyed on livestock. The success of the herd and hence of the farmer depended largely on the latter's ability to minimise livestock predation[1]. This predator-livestock-human relationship remained almost unchanged in Botswana, as in the rest of Africa, until the transfer of wildlife ownership from rural inhabitants to colonial governments (later to

national governments) and the establishment of protected areas[5,6] in the late 19th century and early 20th century. Protected areas were areas where hunting or any form of killing of wildlife, collection of veld products, human residence and farming were prohibited; and access was controlled to keep out local inhabitants. Botswana's first legal protected area was created in 1940 along the north-east of the Nossob river; by 1992 there were 13 national parks, game reserves and nature sanctuaries totalling 23% of the country's total land area (see Appendix 1, p.120). From as early as 1961, control of predators through trapping, pitfalls, hunting with dogs, baiting and the use of poisoned arrows were prohibited by law even outside protected areas[7]. This legislation applied also to subsistence hunting except that it was modified by the Fauna Conservation Act, N°. 47 of 1967 to allow for use of indigenous weaponry by Remote-Area Dwellers[7] (RADs). Control of predators in rural agricultural communities bordering Makgadikgadi Pans National Park (MPNP) in Botswana remains, even to this day, the main source of contention between the villagers and protected area managers[8,9]. Parry & Campbell[10] report a similar situation in Mababe and Chobe Enclave (areas bordering Moremi Game Reserve (MGR) and Chobe National Park (CNP), respectively) in Botswana. They associate this with crop damage by wild herbivores, losses of livestock to predators, loss of land to conservation and lack of control over wildlife resources and revenues derived from them. The phrase "dogs of the state" is commonly used by rural communities to refer to predators during discussions relating to livestock predation, especially in areas bordering national parks and game reserves.

Payment of Compensation for Wildlife-Induced Damage

From as early as 1891, compensation was provided by the then colonial government under the British Protectorate. The emphasis was on the farmer having to capture and/or kill the problem animal so that meat and trophies accruing from it could be used to offset the economic loss. Through the different stages of evolution of the Fauna Conservation legislation in Botswana, ownership of trophies was originally vested with farmers[11], then moved to tribal authorities/government in 1961[12] and then restored to the individual farmer/landowner in 1979[13]. In 1993 an amendment to the Wildlife Conservation and National Parks (WCNP) Act 28 of 1992, transferred ownership back to the state. Only on 15 January 1993 was monetary compensation

legislated and compensation rates determined for different types of livestock, crop and property[9]. Such rates could (through regulations) be revised by the Minister of Commerce and Industry as appropriate[14]. These rates (paid in Botswana Pula) have remained the same since they were promulgated on 2 February 1994 as equivalent to US$145.60 for a bull, ox or tolly; US$112.00 for a cow, heifer or mule; US$56.00 for a calf or foal (with no reference to age and/or body mass); US$224.00 for a horse; US$19.60 for a donkey, goat or sheep; US$28.00 (maximum per hectare) for crops; 50% of replacement value for other property and 80% of purchase price for pedigree breeding animals (on production of a certificate and receipt of purchase). The rates are calculated at January 1997 exchange rates between the Botswana Pula and United States of America's Dollar (P1.00 = US$0.28) to put into a wider perspective the current value of the compensation.

Section 46, subsection 5 of WCNP Act 28 of 1992 required farmers to kill the problem animal as a condition for being paid compensation for damage caused. This system was abused and led to unwarranted killing of predators, especially those whose skins and/or meat could be sold at higher prices than others. Records indicate that lion, leopard and cheetah were killed more than the less tradable species[15]. Although most farmers did not own firearms, and ammunition was hard to obtain, farmers collaborated with the few who owned firearms and ammunition (Kgama, pers. comm. 1996*). Meat and trophies obtained from predator control belonged to the individual livestock owner who would then apportion it to members of the team as he saw fit. The tradable commodities such as skins, claws, teeth and skulls were sold to taxidermists at main population centres and the proceeds used to purchase replacement livestock. This trend is likely to have stimulated concern over predator population declines within Non Government Organisations (NGOs) and other conservation bodies culminating in the abolition of ownership rights of trophies obtained by farmers through predator control. This move manifested itself in the amendment to section 46 of the WCNP Act which was passed into law in 1993 and the actual monetary compensation implemented after February 1994. This amendment vested the ownership of trophies resulting from predator control with government and required

* Mr Ngande Kgama. Headman of Khumaga village. Botswana

that predation be certified by either an officer of the Department of Wildlife and National Parks (DWNP) or a veterinary official. The above-mentioned conservationist legislation, exaggerated by pressure from conservation NGOs, has increasingly created conflict by (i) conservation measures that promoted increase of problem animal numbers and (ii) progressively removing rural communities' rights to solve problems caused by problem animals and (iii) centralising control of predators (with inherent costs and administrative implications such as delayed payments).

In DWNP's effort to create an enabling environment for communities to actively manage and utilise wildlife resources, extensive strengthening of rural residents' capacities to plan and organise community-based natural resource management (CBNRM) activities has remained one of the major thrusts[16]. These efforts would have been undermined if DWNP had not started to actively address the problems of wildlife-livestock interactions[17]. DWNP is currently engaged in a programme of increasing numbers of staff to deal with control of problem animals and training of such staff through the Botswana Wildlife Training Institute (BWTI)[18]. A community liaison unit of DWNP is also involved in establishing community-based wildlife management and utilisation fora with a long term aim of also handing over the control of problem animals and compensation to farmers[19]. Areas where there are intense conflicts between local communities and the DWNP are mainly those with high levels of livestock predation. In 1994 alone, damage caused by wildlife reported to 16 DWNP offices countrywide, totalled 3020 incidences, 75% being on livestock predation and the remaining 25% on crop damage by wildlife. In Chobe district alone, P44 566 was paid out to farmers as compensation in 1994[20]. This implies a high financial burden on central treasury giving the nation a vested interest in minimising these deleterious wildlife-livestock interactions. In Zimbabwe's Communal Areas Management Programme for Indigenous Resources (CAMPFIRE), one of the discernible results is a reduction in problem animal complaints where Rural District Councils have understood the dynamics of the programme and have genuinely promoted proprietorial devolution to producer communities[21].

Patterns of Predation

Livestock predation seems to follow certain spatial and temporal patterns. Age of predator and prey, status of range-land, season, and breeding patterns of livestock seem to be factors influencing predation patterns. For example, wild prey numbers decrease in late winter and spring resulting in less food being available for predators[22]. During this time, older and less robust members of prides and packs resort to preying on livestock. This situation is compounded by the synchronised births of lambs and kids which are, by virtue of their age, highly susceptible to predation[22].

Botswana's free-ranging wildlife is seen as most responsible for the high incidences of livestock predation. Botswana also has an almost unique situation of free-ranging livestock. Bell's[2] study of damage caused by wildlife found that the most important factor in reducing crop damage was protection by owning families. It is not difficult to acknowledge that governments of developing nations will never have adequate financial resources to afford sufficient protection to livestock. Large predators such as lion, leopard and cheetah range widely outside game reserves and national parks and are thought to do most damage as they prey on goats, sheep, cattle, horses and donkeys. Bowland *et. al.*[22] report a different scenario in South Africa where losses of smaller domestic stock are more common. They state that key predators are leopard, cheetah and brown hyena (localised scale) and caracal, black-backed jackal and domestic dog (at a more widespread level) in small-stock farming areas. This is probably because South Africa's national parks and game reserves are fenced[22], limiting movement of large predators.

The Pastoralist Industry

Pastoralism in Botswana and many parts of Africa has been described by planners, conservationists and agricultural administrators as resulting from conservative, traditional and economically irrational behaviour because of the unclear relationship between numbers of livestock kept and the rate of sales[23]. Studies by Schneider[24], Sandford[25], Bembridge[26], Fielder[27] and Danckwerts[28] have, on the other hand, shown that cattle are an integral part of the subsistence rural economies of African pastoralists and that pastoralists' decisions are strongly influenced by the size and age structure of the herd. Herders, within cultural limitations, therefore tend to try and maximise utility (satisfaction) and make rational management and economic decisions in relating their cattle resource to their multiple

requirements. It is not clear from these studies how factors such as the state of vegetation and sustainability of livestock numbers influence (i) movement of herds, (ii) acquisition of more livestock and (iii) sale of livestock. The traditional institution within which livestock predation and livestock build-up occurs needs to be taken into account. Losses incurred due to livestock predation are not only undesirable, but affect other economic activities such as arable farming, traditional ceremonies and availability of basic necessities such as milk, blood and manure. Livestock losses may be desirable in the context of an ecologically over-stocked range with limited seasonal migration pastures hence an indirect economic benefit to the farmer. Compensation paid to farmers for livestock lost to predators needs to be evaluated with respect to the almost irreplaceable utility lost. Food production, draught power and manure form the basic needs of herders with fewer than ten animals and are so crucial that, even young immatures and cows are used for ploughing despite the negative impacts on breeding capacity[26,28,29]. Danckwerts[28] shows that in the Nyanda Province of Zimbabwe, net sales represent only 17% of the total gross income from livestock and that the value of ploughing represents the highest percentage (42%) of gross cattle income. Milk is the second most valuable output at 29%. Livestock predation by wildlife therefore represents much more than the loss of sales for rural inhabitants of the areas in which it occurs and must be quantified to assist in guiding policy formulation and management decisions. Important as livestock is to rural economies, the underlying relationship between their numbers and the veld remains critical. In areas bordering national parks, the growing concern of managers over the increase in grazing area required for livestock is unavoidable. Appropriateness of the concept of carrying capacity to rural pastoral communities has been challenged through a number of studies such as that of Sandford[30]. They argue that variability of rainfall in semi-arid pastoral regions (hence water availability and pasture status) causes carrying capacity to vary and herders are mostly using different areas according to veld conditions. Bell[31] makes the point that human and livestock populations are limited by ecological factors, and that in semi-arid southern Africa, when ecological carrying capacity is exceeded over lengthy periods, more intense and long-lasting economic losses may result. Such losses may even exceed those associated with livestock predation.

Patterns of Livestock Ownership and Herding

Studies conducted in most parts of southern Africa indicate a skewed pattern of livestock ownership, especially with cattle. Colvin[23] observed this general pattern in rural KwaZulu-

Natal where average herd size amongst cattle owners was 8.5 and mean ownership was less than 3 per rural household. Similar results were obtained in Botswana by Behnke[29] and Little[32]. Little[32] quotes Botswana's exaggerated skewed livestock ownership where 50% of the population has access to only 7% of livestock-based incomes. These ownership patterns are likely to influence the impact of livestock predation on rural economies. This is so because compensation is payable to the actual owner while its benefits may not filter down to the herder who would have benefited more from the utility of a live animal. For instance, a herder benefiting from milk, skins and draught power may not necessarily get a replacement when the employer receives monetary compensation from government. Reduction of livestock numbers under the care of a herder may jeopardise the amount of wages payable on the basis of livestock numbers. Employed herders are likely to be less motivated to protect livestock from wild predators since a decrease in the number of livestock under their charge is not closely related to the benefits of their labour (Mazhadza, pers. comm. 1997[†]).

The Study Area

The study area is situated in northern Botswana, within the complex system of protected areas, namely Makgadikgadi Pans National Park (MPNP), Chobe National Park (CNP), Central Kalahari Game Reserve (CKGR) and Moremi Game Reserve (MGR) (see Figure 1). Specific study sites are Khumaga and Gweta, both of which border the MPNP (see Figure 2). The two villages (Khumaga and Gweta) provide, jointly, a scenario in which human population increase, land-use conflict and non-human phenomena (rainfall, wind, tectonic movements, etc.) play a major role in worsening the conservation status of a national park and quality of life of human communities neighbouring the national park. Population sizes in the two villages have increased, at a rate of 2.7% (lower than the 3.2% national average) and so has the livestock population[8]. Both villages are in areas set aside for human habitation and livestock development, i.e. Tribal Land in terms of the Tribal Land Act of 1968[33]. Of the three villages bordering MPNP on the west, namely, Khumaga, Moreomaoto and Motlopi, Khumaga is the only one with a DWNP office just across the river bed.

[†] Mr Gabaikangwe Mazhadza. Employed herder at Polanka cattlepost, Gweta, Botswana.

This allows for a more efficient response system by the protected-area staff and makes it easy for villagers to report all incidents of livestock predation soon enough for evidence to be found. The non-human phenomena facing Khumaga worsen the already tense land-use conflicts. The village is part of the riverine livestock-predator-human interaction whose parameters have been altered by non-human phenomena. A wealth of livestock predation records is available at the Khumaga DWNP office compared to other villages along the Boteti river which are far from the DWNP office and therefore less exposed to the services it provides. Gweta characterises a scenario of human and livestock population increase, and the associated pressures on the national park.

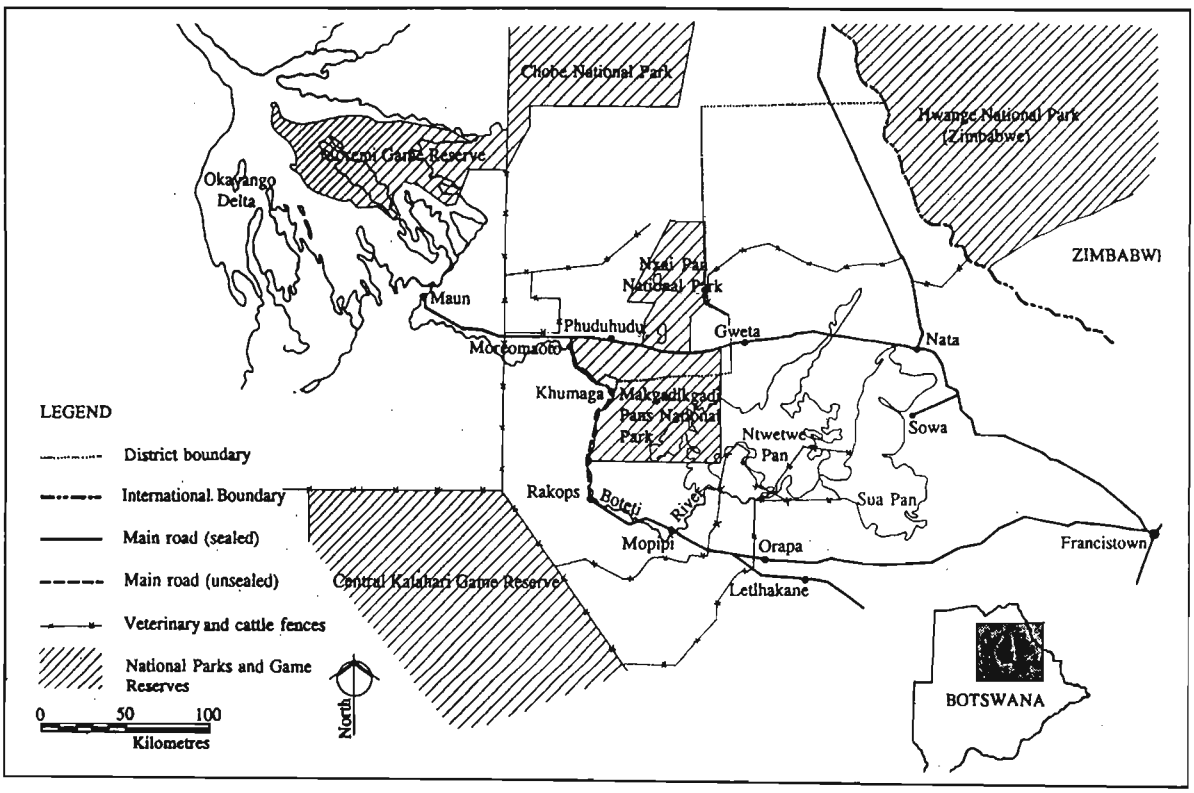


Figure 1: Regional setting of the study area (adapted from IUCN[8]).

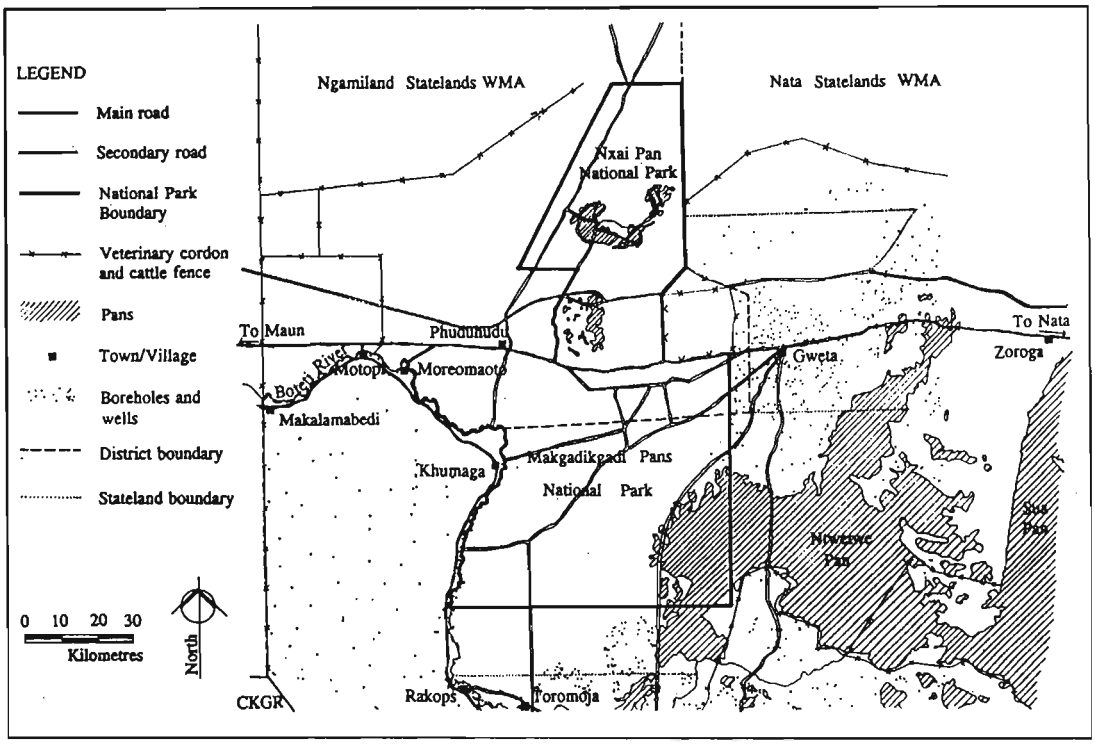


Figure 2: Makgadikgadi Pans National Park and its neighbouring human communities (adapted from IUCN[8]).

STUDY AIMS AND OBJECTIVES

The above review and description of Khumaga and Gweta indicate that predator control is a contentious issue, that pressures have mounted to undermine current systems of predator control and that changes face Khumaga and Gweta. This study aims to assess and document patterns and impacts of livestock predation in the Khumaga and Gweta villages bordering MPNP (see Figure 2). This will provide information to help reduce livestock predation, reduce predator mortality and increase economic returns for local inhabitants in these areas.

To meet these aims, this study

- documents forms of livestock predation in the two areas and assesses predation patterns (spatial and temporal) and predator preferences for particular livestock prey;
- assesses the effects of livestock predation on the economies of Khumaga and Gweta, especially the direct losses of stock, loss of utility and changes in rate of stock sales;
- documents costs of predation control methods used in the two areas by the government agency primarily responsible for the control of problem animals; and
- makes recommendations and suggests management options as to the appropriate methods of predator control and necessary legal changes to the current predator control systems.

A review of literature is first presented relating to the role of livestock in pastoral communities, patterns of livestock predation and predator-prey preferences, and institutional requirements for sustainable predator management. Research methodology for the study is then discussed, emphasising different forms of available data, how they were collected and analysed. Results are presented in graphical form and analysed using the Mann-Whitney method and linear regressions, with the bulk of the baseline data presented as appendices. Policy options and adaptive-management strategies are recommended on the basis of this study and case studies in similar fields. This is the first study to draw together observations of livestock predation, economic impacts of livestock losses and policy underlying control of predators in Khumaga and Gweta.

CHAPTER 1 : LITERATURE REVIEW

Literature covering aspects of patterns and impacts of livestock predation is spread across different fields of study such as wildlife biology, range ecology, rural development, natural resource economics and environmental history. This chapter has adopted titles that assist to build a picture of current knowledge of factors relating to this study and not necessarily titles of the traditional divisions of knowledge-base. The purpose of this chapter is to identify currently available knowledge-base that can be of assistance in defining and explaining phenomena underpinning patterns and economic impacts of livestock predation in the rural areas in question.

1.1. Patterns of Livestock Predation

Past studies on patterns of livestock predation are surprisingly limited, especially for southern Africa where majority of the human population is economically linked to livestock. This situation is probably due to a decline of free-ranging wildlife populations in most of southern Africa where only the small predators that have adapted to the modified habitats around human settlements, such as jackal, hyena and caracal, continue to prey on small-stock (goats and sheep). Large predators such as lion, cheetah, and leopard are confined mostly to national parks and game reserves[22]. Non-territorial males, as found in Caro & Collins's[34] cheetah survey in Kenya, travel longer distances, hence increasing chances of moving into livestock areas. Though Nile crocodile have not attracted as much interest among researchers as have Felid, Canid and Hyaenid predators, extensive documentation from the turn of the 18th century exists from travellers on the behaviour, feeding and sociality of these animals. Because of trade in crocodile skins, a lot has been known through the study of captive crocodile populations. Livestock predation by crocodile occurs only in Khumaga and not in Gweta.

1.1.1. Predator-Prey Preferences

Mizutani[35], in a study relating to leopard home ranges and livestock in Kenyan ranches, found that leopard targeted mostly newly-born calves and sheep but rarely cattle; cheetah targeted sheep but never cattle and lion targeted cattle more than they did sheep; spotted hyena preyed on sheep at a rate higher than that of other predators but less so for cattle; jackal killed more sheep than cattle; and wild dog

killed only sheep. This study further noted that continued human presence deterred predators (leopard, lion and cheetah) from killing livestock. Bothma & Le Riche[36] noted that, in the Kalahari desert, leopard prefer prey size less than an adult springbok (*Antidorcas marsupialis*) as 54% of kills were of juvenile animals. Le Roux & Skinner[37] observed that leopard prey upon animals less than 70 kg in mass (predominantly impala, *Aepyceros melampus*) and below that upper limit, would take any animal within their 33 km home range. Similar patterns are reported for the Serengeti area, Tanzania, by Kruuk & Turner[38]. These studies, though not on livestock predation, could indicate seasonal patterns of size-specific predation and hence preferences for domestic prey by Felid, Canid and Hyaenid predators.

A comparative analysis of prey preferences of Canidae and Felidae by Kruuk[39] shows a significantly lower number of food categories taken per species of Felidae compared to Canidae. All other members of the Carnivora (except Canidae) extensively exploit vegetable and invertebrate food sources. Felidae also have a higher and positive "body-size to prey-size" correlation[39]. It is therefore likely that prey acquisition by Felidae will be vulnerable to impacts of seasonal migration of wild herbivores, the impact of which might increase predation on livestock (assuming wild prey moves beyond home ranges of these predators). Canidae species are likely to have a consistent livestock predation intensity due to the high variety of their diet.

Sheldon[40] describes black-backed jackal as opportunistic predators and scavengers feeding on a highly varied diet ranging from plant matter, through Insecta, Reptilia, Aves to Mammalia. Sheldon[40] further notes that larger prey such as Thomson's gazelle are hunted by a group of jackals, while smaller prey such as rodents are hunted individually. This high variety of diet is likely to make black-backed jackal consistent predators, assuming level of care by farmers does not change between wet and dry seasons.

Sheldon[40] also describes hunting and feeding behaviour of wild dog as carnivorous with occasional scavenging. Prey varies from region to region but is mostly of medium-sized ungulates, including domestic stock where it can be found. Solitary

hunts are conducted when smaller prey animals (such as mice, rats, squirrels and birds) are involved. Similar findings are reported for Serengeti, Tanzania, by Kruuk & Turner[38]. In comparison to lion, wild dog are likely to have high seasonal variation in their level of livestock predation due to the relatively wider range of prey type.

Spotted hyena feed on a variety of prey including wildebeest (*Connochaetes taurinus*), impala, springbok, Thomson's gazelle (*Gazella thomsoni*), flamingos (*Phoenicopterus* sp.), zebra (*Equus burchelli*), buffalo (*Syncerus caffer*) and avian eggs in areas where they occur[41]. Cooper[42] found that spotted hyena in CNP, Botswana preyed mainly on medium-sized herbivores of mass 30 - 150kg; spotted hyena hunted zebra more than antelope during the wet season; and that zebra migrated into the Savuti marsh (home range for spotted hyena) during the wet season. Mills[43] observed in Kalahari, Botswana that 72.6% of the biomass of spotted hyena diet was from kills which consisted of gemsbok calves (43%), wildebeest (15%) and gemsbok adults (10%). The balance probably consists of squirrels and birds. With the two study areas having wildebeest and zebra (both seasonally migrating herbivores), spotted hyena are likely to depend on resident herbivores, some of which is domestic, during times when wildebeest and zebra have emigrated.

Pienaar[44] was able to calculate preference rating of a prey species for a particular predator on the basis of 1954-1966 census data from Kruger National Park (KNP), South Africa, on kills and predators involved as;

Preference Rating = Kill Frequency/Relative Abundance

Emlen[45] formulated a model to determine factors influencing patterns of predation and concluded that (i) food preferences can be described adequately only if a number of factors other than relative frequencies in the diet and relative abundance of the food types are known; (ii) animals are more selective when they are satiated and less so when starved and (iii) certain prey types can be preferred simply on the basis of abundance compared to more nutritious and efficiently obtainable prey.

These two studies can reliably inform the reasoning behind patterns of predation especially in the context of livestock predation.

Roberts[46] reports an association between domestic prey and predators from a study in Western Natal, South Africa. On the basis of these associations, some degree of certainty can be obtained in establishing the predator responsible for the killing of a specific animal. It is essential for predator control to know the type of predator that killed at particular livestock. Predator control policies will revolve around knowledge of which predators cause the most damage to livestock.

1.1.2. Time of Day

Mills & Biggs[41] provide essential insights into the relationships between large predators and their hunting times, most needed for assessment of patterns of livestock predation. They show that in Kruger National Park, lion hunt during the night with peak times between 22:00 and 24:00hrs; cheetah in the afternoons with peak times between 14:00 and 16:00hrs; wild dog in the early mornings with peak times between 06:00 and 08:00hrs, or at sunset, according to Sheldon[40]. Despite their high hunting success rate, hunting may continue till dark if no prey has been caught[40]. According to Fuller & Kat[47], wild dog hunt before or within two hours after sunrise and within one hour after sunset; and spotted hyena at night. According to Kruuk[48], spotted hyena hunt especially during the first half of the night. Pooley[49]'s study of Nile crocodile ecology in KwaZulu shows that prey capture depends on availability of prey species irrespective of time of the day or night and that most activity is at night. With only the top of the head and nostrils protruding above the water surface, crocodiles can remain undetected by prey coming to drink. Their ability to remain under water for over one hour[49] allows them to only resurface when prey is nearby and occasionally to re-establish the position and location of prey.

Differences in hunting times can influence livestock predation patterns of those livestock types not kept in kraals overnight (for lion, wild dog and spotted hyena) and not herded during the day (for cheetah, leopard and jackal). Predation by

crocodile is less likely to depend on the above factors since crocodile have no known peak hunting-times of the day.

1.1.3. Vulnerability of Wild vs. Domestic Prey

Yalden's[50] study of carnivores emphasises a commonly stated view that livestock are much more vulnerable to predation by carnivores than wild herbivores because they are semi-captive and are bred for purposes other than fleetness and ability to escape. Responses of cattle to presence of predators is usually not as precise as that of wild herbivores. Muzitane[35] in a Kenyan study, noted that their vulnerability is increased when they flee from their enclosures at the sound of lion roars. Oli *et. al.*[51] observed that more livestock predation occurred at the grazing areas than in or near villages, i.e. vulnerability of livestock to predation increases with distance from human presence. Pfista *et. al.*[52] found, in a study based in America, that cattle and sheep avoided feeding areas contaminated with predator faecal odours, and that this reduced the time spent in a feeding area but would not deter livestock from entering a contaminated area. In the case of livestock predation by crocodile, Pooley's[49] observations of successful attacks on inyala (*Tragelaphus angasi*) and impala at Lake Inyamiti, Ndumu, show that antelope drinking at the edge of the water hole are vulnerable as (i) the approach to the shore-line may be muddy, and animals sink into the mud; (ii) the steep shore-line may be a disadvantage to animals trying to leap backwards from an attacking crocodile; (iii) the antelopes splay their front legs apart to reach the water, and so cannot speedily leap backwards in case a crocodile attacks; or (iv) antelopes drink at the same time and can fail to notice an oncoming crocodile.

1.1.4. Meat Intake Rates

A study by Viljoen[53] in Chobe National Park, (Botswana) on predation by lion revealed that lion biomass increased at the end of the dry season (October); home range sizes increased 1.7 times during the dry season; predation on resident warthog population intensified during the dry season; there were no significant differences in killing rate by lion between the wet and dry seasons; and daily meat intake of lion did not differ significantly between seasons. Van Orsdol[54] and Bothma & Le Riche[36] in studies of lion and leopard, respectively, report daily meat intakes of lion

as 5.0kg for adult females and leopard as 4.9kg for adult females (with cubs) and 3.5kg for adult males. Sheldon[40] reports that free-ranging wild dogs generally eat about 2.7 - 5.0 kg/dog/day, with maxima occurring during periods of raising cubs. Fuller *et. al.*[55] observed, contrary to Sheldon's[40] report, that wild dog in Masai Mara, Kenya consumed on average 4.7 kg prey/dog/day and that in Aitong area, Kenya[47] wild dog consumed 1.7 kg prey/dog/day. According to Fuller *et. al.*[55], differences in these rates may be due to pack size, presence of cubs and prey abundance. Henschel & Skinner[56] found spotted hyena in KNP, South Africa to consume about 3.8 kg of meat per day per adult animal, much in correspondence with the estimate made on the basis of their body weight and social behaviour. Significant reductions in both the frequency of feeding and the quantity per meal for Nile crocodile in South Africa have been observed during cold winter months by Pooley[57]. Hutton[58] similarly found that in Zimbabwe, the Nile crocodile's feeding rate was reduced during the cold season because temperatures were below those required for efficient digestion. The time taken to digest a meal amounting to 5% of the body weight increased by 325% during the cold season when temperatures were 15 ^{0}C and feeding frequency was $^{1}/_{8}$th of that of the summer season.

Livestock predation by crocodile is likely to vary between wet and dry seasons due to the temperature differences between these seasons. Mammalian predators are not likely to have seasonal variation in livestock predation attributable to consumption rate.

1.1.5. Predator Survival in Pastoral Farming Areas

Further work to explain the relationship between carnivores, prey (both wild and domesticated) and people by Hamilton[59] describes the status of cheetah in Kenya as satisfactory based on both empirical data and the extent of the country-wide nuisance the species poses for pastoral farming communities. The following have contributed to cheetah survival even within the above-mentioned conditions; (i) timidity, (ii) seldom re-visitation of a kill or scavenging, and (iii) less regular habits and predictability than leopard. The second trait is affirmed by the works of Bertram[60], Burney[61], Kruuk[62] and others studying cheetah-habitat-prey relationships. Clark & Lubbe[63] attribute cheetah population decline in Namibia to

both predator control and the species' lack of genetic variation. McNutt[64] attributes decline of wild dog in Botswana to the species' reproductive behaviour of having one cub-bearing female per pack. For purposes of physically excluding predators from livestock areas, Hoare[65] classified predators as type D (those that can climb up fences) and E (those that can dig underneath fences). Hoare[65] recommends the use of electric fences due to the advantage of "conditioned avoidance" by target species and notes aspects that reduce effectiveness of such fences, some of which are related to the morphology and behaviour of the species being excluded.

1.1.6. Factors Affecting Prey Availability

Migration of wild herbivores is described by Viljoen[53] as influencing predation levels of resident herbivores and home ranges of lion. Kgathi & Kalikawe[66] report migration of wildebeest and zebra from Boteti river to the salt pans during the wet season of December to April, and back to the river during the dry season of May to November in response to rainfall and subsequent food availability (see Figure 3). This compares with migrations of zebra and wildebeest into Chobe National Park, in terms of its impacts on predator-prey relationships studied by Viljoen[53]. Similar patterns are reported by Inglish[67] for wildebeest in the Serengeti. Harsted & Bunnel[68] report that home-ranges sizes increase with body-size for both herbivores and predators. McNab[69] explains this by relating home-range-sizes, energetics and foraging. Ritter[70] found springbok in Nxai Pan National Park, Botswana, to have no significant differences in their seasonal home-ranges. Springbok maintained their home-range size by reducing group sizes during the dry seasons. Smaller herbivores in Khumaga and Gweta are therefore likely to be more resident than larger herbivores and hence their influence on leopard, black-backed jackal, and cheetah. During dry seasons, small herbivore prey may become more susceptible to predation due to their smaller groups-sizes. This could in-turn reduce dependence of Canidae on domestic prey.

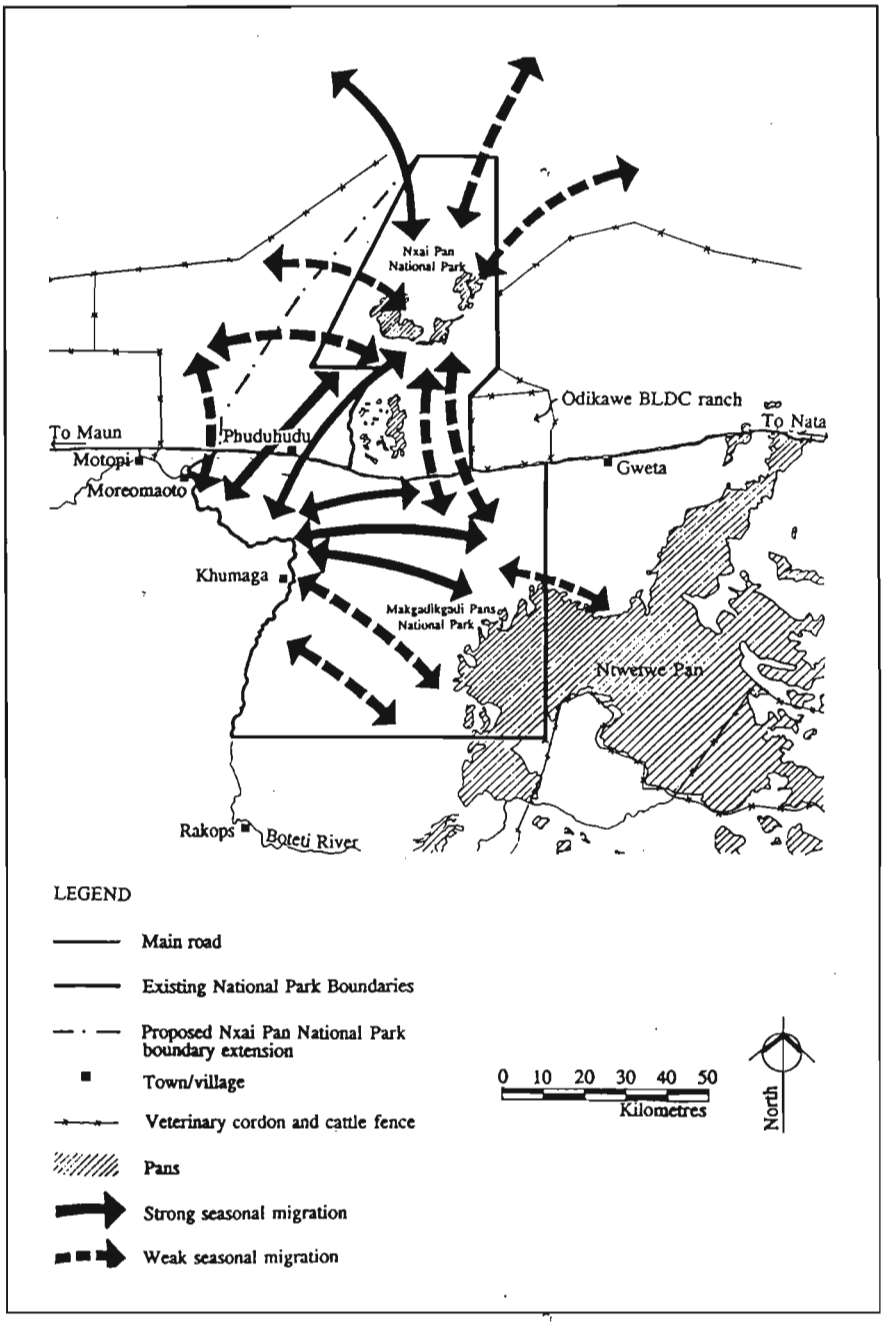


Figure 3: Migration routes of large herbivores in and around Makgadikgadi Pans National Park (adapted from IUCN[8]).

Kofron[71] noted that crocodiles in seasonally fluctuating water-level habitats in Gonarezhou National Park, Zimbabwe, travel long distances out of the water during the night to reach seasonal pools or prey on carcasses near rivers or pools. Hutton[72] also found that, with Nile crocodiles at Ngezi in Zimbabwe, home ranges of juveniles increased in the hot seasons and that of adults followed no specific trend. Large breeding females had small home ranges closest to their breeding grounds.

Age of an individual Nile crocodile and availability of water influence the amount of food available.

1.2. Economic Impacts of Livestock Predation

Though few studies on livestock predation in afro-tropical range-lands exist, the economic importance of livestock to pastoral communities is shown by Danckwerts[28] in the Nyanda province of Zimbabwe, Fielder[27] in the Ila community of Zambia, and Wood[73] and Behnke[29] in Botswana. These studies indicate the benefits of livestock to economies of these rural communities, and hence the potential economic significance of livestock predation. Few attempts have been made to quantify in monetary terms the loss of utility associated with loss of livestock to predators. A national study by Carl Bro International[74] in Botswana estimated a gross margin per year for different herd-size classes on the basis of live sales, services and goods (in kind) such as milk, draught power and meat (see Table 1). This study recognises the use of skins for harnesses and floor mats as equally beneficial to the farmer, although no monetary equivalents are attached to any of these. Average annual gross margin is reached by cattle-posts with over 60 herd of cattle. A similar pattern applies to average net cash, total output and total variable costs, implying a threshold herd-size of 60. For all herd-size groups, cattle sales exceed cattle purchases - though the ratio of sales to purchases decreases with increasing herd-size. Milk is the highest form of output in kind. The value of milk is the next highest form of output (in-kind) in all herd-size groups below 100, followed by meat and draught power (in decreasing order). As Danckwerts[28] has also shown in Nyanda Province of Zimbabwe, milk is one of the most important forms of output derived from cattle. This indicates that the value of live animals is high compared to compensations for livestock preyed on by wild predators. At herd-size classes of 40 and below, no labour costs are incurred. At these livestock endowment levels, family members share the different tasks of herding hence no paid labour is involved.

The study by Carl Bro International[74] further reports differential payment systems by herd-size whereby employed herders are only engaged when cattle herd-size exceeds 60 (that being one herder, two herders for herd-size above 100 and three herders for herd-sizes above 150) all charged at US$86.97 per herder paid in cash or in kind. The exchange rate of Botswana Pula to the United States Dollar used in the study was P1.15 = US$1.00.

Table 1: Gross margin per year for different herd-size classes at communal area cattle-posts (expressed in US$).

Item	Herd Size Group						
	1-20	21-40	41-60	61-100	101-150	>150	Average
Livestock Sales	101	193	400	704	1,317	3,649	530
Less Livestock Purchases	6	36	63	34	30	174	55
Net Cash Receipts	95	157	337	670	1,287	3,475	476
Valuation Difference	69	190	496	620	930	590	459
Output (ex in-kind)	163	348	833	1,290	2,217	4,065	935
Value Meat	48	93	137	190	253	336	190
Value Milk	87	157	191	217	252	313	191
Value Draught	21	24	35	35	45	63	35
Total Output	319	622	1,196	1,732	2,767	4,785	1,351
Variable Costs & Others							
Feed, Vaccines & Medicine	12	27	43	69	107	185	55
Water Fees	4	10	17	28	43	74	21
Labour	-	-	87	130	174	261	87
Total Variable Costs	17	37	148	227	323	520	163
Gross Margin	**303**	**584**	**1,048**	**1,505**	**2,443**	**4,265**	**1,189**

Source: Carl Bro International[74]

Polet[75] reports an average of 2.5 herd of cattle per household per year being lost to wild predators in the Chobe Enclave, Botswana. Parry & Campbell[10] report (at an exchange rate of P1.00 = US$ 0.50) average losses of livestock to predators of US$11.90 per household per annum in Mababe; US$550.00 in Chobe Enclave, and a positive correlation (r = 0.39) between losses and livestock endowment. Lawson's[76] survey in KwaZulu-Natal province, South Africa was restricted to small-stock owing to the scarcity of free-ranging large predators[22], and hence showed insignificant predation on cattle, donkeys and horses. Economic losses were estimated by numbers and value of sheep lost but there were no utility-associated losses, due to the commercial nature of the farming methods within the study area[76].

1.3. Biodiversity Losses Associated with Predator Conflict

Studies on the economics of biodiversity loss are those such as Pearce[77], Pearce & Morran[78], Barbier[79], Tisdell[80] and McNeely[81]. Combating predators in range-lands where both wildlife and livestock are free-ranging poses problems mostly of a "win or lose" type since, according to Pearce[77], economic growth (or even mere sustenance) assumes higher priority than conservation of wild resources especially in developing countries. Pearce & Morran[78] define biodiversity at three levels, namely; genetic diversity, species diversity and ecosystem diversity. Loss of genetic diversity occurs mostly when young sub-dominant males are killed during predator control in pastoral areas, nullifying their chances of contributing to the genetic pool. Loss of species diversity might occur when a particular species such as cheetah is killed during predator control in addition to other biological

factors such as lack of genetic variability (as in cheetah). Loss of ecosystem diversity may occur when key species supporting an ecosystem are eliminated through predator control or conversion of habitat into agricultural or industrial land.

Barbier[79] argues that in areas adjacent to national parks, problems of carnivores killing livestock and the latter grazing beyond the boundaries of national parks are similar. Hofer *et. al.*[82] also note that grazing of livestock within protected areas results in some of the livestock been killed by predators. Predators hunting beyond park boundaries also kill livestock in neighbouring kraals and pastures. Both cases represent losses to farmers in terms of the forgone utility of a live animal and the opportunity of monetary return from its sale. Hofer *et. al.*[82] found that in the Serengeti, interactions between people and wildlife at the periphery of the protected area could impact on the wildlife throughout the entire protected area. Child[83] describes the times when leopard pelts and leopard hunting in Zimbabwe could be sold legally, as times when conservation of the species was supported by many farmers who even chastised fellow farmers for keeping packs of dogs and traps for eradicating leopard.

Competition with wild herbivores for forage occurs within national parks where livestock grazes. Alteration of protected areas' biological functions may then occur, leading to local extinction of some species of plants and of animals. Such a loss may manifest itself in significant reductions in predator populations (independent of prey biomass within protected areas) where farmers trap, snare, poison-bait and kill predators to protect livestock - encouraging a build-up of prey biomass to the detriment of plant communities supporting such herbivores. Principe[84] argues that a vast majority of plant-based chemicals have not been successfully synthesised, hence the need for continued existence of parent material for production of medicines. Avi-fauna and invertebrates directly or indirectly depending on such plant communities may also be affected. Pearce & Morran[78] argue that this disturbance may result in local extinction of more species than are directly subjected to predator control.

1.4. The Economic Value of Biological Diversity

The main proximate cause of loss of biological diversity, according to Pearce & Morran[78] is the conversion of one land-use type to another. Wild lands are converted to arable fields,

pastoral lands, sporting areas, mining areas, and commercial industries, mostly letting the biological components of such areas adjust to the change, move out of the area or die. Hetch, *et. al.*[85] in Pearce & Moran[78] show Internal Rates of Return (IRRs) to a corporation's own (livestock-based) resources to be 16-29% depending on the escalating land values, but nearly all rates are negative without resources provided by government. Barnes & Pearce[86] indicate IRRs for a land user being more for wildlife than cattle without resources from government.

The theory and practice of economic evaluations has been developed and applied mainly to developed countries and yet much of the world's threatened biological diversity is found in developing countries[78]. Due to the absence of freely (or even moderately) functioning markets for inputs such as labour, capital and raw materials and outputs such as agricultural produce in developing countries, a number of economic evaluation methods will not be applicable. Attempts to value individual resources within wild-lands, though practised, cannot readily transform into evaluation of biological diversity of habitats. The latter requires some measure of (i) people's willingness-to-pay (WTP) for the range of species and habitats rather than just the specific biological resources they happen to support and (ii) the next best land-use option's economic benefits[79,84].

1.5. Policies Relating to Predator Control and Economic Incentives

Though livestock is important (especially cattle) to economies of rural southern Africa, there is scant literature on the economics of livestock losses to predators and associated policy discussion and analysis. Financial compensation for damage caused by wildlife to livestock, crops and property seems to be the logical solution to offsetting losses incurred by farming communities. This raises a key policy issue related to the ownership of carnivores (and other wildlife). The responsibility to compensate farmers for predator losses rests with the owner of predators - this being the government in the case of Botswana and land owners on private game ranches. Loss rates for livestock have to be established before a compensation scheme commences, since there are major financial implications to the compensating organisation[50]. Cozza *et. al.*[87] recommend, from their assessment of livestock predation in Italy, continuous assessment and re-appraisal of factors affecting livestock predation. Where compensation is seen as necessary, Cozza *et. al.*[87] recommend that policy should address research needs of both the biological and social

aspects of livestock predation, and strengthening of the compensation process. Botswana appears to be the only State in southern Africa in which farmers are compensated for damages caused by wildlife to livestock, crops and property in addition to active state involvement in control of problem animals. Governments of Zimbabwe, Zambia, Namibia, South Africa, Tanzania and Malawi have no compensation schemes for any wildlife-related damages (Maveneke, pers. comm. 1995[‡]; Phiri, pers. comm. 1995[§]; Kazwela, pers. comm. 1995[**]; Johnson, pers. comm. 1995[††]; Bell, pers. comm. 1996[‡‡]). This involvement puts a different view to the issue of livestock predation as compared to neighbouring countries. However, the degree of discontent amongst farmers such as those of Gweta and Khumaga may be an indication that perceived benefits are lower than the costs[96] of having a national park bordering a pastoral farming area. The costs of conserving biodiversity are borne locally while benefits accrue at national or global levels; this is a powerful disincentive to sustainable use/interaction[88,89]. Studies from other continents such as by Nepal & Weber[90] in Nepal on local people-park relationships indicate that monetary compensation has been an unsuccessful substitute for an integrated approach to the problem.

Veck[91], Tisdel[80] and others who have assessed the relationship between policy and natural resource management identify the following potential economic instruments to control the behaviour of users; (i) tradable emission permits, (ii) liability insurance, (iii) liability transfers, (iv) charges and taxes, (v) effluent or emission charges, (vi) user charges, (vii) product charges, (viii) taxes and tax differentials and (ix) subsidies. In cases where there is conflict between an existing land-use type and a proposed one, evaluation of the economic

---

[‡] Mr T. Maveneke, Director - CAMPFIRE Association, P. O. Box 661, Harare, Zimbabwe.

[§] Mr K. Phiri, Luangwa Integrated Resource Development Project, P. O. Box 510249, Chipata, Zambia.

[**] Mr P. Kazwela, Ministry of Environment and Tourism, P/Bag 1020, Katima Mulilo, Namibia.

[††] Mr S. Johnson, The Editor, Resources Africa, P. O. Box 30131, Lilongwe 3, Malawi. (then with Northwest Environmental Conservation, South Africa)

[‡‡] Dr R. H. V. Bell, Senior Wildlife Park Planner, Department of Wildlife and National Parks, P. O. Box 11, Maun, Botswana. (Previously with community-based wildlife conservation projects in Tanzania, Malawi and Zambia)

benefit of the two is pursued through either or all of the following evaluation methods; (i) changes in productivity, (ii) opportunity costs and (iii) travel-cost approach. Though all three methods are numerically based, where differences between two land-use types are marginal, unquantified benefits have to enter the evaluation equation[91].

Policies on agricultural production in southern Africa have tended to favour large-scale farmers through subsidies and, market and credit access priorities. Notable examples are Botswana's Tribal Grazing Land Policy (TGLP) and Malawi's commercial estates' subsidy, credit access and extension schemes which have undermined small-scale pastoral and arable farming respectively[6]. A similar conclusion about Botswana's TGLP is reached (independently) by McNeely[81] and Mazonde[92]. There is currently no policy for assisting small-scale farmers to overcome the high costs of predator control, especially now when most of the past indigenous predator control methods are prohibited by law. Though government expenditure on livestock is not easy to separate from the overall agriculture budget and agriculture-related expenditure by other departments, the Government of Botswana (GoB) is believed to spend (at an exchange rate of P1.00 = US$ 0.32) over P112.5 (US$36) million per annum on livestock production (see Appendix 2 and Appendix 3, p.121). An average of P800.00 (US$256) per household is believed to be spent per annum on each livestock-keeping family by the state[114]. Mazonde[116], however, argues that this figure (P800.00) is misleading since the greatest share of these benefits go to a small proportion of livestock owners, i.e. large-scale producers.

1.6. Community-Based Predator Control and Policy

Involvement of local communities in predator control has, as indicated in Spinage[7], always been subjected to government control in both the colonial and post-colonial eras through regulation. The abrogation of wildlife and wild-lands by the state, according to Barbier[93] and Adams & M^{c}Shane[94], meant that many communities no longer had access to resources that they traditionally exploited for generations. Programmes to engender collaboration of local communities in wildlife and wild-lands conservation have been established in most parts of the developing world, notable southern African examples being Botswana (Natural Resource Management Programme - NRMP), Zambia (Luangwa Integrated Resource Development Project - LIRDP, Zambia Wetlands Project - ZWP and Administrative Management Design for Game Management Programme - ADMADE), Zimbabwe

(CAMPFIRE) and Namibia (Living In a Finite Environment - LIFE)[21,93]. Zimbabwe's CAMPFIRE, for example, originated from a regional land use plan of Sebugwe Region of north-west Zimbabwe where communities neighbouring protected areas and living within wildlife habitats were suffering intense crop losses to wild animals. The programme has reached a stage where revenues accruing from wildlife and wild-lands utilisation are administered by local communities and paid out as compensation for crop and livestock damage, and trophies and meat accruing from PAC are controlled and used by such communities[93].

These programmes and others such as the Selous Conservation Programme (SCP) in Tanzania have had their failures mostly influenced by issues such as (i) excessive and/or inefficient administrative structures, (ii) lack of local institutional capacity building, (iii) a tendency for education not to address the community's real needs, and (iv) insufficient government commitment[6]. Bell[31] and Murphree[95] also note inaccuracy in channelling funds accruing from CBNRM programmes to affected sectors of society, especially the problem of targeting too large a unit such as a district or chieftainship, instead of a village or ward.

Discernible results whereby rural inhabitants have taken control of livestock predation and arranged (within their financial limitations) compensation schemes for damages caused by wildlife to livestock, property and crops are evident in parts of Zimbabwe[21]. Noting Murphree[96] and Child's[83] propositions that people seek to manage the environment when the benefits of doing so exceed its costs, it is evident that pastoralists would sustainably manage predators living in their grazing areas if there are benefits to doing so. Tisdell[80] notes scepticism by Homma[97] and Godoy & Bawa[98] in allowing control of natural resources to be devolved to communities living with them. Prins[99], Brown[100], Semple[101] and others condemn this approach, much to the worry of efforts being invested in NRMP, LIRDP and their sister projects in southern Africa. The general perception forming the basis of their objections is that conservation (in its original form) was once an alien concept in the West too, continues to be so in nations newly introduced to it and will be accepted with time. They believe that policy makers need to spend more time in designing programmes that seek to improve the plight of impoverished rural communities neighbouring protected areas instead of allowing for the quick but less sustainable option of opening-up protected areas for occupation and utilisation.

1.7. Institutional Arrangements for Managing Livestock Predation

Collapse of institutions that previously governed natural resource utilisation in most African communities is associated with the shocks of colonial domination[102]. This is noticeable in agricultural societies where institutions traditionally charged with the responsibility of allocating usufructual rights and with regulation of the level of activity have either disappeared or been severely weakened[6,79,103,104,105]. Wa-Githinji & Perrings[103] and Barbier[93] note further that replacement institutions have failed to exercise the authority vested in them in successfully conserving biological diversity. In the case of livestock predation in Botswana, authority has been shifted from local institutions from as early as 1891. This happened at the introduction of the Game Law Amendment Act of 1886 which declared the killing of wildlife in protection of crops and livestock illegal unless the accused could prove the contrary[7]. This trend has influenced the behaviour of resource users such that common property resources are subjected to open-access property regimes where property relationships do not exist and no resource-use regimes apply[79,104,105]. The highest diversity of wild plants and animals mostly occurs in areas outside the industrialisation and development network, i.e. in rural areas of most developing countries. These biological resources are often under threat because the responsibility for managing them has been removed from the people living close to them, and instead has been transferred to government agencies located in distant capitals[79,104]. Little[106] concluded, from a study of part-time pastoralism in Northern Kenya, that mismanagement of pastoral resources in communal areas is attributable to business people, civil servants and townsmen who do not reside in the area. Little[106] notes similar observations made by Behnke[107] in Botswana's communal grazing areas.

Ways of inducing stewardship and biological resources management by local people may include assigning at least some management responsibility to locally-based institutions, strengthening community-based resource management systems, putting in place taxes and pricing policies that encourage sustainable use of natural resources and introducing a variety of property rights and land tenure arrangements. Compensating villagers for damages suffered from the depredation by wild animals on crops and livestock is one of several incentives to conserve biological diversity. Hoare & Mackie[108] and Nepal & Weber[90], however, independently concluded that compensation and park revenue sharing

are indications of notable failures of alternatives aimed at redressing effects of problem animals. The extent of discontent amongst farmers in Khumaga and Gweta possibly shows the basis of the conclusions of Hoare & Mackie[108] and Nepal & Weber[90].

The following subsections describe incentives and their role in sustainable utilisation of natural resources as adapted from McNeely[81].

1.7.1. The Use of Incentives at Community Level

Incentives at the local level improve the *status quo* by rewarding local people who bear the costs through which the larger public benefits. Such incentives can take the form of avenues for local communities mostly affected by conservation of biological diversity to participate in decision-making. Parry & Campbell[10], Polet[75], Fiallo & Jacobson[109], Infield[110] and others have established the relationship between benefits derived from protected areas and attitudes of communities living within or adjacent to such areas. Aboud[111] notes, for Narok ranches in Kenya, that ranchers' direct involvement in planning and implementation of predator control systems is a key ingredient to successful management of predators. At the level of herders, incentives for employed herders to efficiently guard livestock under their charge against predators may be lacking owing to the lack of association between the number of cattle under the herder's charge and payments (wages or in-kind).

1.7.2. Function and Form of Different Incentives

Direct incentives are applied to resource-use systems to achieve greater benefit and equity. This can be in the form of subsidies to sustainable wildlife utilisation initiatives and compensation to farmers for livestock losses caused by wild predators with differential compensation rates dependent on degree of protection awarded to livestock by individual farmers. Disincentives aimed at discouraging unsustainable resource-use systems can take the form of penalties (through legislation), or taxation for less desirable utilisation systems. Social incentives are designed to improve quality of life within a community, and ensuring that benefits of conservation are equitably distributed, especially strengthening of resource management institutions, tenure and proprietorship.

1.7.3. Costs and Benefits of Incentive Systems

All incentives, especially in the formal sector require, though to different degrees, regulation, enforcement, monitoring and feedback in order to function effectively and continuously meet their set objectives. Timely response to changing economic environments such as world commodity price fluctuation and local demands, and changes in behaviour of resources users, is also needed. Bell (pers. comm. 1996[‡‡]) argues that the aspect of regulation has prohibitive costs for most governments of developing countries and should be avoided by ensuring that costs-bearers are also the primary beneficiaries. If they are not, beneficiaries will need to pay something to cost-carriers - a process that requires regulation.

1.7.4. Guidelines for Using Incentive Systems

A constraint facing any incentive system in natural resource management (where beneficiaries and cost-carriers are separated) are (i) the length of time between investment and return on benefits, (ii) short-term hardships caused to subsistence resource users who lack alternative livelihoods, (iii) lack of financial resources, (iv) lack of information on the value of the resources being managed and (v) weakness of government institutions at local level leading to ineffective management. McNeely[81] recommends five guidelines for using incentives in natural resource management, namely; (i) rapid initial assessment of available biological resources; (ii) estimation of the contribution of biological resources to the local economy; (iii)

establishment of national policies for managing biological resources; (iv) removal or reduction of perverse incentives and (v) establishment of structures of responsibility for the management of biological resources in the region.

In conclusion, more literature is available on factors influencing patterns of wild herbivore predation by wild carnivores following extensive ecological studies in protected areas around the world than on interactions between livestock and predators. A similar pattern emerges from a review of literature associated with range ecology, i.e. a bias towards the factors influencing economic returns from livestock independent of livestock predation. Studies on natural resource management are also biased towards utilisation of wildlife and wild-lands independent of the role of livestock in rural pastoral communities. This literature, however limited, helps build a picture of the possible factors that influence livestock predation by wild carnivores, variations in livestock predation levels between farmers of various categories of livestock endowment, trends in natural resource management - especially with particular reference to problem animals, the role of policy on the future of natural resource management and utilisation, and elements of pastoral farming economy.

CHAPTER 2 : RESEARCH METHODS

This chapter describes the two villages (Khumaga and Gweta) in which the surveys were conducted, the sampling and data collection methods and the statistical methods employed in the study.

2.1. Description of the Study Area

2.1.1. Khumaga

A village of approximately 450 inhabitants[112], Khumaga lies on the western border of MPNP within Boteti sub-district in north-central Botswana. The village of Khumaga forms the central settlement with cattle-post areas within a radius of twenty five kilometres at most. These are Beechana, Bosobea, Dikwalo, Gwaraga, Khweligcum, Mangana, Marotobolo, Menoakwena, Ncamisane, Ncwee, Senagomo, Sesanasamotswere and Tsoi. Most of the cattle-post areas are situated along the river, except for Khweligcum and Mangana. These two are not entirely dependent on the status of the Boteti river and are supplied with underground water from boreholes pumped from the source by diesel engines. Their ownership may therefore be restricted only to affluent individuals or syndicates.

The Boteti river forms the physical boundary between Khumaga village and MPNP, and is a key source of water for people, wildlife and livestock. The river originates from the Boro river - an outflow of the Okavango delta - and is part of the central Botswana drainage system that feeds into the Makgadikgadi salt pans. Other rivers feeding into Makgadikgadi salt pans are Mosetse and Nata rivers from the north (not indicated on the map). River-bed cultivation and pastoral farming are the main sources of agriculture-based income in Khumaga and other villages upstream of the Boteti and Boro rivers[113]. Low flood levels and drying up of the river (during the dry seasons of October to March) have posed great challenges to agricultural systems in the area. Boteti river last contributed water to Makgadikgadi pans in 1970 and flowed as far as Tsienyane (indicated on Figure 2, p.9 as Rakops) once since 1985[8]. The river dried up for the first time in 1992 and has since then been flowing only for a few days during the rainy seasons. Deeper pools within the river-

bed support both hippopotamus (*Hippopotamus amphibius*) and Nile crocodile while the shallow pools support only the latter.

Compensation for damage caused by wildlife depends on sufficient proof that livestock was preyed on or injured by wild predators[14]. Losses due to crocodile are rarely compensated because these predators take their prey into holes dug in the calcrete sides of the pools (Ntau, pers. comm., 1996[§§]) - reducing the ease of carcass retrieval. In the case of damage due to terrestrial predators, farmers do retrieve some of the remains of livestock (meat and skins) for home utilisation. Some of the meat is eaten by other predators that did not do the killing (scavengers) and ones not included in this study. These include, but are not restricted to, brown hyena (*Hyaenae brunnea*), caracal (*Felis caracal*) and silver jackal (*Vulpes chama*). Vultures (*Gyps africanus*, *Necrosyrtes monachus* and *Torgos tracheliotus*) also feed on remains of livestock predation. Vultures benefit farmers in situations where livestock is attacked and preyed on far from homesteads and without the farmers knowledge. The sight of vultures hovering in the sky possibly indicates a dead animal in the vicinity, allowing farmers to retrieve the carcasses much needed for compensation procedures (Moleta, pers. comm. 1995[***]).

Pastoral farming is practised by most families and involves a wide range of livestock such as cattle, goats, sheep, donkeys, horses and poultry. The Khumaga Consumers' Co-operative is a marketing agency for Khumaga and surrounding cattle-posts for livestock sold to the Botswana Meat Commission (BMC) in Maun or Francistown. Only cattle are marketed to BMC and farmers in Khumaga allege that returns from marketing small stock are not as lucrative. This could be due to the relatively lower prices of mutton in both local and regional markets compared to the beef prices supported with import subsidies into European Commission (EU) markets, through the LomΠ Convention IV of 1990[114]. With the outbreak of Contagious Bovine Pleuro Pneumonia (CBPP) in Okavango and Ngamiland areas of northern Botswana and subsequent closure of the Maun BMC branch, farmers

---

[§§] Mr P. Ntau, Game Scout at Khumaga DWNP Camp, Botswana.

[***] Mr Goloswamang Moleta. Herder at Khumaga village. Botswana

may now have to send (through Consumers' Co-operatives) their cattle to the Francistown BMC branch - at higher transport costs, owing to the longer distances (see Figure 1, page 8).

All livestock types, except poultry, stray across national park boundaries in search of better grazing. For most of each day, these animals are unattended and are only brought back to the kraals during the late afternoons. Since 1992 when the river flow became unreliable, villagers have requested that the national park boundary be changed from being the centre of the Boteti river to a line 10 kilometres away from the river on the national park side. No compensation is awarded for livestock preyed on by predators inside the national park. This makes the position of the park boundary an even more contentious issue as farmers allege that livestock predation within the national park occurs mostly within this 10km strip.

Wildlife utilisation through hunting is a minor economic activity available only during the hunting season of April to September. DWNP issues a hunting quota divided into citizen, resident and non-resident categories. The non-resident category goes to the concessionaire of the respective hunting concession while the two other categories are divided through a raffle system to all eligible applicants. Wildlife resources in any one area can be utilised by any person who wins (through the raffle system) a license for a particular species in that area. This system reflects national policy and does not afford residents of Khumaga a competitive advantage of being within close proximity to wildlife resources. With increasing interactions between livestock and wildlife, and the disappearing physical boundary (the Boteti river) between the two, livestock predation is likely to increase, as will the costs borne by both the inhabitants of Khumaga[8] and the state.

2.1.2. Gweta

This village of approximately 500 inhabitants[112] borders Makgadikgadi to the east and lies on the far northern fringes of the Makgadikgadi salt pans (see Figure 2, page 9). Until the 1930s, the area was inhabited by the BaSarwa, BaKalanga, BaNgwato, BaKhurutshe, BaRotse, BaKwe and BaNadzbwe. Intermarriages between the different ethnic groups are believed to have been encouraged since settlement of the

area by non-BaSarwa peoples began in the mid 1930s. The dominant language group now residing in the area is the BaKalanga[8]. The 1991 population census reports that Gweta, Zoroga and Tshauxaba villages, together with their associated localities had a population of 6572 persons, 55% of whom were females and 40% under the age of 15. Female-headed households account for 69% of all households within the main village of Gweta[8]. As is the case in most rural villages in Botswana, Gweta and Khumaga experience an under-supply of labour as young men and women emigrate to centres of higher economic activity and children leave cattle-posts to attend school in village centres[115]. Paid labour is affordable to farmers with large herds. Livestock predation does not seem to jeopardise the amount of wages payable to the herder since these employed herders are paid mostly in kind with maize-meal, milk and tobacco - quantities determined more by sustenance requirements than the number of livestock herded[116].

A much wider range of income-generation activities occurs here than in Khumaga. These include two tourism ventures, a recently established morula (*Sclerocarya birrea*) harvesting/marketing operation and bottling of local spring water, to take advantage of the growing demand for bottled natural water[117]. Gweta village has, in conjunction with two neighbouring villages (Zoroga and Tshauxaba), formed a committee called Gwezotsha Natural Resources Trust (GNRT) to oversee issues of wildlife utilisation and tourism. Cultivation is rain-fed and therefore depends entirely on the sporadic rainfall patterns of this area[118,119,120]. Grazing areas are mainly to the west and south of the village. Those families that own livestock usually have basic housing for themselves and their labourers at cattleposts[8]. Livestock does stray into MPNP in search of water and better grazing. All boundaries of the MPNP are unfenced. The eastern boundary is, even today, a highly contentious issue. Villagers allege that it was moved further towards the village from Wateka's palm trees following uninformed decisions as to the true location of the physical landmarks that were stipulated in the Fauna Conservation Act. They have appealed before the cabinet. Cattle-posts to the south of Gweta extend into a Wildlife Management Area (WMA) called CT11. This is an error by the Boteti sub-Land Board since such a Board has no jurisdiction in state land. These cattle-posts are now established with boreholes that provide year-round

supply of water for livestock. Gweta and surrounding cattle-posts sell their livestock to BMC in Maun or Francistown through Gweta Consumers' Co-operative. A similar situation of livestock-based economics and access to international markets exists in both villages. Gweta is also affected, like Khumaga, by impacts of the CBPP outbreak in Ngamiland and Okavango. Arable farming is similarly important except for the absence of river-bed cultivation. Gweta village is an ideal case for assessing aspects of livestock predation in an environment where change can almost entirely be attributed to human expansion (a scenario faced by most protected areas of developing countries). It is the only village bordering MPNP on the east.

2.2. Sampling Procedure

2.2.1. Stratification of Samples

Khumaga refers to both the village centre, an area covering up to 10 km^2 and surrounding cattle-post-areas totalling an area of 40 km^2. Each of the nine cattle-post-areas (Dikwalo, Gwaraga, Khumaga, Khweligcum, Marotobolo, Menoakwena, Ncamisane, Ncwee and Tsoi) formed a stratum. Such sampling was conducted on a list of names of farmers obtained from a national socio-economic survey carried out at the beginning of September, 1996 and the assistance of the local Chief.

Gweta refers to both the village centre, an area covering up to 15 km^2, and cattle-post-areas to the south of the village covering an area of 90 km^2 and bordering MPNP. Each of the five cattle-post-areas (Chaneo, Ngaiso, Polanka, Kgaolasetlhako and Gcingcara) formed a stratum within which random sampling was applied.

2.2.2. Random Sampling

In Khumaga, for cattle-post-areas with less than six cattle-posts, all owners of cattle-posts were interviewed. For cattle-post-areas with six or more cattle-posts, a random sample of five cattle-posts was extracted from the lists of cattle-post owners using the Microsoft Excel, version 5 computer spreadsheet programme.

In Gweta, sub-areas selected for the survey were Chaneo, Ngaiso, Polanka, Kgaolasetlhako and Gcingcara because of their proximity to the eastern boundary of MPNP. A random sample was taken only where numbers of cattle-posts exceeded five. A random sample of cattle-posts was extracted from the lists of cattle-post owners again using Microsoft Excel, version 5.

2.3. Data Collection

2.3.1. Primary Data

2.3.1.1. Questionnaires

A questionnaire adapted from Molamu, *et al.*[121], was used to collect socio-economic data from the heads of randomly selected households/cattle-posts (see Appendix 5, p.123). The questionnaire from Molamu, *et. al.*[121] was designed primarily for eliciting parameters of gender, ethnicity and class as they operate in natural resources management in the Zutshwa area of Kalahari District in Botswana. The adapted questionnaire, written in English, was used in this study to gather information relating to numbers of livestock (by type) owned by each of the selected families, numbers of livestock (by type) lost to predators by each of the selected families, the frequency of sale and centres where livestock is sold. All questions were asked in SeTswana and interviewees also responded in SeTswana, and at times in IKalanga through a family member who understood both languages. Each interviewee was asked to choose between no recording of any information, paper recording (note taking) and audio recording. With careful explanation of the implications of each method, all interviewees chose to be recorded, some with a proviso that they be allowed to listen to part of the tapes. This had the advantage of maintaining a constant flow of thought and less of a feeling of being interrogated (from the interviewee's viewpoint). Limitations associated with structured questionnaires have been noted by Infield[122], Babbie[123] and others. Such interviews give only the information that interviewees think the researcher wants and not necessarily the truth. Structured questionnaires also assume that the researcher understands all the factors influencing the situation or phenomenon being studied, hence not allowing the interviewer to explore unexpected factors, resulting in key

aspects being missed. Questionnaires were therefore completed by the researcher at the end of the day following unstructured informal discussions which were audio-recorded. This approach, though less appropriate for surveys that deal with opinions of the interviewees, was considered appropriate for this work since numerical information was required from interviewees, such as numbers of cattle sold, goats killed, etc. since the beginning of the year.

The questionnaire had scope for including all livestock owners, even those that owned no cattle. This was considered appropriate since cattle are the most important form of livestock in the two study areas and focusing only on them could ignore predation trends specific to other types of livestock such as goats, sheep, donkeys and horses. Although it is more convenient to express numbers of livestock in livestock units (Schneider[24], Sandford[25], Bembridge[26], Fielder[27], Danckwerts[28] and Behnke[29]), in order to show the effects of skewed ownership and phenomena specific to each livestock type, this study also assesses each livestock type separately. Small stock ownership is less skewed and therefore less likely to show the skewed impact of livestock predation than cattle. The latter are used more in the *mafisa* system than small stock; a system common to Botswana and the Bulozi area in Zambia[73].

Only information for predation incidences and livestock sales that occurred during 1996 was recorded during interviews with farmers. This was considered the best available information since education levels in Khumaga and Gweta (typical of most rural areas in Botswana) are low with most elderly people having had no formal education[8]. Such respondents did not know the exact year during which predation incidences and livestock sales occurred in past years with sufficient accuracy. Livestock sales included those of 1995 in situations where the interviewee had not sold any livestock in 1996 due to the closure of Maun abattoir pending eradication of CBPP in Okavango and Ngamiland areas. Bell (pers. comm. 1996[‡‡]) reports extremely high accuracy in reporting incidences relating to livestock by

livestock owners in Sudan, even those with no formal education but high levels of attention on their herds (including night herding). Livestock herding, highly contrasting with Botswana's herding patterns, may be a cause to lack of accuracy in farmers of Khumaga and Gweta relating to incidents of livestock predation.

2.3.1.2. Informal Discussions

Indigenous methods of predator control (including those not currently permitted by law) were assessed through in-depth discussions with local inhabitants of Gweta and Khumaga. For each data set collected, immediate feed-back was provided to focus groups and to the wider community of the study areas to confirm the validity of the information which could in the future influence predator control policy in their areas. The former was done through a series of focus group discussions and the latter through *Kgotla* meetings.

2.3.1.3. Participant Observation

To triangulate the information obtained from informal discussions and questionnaires, observations were made on predation incidents occurring during the time of the research, design of kraals, location of kraals relative to national park boundaries, and the utility derived from different livestock types. The researcher interacted with, interviewed farmers at cattle-posts, and observed activities such as construction of kraals, milking of goats and cattle and the use of horses, donkeys and cattle for draught power[123]. This enhanced the level of understanding, in particular, of the utilitarian role of livestock in rural communities.

2.3.2. Secondary Data

Records of numbers of livestock killed (by type) and predators implicated (by type) for the period of August 1994 to August 1996 were obtained from the DWNP offices at Khumaga and Francistown for livestock predation incidences occurring at Khumaga and Gweta, respectively. For purposes of this study, the term "predators" refers only to lion, leopard, cheetah, wild dog, black-backed jackal, spotted hyena

and Nile crocodile. The term "livestock" refers only to cattle, sheep, goats, donkeys and horses. The importance of poultry in the power relations of gender where women have control only over poultry and men over a wider variety of livestock types must be noted. However, due to time constraints, the scope of the research was limited only to livestock mentioned above.

2.4. Statistical Methods

Intensity of livestock predation and seasonal variations were analysed on the basis of data on numbers and types of livestock preyed on during specific months of the year. Methods for establishing statistical significance of differences between two samples were investigated, namely; (i) F-test (comparing variances), (ii) T-test (comparing means) and Mann-Whitney (comparing medians). Count data was expected hence the choice of the Mann-Whitney test (Minitab for Windows - Release 10.51 Xtra) which is a two-sample non-parametric test used to compare two independent populations (sets of data) for differences in medians. This test method is essential when the two populations have highly skewed distribution curves and sample sizes are small - as was the case with predation figures in this study. Higher power, i.e. less chance of rejecting a true hypothesis is obtained when employing the Mann-Whitney test than parametric tests such as the F-test (comparing variances) and T-test (comparing means)[124]. The test statistic, "W" is a sum of the ranks of the second population as compared with a critical value established on the basis of the significance level, "p". In this case, p was 0.05[125]. Although Wilcox[124] notes problems arising from ties during the ranking process, Minitab for Windows could produce values of the test statistic corrected for ties. This test procedure assumes that even when the two populations differ, they still have the same shapes. This assumption was considered relevant in this study because all comparisons were for "within livestock types" and "between seasons" since the behavioural pattern of predator-livestock is expected to remain unchanged between seasons - hence similar distribution shapes of predation figures.

Regression analyses were conducted on data obtained from questionnaires, namely; livestock endowment, predation levels and sales. A $p = 0.05$ significance level was maintained. Plots of (i) number of livestock owned against predation levels of each livestock type, and (ii) number of livestock owned against sales for each livestock types were generated through Microsoft Excel, version 5. The slope of the curve is expressed as

β. A α value is computed and compared with a set *p* value of 0.05. The statistical significance of the regression is confirmed when α is less than *p* and the strength of the regression is determined by the value of β.

In order to estimate the impact of livestock predation on livestock sales and on livestock endowment, a predation-free scenario is modelled based on the following assumptions: (i) livestock endowment would be greater without livestock predation; (ii) more stock would be added to the veldt as and when it becomes available; (iii) numbers of livestock available for sale would be greater without predation; (iv) other causes of livestock loss such as disease and theft will still be present irrespective of predation; (v) the efficiency of livestock marketing does not change with livestock predation and that (vi) livestock mortalities caused by insufficient food resources (during periods of overstocking) balance out with reductions in livestock predation intensity. The proportion of livestock (by type) lost through predation inflicts an equal reduction on livestock endowment and subsequent sales as shown by the hypothetical figures in Table 2 below:

Table 2: Hypothetical figures illustrating the simulation of predation-free sales and livestock endowment.

	Cattle	Goats	Donkeys
Endowment (with predation)	60	31	8
Sales (with predatiion)	6	2	0
Predation	10	12	6
Endowment (without predation)	70	43	14
Sales (without predatiion)	7	3	0

Following from Table 2, predation-free cattle endowment (70) is the sum of cattle in the predation-driven scenario (60) and cattle preyed on (10). The ratio of cattle sales to cattle endowment ($^1/_{10}$) in a predation-driven scenario is applied to the predation-free cattle endowment (70) to yield predation-free cattle sales (70 x $^1/_{10}$). A similar approach is applied to other livestock types.

CHAPTER 3 : RESULTS AND DISCUSSION

Analysis of the three data sets - livestock predation, losses in rural economy and government costs on predator control - is presented in this chapter for both Khumaga and Gweta. Significance of differences between predation levels of each season are analysed using the Mann-Whitney test at $p = 0.05$. The significance of the dependence of (i) livestock predation levels on livestock endowment and (ii) livestock sales on livestock endowment are measured by regression analysis. Note that the official livestock predation diary only contains predation incidences that were reported to the office. The figures presented may be under-estimated for the following reasons:

- the government compensation programme only started in 1994, so it is possible that some farmers may not have known of the system during its early stages of implementation, resulting in figures recorded at DWNP offices being lower than numbers actually killed.
- some farmers may have been reluctant to report livestock losses to DWNP offices, especially since there has been up to two years delay in compensating some farmers in both Khumaga and Gweta.

3.1. Khumaga Survey

3.1.1. Intensity of Livestock Predation

Aggregate figures of predation levels divided according to livestock types and season are shown in Figure 4, giving an overview of intensities of livestock predation in Khumaga from August 1994 to August 1996.

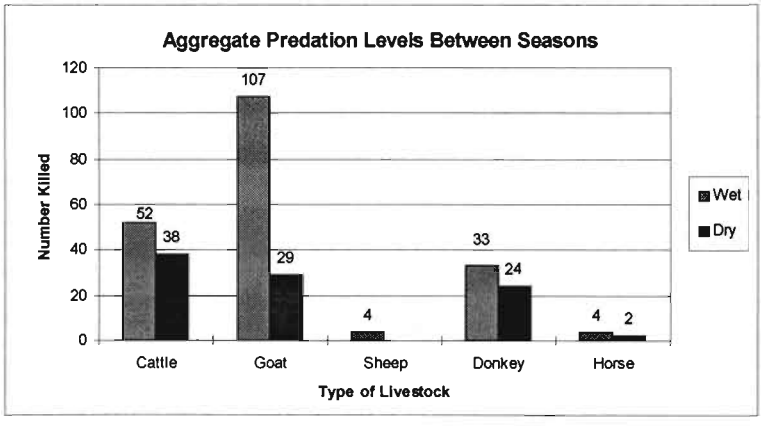


Figure 4: Aggregate wet and dry season predation levels in Khumaga, 1994-96.

Highest predation levels are those of goats during the wet seasons, while in the dry seasons, cattle are preyed on more than other livestock types. Sheep are preyed on only during the wet seasons. For all livestock types, wet season predation levels are relatively higher.

Numbers of livestock (by type) preyed on and species of predator involved are shown below for the wet seasons of August 1994 to August 1996 (see Figure 5) and for the dry season of the same period (see Figure 6). This is based on the PAC unit's database from DWNP's Khumaga office (see Appendix 7, p.126).

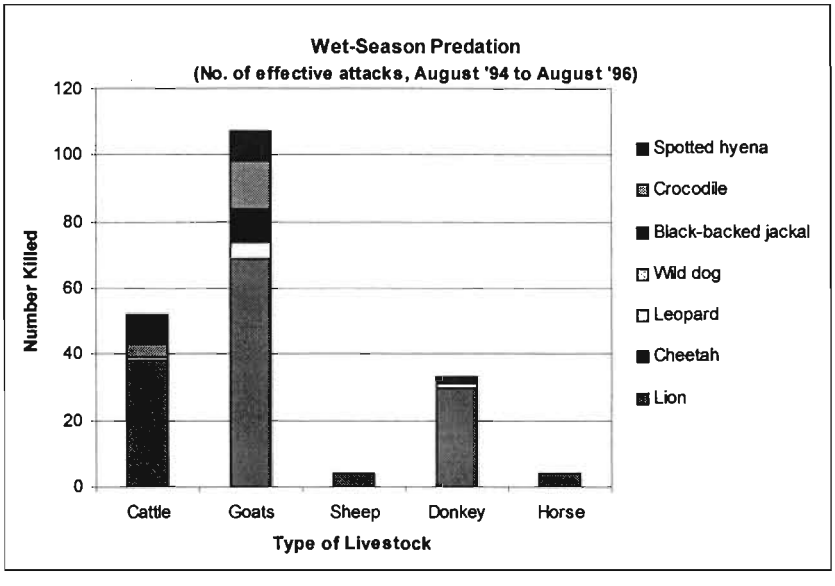


Figure 5: Livestock predation levels at Khumaga during the wet seasons of 1994-96.

During the wet seasons, cattle were preyed on by lion, spotted hyena, crocodile, and leopard (in decreasing order of predation levels). Goats were preyed on mainly by lion, then crocodile, black-backed jackal, spotted hyena and leopard. No livestock were preyed on by cheetah or wild dog at Khumaga during the wet seasons under study. Sheep were preyed on only by lion, donkeys by lion, spotted hyena and leopard while horses were only preyed on by lion. Goats were preyed on by a wider variety of predators (5 species) than any other livestock type, followed by cattle (4 species), donkeys (3 species) and horses and sheep (1 species). The most effective predator (in terms of number of livestock preyed on) is lion on all types of livestock. Lion preyed more on goats than on cattle, donkeys, horses or sheep.

Degrees of livestock predation (by livestock type) for the dry seasons of August, 1994 to August, 1996 are shown in Figure 6 below. The same scale as that of Figure 5 has been used to show the differences in intensities of livestock predation between the wet and dry seasons.

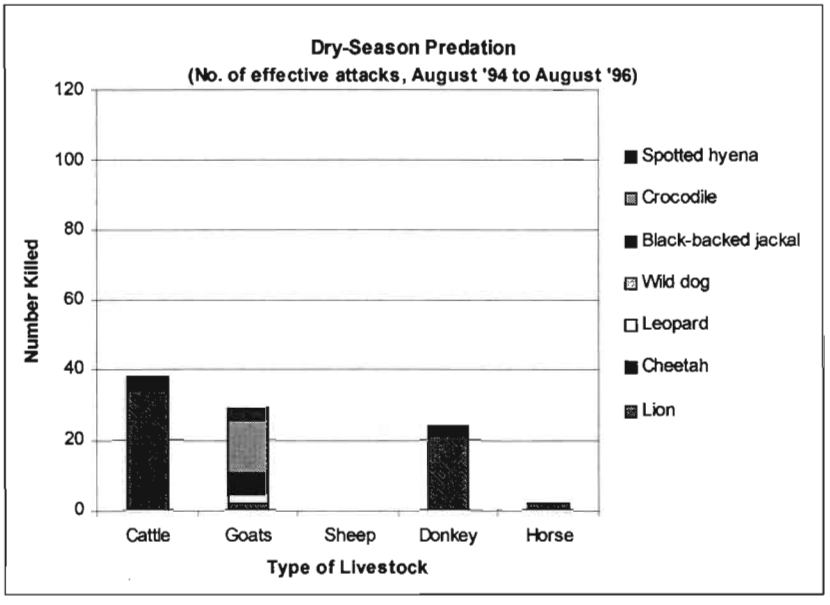


Figure 6: Livestock predation levels at Khumaga during the dry seasons of 1994-96.

Cattle and donkeys were preyed on only by lion and spotted hyena, with more lion-related incidents. This, in comparison to the wet season, shows two less predator species for cattle. Using studies of livestock predation by Mizutani[35] (in Kenya) and those of predator prey preferences by Bothma & Le Riche[36], Cooper[42], Kruuk & Turner[38] and Le Roux & Skinner[37], most predators prey on small stock and smaller antelopes (less than 70kg or less than the size of and adult impala). It therefore becomes evident that cattle predation would involve more predator species during times when calf population is highest, i.e. during the wet season.

Goats were preyed on by, as in the wet seasons, five different species of predators (lion, leopard, black-backed jackal, crocodile and spotted hyena). Studies of livestock predation by Mizutani[35] (in Kenya) and those of predator prey preferences by Bothma & Le Riche[36], Cooper[42], Kruuk & Turner[38] and Le Roux & Skinner[37], indicate small stock fitting within prey-size of all the predators considered in this study. Breeding seasons of goats are less likely to cause increases in diversity of predator species preying on goats.

No sheep were preyed on during the dry seasons of the observation period. Sheep constitute a small percentage of livestock population in Khumaga. Using Pienaar's[44] predator prey-preference rating (refer to page 13) and Mizutani's[35] findings in Kenya, it is evident that even though sheep fall within the same prey-size range as goats (hence preyed on by all predators) their being few makes them less significant as prey. Relative proportions of each livestock type for Khumaga are listed on page 43 as 51% (cattle), 43% (goats), 5% (donkeys), 0.8% (horses) and 0.2% (sheep).

The sole predator for horses during this period was lion. No livestock were preyed on by cheetah or wild dog during both the dry and wet seasons of the observation period. Relative numbers of horses, according to Pienaar's[44] preference rating technique makes them less significant as prey, hence the low numbers of horse predation incidences. The body size of horses would reduce the diversity of prey species that can prey on horses since they are large than 70kg, adult springbok or small stock (for leopard[37, 38, 36, 35]), larger than an Thomson's gazelle, outside the 30-150kg prey-size range or larger than gemsbok calves (for black-backed jackal[40, 38, 42, 43]) and larger than sheep and medium-sized ungulates (for wild dog[35, 38]). Livestock predation by cheetah or wild dog was not experienced during the dry seasons, despite the high relative abundance of domestic prey (see page 43) falling within their prey-size range. This is explained by Pienaar's[44] preference rating technique as relating to the likely low numbers of cheetah and wild dog in comparison to other predators in Khumaga.

3.1.2. Predator-Prey Relationships

Preferences for livestock-based prey by predators (expressed as a percentage of predators' livestock-based diet) are shown in Figure 7 to Figure 10. Relative proportions of each livestock type in Khumaga's livestock population are 51% (cattle), 43% (goats), 5% (donkeys), 0.8% (horses) and 0.2% (sheep). Cattle, being more abundant than other livestock types, would (according to Pienaar's[44] preference rating technique - page 13) be preyed on more if its predator preference rating is equal to that of other livestock types.

3.1.2.1. Predation by Lion

During the wet seasons (see Figure 7), lion preyed on all types of livestock, with more preference for goats (47%), cattle (26%) and donkeys (21%). Horses and sheep were preyed on in equal proportion, with each livestock type constituting just 3% of lion's livestock-based diet.

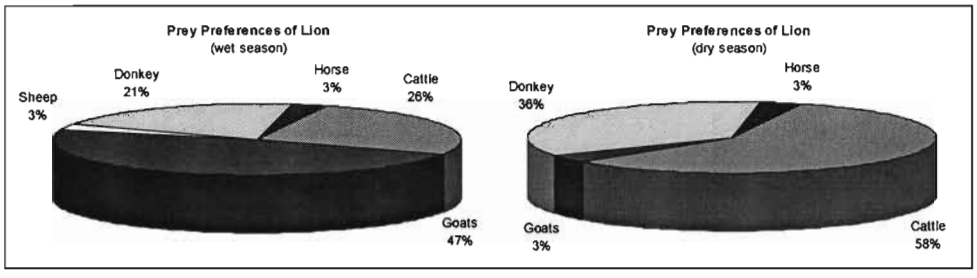


Figure 7: Proportionate prey preferences of lion at Khumaga; 1994-96.

During the dry seasons, lion's livestock-based prey comprised of cattle (58%), donkeys (36%), goats (3%) and horses (3%). Goats and horses again constituted only 3% of lions' livestock prey. Sheep were not preyed on.

Livestock-based prey of lion shows a lower proportion of cattle during the wet seasons (26%) than during the dry seasons (58%); a lower proportion of donkeys during the wet seasons (21% versus 36%); a constant proportion of horses (3%) during both seasons; while sheep only featured in the wet seasons at 3%. Goats, unlike other livestock types, formed a higher proportion during the wet seasons (47%) than during the dry seasons (3%). There was a significantly higher degree of goat predation by lion in wet compared to dry seasons (Wet season median predation 0.5 goat; mean 6.9 goats; dry season median 0.0 goat; mean 0.15 goat; Mann-Whitney statistic, W = 127.0 ; degrees of freedom, df = 10 and 13; p = 0.05). There was no significant difference in cattle predation by lion in wet and dry seasons (Wet season median predation 3.5 cattle; mean 3.8 cattle; dry season median 2.0 cattle; mean 2.6 cattle; W = 135.5; df = 10 and 13; p = 0.05). Similar test results apply with horse predation (Wet season median predation 0.0 horse, mean 0.4 horse; dry season median 0.0 horse, mean 0.2 horse, W = 140.0; df

= 10 and 13; $p = 0.05$). Donkey predation was only marginally significantly higher in wet than dry seasons (Wet season median predation 2.0 donkeys, mean 3.0 donkeys; dry season median 1.0 donkey, mean 1.6 donkeys, W = 134.5; *df* = 10 and 13; $p = 0.1$). Sheep predation could not be evaluated by Mann-Whitney test because no predation was recorded for the dry seasons.

A constant population of livestock (cattle, goats, sheep, donkeys and horses) will contribute more prey during the wet season when the majority of wild prey has migrated elsewhere. This follows from the findings of Viljoen[53] that lion in Chobe National Park preyed more on resident warthog (during the dry seasons) when migratory wild herbivores had moved away from the study area. In the case of Khumaga, wild herbivores (zebra and wildebeest) emigrate to the north-eastern plains of Makgadikgadi Pans National Park during the wet seasons[8,66] (see Figure 3, p.18). Livestock predation therefore increases during the wet season in Khumaga to meet the otherwise constant daily meat intake of lion, while wild herbivores emigrate.

A general relationship between wild and domestic herbivores is realised from the changes in wild herbivore numbers between wet and dry seasons whereby total dry season prey availability does not differ significantly with wet season's. This relationship makes use of the following biological phenomena:

- daily meat intake per lion does not change significantly between wet and dry seasons[53].
- killing rate of lion does not change significantly between wet and dry season[53].
- wild herbivores, especially wildebeest and zebra migrate away from the Boteti river to the centre of Makgadikgadi Pans National Park[8,66] during the wet seasons.
- Lion do not migrate but their home ranges increase by a factor of 1.7 during seasons of herbivore emigration[53].

- predation on resident herbivores intensifies when migratory herbivores emigrate[53].

With goat predation numbers significantly higher during the wet than dry seasons, a reduction in wild herbivore population during the wet seasons was buffered by goats, hence providing a constant availability of prey for lion (a reduction in farmers' goat resource base). The wild herbivore deficit can therefore be attributed to the increase in goat predation levels.

3.1.2.2. Predation by Crocodile

Crocodile preyed only on cattle and goats during the wet seasons (see Figure 8). Goats constitute 78% of crocodiles' livestock prey and cattle constituted 22%. The livestock-based diet of crocodile in the dry season consisted entirely of goats.

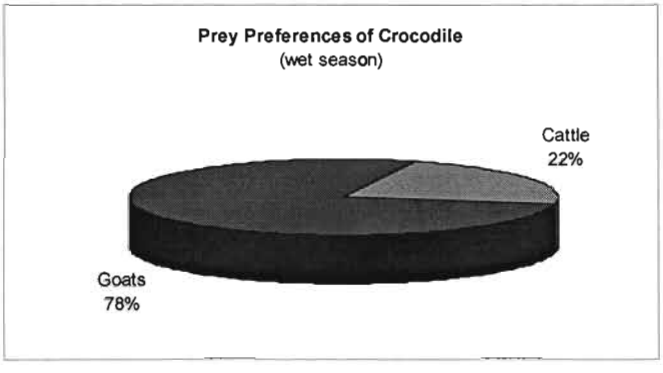


Figure 8: Wet season prey preferences of crocodile at Khumaga; 1994-96.

There was no significant difference in goat predation by crocodile in wet and dry seasons (Wet season median predation 1.0 goat, mean 1.4 goats; dry season median 1.0 goat, mean 1.2 goats, W = 154.5; df = 10 and 13; p = 0.05). Cattle predation could not be evaluated by the Mann-Whitney test because no predation was experienced in the dry season to compare against wet seasons'. The wet season cattle predation was, however, considered significantly higher than the nil dry season predation, hence overall crocodile predation is higher during the wet than dry seasons. During wet seasons, a decline in wild prey is experienced. In the case of Nile crocodile at Khumaga, a higher consumption rate is expected since wet seasons are

also periods of higher atmospheric temperatures[49,58] - increasing even more the dependence of crocodile on domestic herbivore-based prey. This increased consumption, coupled with a possible state of equilibrium (between seasons) in goat vulnerability, leaves cattle (the most abundant livestock type, see page 43) to meet the increased demand. Emlen[45] also supports the argument that certain prey types can be preferred simply on the basis of relative abundance compared to the efficiently obtainable prey. Cattle are, therefore, preyed on more under these conditions, providing a buffer against the two factored increase of predation by crocodile. During dry seasons, an increase in wild prey availability in Khumaga is experienced. A decline in consumption rate of crocodiles is also expected as atmospheric temperatures fall[57,58] - reducing predation pressure from both domestic and wild prey animals. It has not been possible to establish the relative contribution of temperature and rainfall to the patterns of livestock predation by crocodile beyond the relationships indicated below, whereby C_W represents a monthly average number of cattle preyed on by crocodile during the wet season; G_W, goats; H_W, horses; D_W, donkeys; S_W, sheep; W_W, wild herbivores; C_D, monthly average number of cattle preyed on by crocodile during the dry season; G_D, goats; H_D, horses; D_D, donkeys; S_D, sheep and W_D, wild herbivores.

Equation 1

$$G_W + C_W + W_W \leftrightharpoons G_D + C_D + W_D$$

The following biological phenomena affect the crocodile-predator relationship:

- Nile crocodile do not hunt outside a home-range, hence all predation takes place at or near the water pools[72].
- daily meat intake of Nile crocodile is eight times higher during the summer than during the winter[71]. The winter takes three out of the seven months of the dry season.

Denoting monthly predation for warm months by P and total predation for the dry season by T;

$$4P + 3P/8 = T;\ P(4 + 3/8) = T;\ P = T/4.375$$

For warm months, predation will be; $4P = 4 \times T/4.375$ hence the factor of 0.914.

For cold months, predation will be the balance of that of warm months hence the factor of 0.086

Since there was no significant difference between the wet and dry season goat predation by crocodile, Equation 1 reduces to;

Equation 2

$$C_W + W_W = C_D + W_D$$

The second biological phenomenon relating to predation by crocodile means that the right hand side of Equation 2 splits into the winter and summer ratios of 0.086 and 0.914 respectively, yielding;

Equation 3

$$C_W + W_W = 0.086(C^C_D + W^C_D) + 0.914(C^H_D + W^H_D)$$

where in, for example, C^C_D, the superscript denotes the cold season and in C^H_D denotes the hot season. With numbers of cattle preyed on by crocodile higher during the wet (mean $C_W = 0.4$) than the dry season (mean $C_D = 0$), an increase in demand for prey by crocodile during the hot months is met, much to the loss of the farmers' cattle resource base. The wild prey deficit ($0.086W^C_D + 0.914W^H_D - W_W$) can therefore be equated to the increase in predation levels of cattle ($0.086C^C_D + 0.914C^H_D - C_W$), and assuming dry season predation on cattle is insignificant, yielding;

Equation 4

$$C_W = 0.086W^C_D + 0.914W^H_D - W_W$$

which represents the level of cattle predation by Nile crocodile in response to the combined effect of emigration of wild prey and increase in consumption rate of crocodiles during the wet seasons.

3.1.2.3. Predation by Spotted Hyena

Spotted hyena preyed on cattle, goats and donkeys in decreasing order of intensity during the wet seasons (see Figure 9, below). In the dry seasons, the proportion of cattle in domestic herbivore prey of spotted hyena fell - similarly so for goats - but increased for donkeys.

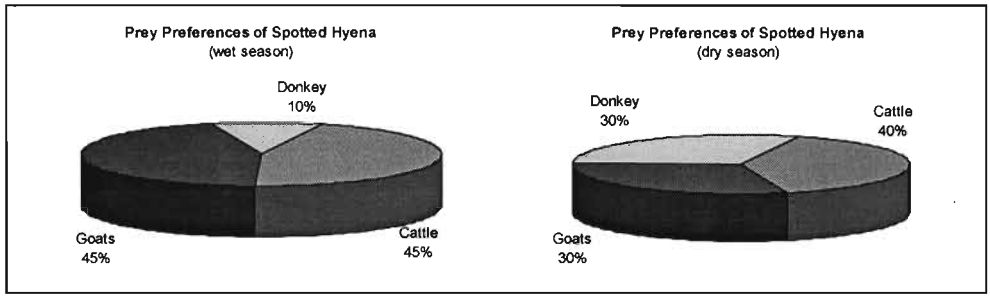


Figure 9: Proportionate prey preferences of spotted hyena at Khumaga; 1994-96.

There was no significant difference in cattle predation by spotted hyena in wet and dry seasons (Wet season median predation 0.0 cattle, mean 0.9 cattle; dry season median 0.5 cattle, mean 0.3 cattle, W = 139.5; *df* = 10 and 13; $p = 0.05$), or in goat predation in wet and dry seasons (Wet season median predation 0.0 goat, mean 0.9 goat; dry season median 0.0 goat, mean 0.2 goat, W = 151.0; *df* = 10 and 13; $p = 0.05$). The same applies to donkey predation in wet and dry seasons (Wet season median predation 0.0 donkey, mean 0.2 donkey; dry season median 0.0 donkey, mean 0.2 donkey, W = 158.0; *df* = 10 and 13; $p = 0.05$). Descriptions by Kruuk[39] and Mills & Biggs[41] of spotted hyena predator-prey interactions seem to suit the Khumaga scenario where seasonal migration of two prey species (zebra and wildebeest) influences livestock predation levels by spotted hyena (a Canid species) to a lesser extent than it does for livestock predation by lion (a Felid species). Sheep, though similar to goat in average body-size, were not preyed on. In the absence of literature on the differences in vulnerability between the two livestock types, this study considered the two livestock

types as equally vulnerable. According to Pienaar's[44] preference rating, sheep and goats would therefore have the same preference rating. Goats being more abundant (43%) than sheep (0.2%) were preyed on more and a decrease in numbers of wild herbivore prey would not be expected to influence livestock predation.

3.1.2.4. Predation by Black-backed Jackal

Black-backed jackal preyed entirely on goats during both the wet and dry seasons. There was no significant difference in goat predation in wet and dry seasons (Wet season median predation 0.0 goat, mean 1.0 goat; dry season median 0.0 goat, mean 0.5 goat, W = 152.0; df = 10 and 13; p = 0.05). Being opportunistic predators and scavengers, black-backed jackal prey on a wide variety of both Mammalia, Reptilia, Amphibia, Aves, Insecta and plant matter[40]. This guards them against the impact of seasonal fluctuations of wild herbivores resulting from emigration of wildebeest and zebra. Kruuk[39] also reports that black-backed jackal prey on a wider variety of animal species than lion and other felid predators. Considering also that black-backed jackals live mostly in pairs, the chances of hunting prey bigger than impala would be minimal, hence they are less affected by emigration of wildebeest and zebra. As in the case of spotted hyena, no preference for goats to sheep is expected. Goat predation is therefore attributed to their relative abundance (43%), as noted by Pienaar[44] and Emlen[45].

3.1.2.5. Predation by Leopard

Leopard preyed mainly on goats (72%), with cattle and donkeys taken in equal proportions (14%) (see Figure 10). During the dry seasons, leopard preyed only on goats.

There was no significant difference in goat predation by leopard in wet and dry seasons (Wet season median predation 0.0 goat, mean 0.5 goat; dry season median 0.0 goat, mean 0.2 goat, W = 163.0; df = 10 and 13; p = 0.05). Cattle predation could not be evaluated by the Mann-Whitney test because no predation occurred in the dry seasons, but the numbers of cattle

preyed on during the wet seasons were considered higher than the nil predation of the dry seasons.

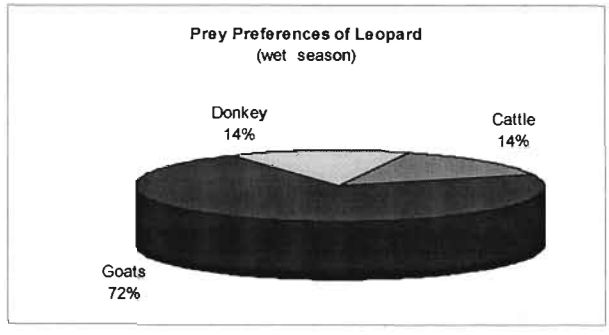


Figure 10: Wet season prey preferences for leopard at Khumaga; 1994-96.

These results conform to the following biological principles;

- Leopard prey more on small stock and young calves but rarely on adult cattle[35].
- Leopard's wild herbivore diet consists of prey of size no larger than an adult springbok[36,37] - impala in the case of Khumaga[8].
- Calving incidents of cattle are higher during the wet than dry seasons.

Wild herbivore prey of leopard is not affected by the seasonal changes reported by Kgathi & Kalikawe[66] for wildebeest and zebra. Cattle predation experienced during the wet season, C_W, is a likely indication of opportunistic responses by leopard to availability of calves, since most of the animals preyed on were young calves and one young heifer with a broken leg. Therefore, an increase in calving rate of cattle during the wet seasons and the impacts of seasonal variations in wild herbivore prey account for the increase in livestock predation by leopard during the wet seasons.

3.1.3. Economics of Livestock Predation in Khumaga

Relative livestock population (by type), livestock mortality due to carnivores and the nature/frequency of livestock sales characterise Khumaga's pastoral farming. The well-being of any one farmer is interrelated to these three factors. Livestock

from Khumaga is sold at different centres, depending on the type of livestock, nature of the centre of sale, and the proximity of the centre of sale. The choice of a livestock sale centre by a farmer is influenced by the centre's geographical location and institutional arrangements (see Table 3), although this aspect has not been included in this study.

Table 3: Description of centres of livestock sale.

Centre of Livestock Sale		Most Frequently Sold Livestock Type
Name	**Description of Institutional Arrangements**	
Gweta Consumers' Cooperative	Consortium of members market livestock, with the aid of government, to nearest abattoirs and charge commission and transport/handling fees to farmers. The farmer receives an advance part-payment and the balance when the abattoir has paid for the stock.	Cattle
Khumaga Consumers' Cooperative	As Above	Cattle
Tsienyane Consumers' Cooperative	As Above	Cattle
Gweta Kgotla	Farmer sells to individuals, including owners of local butcheries, through the Kgotla where each stock is registered with the chief and local police officers. Payments are usually made within few minutes of receipt of stock by the buyer.	Goat
Khumaga Kgotla	As Above	Goat
Tsienyane Kgotla	As Above	Goat
Francistown BMC	A parastatal marketing beef and small stock (through the former assumes a much higher status) both locally, regionally and internationally. BMC charges a farmer a "per animal" tax, which unlike in tax legislation, is independent of livestock endowment.	Cattle
Maun BMC	As Above	Cattle

The nature of a livestock sale centre influences the unit prices of each livestock type, such that prices within any one institutional arrangement are systematically different from those of others, to a large extent even irrespective of location. For instance, the unit price of cattle may be standardised for co-operatives within any one region, and similarly so with BMCs and *Kgotlas*.

3.1.3.1. Influence of Herd Size on Predation Levels

To understand the relationship between socio-economic status of farmers in Khumaga, livestock sales and losses (to predators) were each compared against total livestock owned by each farmer. Farmers were categorised according to their livestock endowment. Table 4 shows the ranges of livestock endowment assigned to categories A to F.

Table 4: Classification table for farmers on the basis of total livestock endowment.

Category No.	Min.	Max.
A	0	15
B	>15	25
C	>25	35
D	>35	50
E	>50	100
F	>100	300

Losses due to livestock predation divided according to category of farmer are shown in Table 5. Farmers with lower livestock endowment (categories A to D) lost a higher proportion of goats than any other livestock types and also sold a higher proportion of goats. Only farmers in category F lost more cattle (in actual numbers) than other types of livestock. Category E farmers lost more cattle than did those of category F and also more goats than any other category of farmers. Category E farmers, therefore, lost most in terms of both utility and monetary values of goats and cattle, respectively. Utility is more relevant at lower livestock endowment categories where draught power, milk, dung/manure and skins are basic essentials to the farmer.

Table 5 : Economic characteristics of pastoral farming in Khumaga.

Farmer Category	Type of Livestock	Total Preyed on	Average	Total Sold	Average
A	Cattle	0	0.00	0	0.00
	Horse	0	0.00	0	0.00
	Sheep	0	0.00	0	0.00
	Goat	5	2.50	0	0.00
	Donkey	4	1.33	0	0.00
B	Cattle	0	0.00	1	1.00
	Horse	0	0.00	0	0.00
	Sheep	1	1.00	0	0.00
	Goat	23	7.67	5	1.67
	Donkey	6	3.00	0	0.00
C	Cattle	2	1.00	4	2.00
	Horse	0	0.00	0	0.00
	Sheep	0	0.00	0	0.00
	Goat	24	8.00	8	2.67
	Donkey	3	3.00	0	0.00
D	Cattle	8	1.60	14	2.00
	Horse	0	0.00	0	0.00
	Sheep	0	0.00	0	0.00
	Goat	61	7.63	9	1.80
	Donkey	4	1.00	0	0.00
E	Cattle	45	4.50	55	4.23
	Horse	4	2.00	0	0.00
	Sheep	17	8.50	0	0.00
	Goat	154	11.85	33	3.30
	Donkey	16	2.00	0	0.00
F	Cattle	51	4.64	91	6.07
	Horse	2	1.00	0	0.00
	Sheep	0	0.00	0	0.00
	Goat	182	13.00	47	3.36
	Donkey	11	1.83	4	4.00

The impact of proximity to Makgadikgadi Pans National Park on intensity of livestock predation is acknowledged. It is likely that this proximity may account for some of the balance of the variation not attributed to differences in livestock endowment. Figure 11 compares livestock predation with livestock endowment for cattle and goats. Livestock predation significantly increased with total livestock endowment only for cattle predation (β = 0.020, t = 3.000; df = 106; α = 0.004; p = 0.05).

Farmers that own more livestock usually engage the services of a herder paid for in kind with little or no relationship to the size of the herd (Mazhadza, Pers. Comm. 1997[†††]). In this study, numbers of herders engaged per cattle-post have not been available. The amount paid to the herder is dependent upon wide margins of herd size, as established by Carl Bro International[74] as 0-60, 61-100, 101-150 and 151-∞. This, as McNeely[81] argues, does not provide an incentive for the herder to protect the livestock from predation, hence the higher predation levels for bigger herds.

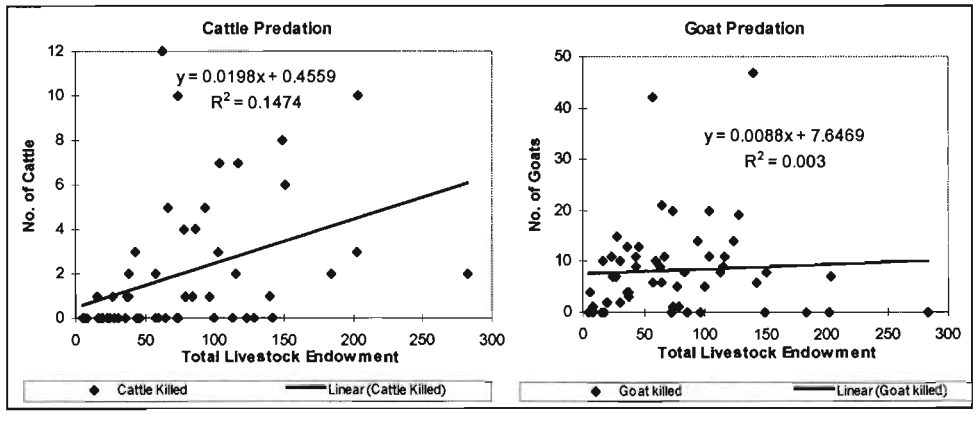


Figure 11: Estimated relationship between livestock predation and total livestock endowment (LSU) for Khumaga.

Mazonde[116] notes an acute shortage of labour as a result of human migration to urban areas and major population centres, and the preference paid herders have for commercial ranches since these ranches pay higher wages. The result is a scarce and unwilling work force tending livestock in cattle-post

[†††] Mr Gabaikangwe Mazhadza. employed herder at Polanka cattlepost, Gweta, Botswana.

systems. Little[106] also notes a reduction in the level of responsibility in Kenya as livestock owners became more detached from their livestock through what he calls "Absentee Herd Ownership and Part-time Pastoralism", whereby owners employ herders or hand over their livestock to acquaintances for safe keeping. The latter, in the Botswana context, is referred to as the *mafisa* system.

Goat predation did not vary significantly with variations in livestock endowment (β = -0.009, t = -0.397; df = 106; p = 0.05) (see Figure 11). Given the fact that goat endowment linearly varies significantly with cattle endowment (β = 0.234, t = 3.220; df = 106; α = 0.001; p = 0.05), goat predation would be expected to increase with increasing livestock endowment. Goats are localised grazers/browsers[74] and easily habituated to coming home in the evenings. They are therefore less susceptible to straying than cattle even at low levels of care. The existence of the *Matimela* programme (which deals more with cattle than other livestock types) is testimony to the distance travelled by cattle and the extent of straying. Figure 4, (p. 40) shows that goats are subject to heaviest predation, but this is due to their prey-size which, unlike cattle's, falls within most predators' prey-size preference.

There is no significant linear relationship between total livestock endowment and donkey predation (β = -0.001, t = -0.256; df = 106; p = 0.05). Only 20% of the decrease in donkey predation could be associated with increases in total livestock endowment. There seem to be other factors influencing the relationship between donkey predation and livestock endowment which play a more important role than the relative numbers of donkeys and other livestock types. Such factors are likely to include the role of donkeys as a source of draught power in rural pastoral communities, whereby their care has more immediate and practical benefits than cattle.

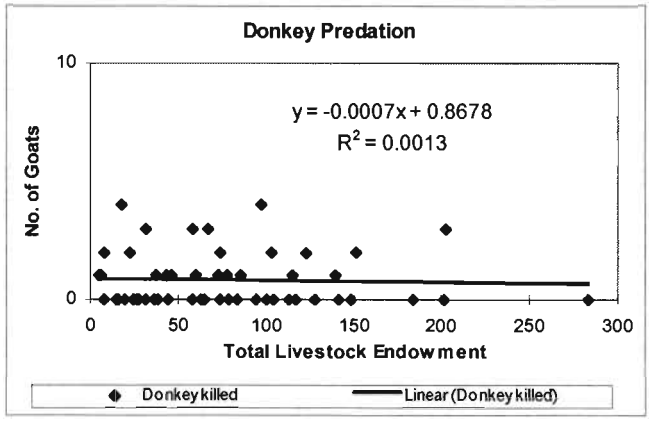


Figure 12: Estimated relationship between donkey predation and total livestock endowment in Khumaga, 1996.

Participant observations at Khumaga revealed a more frequent use of donkeys in drawing water carts, thorn bushes (for renovating livestock enclosures) and transporting people. This means that absence, especially straying, of donkeys is readily noticed and responded to, in order for daily activities to proceed unhampered. This reduces the probability of predator-donkey contact in remote areas of high predator-presence. Due to low numbers of horses and sheep relative to other livestock types, their levels of predation have not been analysed, since the economic impact of these losses to predators appears small.

3.1.3.2. Influence of Herd Size on Live Sales

Figure 13 shows the relationship between numbers of cattle and goats sold, and livestock endowment of the respective farmers. Off-take relating to battering, celebrations and home consumption has been excluded from the computation of livestock sold. There is a significant positive linear relationship between cattle sales and total livestock endowment ($\beta = 0.052$, $t = 6.710$; $df = 106$; $\alpha = 0.001$, $p = 0.05$). There is no significant linear relationship between goat sales and total livestock endowment ($\beta = 0.009$, $t = 1.536$; $df = 106$; $p = 0.05$). There is also no significant linear relationship between donkey sales and total livestock endowment ($\beta = 0.001$, $t = 0.709$; $df = 106$; $p = 0.05$), see Figure 14, page 57.

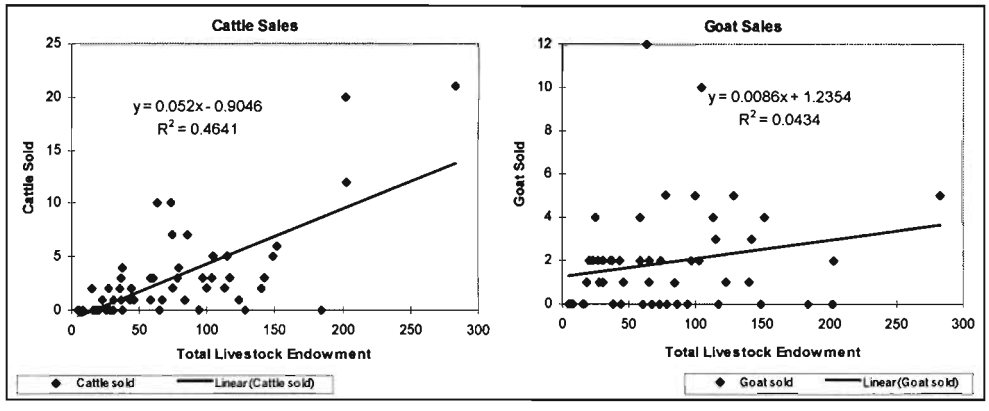


Figure 13: Estimated relationship between livestock sales and total livestock endowment in Khumaga.

The relationship between sales and total livestock endowment could not be evaluated for horses and sheep because there were no sales reported for these livestock. Results indicate the market bias towards cattle associated with the EC preferential import subsidies and GoB emphasis on cattle production, together with the utility of cattle in rural pastoral communities.

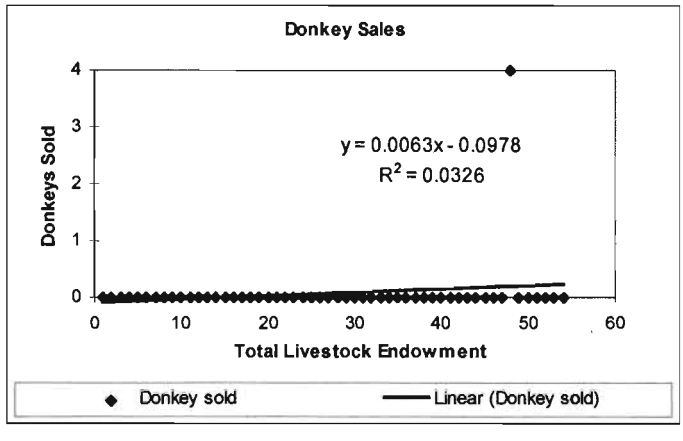


Figure 14: Relationship between donkey sales and total livestock endowment in Khumaga, 1996.

In Khumaga, therefore, increases in numbers transform more readily into sales for cattle than goats and other livestock - a phenomenon also attributed by Deliotte & Touché Tohmatsu International[114] to services and subsidies afforded livestock production and marketing in the form of quarantine, veterinary cordon fences, foot and mouth campaigns, the *Matimela* programme, cattle trek routes, boreholes for trek routes and artificial insemination services. These services benefit cattle proportionately more

than other livestock types. With the listed services provided at little or no cost to the farmer, there are more economic incentives to keep cattle than small stock.

3.1.3.3. Livestock-related Utility and Livestock Endowment

A summary of livestock predation for Khumaga in Table 6 shows (i) livestock endowment; (ii) services and goods obtained from each type of livestock; (iii) number of live sales for 1996; and (iv) centres of livestock sale. Goats were sold more at Khumaga local market (*Kgotla*) than at other centres of sale (see Table 6). Cattle were sold more at Khumaga Co-operative than at other centres. Co-operatives and BMC are more institutionalised centres, placing them in a better position to transact with larger volumes of cattle sales. Sales of sheep, donkeys and horses are insignificant primarily because there are far less of these livestock types (refer to page 43).

Table 6: Summary of livestock predation implications for Khumaga.

Type of Livestock	Livestock Endowment (Predation-free)	Most Frequently Used Center	Livestock Killed	Percentage Livestock Killed	Compensation Due (US$)	Utility of livestock
Cattle	2209	Coop-Khumaga	106	4.8	14,008.96	Draught power, milk, meat & skin.
Horse	39	N/A	6	15.4	792.96	Draught power
Sheep	30	N/A	18	60.0	2,378.88	Meat & skin.
Goat	2205	Local-Khumaga	449	20.4	59,339.84	Meat & skin.
Donkey	252	Local-Khumaga	44	17.5	5,815.04	Draught power
Totals	4735		623		82,335.68	

Cattle are the most versatile livestock type in terms of utility, offering what small stock and equines together can provide. The losses of goats alone far exceed the combined losses of cattle, sheep and equines in numbers. These losses represent approximately US$60,000 due from government in the form of compensation and as indicated in Table 5 (p.53), are dominated by category E farmers. In proportionate terms, however, farmers of the lower livestock endowment categories lost more since they depend more on goats as a source of income, meat, milk and skins.

The economic impact of livestock predation is most pronounced through predation on goats (over 20%) and on donkeys (17%). Sheep form a small fraction of livestock numbers in Khumaga and are therefore not representing a significant economic impact. The combined loss of donkeys and goats represents a much higher loss than that of cattle because of their combined utility accruing to farmers, especially those of low endowment categories. These farmers have fewer alternative sources of livelihood than those of higher livestock endowment who usually are absentee herders.

3.1.3.4. Predation-free Simulations and Sale Centres

A relationship between sales and endowment of any one livestock type has been assumed as linear (a decrease in endowment would lead to a proportional decrease in sales of the same livestock type). This forms the basis of the simulation of predation-free sales and predation-free endowment. Aggregate losses due to livestock predation and their associated monetary equivalents (expressed in US$) incurred are shown in Table 7. Calculations of monetary loss are based on the unit price of each livestock type shown in Appendix 6 (p.125) and are thus a product of numbers of livestock and the unit selling price in US$. A comparison of financial benefits and their theoretical equivalents (assuming predation-free scenario) accruing from the sale of stock at different centres of sale is shown in Figure 15 (for goats) and Figure 16 (for cattle). Figure 15 indicates a higher number of goats being sold at the Khumaga local abattoir (Local-K) than at the same facility in Tsienyane (Local-T) and that farmers who sold goats to Tsienyane abattoir had also lost more goats to predators than those who sold at Khumaga.

Table 7: Comparison of financial gains from livestock without and with predation in Khumaga, 1996.

Livestock Type	Centre of Sale	Without Predation	With Predation	Deficit
Cattle	BLDC-Tsienyane	8390.84	8064.00	326.84
	BMC-Francistown	2256.80	2256.80	0.00
	BMC-Maun	8075.20	7761.60	313.60
	Coop-Khumaga	7654.31	6843.20	811.11
	Coop-Tsienyane	1176.67	1120.00	56.67
	Local-Khumaga	784.00	784.00	0.00
	Local-Tsienyane	786.62	747.60	39.02
Sub-Totals		29124.44	27577.20	1547.24
Goat	Local-Khumaga	5423.52	4166.40	1257.12
	Local-Tsienyane	709.03	403.20	305.83
Sub-Totals		6132.56	4569.60	1562.96
Donkey	Local-Khumaga	112.00	112.00	0.00
Sub-Totals		112.00	112.00	0.00
Totals		35369.00	32258.80	3110.20

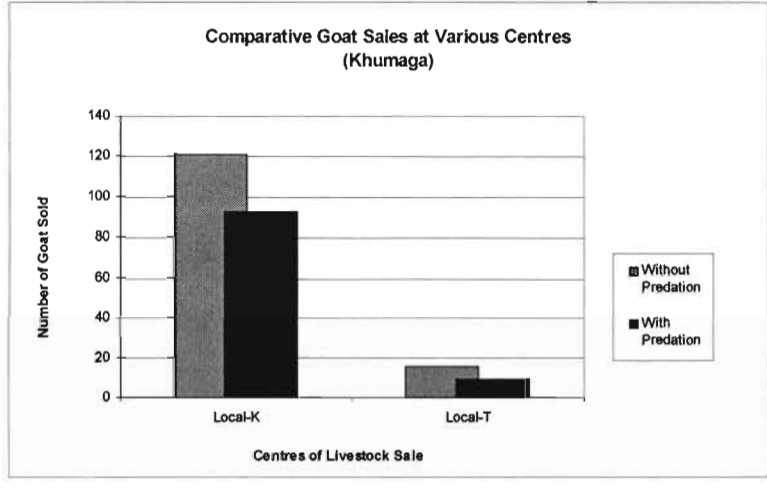


Figure 15: Possible impact of livestock predation on goat sales in Khumaga.

There does not seem to be a discrete association between the centres of sale and the proportion of predation-free to predation-influenced sales. Goat sales from Khumaga are dominated by farmers of category D and E, (i.e. those owning 35 - 100 livestock) (n = 55, mean sales = 3.8), who are unlikely to afford paid labour but have herd sizes large enough to pose problems to family-based herders. This is especially so in the context of reduced rural agricultural labour as noted by Mazonde[116], Campbell[115] and Maswa (Pers. Comm. 1996[‡‡‡]), where the herd includes livestock belonging to relatives away on paid urban employment. There is no established association between centre of sale for goats and category of farmer. Cattle from Khumaga were sold at seven different markets (see Figure 16), the most popular being the Tsienyane BLDC (BLDC-T) followed (in decreasing

[‡‡‡] Mr Kesule Maswa. Farmer at Dikwalo cattlepost, Khumaga, Botswana.

order of sales) by Khumaga Consumers Co-operative (Coop-K), Maun BMC (BMC-M), Francistown BMC (BMC-F), Tsienyane Consumers Co-operative (Coop-T), Khumaga local sales (Local-K) and Tsienyane local sales (Local-T). The high number of centres of sale for cattle (in comparison to those of other livestock types) in indicative of the importance of cattle in the cash-economy of Khumaga. In addition to the supply-demand relationship, the high numbers of centres of sale for cattle can also be attributed to ease of raising cattle (due to subsidies), hence the high turnover as compared to other livestock types.

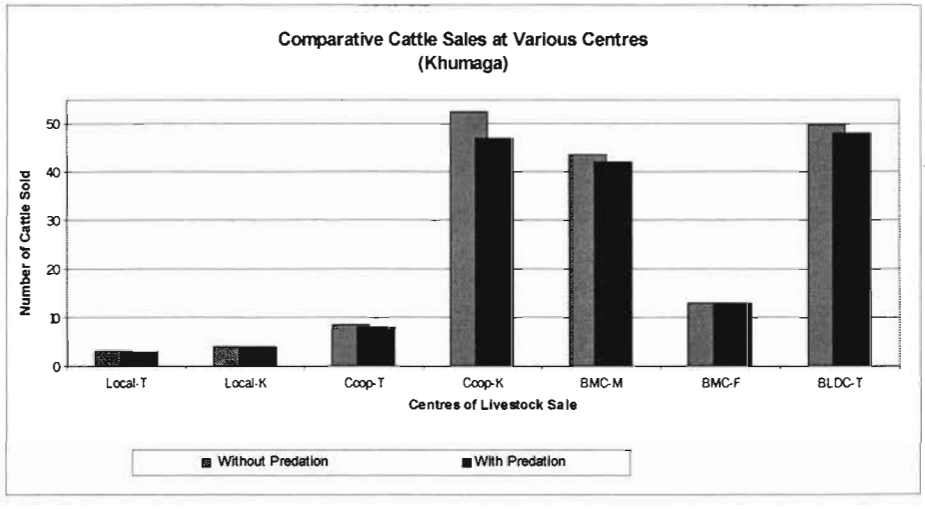


Figure 16: Centres of sale for Khumaga and comparative numbers of cattle sold, assuming nil predation and with predation.

Farmers that had sold cattle to BMC-F, Local-K or Local-T had also experienced predation-free sales equal to predation-influenced sales (i.e. no predation). Farmers who had sold cattle to Coop-K had also experienced predation-free sales higher than predation-influenced sales. No association has been established between centre of sale for cattle and category of farmer. Only four donkeys from Khumaga cattle-posts were sold within Khumaga during the year 1996 and the farmers had also not lost any donkeys to predators.

3.2. Gweta Survey

3.2.1. Intensity of Livestock Predation

The intensity of livestock predation in terms of numbers of livestock (by type) preyed on in Gweta from August 1994 to August 1996 is shown in Figure 17. All livestock types are preyed on more during the dry than wet seasons. Wet season predation is highest for cattle and dry season predation is highest for goats.

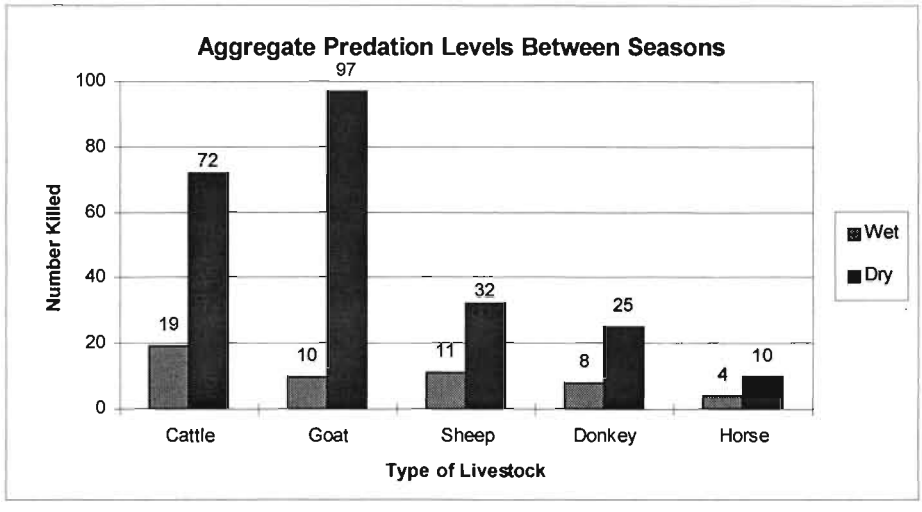


Figure 17: Aggregate wet and dry season predation levels in Gweta (Aug. 94 - Aug. 96).

Numbers of livestock (by type) preyed on and species of predator involved are shown in Figure 18 below for the wet seasons of August 1994 to August 1996 and in Figure 19 for dry seasons of the same period. These data are based on the PAC unit's database from DWNP's Francistown office (see Appendix 8, p.129). During the wet seasons, cattle were preyed on by lion, spotted hyena and leopard, with higher predation levels being due to lion. Goats were preyed on by black-backed jackal, lion, spotted hyena and wild dog, with highest predation levels being due to black-backed jackal. Sheep were preyed on by leopard, spotted hyena, black-backed jackal and lion. Donkeys and horses were preyed on by lion only. Goats and sheep were preyed on by a wider variety of predators (four species) than were cattle (three species) and, horses and donkeys (one species each).

Patterns (in terms of diversity of predator species for each livestock type) similar to those of Khumaga emerge for Gweta's livestock predation (refer to page 42). The

most pronounced difference in the diversity of predator species is the presence of crocodile in Khumaga, where unlike Gweta, there is surface water.

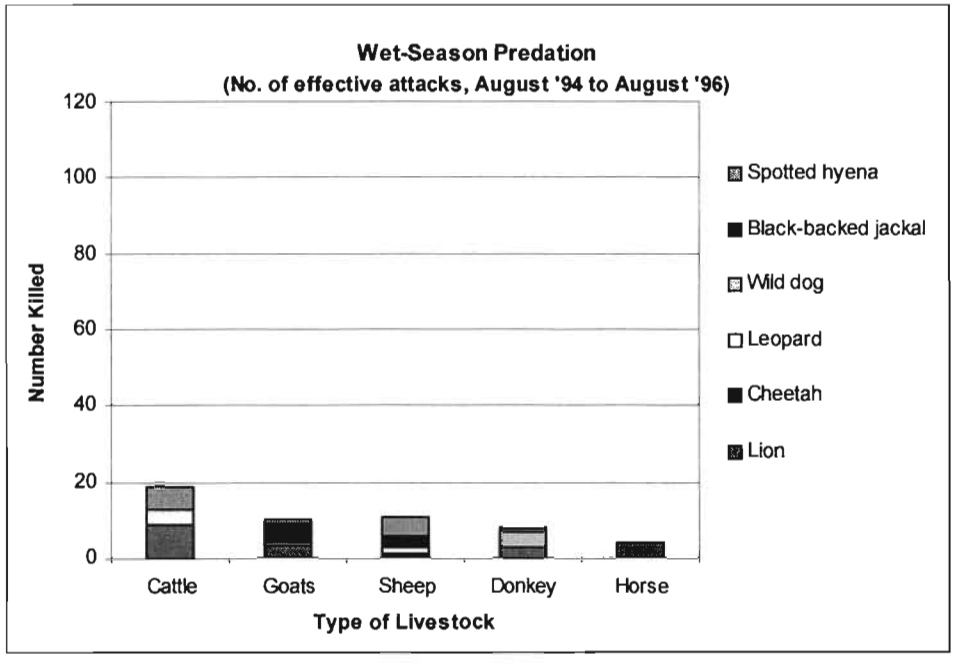


Figure 18: Livestock predation levels at Gweta during the wet seasons, 1994-96.

Degrees of livestock predation (by livestock type) for the dry seasons of August, 1994 to August, 1996 in Figure 19 show that all livestock types were preyed on.

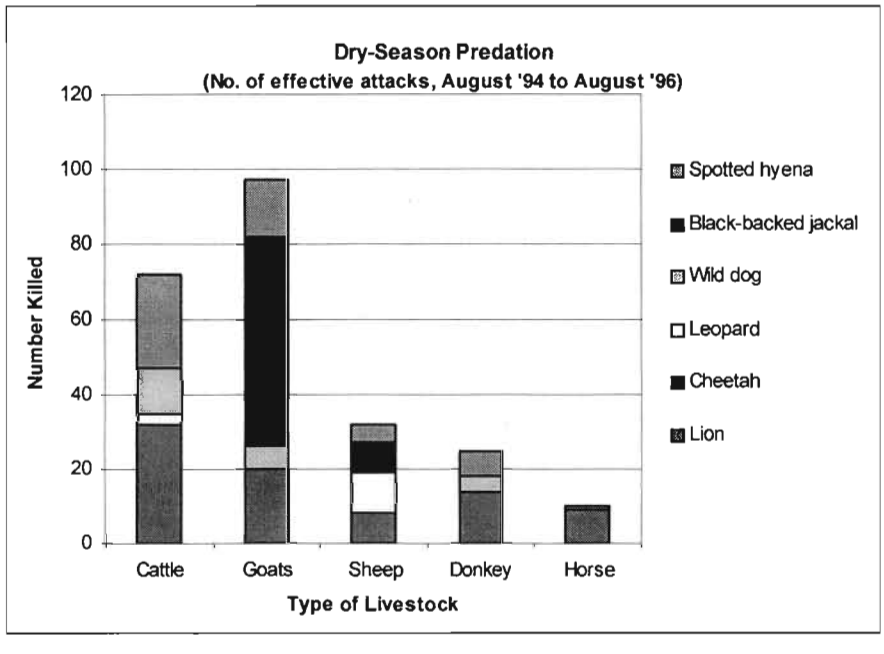


Figure 19: Livestock predation levels at Gweta during the dry seasons, 1994-96.

Cattle were preyed on by lion, spotted hyena, wild dog and leopard (in decreasing order of predation intensity). Goats were preyed on by black-backed jackal, lion, spotted hyena and wild dog. Sheep were preyed on by leopard, black-backed jackal, lion and spotted hyena, while donkeys were preyed on by lion, spotted hyena and wild dog (in decreasing order of predation intensity). Horses were the prey of lion and spotted hyena.

Spotted hyena in Gweta preyed on more livestock types (five) than in Khumaga (three) during the dry seasons. During the dry seasons, there is a much lower wild herbivore prey for spotted hyena since juveniles of wildebeest and zebra by then emigrate to the Boteti river[66]. Spotted hyena population remaining in Gweta is then to be supported by remaining herbivore population (both wild and domestic). A similar pattern is noted for wild dog, black-backed jackal and leopard, with livestock types preyed higher than in Khumaga.

3.2.2. Predator-Prey Relationships

Preferences for livestock-based prey by predators are shown in Figure 20 to Figure 24 below. Relative proportions of each livestock type in Gweta's livestock population are 49.7% (cattle), 33.7% (goats), 7.4% (sheep), 6.8% (donkeys) and 2.4% (horses). Cattle, being more abundant than other livestock types, would (according to Pienaar's[44] preference rating technique - page 13) be preyed on more if their preference rating is equal to that of other livestock types.

3.2.2.1. Predation by Lion

During the wet seasons, cattle constitute the highest proportion of lion livestock prey (45%), followed by horses (20%), goats and donkeys (15% each) and sheep (5%) (see Figure 20). In the dry seasons, cattle were again the main lion domestic herbivore prey (38%), followed by goats (24%), donkeys (17%), horses (11%) and sheep (10%).

Cattle predation by lion in wet seasons is significantly lower (in actual numbers) than in dry seasons, though higher in proportionate terms (Wet

season median predation 0.0 cattle, mean 0.27 cattle; dry season median 1.0 cattle, mean 2.0 cattle, W = 282.5; *df* = 11 and 17; $p = 0.05$).

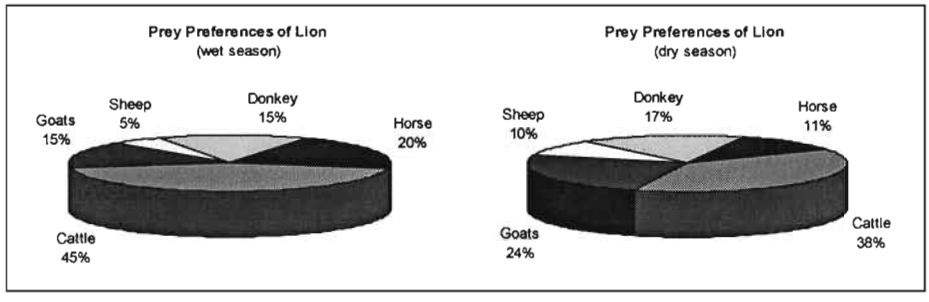


Figure 20: Proportionate prey preferences of lion at Gweta, 1994- 96.

Goat predation by lion in wet seasons is significantly lower than in dry seasons (Wet season median predation 0.0 goat, mean 0.27 goat; dry season median 1.0 goat, mean 1.0 goat, W = 283.5; df = 11 and 17; $p = 0.05$). Donkey predation by lion in wet seasons is significantly lower than in dry seasons (Wet season median predation 0.0 donkey, mean 0.18 donkey; dry season median 0.0 donkey, mean 0.88 donkey, W = 278.5; *df* = 11 and 17; $p = 0.05$). The above patterns of livestock predation by lion on cattle, goats and donkeys in Gweta show the variety in herbivore prey typical of lion. Past studies (though on wild herbivores) by Kruuk & Turner[38], Pienaar[44], Van Orsdol[54] and Kruuk[39] give the same picture in terms of weight of herbivore species preferred. Such preferences, as Emlen[45] also established, depend not only on abundance of a particular prey species but on a series of factors such as the risk of obtaining prey and nutritional value of a particular prey. The pattern arising for cattle, goats and donkeys predation in Gweta is likely to be influenced by abundance (all three livestock types are the most abundant, refer to page 64) and average weight of livestock type. Agility (or lack of it) is less likely to influence the pattern since none of these livestock types have defences comparable to those of wild herbivores. On a seasonal scale, cattle, goats and donkeys are preyed on more during the dry than wet months. This could result from the large-herbivore immigration (mainly zebra and wildebeest) into the eastern and north-central parts of MPNP and to the Boteti river as established by Kgathi & Kalikawe[66]. Wild herbivore movements in Gweta correspond to those of Khumaga but have different

directions of the seasonal migration (see Figure 3, p.18). These movements cause a decrease in the availability of wild herbivore prey, which has to be compensated for by an increase in livestock predation by lion. Lion's meat intake, according to Viljoen[53], does not significantly vary with seasons and they will therefore prey more on cattle, goats and donkeys during dry seasons when the large wild herbivores have returned to the Boteti river.

Predation on sheep and horses, however, did not vary between seasons. There was no significant difference in sheep predation by lion in wet and dry seasons (Wet season median predation 0.0 sheep, mean 0.09 sheep; dry season median 0.0 sheep, mean 0.47 sheep, W = 255.5; df = 11 and 17; p = 0.05). There was no significant difference in horse predation by lion in wet and dry seasons (Wet season median predation 0.0 horse, mean 0.55 horse; dry season median 0.0 horse, mean 0.41 horse, W = 235.5; df = 11 and 17; p = 0.05). Both sheep and horses are proportionately less abundant than the other livestock types in Gweta. Note that the data used for assessing seasonal variations are aggregated for all cattle-posts around Gweta and are therefore likely to blur any localised patterns such as those anticipated for cattle-posts along MPNP's eastern boundary and further south to the Makgadikgadi salt pans. These cattle-posts, namely; Polanka, Gcingcara, Ngaiso, Kgaolasetlhako and Chaneo are within an area specified by IUCN[8] and Kgathi & Kalikawe[66] as experiencing an increase of wild herbivores (specifically wildebeest and zebra) during the wet seasons and the opposite during the dry seasons. The above seasonal variations in livestock predation levels in Gweta are likely to be obscured by the geographical scale since only cattle-posts that are along the MPNP's eastern boundary and further south to the northern fringes of Makgadikgadi salt pans are likely to vary in response to seasonal variation of wild herbivore prey. Patterns emerging from this survey would have been more pronounced if original data from DWNP's Francistown office were separable on spatial basis.

A change in numbers of wild herbivore prey is not likely to affect sheep and horse predation by lion in Gweta. Any decreases in wild herbivore in the wet season may result in an increase in cattle, goat and donkey predation by lion.

3.2.2.2. Predation by Spotted Hyena

During the wet season, spotted hyena prey on cattle (46%), sheep (38%), donkeys and goats (8% each) (see Figure 21). During the dry season, cattle constitute 48% of livestock prey for spotted hyena, goats 28%, donkeys 13%, sheep 9% and horses 2%. There appears to have been more variety in domestic herbivore prey during the dry (five livestock types) than the wet seasons (four livestock types). This corresponds to periods of less clustering of wild herbivores, whereby most water dependent wild herbivore species are concentrated around permanent water points mostly within MPNP. The apparent shift of proportion from sheep during the wet seasons to goats during the dry seasons is less pronounced when actual figures are considered. The significant increase in goat predation, as shown in the statistical analysis, is the source of the shift of proportions.

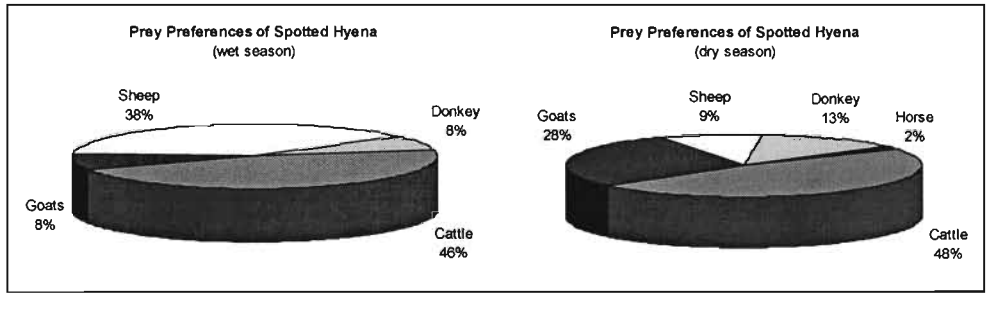


Figure 21: Proportionate prey preferences of spotted hyena at Gweta, 1994-96.

Cattle predation by spotted hyena in wet seasons is significantly lower than in dry seasons (Wet season median predation 0.0 cattle, mean 0.45 cattle; dry season median 1.0 cattle, mean 1.53 cattle, W = 279.5; df = 11 and 17; p = 0.05). Goat predation by spotted hyena in wet seasons is significantly lower than in dry seasons (Wet season median predation 0.0 goat, mean 0.09 goat; dry season median 0.0 goat, mean 0.94 goat, W = 278.0; df = 11 and 17; p = 0.05). Spotted hyena overall preferences for cattle and goats can

mostly be attributed to the relative abundance of the two livestock types. Mizutane[35] found that spotted hyena in Kenya preferred cattle and sheep, both of which were also abundant. In Gweta, cattle have a similar role as in Mizutani's[35] study and goats (the most abundant small stock) replace sheep. Yalden[50] notes that domestic herbivores are less agile than wild herbivores and would therefore impose less stringent preference strategies on wild carnivores than would wild herbivores. Spotted hyena are therefore likely to select goats purely on the basis of their abundance relative to sheep. Cattle and goats, in addition to being selected for their high relative abundance, also fall within mass restrictions identified for spotted hyena by Kruuk[48], Kruuk & Turner[38], Mills & Biggs[41], Henschel & Skinner[56] and Cooper[42]. They found that spotted hyena fed on wild herbivores of average mass no larger than 150kg such as wildebeest. These restrictions will be less stringent in the case of livestock predation because of factors described by Yalden[50] (speed and team work), hence even cattle of body mass larger than wildebeest could be taken by spotted hyena. On a seasonal basis, cattle and goats are preyed on more during the dry than wet seasons. This pattern is probably due to the same factors influencing seasonal patterns of livestock predation by lion. Cooper[42] confirms for spotted hyena, a pattern similar to that reported (for lion) by Viljoen[53] in Chobe National Park, Botswana where resident herbivores were preyed on more during seasons when migratory herbivores had emigrated from the study area. The increase in home ranges of spotted hyena experienced during the seasons of wild herbivore emigration may, in Gweta, lead to the spreading of livestock predation intensity across a wider area, hence reducing local impacts. When this happens, a study of this nature will show less significant seasonal differences in livestock predation.

Horses were preyed on only during the dry season (H_W mean = 0.0, H_D mean = 0.06) and could therefore not be evaluated by the Mann-Whitney test. Donkeys and sheep were preyed on during both seasons. Donkey predation during wet seasons is not significantly different from dry seasons' (Wet season median predation 0.0 donkey, mean 0.09 donkey; dry season median

0.0 donkey, mean 0.24 donkey, W = 255.0; *df* = 11 and 17; *p* = 0.05). Sheep predation in wet seasons is not significantly different from dry seasons' (Wet season median predation 0.0 sheep, mean 0.09 sheep; dry season median 0.0 sheep, mean 0.53 sheep, W = 255.0; *df* = 11 and 17; *p* = 0.05). Fewer livestock types were taken by spotted hyena during the wet than the dry seasons. As Emlen[45] noted, predators are more selective when they are satiated - hence spotted hyena are more selective during the wet seasons when there is abundant wild herbivore prey than during the dry seasons.

Dry season declines in wild herbivore prey available to spotted hyena are compensated for by higher cattle and goat predation. An increase in wild herbivore prey available for spotted hyena is likely to reduce dry season predation of cattle and goat.

3.2.2.3. Predation by Black-backed Jackal

During the wet seasons, black-backed jackal preyed on goats (62%) and sheep (38%) only. A similar pattern was observed for the dry seasons (see Figure 22), but the proportion of goat prey rose (87% versus 13% for sheep). In actual numbers, less sheep are preyed on during wet seasons than during dry seasons (S_W mean = 0.27, S_D mean = 0.47), implying that a proportionately lower number of goats are preyed on during the wet seasons.

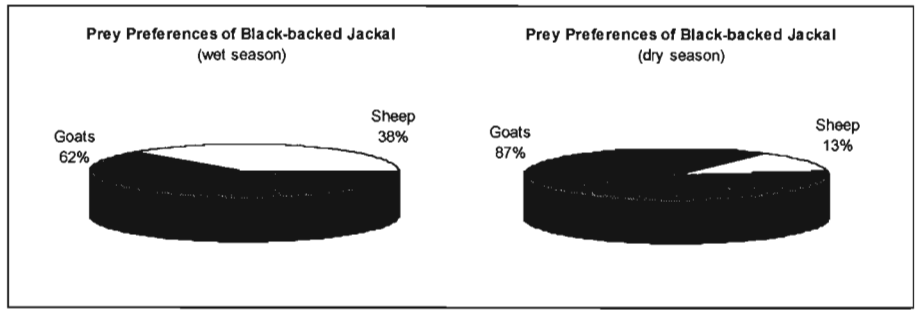


Figure 22: Proportionate prey preferences of black-backed jackal at Gweta, 1994-96.

Goat predation by black-backed jackal in wet seasons is significantly lower than in dry seasons (Wet season median predation 1.0 goat, mean 0.64 goat; dry season median 0.0 goat, mean 2.59 goats, W = 280.0; *df* = 11 and 17; *p*

= 0.05). Sheep predation in wet seasons is not significantly different from that in dry seasons (Wet season median predation 0.0 sheep, mean 0.27 sheep; dry season median 0.0 sheep, mean 0.47 sheep, W = 261.5; *df* = 11 and 17; $p = 0.05$). This pattern of livestock predation by black-backed jackal does not show the predator's prey diversity as described by Sheldon[40], as there were so few prey types in domestic herbivores in contrast to wild herbivores. Black-backed jackal's preference for small stock is reported almost uniformly in African pastoral farming areas that keep small stock, notably by Lawson[76], Bowland, *et. al.*[22] and Roberts[46]. Muzitane[35] also reports of a similar general pattern in Kenya, where black-backed jackal preyed more on sheep than cattle. This is attributed to the correlation between body size of prey and predator as noted by Kruuk[39], where predators of smaller body-size prey more on prey species of small body-size. On a seasonal scale, black backed jackal preyed on goats more during dry than wet seasons, probably due to the same factors influencing patterns of livestock predation by lion. With black-backed jackal, the impact of seasonal variation is less pronounced, i.e. the proportions and numbers of livestock types preyed on do not vary with seasons as much as they do for other predators. Key species involved in seasonal changes of wild herbivore biomass, as established by Kgathi & Kalikawe[66], are zebra and wildebeest, both of which are not key prey species for black-backed jackal (only eaten in the form of carrion). Spatial and temporal changes in their biomass will not significantly be felt by black-backed jackal. Given no past work on preferences by black-backed jackal for particular small stock, i.e. between sheep and goats, relative abundance is the only logical reason for the patterns indicated in Figure 22.

Dry season declines in wild herbivore prey (in the form of carrion or newly-born wildebeest and zebra offspring) are compensated for by higher goat predation. An increase in wild herbivore prey available for black-backed jackal is likely to cause a decrease in dry season goat predation. Unlike in Khumaga (see p.50), juveniles of wildebeest and zebra are more significant in numbers because this is at the time when synchronised births take place,

and these herbivores only reach Khumaga after the calves have grown and are less vulnerable. Goat predation by black-backed jackal in Gweta does, unlike in Khumaga, depend on wild herbivore migration.

3.2.2.4. Predation by Leopard

Domestic herbivore prey of leopard consisted of cattle (67%) and sheep (33%) during the wet seasons and, cattle (21%) and sheep (79%) during the dry seasons (see Figure 23). There was a major shift of proportions of the two livestock types which constitute leopard's domestic herbivore prey, with cattle the main prey type during wet seasons and sheep during the dry seasons. The actual numbers of cattle preyed on (wet 4, dry 3) do not show such large differences but those of sheep do (wet 2, dry 11). A large increase in sheep predation is the cause of this shift of proportions.

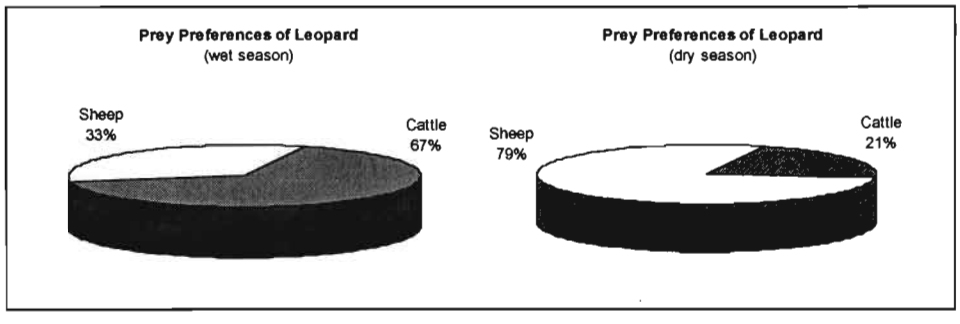


Figure 23: Proportionate prey preferences of leopard at Gweta, 1994-96.

Cattle predation by leopard during wet seasons is not significantly different from dry seasons' (Wet season median predation 0.0 cattle, mean 0.36 cattle; dry season median 0.0 cattle, mean 0.12 cattle, W = 239.5; *df* = 11 and 17; $p = 0.05$). Sheep predation is also not significantly different between seasons (Wet season median predation 0.0 sheep, mean 0.18 sheep; dry season median 0.0 sheep, mean 0.64 sheep, W = 260.0; *df* = 11 and 17; $p = 0.05$). Only at $p = 0.25$ does sheep predation differ between seasons. No incidences of goat, horse or donkey predation were reported for the observation period.

During the wet seasons, leopard in the Gweta area are likely to depend on juveniles of wildebeest, zebra and cattle, small stock and resident small wild herbivores. These patterns have been found to occur in habitats where leopard occur, notable by Bothma & Le Riche[36] in the Kalahari desert (Botswana), Le Roux & Skinner[37] in Londolozi Game Reserve (South Africa), Kruuk & Turner[38] in the Serengeti area (East Africa) and Kruuk[39] (a general review). Wildebeest and zebra are, however, plains animals while leopard are undercover hunters - reducing the dependence of leopard on these herbivores. Leopard prey reduces to juveniles of cattle, adult small stock and resident small-sized wild herbivores. During the dry seasons when calving in cattle reduces significantly and wild herbivore juvenile prey emigrates to the Boteti river, leopard prey is likely to shift to small stock - hence the shifts noted in Figure 23. It is not clear why the shift to small stock is manifested on sheep which are less abundant than goats. This is a possible preference of sheep to goat by leopard - the only indication so far of possible differences in preferences between goats and sheep. Mizutani[35] reveals similar patterns in Kenya where leopard preyed on young calves and small stock (specifically sheep).

With no significant seasonal differences for cattle predation and for sheep predation (at $p = 0.05$), increases in wild herbivore prey in Gweta are not anticipated to reduce livestock predation, especially since leopard prey mostly on smaller herbivore species which are not involved in major seasonal migrations.

3.2.2.5. Predation by Wild dog

Domestic herbivore prey for wild dog during wet seasons consisted of donkeys (80%) and goats (20%), while predation in dry seasons was dominated by cattle (55%), goats (27%) and donkeys (18%) (see Figure 24).

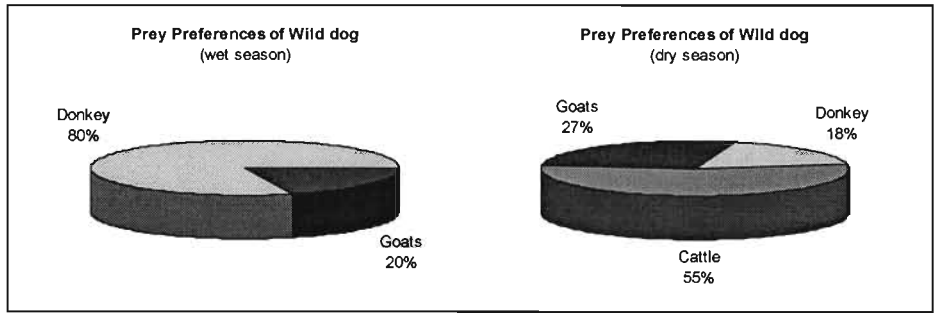


Figure 24: Proportionate prey preferences of wild dog at Gweta, 1994-96.

Goat predation during wet seasons is not significantly different from dry seasons' (Wet season median predation 0.0 goat, mean 0.09 goat; dry season median 0.0 goat, mean 0.35 goat, W = 261.0; *df* = 11 and 17; $p = 0.05$). Donkey predation by wild dog during wet seasons is not significantly different from dry seasons' (Wet season median predation 0.0 donkey, mean 0.09 donkey; dry season median 0.0 donkey, mean 0.41 donkey, W = 266.5; *df* = 11 and 17; $p = 0.05$). Horses and sheep were not preyed on at all. Cattle predation could not be evaluated by the Mann-Whitney test because no predation occurred in the wet seasons.

Hunting times of wild dog have been sighted as reason for their low breeding success. Fuller & Kat[47] attribute the insignificant position of wild dog in livestock predation in Masai pastoral communities (Kenya) to the predator's hunting times and the herding methods of Masai. Wild dog hunt during the early hours of the mornings and late afternoons[41,40,47], and the Masai keep their livestock in enclosures overnight and maintain permanent herders at grazing fields during the day[47]. This means that livestock are only found outside their enclosures during times when wild dog are not hunting. Human presence was noted by Mizutani[35] in central Kenya and Oli *et. al.*[51] in Nepal, as a factor reducing incidences of livestock predation. Wild dog predation patterns in Gweta can therefore be attributed to (i) low densities of the predator, (ii) hunting times which are not synchronised with livestock availability and (iii) herder presence. Herder presence may be contributing less than the other two factors in Gweta and Khumaga taking into account the low labour inputs prevalent in Botswana's cattle-post system. However,

during the dry seasons, cattle receive even less attention since they produce less milk, are not required for drought labour and need more time to graze (poor pasture conditions). Cattle spend fewer nights in enclosures during dry seasons. With no significant differences between wet and dry season predation levels (in exception of cattle), decreases in wild herbivore prey available to wild dog in Gweta appear to impact only on cattle predation, because this occurs at the time when cattle receive less attention.

3.2.3. Economics of Livestock Predation in Gweta

The role of livestock in the economy of Gweta is determined partially by livestock predation. The relationship between livestock predation, sale frequencies and farmers' livestock endowment is investigated below. Institutional arrangements indicated in Table 3 (p.52) influence the unit prices of each livestock type in a similar way to those of Khumaga.

3.2.3.1. Influence of Herd Size on Predation Levels

Losses due to livestock predation and their associated monetary equivalents are shown in Table 8 (divided into category of farmer) and in Table 10 (p.80) (divided into centres of sale).

Calculations of monetary losses are based on the unit price of each livestock type (p.3) and are thus a product of numbers of livestock and the unit selling price. Goat and donkey predation is concentrated in the lower farmer categories (A and B), cattle in upper middle categories D and E and horses in the upper categories (E and F).

Proximity to the national park has been acknowledged as a likely source of variation in predation levels, though the significance of this factor has not been covered in this survey.

Table 8: Economic characteristics of pastoral farming in Gweta.

Farmer Category	Type of Livestock	Total Preyed on	Average	Total Sold	Average
A	Cattle	0	0.00	0	0.00
	Horse	0	0.00	0	0.00
	Sheep	0	0.00	0	0.00
	Goat	0	0.00	0	0.00
	Donkey	0	0.00	0	0.00
B	Cattle	1	1.00	9	4.50
	Horse	2	2.00	0	0.00
	Sheep	0	0.00	0	0.00
	Goat	31	31.00	0	0.00
	Donkey	5	2.50	0	0.00
C	Cattle	0	0.00	0	0.00
	Horse	0	0.00	0	0.00
	Sheep	0	0.00	0	0.00
	Goat	7	7.00	3	3.00
	Donkey	0	0.00	0	0.00
D	Cattle	0	0.00	0	0.00
	Horse	0	0.00	0	0.00
	Sheep	5	5.00	0	0.00
	Goat	22	7.33	0	0.00
	Donkey	3	3.00	0	0.00
E	Cattle	17	5.67	47	7.83
	Horse	3	1.00	0	0.00
	Sheep	19	6.33	0	0.00
	Goat	48	6.86	15	5.00
	Donkey	0	0.00	0	0.00
F	Cattle	2	1.00	63	2.74
	Horse	2	2.00	0	0.00
	Sheep	0	0.00	0	0.00
	Goat	12	6.00	21	0.91
	Donkey	1	1.00	0	0.00

Figure 25 illustrates the endowment-predation relationship for livestock in Gweta. There is no significant linear relationship between cattle predation and livestock endowment ($\beta = 0.007$, $t = 0.747$; $df = 22$; $p = 0.05$). At $p = 0.05$, 54% of the variation in cattle predation can be attributed to variation in livestock endowment.

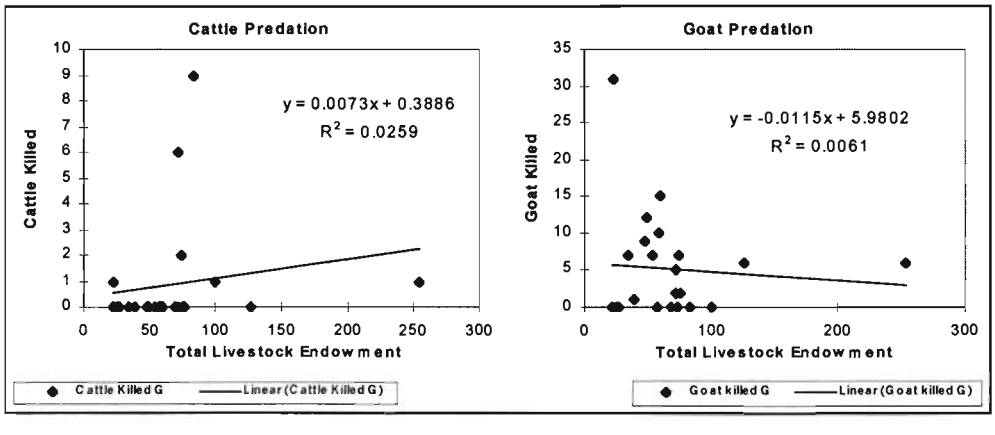


Figure 25: Estimated relationship between livestock predation and total livestock endowment for Gweta.

Bell[2] found a close inverse relationship between labour input and degree of crop damage by elephants in fields in Malawi. A similar relationship is likely to be true for livestock predation in Gweta. With the more sophisticated community of Gweta (compared with Khumaga), there could be more permanent labour relations between farmers of higher livestock endowment categories and employed herders, leading to greater responsibility for such herders. Participant observations revealed that were more permanent-residence structures within cattle-posts of Gweta and more labour available for livestock care. Though no definite age-group determinations were recorded for each family during this survey, families residing at cattle-posts in the Gweta area appeared much younger than those of Khumaga. This may be a contributing factor to lower predation intensities in Gweta since younger herders are likely to herd more actively.

Goat predation in Gweta did not significantly vary with livestock endowment (β = -0.012, t = -0.359; df = 22; p = 0.05). Only 28% of the variation in goat endowment could be attributed to variations in livestock endowment (see Figure 25). This situation is likely to be influenced by the same conditions of labour relations and population age structure as for cattle predation. There appear to be higher losses at lower livestock endowment categories, which if the above factors hold, could explain the importance of improved supervision to reduce goat predation.

Donkey predation did not significantly vary with livestock endowment (β = -0.001, t = -0.128; df = 22; p = 0.05). Only 10% of the variation in donkey predation could be attributed to variations in livestock endowment. This could be an indication of a much higher role of donkeys in daily activities in Gweta's cattle-posts as compared to Khumaga. From participant observations, Gweta cattle-posts were found to be far away from Gweta village, warranting reliable local transport. Most cattle-posts obtained their drinking water from hand-dug wells within one kilometre, and others used donkeys-drawn carts to transport water. Unlike in Khumaga where cattle-posts are located along the river and water is collected with buckets, Gweta

has more use for donkeys in transportation of water. It is thus likely that donkeys are kept proximal to the compounds, a practice which, as observed by Mizutani[35] and Oli[51] can reduce predation levels.

3.2.3.2. Influence of Herd Size on Live Sales

Livestock sales, especially in rural pastoral communities such as those of Gweta, depend on both economic and socio-political factors. Of immediate concern is the need for a breeding nucleus within the herd and the basic needs which are met by the utility of livestock. The impact of livestock predation on these requirements is more pronounced than the impact of the frequency of sales. This conceptual frame-work is the basis for modelling predation-free sales, i.e. what the frequency of sales would be for the different livestock types if there was no predation. Live sales would be an obvious economic option for all the farmers compared to mortalities associated with overstocking (Mpatwa, pers. comm. 1996[§§§]).

The relationship between livestock endowment and livestock sales is explored in Figure 26 for both cattle and goats (note that sheep, donkeys and horses do not have major sales levels). There is no significant positive linear relationship between cattle sales in Gweta and livestock endowment (β = 0.016, t = 0.655; df = 22; p = 0.05). Forty eight percent (48%) of the variation in cattle sales could be attributed to variations in livestock endowment. Goat sales in Gweta did not significantly vary with livestock endowment (β = 0.002, t = 0.202; df = 22; p = 0.05). Only 16% of the variation in goat sales could be attributed to variations in livestock endowment. Unlike in Khumaga, there is no significant positive relationship between cattle sales and total livestock endowment in Gweta. The 48% variation in cattle sales (compared with 16% for goat sales) attributed to variations in livestock endowment may still be indicative of the market bias towards cattle associated with the EC preferential import subsidies for

[§§§] Mrs Kanyana Mpatwa. Cattlepost owner at Marotobolo, Khumaga, Botswana.

Botswana beef and GoB emphasis on cattle production, backed by the higher utility of cattle (see Table 9, p. 79).

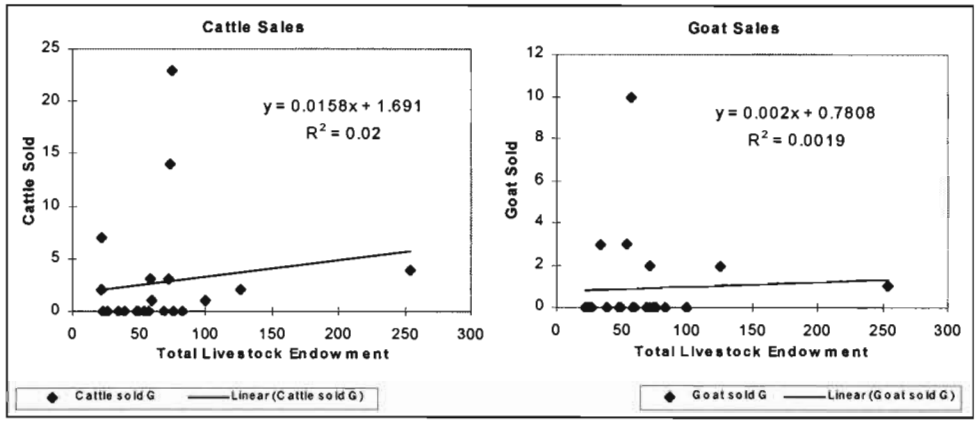


Figure 26: Estimated relationship between livestock sales and total livestock endowment in Gweta.

Higher cattle endowments transform into money more easily and efficiently than other livestock types. This is to be expected since the marketing network is most geared for cattle and the bulk of the subsidised services benefit cattle more than other livestock types. Services provided by GoB (see page 57) are a major economic incentive for livestock owners to produce cattle. Deloitte & Touché Tohmatsu International[114] point out that tax evasion is a perverse incentive since it does not encourage speedy turnover in the livestock industry, instead it encourages livestock owners who have other economic means to keep livestock even to the detriment of the grazing pastures and other livestock owners who directly depend on livestock for a living.

3.2.3.3. Livestock-related Utility and Livestock Endowment

A summary of livestock predation for Gweta in Table 9 shows (i) livestock endowment; (ii) services and goods obtained from each type of livestock; (iii) number of live sales for the year 1996; and (iv) centres of livestock sale. As in Khumaga (see Table 6, p.58), more goats are lost to predators than any other livestock type. However, farmer-specific data in Figure 11 (p.54) and Figure 25 (p.75) indicate that cattle predation increases with livestock

endowment at a higher rate than goat predation. On aggregate (see Table 9), cattle are the least affected in proportionate terms.

Goat sales are conducted mostly at the Gweta Kgotla (Local-G) while cattle sales are conducted mostly at Gweta BLDC. The BLDC, (like the Khumaga Co-operative) is more institutionalised than the Kgotla and so attracts sales for cattle. As indicated in Table 8 (p.75), losses of equines and cattle represent utility-related loss mostly of milk and draught power, while loss of goats and donkeys represent a loss of meat and skins, and draught power utility, respectively.

Table 9: Summary of livestock predation implications for Gweta.

Type of Livestock	Livestock Endowment (predation-free)	Most Frequently Used Centre	Livestock Killed	Percentage Livestock Killed	Compensation Due (US$)	Utility of Livestock
Cattle	777	BLDC-Gweta	20	2.6	2,643.20	Draught power, milk, meat & skin.
Horse	44	N/A	7	15.9	925.12	Draught power
Sheep	136	N/A	24	17.6	3,171.84	Meat & skin.
Goat	632	Local-Gweta	120	19.0	15,859.20	Meat & skin.
Donkey	120	N/A	16	13.3	2,114.56	Draught power
Totals	1709		187		24,713.92	

Livestock predation has large impacts on farmers of lower livestock endowment categories both in Khumaga and Gweta. This is shown by the high losses in goat, sheep and donkeys. These three livestock types are important economically more for their utility than as sources of cash. Even in monetary terms, goat owners are affected more than cattle owners. Table 9 shows up to US$ 16,000 due in compensations for lost goats to predators in comparison to less than US$ 3,000 for cattle.

3.2.3.4. Predation Free Simulations and Sale Centres

Assumptions similar to the Khumaga study (see page 59) were used to simulate the frequency of live sales under nil predation. Financial gains from sales have been calculated on the basis of the unit prices for different livestock types and specific for each livestock type as shown in Appendix 6 (p.125). Results are shown in Table 10 and further broken down by livestock type in Figure 27. Goat sales are highly localised while cattle sales are

conducted at three different markets, the most popular being the Gweta BLDC (BLDC-G), followed by Gweta local sales (Local-G), Gweta Consumers Co-operative (Coop-G) and Maun BMC (BMC-M).

Table 10: Comparison of financial gains from livestock without and with predation for Gweta, 1996.

Livestock Type	Centre of Sale	Without Predation	With Predation	Deficit
Cattle	BLDC-G	5027.72	4872.00	155.72
	BMC-M	0.00	0.00	0.00
	Coop-G	4078.92	1232.00	2846.92
	Local-G	6081.30	5969.60	111.70
Sub-Totals		15187.93	12073.60	3114.33
Goat	Local-G	1128.31	999.60	128.71
Sub-Totals		1128.31	999.60	128.71
Totals		16316.24	13073.20	3243.04

All farmers who sold to the above markets had predation-free sales higher than predation-influenced sales, except for those that sold to Coop-G.

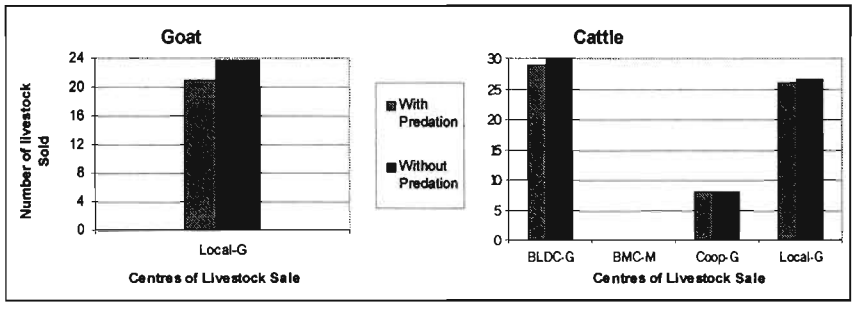


Figure 27: Comparison of livestock sales assuming predation-free sales for goats and cattle in Gweta.

Farmers that sold to Coop-G experienced no predation. Farmers that had sold to BLDC-G and Local-G also experienced reduction in sales. No specific relationship emerges from the results, probably due to the wide spectrum of factors that could lead to predation differences between farmers who had sold to different centres.

3.3. Characteristics of the PAC System

The system of PAC and compensation at Khumaga and Gweta is similar to that used in all villages in Botswana where damage to crops and livestock is prevalent. This section reports on the nature of the institution that oversees PAC and the financial implications to government.

3.3.1. Institutional Characteristics

The PAC programme in Botswana is the prerogative of the DWNP through its PAC unit which operates by way of "satellite" personnel establishments in main population centres such as Maun, Francistown, Serowe, Tsabong and Kasane. Such personnel receive high level training to enable them to:

- respond promptly to PAC reports;
- competently make decisions as to the approach needed for a particular problem animal (could involve trapping, relocation, threatening, or killing);
- assess circumstances surrounding the damage caused and recommend payment or non-payment of compensation;
- advise farmers on ways of minimising chances of attacks and continuously follow-up and monitor the impact of recommended steps.

In more remote villages, especially those bordering national parks and game reserves, PAC is carried out by officers of the nearest protected areas. These officers receive minimal training and most have only been told by long-serving fellow officers what is to be done. Participant observations during the field-work have revealed low levels of competence as regards procedures for assessment of damages and advisory services to be given to farmers. Most officers had no formal knowledge of taxidermy, the use of traps, fireworks and firearms. Very few of the techniques developed by Bowland[22], Roberts[46], Rowe-Rowe[126] and Wade & Bowns[127] for identification of predator types causing damage appeared to be known to these officers. In addition to training limitations at remote stations, transport was another major limitation, since most of the vehicles allocated to a station spent several weeks at the maintenance workshop.

The issue of taxidermy deserves special mention because of what farmers see as a major resource that has been taken off their hands. None of the farmers in Khumaga

and Gweta villages showed any knowledge of the value of these trophies to government once they (farmers) have surrendered them to GoB. These trophies are collected by DWNP staff from farmers, registered and handed over (to Store Keepers) in accordance with procedures prescribed by the Ministry of Finance and Development Planning's Department of Supplies. Their sale is the duty of personnel specially appointed by the Ministry of Finance and Development Planning's Department of the Auditor General to collect government revenue - following recommendation from DWNP. The DWNP officers are not trained to process skins and other trophies for storage. It is not clear (from an operational perspective) which department is charged with ensuring proper storage of trophies. The result is that skins lose their value (due to improper treatment and storage) between the time when they are surrendered to DWNP field officers and when they are sold by public auction.

Khumaga village is served by a DWNP remote office across the Boteti river. In order for compensation to be considered, farmers have to report the damages to the DWNP office. It is not clear whether the carrion should be brought along or will be found at the site by the assessing officer. Most farmers quoted their inability to transport carrion to the DWNP office as the reason for not having reported some of the damages. Predation reports are compiled and stored until a vehicle is available, at which time all pending assessments will be carried out. This is usually self-defeating because the spoors of problem animals implicated would be erased by wind, rain and/or other spoors. It also becomes difficult to diagnose the predator involved from the skin bites or the manner in which the carcass was fed-on once such a carcass has been fed on by scavengers.

In Gweta, problem animal incidences are reported at the Gweta police station as soon as they occur. PAC officers from Francistown come to Gweta on a tour that involves other villages and commercial farms to collect these reports, do assessments and fill compensation claim forms to be submitted back to the Francistown office. Francistown is also affected by transport delays. Disadvantages of delayed assessments of damages apply even more strongly to Gweta since Francistown is over 300 km from Gweta and such tours are taken at the most once a

month. Only in emergencies (such as elephant intrusions from CNP through Nxai Pan National Park) are staff from Makgadikgadi camp engaged. Makgadikgadi camp is less than 100 km from Gweta village. The rationale for engaging Francistown staff is that they belong to the PAC unit (even though some of these officers have not received any formal training), and that staff from Makgadikgadi camp are under DWNP's Parks & Reserves Division, hence have a different mandate. The irony of this arrangement is magnified by the fact that staff of the same Parks & Reserves Division carry out PAC duties at Khumaga village (from Makgadikgadi Pans National Park), Cacaba and Khwai villages (from Moremi Game Reserve), and Khudumelatswe and Letlhakeng villages (from Khutse Game Reserve).

3.3.2. Financial Characteristics

Compensation by livestock type (based on rates stated on page 3), firearms and ammunition used in predator control, vehicle mileage and personnel emoluments are the most immediate costs borne by DWNP in predator control. The cost of firearms and ammunition, vehicle operation, and personnel emoluments used to calculate operational costs of PAC are based on work previously done on costing the hunting of wildlife for rations by protected area management staff in Botswana's national parks and game reserves[128]. Figure 28 summarises the costs for Khumaga and Gweta. It was not easy to separate the two because of the joint management approach in PAC for these two villages. There are no audit records specific to any one of the two villages. Instead, the entire district budget includes expenditure for other protected areas within the district, namely Nxai Pan National Park and Moremi Game Reserve. On the basis of the relative predation figures for Gweta and Khumaga, a 1:1.8 ratio of costs has been applied to cost estimates of Khumaga DWNP office PAC activities to get an estimate for Gweta. The vehicle-running costs ratio, however, was 1.86:1 on the basis of distances involved in the case of Gweta because staff attending reports on a monthly basis there do so from Francistown (see Figure 1, p.8).

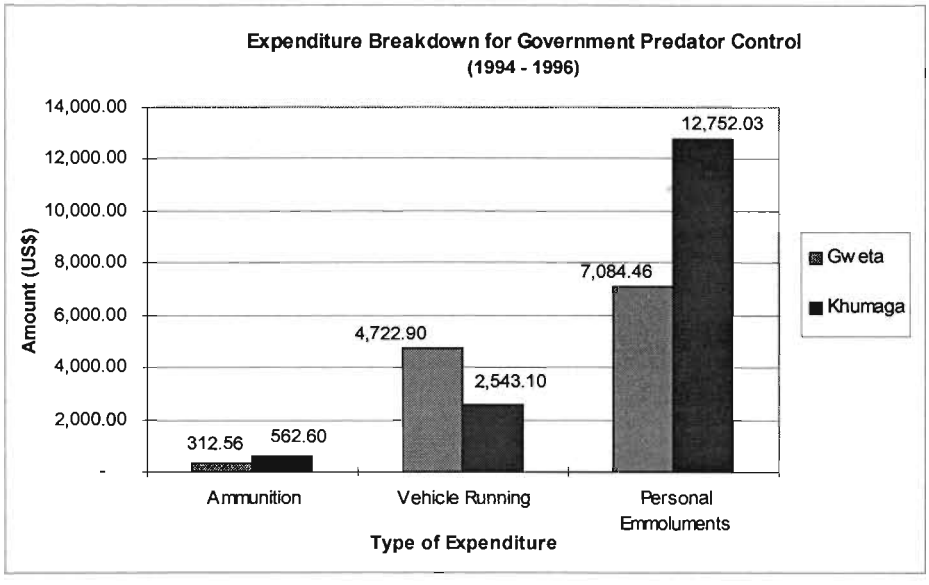


Figure 28: State expenditure on predator control less capital and institutional costs.

The PAC costs borne by DWNP, at current levels, are considered by farmers as insufficient and not seen to be reducing predator mortality, increasing rural income or reducing livestock losses. Increasing DWNP costs beyond the current levels and under the same institutional arrangements would not be economic, noting that the cost of inputs in livestock production in pastoral farming areas bordering protected areas also include Ministry of Agriculture's recurrent and development costs (see Appendix 2 and Appendix 3, p. 121). In agricultural areas bordering Moremi Game Reserve and Chobe National Park, studies by Parry & Campbell[10] and Polet[75] confirm discontent amongst farming communities at no consideration of the current PAC efforts by DWNP. It seems unlikely that an increase in these costs will change these perceptions even for Khumaga and Gweta, especially in light of the fact that in Parry & Campbell's[10] study, people who had interacted with DWNP had a less positive opinion about it than those who had not.

CHAPTER 4 : CONCLUSION

Patterns of Livestock Predation

Patterns of livestock predation varied by livestock type and season for both Khumaga and Gweta. Intensities of livestock predation also varied between the two villages.

Khumaga

Livestock predation was higher in wet seasons than dry seasons in Khumaga due to predator response to decreases in wild herbivore prey during wet seasons as wildebeest and zebra emigrate to the north-eastern plains of Makgadikgadi Pans National Park and the northern fringes of Makgadikgadi salt pans. Goats were preyed on more than any other livestock type during the wet seasons while cattle were the main prey in the dry seasons.

Lion were the main wet season predators for all livestock types in Khumaga. Only during the dry seasons did goat predation by Nile crocodile exceed that by lion. Goats were more vulnerable to predation by all predator species considered, with reductions in lion wild herbivore prey in Khumaga during the wet seasons resulting in an increase in goat predation. Cheetah, leopard and wild dog were less of a threat as predators in Khumaga. Crocodile predation on cattle increased during the wet seasons as a result of increased metabolism and consumption rate of these predators associated with warm weather. Though no accurate mammalian predator census exists for any of Botswana's protected areas, there appeared to be fewer leopard, cheetah and wild dog than lion, spotted hyena and black-backed jackal. Lion, crocodile, spotted hyena and black-backed jackal require more active management than other predators considered in this study.

Prey preferences of the different predators established in this study result from the relationship between predator body size and prey body size. Notably, lion had much higher upper limits in terms of body size of prey and therefore preyed on all livestock types. Leopard preyed on goats and young calves; black-backed jackal preyed on goats, and crocodile on goats and cattle. Spotted hyena preyed on cattle,

goats and donkeys. Hunting system of spotted hyena makes it possible to prey on cattle. Goats are preyed more than donkeys due to their relative abundance.

Gweta

Predation levels in Gweta appeared lower than those of Khumaga. Nile crocodile is a major contributor to goat and cattle predation in Khumaga, but do not occur in Gweta. Livestock predation in Gweta is highest during the dry seasons, in contrast to Khumaga where predation in highest during the wet seasons. Gweta is one of the wet season migration destinations of wildebeest and zebra. This explains the low predation levels on livestock during this period. The lower livestock predation levels in Gweta are attributed to age structure of herders in Gweta and more permanent residence (depicted by housing). With the drying up of the Boteti river, the significance of large wild herbivores migrations may decline.

Predator-prey preferences of lion, spotted hyena, black-backed jackal, leopard and wild dog were similar in both Khumaga and Gweta. Lion were the main predators only on donkeys and horses. This is attributed to the higher relative abundance of the equines in Gweta as compared to in Khumaga. Black-backed jackal were the main predator on goats and sheep. The presence of juvenile wildebeest and zebra during the wet season (noting predator-prey preferences) support a black-backed jackal population which during the dry seasons depends on small stock (goats and sheep).

Economic Impacts of Livestock Predation

Khumaga

Livestock predation in Khumaga accounts for an estimated 8.8% reduction in projected annual returns from predation-free live sales and additional losses due to lost utility from a herd, especially to farmers with lower livestock endowment. Compensation claims payable to Khumaga village are over US$82, 000 per annum, few of which have been paid since 1994. This figure may be an under-estimate because farmers lack the incentive to submit claims since so few other people have been paid and the delays are considerable.

Cattle predation increased with total livestock endowment, a phenomenon attributed to the different management systems employed by farmers of the high and low livestock endowment categories. The level of care in high livestock endowment systems was lower since direct responsibility was being shifted from owner to herder without a proper system of incentives for the latter. For all other livestock types, predation did not increase with livestock endowment.

Gweta

Livestock predation in Gweta accounts for about a 3.1% reduction in projected annual returns from predation-free sales of livestock, and additional losses in the utility derived from live animals (mainly milk and draught power). This leads to lower production levels in the arable farming sector (although unreliable rainfall is another major factor). The issue of compensation for wildlife-induced crop damage and livestock predation in Gweta has a different set of problems, though they also lead to a loss of income to farmers through pending payments. The costs borne by DWNP in predator control, even though only a part of the total expenses do not seem to achieve a reduction in livestock predation and predator mortality much wanted by farmers. Vehicle-running costs incurred due to PAC officers travelling from Francistown to assess damage in Gweta are costs that farmers do not see as being to their benefit, as are other costs which are more institutional in nature. Only a small proportion of the DWNP PAC costs can be regarded (especially by farmers) as "well spent".

Only 3% (Khumaga) and 2.3% (Gweta) of the sample farmers reported no knowledge of the possibility of being compensated for wildlife-induced damages. Due to this and the fact that utility derived from livestock (especially at low livestock endowment categories) may outweigh the option of live sales, livestock predation in Khumaga represents an irrecoverable cost to farmers.

Institutional and Financial Implications of Predator Control

With DWNP spending in excess of US$18,000 per annum (over 1994-1996) only on transport, personal emoluments and ammunition, there should be a satisfactory state of predator control. From the surveys in Khumaga and Gweta, this does not appear to be the

case. Costs such as those of vehicle running and staff time associated with Francistown staff having to attend PAC reports at Gweta do not serve the immediate interest of the farming communities. Participant observations reveal great resentment to DWNP's lack of concern about livestock predation. Delays in compensation are more likely to reduce the credibility of DWNP, especially since farmers believe that livestock predation has gone out of control from the time it became a purely government prerogative.

A review of case studies from elsewhere in the world shows a major disparity between practices there and the DWNP in terms of the approach to predator control. Costs borne by governments of these nations focus more on community support to enable them to manage predators better within their pastoral areas, and to derive financial benefits from the existence of predators. This approach is lacking from the farmers' view-point in the Botswana study areas.

Change in Society and Pastoralism

Changes occurring within the Botswana society such as more available transport, medical and educational services have impacted on several of the traditional management systems, mainly through a change in societal values and economic opportunities. In traditional pastoral systems, participant observations show a decline in rural labour as children went to school and young men to urban centres to find wage employment. This leaves the care of livestock to elderly members of families or employed herders where livestock numbers warrant. Absence of herding personnel is one of the reasons why predation levels have escalated.

This situation requires that absentee herders be more involved in the care of their livestock through providing money required for cash labour and such wages be proportional to the amount of care accorded the livestock by the herder. An improvement in accessibility of markets is likely to improve the financial turnover and hence reduce the need for young men to leave rural areas in search of cash labour.

CHAPTER 5 : RECOMMENDATIONS AND MANAGEMENT OPTIONS

Management options discussed below for reducing livestock losses due to predation are based on analysis of empirical data and informal discussions held with the farmers during field work. The main emphasis is on establishing or strengthening (where possible) community-based institutions to reduce livestock predation and predator mortality, while at the same time generating income from predators within pastoral areas of Khumaga and Gweta. This study also identifies information deficiencies within the system of managing problem animals, most of which are listed under Adaptive Management Requirements (p.97). The study acknowledges the differences between the current predator control management system in Botswana and what farmers would like both in the interest of pastoral farming and the well-being of wildlife. The current system of predator control has, in practice, excluded farmers from the responsibility of active involvement in policy, systems and practice regarding predator control. It is recommended that a two-phase approach be adopted to improve predator management.

Phase One

Pro-active Approach to Predator Control

With knowledge about the seasonal differences in livestock predation levels and the impacts of the respective predators, allocation of human resources, transport and firearms needs to respond to these cycles. In Khumaga, such resources required to minimise the impact of crocodile predation (particularly on goats) must be made available on a full time basis. For lion, leopard and spotted hyena, appropriate resource allocations need to be made for the wet seasons when predation on livestock increases; for cheetah and wild dog, no resources other than those required for day-to-day PAC operations appear necessary. In Gweta, appropriate resource allocations for dry seasons are required to minimise increasing predation levels by lion, black-backed jackal and spotted hyena. Leopard and wild dog predation on their respective domestic herbivore prey do not change with seasons, hence a constant availability of resources is necessary.

Responsive Compensation Procedures

Given the seasonal patterns of predation established during the year and the factors from other pastoral communities that influence fluctuation of predation, the inflow of claims for compensation will increase in response to increased livestock predation. Streamlining the procedure for compensation claims, especially reducing the size of committees assessing the claim forms, is essential. It is necessary that the amount of PAC effort (in person-hours) be increased to handle the increasing number of reports at Gweta during the dry seasons and at Khumaga during the wet seasons. A similar response pattern will be required at the offices that process application forms for compensations from Gweta and Khumaga, respectively. Existing staff could be assigned to help reduce the back-log in the processing of compensation claim forms to prevent accumulation and delays of such payments. Through this, DWNP can improve its image and the efficiency of its PAC efforts (i.e. directing efforts to where they are needed most) and farmers can benefit from a more responsive PAC system and timely compensations, especially since the value of these compensations is not adjusted for inflation. PAC must be made an integral part of the training that all the officers have to undergo before joining the DWNP.

Competent Work-force

Assessment of damage for compensation purposes involves an understanding of the circumstances under which stock was killed and the amount of effort invested by the farmer to prevent stock loss. Where efforts to prevent livestock from being preyed on are absent or lacking, compensation may not be awarded and the assessing officer must advise the farmer on ways to prevent re-occurrences. Participant observations revealed that minimum time is spent by officers doing assessments with little information on which to base management decisions. This requirement by Act of Parliament is largely ignored in both Khumaga and Gweta as there are;

- no accurate records of the different incidences and the farmers involved;
- no re-visits to establish the effectiveness of advice given to the farmers;
- no kraal-type specifications on the basis of intensities of predator intrusions into kraals.

Proper training on the above aspects to all officers that have to conduct PAC assessments is critical to having a work-force competent enough to reduce the costs to GoB on compensations, reduce costs to farmers, improve the quality of information required for management decisions and revive DWNP's image in rural pastoral communities. A specialised training module could be developed on the basis of the existing PAC training manual which caters only for PAC officers (for which there is less than twenty nation wide).

Improved trophy management is not easily achievable in view of its complexity within a government structure which involves several ministries and departments, all of which confer it different degrees of urgency (see page 81). The sooner the initiation of a community-based PAC approach, the better, considering the amount of money being lost through improper handling and storage of trophies. The view-point that trophies represent an economic support for community-based PAC is the basis for phase two recommendations.

Phase Two

The following recommendations are motivated by the findings that (i) costs of state-run PAC is higher than the compensation rates, (ii) trophies lose their value through the way government handles them, (iii) more money is spent on institutional costs than actual PAC and (iv) compensation system does not take into account the level of care by the farmer and the loss of utility.

Changing the Rights to Own Predators

Predators impose costs on farmers practising pastoral farming in Khumaga and Gweta. Some form of predator ownership could give farmers a chance to consider these predators as resources which, if properly utilised, could improve household welfare. This step requires legal support for the collective decisions made with regards to predators by farmers. Legitimate and democratic representation of community ideas, jurisdiction over wildlife utilisation and tenure of land are some of the aspects which will need backing of policy and legislation. Such support will be difficult to obtain because control of land, water, trees, fish and other animals is vested with different government departments and ministries - complicating the negotiating process for appropriate administrative arrangements necessary to adapt

policy to new approaches. If having predators in the tribal areas of Khumaga and Gweta improves the welfare of the inhabitants significantly, long term economic success of both the pastoral system and predators will be promoted.

Each community faced with high losses of livestock to predators needs to be able to make decisions on management of predators. This implies a need for clear rights to (i) establishing annual predator off-take, (ii) ownership and disposal of trophies accruing from predator management, (iii) use of agreed portions of communal land for safari hunting in pursuit of the "predator sink" practice, (iv) ownership of rifles and ammunition for predator control and (v) establishing criteria for payment of compensations to farmers through a Representative and Accountable Legal Entity (RALE).

There will therefore need to be facilitation exercises to introduce the farming communities to these concepts and options available. Willingness by farmers to be involved in this exercise has been detected during oral interviews. Most farmers are not satisfied of the current legal arrangements which preclude them from active involvement in predator control. No precedents have been set anywhere in Botswana and the Khumaga-Gweta initiative will be a good example in line with the current devolution of user rights to rural communities directly depending on or interacting with wildlife. Notable examples are communities of the Chobe Enclave and Sankuyo village.

Increasing Capacity of Rural Communities to Deal with Predators

DWNP's community liaison programme should be extended to include the strengthening of local communities' capacity to deal with problem animals. Although most of the irregularities in PAC are less directly related to under-staffing than to mis-direction of resources, this study acknowledges lack of human resources facing DWNP in general. This study however sees DWNP as a co-ordinating body because of its legal mandate - allowing it to co-opt NGOs well equipped to carry out capacity building. This process will require integration of contemporary methods such as the use of thunder-flashes and firearms, as well as indigenous methods such as snaring, trapping and hunting with poisoned arrows. Snaring and

trapping will require more specificity to ensure that non-target species are not affected. This can be done if local inhabitants' knowledge of the behaviour of different species is utilised.

Adjustments to the Legal Framework

There is currently no legal framework for community-based PAC. Registration of firearms, permits to kill problem animals, permits to deal in trophies, authority to use locally affordable and available skills and equipment, and compensation of farmers are not vested with farmers but with government institutions. The WCNP Act gives private individuals the right to kill a problem animal if it is causing damage, but not pro-active responses. Compensation of farmers has major financial implications and will require that there be a community-based income generation activity closely associated with PAC. Community ownership of trophies accruing from PAC could reduce costs associated with PAC where the farmer would pay a fee to the community-based PAC team after the sale of such trophies. The current system of state-ownership of trophies has gained bureaucratic support primarily on the basis of its "false" low requirement for policing. A community-based scenario would genuinely ease policing at village level. State-ownership of trophies, as indicated previously (p.81) has led to acute loss of trophy value (except for ivory) because of lack of skill and incentives for government personnel to process, store and market perishable trophies.

Legitimate Representation

In the establishment of mainstream CBNRM initiatives in other parts of Botswana such as Chobe Enclave and Ngamiland, legitimate representation has been a key requirement to relinquishing some decision-making powers by DWNP. Community Trusts have been an acceptable legitimate representation for these purposes and could be considered to allow Khumaga and Gweta communities to manage predators. Each cattle-post area such as Marotobolo, Dikwalo, etc. in the case Khumaga will need representation in the RALE. Such a member will service the particular cattle-post area and provide prompt decisions in emergency situations.

The RALE for each of the two villages (Khumaga and Gweta) must attain consensus on different opportunities available to them for reducing livestock predation and negotiate their preferred opportunity with other interested parties namely; government (DWNP and Forestry Department, Department of Water Affairs), local authorities (Tribal Land Boards and Council) and the private sector (hunting and photographic tour operators). The RALE also has the important role of distributing the benefits derived from predator control to the different beneficiaries - farmers who incurred losses, farmers most at risk and other members as may be stipulated in their mandate. The aim should be to negate the costs of livestock predation and reduce future occurrences. Some of the proceeds may be invested into protective barriers and relocation of watering points for livestock.

Gweta already has an institution of legal standing - the Gwezotshaa Natural Resources Trust - whose mandate can be extended to include negotiating with relevant government departments for a predator management policy based on the skills and needs of farmers of Gweta. Khumaga will require a DWNP initiated community facilitation aimed at consolidated the aspirations of the farmers into an interim committee for purposes of forming a RALE. Such facilitation capacity is available through DWNP community liaison office, which is currently only concentrating on community-based tourism in areas already zoned for wildlife-based tourism.

The Predator Sink

This section outlines a situation where reduction of predator population size is adopted as a way of reducing chances of predator-livestock interactions. The area within which this occurs is called a predator sink because it constantly creates a lower predator density so that more can come into the area. Botswana Outfitters and Professional Hunters Association[129] (BOPHA) notes four possible objectives for PAC, namely;

- to prevent or reduce damage to crops, livestock, property and human lives by deterring or killing the animals directly involved,
- to prevent or reduce damage by reducing the density of the animals directly involved in damage through live sales or culling,

- to compensate owners for such damage using revenues derived from animals declared as problem animals, and
- to relieve the psychological stress that farmers incurring losses undergo by targeting the actual individual causing damage and traumatising or killing it.

The second and third options suit the situation of livestock predation in Khumaga and Gweta because they are more pragmatic. Few farmers believe that predators can be totally excluded from pastoral areas by means of physical barriers. Observations during this study showed that farmers had been shifting cattle-posts from Gwaraga cattle-post area to other areas such as Khweligcumo and Khumaga village in response to livestock predation. The main push-factor is proximity to MPNP. Since these areas ecologically support a predators, they could be used for small-scale safari hunting, initially marketed through already established hunting companies. Such areas constitute a predator sink through which predators in the area are being continuously removed by PAC (formal and informal), and replaced by those dispersing from areas not subject to PAC, i.e. MPNP and CKGR. Safari hunting could generate income for the community. However, in the sink situation, large trophy males commanding high prices in the safari market would be relatively rare. It will be necessary to promote the lower-priced market for small-trophy predators already existing. Policy issues that need to be resolved prior to involvement of safari hunting in PAC are summarised in Table 11 below.

Table 11 : Policy issues relating to involvement of safari hunting in predator control.

Objective	Approach	Implications
Punish Predators (psychological cosmetics)	Identify the individual predator responsible for the damage, send safari hunter (s) to hunt and kill them.	Hunts can not be marketed in advance with sufficient precision on numbers; hunting will need to be conducted outside the hunting season; guidelines for revenue sharing amongst interested parties.
Reduce Predation on Livestock	Identify patterns and modes of predation, send safari hunter(s) to hunt and kill it.	As above and the exercise has to meet the specific objective of reducing livestock predation.
Earn Revenue to Compensate for Losses	Target specific age groups and sex of predators for hunting at set times of the year, send safari hunters to hunt and kill according to set quota.	Apply for a set quota to be utilised during the hunting season; set guidelines for revenue sharing amongst interested parties.

The approach adopted by the predator management group will depend on the management objectives. Due to the high financial implications of predator

management, especially compensation, the objective should be to earn revenue required to compensate for livestock losses.

Integrating Predator Management into Livestock Management.

Studies in southern African countries by Barnes & Pearce[86] (Botswana) and Child[130] (Zimbabwe) show that hunting safari operations give higher returns per unit area than photographic ones and that both give higher returns than cattle ranching. At present, rural citizens have no incentive to protect or conserve predators that often kill their livestock. Conservation of a predator by rural communities for aesthetic reasons alone in a developing nation with expanding livestock and human populations is difficult. In order to reach a balance between the conservation objective (existence of predators) and the pastoral farming objective (derive utility and income), interested parties will need to set objectives in terms of the acceptable number of predators (by species) based on the acceptable limits to livestock predation. This objective will form the basis of the off-take levels for predators in this farming area.

Re-Focusing of Government Expenditure on Predator Control

Given the large government expenditure on compensation and the dissatisfaction of communities neighbouring protected areas in Botswana, such expenditure does not appear to address the problems faced by pastoral communities. This study notes the high expenses on personnel emoluments for an activity in which the key parties are sidelined. Savings could be made if the bulk of the work is carried out by the farmers, and DWNP plays the role of government of the management regime.

Deficiencies in the system of processing claims and payment prevented farmers from realising the well intended replacement of trophy-ownership with monetary compensation. Costs associated with non-payment warrant establishment of locally-managed PAC assessment committees working on subventions from government and funds raised at local level.

Adaptive Management Requirements

This study has suffered lack of baseline information for firm conclusions to be reached. For purposes of adapting the current PAC system, the following areas of information need to be strengthened:

- proper and standardised documentation of the circumstances under which a particular stock was preyed on;
- statistics of payments and time-frames within which they occur;
- distribution, numbers, age and sex of predators during different times of the year;
- numbers of predators killed, money recovered from the disposal of their trophies and the input costs borne by GoB,
- information on perceptions of predator control, opportunities and prospects for communities neighbouring MPNP,
- spatial patterns of livestock predation.

Without such information, it cannot be concluded if the current compensation was or did benefit the intended beneficiaries; whether shooting of problem animals does reduce crop damage and livestock predation; whether it is less costly for government to possess or even re-possess trophies accruing through PAC and whether there could be less predators being killed through PAC and more revenue accruing through controlled-off-take commercial operations. This philosophy needs to form the basis of a land-use policy for pastoral areas bordering protected areas in Botswana.

It is imperative that losses incurred by pastoral communities be accounted for, especially considering that areas outside MPNP are on communal grazing land and pastoral farming is a legitimate land use. Direct economic benefits from predators which can be offset against losses within a farming system must be considered.

SUMMARY

Livestock predation in rural pastoral communities bordering national parks and game reserves remains a major challenge to contemporary conservation bodies. In Botswana, as in many southern African countries, legislation to regularise systems of predator control has a long history. This legislation now vests the ownership of trophies accruing from predator control with the state, and losses of livestock and crops by farmers are compensated by the state. Despite the financial commitment of the Government of Botswana, the standard of both the compensation scheme and predator control systems employed by the PAC unit of DWNP is still questionable, especially to farmers. These farmers have a very minor role in PAC system design and implementation although this operates within and impacts directly on their economic practices. Human and cattle population increase has been one reason for escalating livestock predation levels, as has the drying up of the Boteti river that separated pastoral areas from MPNP.

Two villages bordering MPNP were selected to study predation patterns and impacts on the basis that each reflected one or both of the factors responsible for the rising livestock predation levels; Khumaga village borders MPNP to the west and is separated from it by the now dry Boteti river. Gweta village borders MPNP to the east and has a cattle-post network which stretches to the currently contentious eastern border of MPNP. With the aim of providing recommendations intended to assist the responsible authorities in reducing livestock predation, reducing predator mortality and increasing economic returns for communities of Khumaga and Gweta, the study;

- assessed and documented patterns of livestock predation,
- assessed the economic impacts of livestock predation in Khumaga and Gweta, and
- documented costs of predator control by government in the two areas.

Past research shows that factors that influence predator-prey interactions include availability of wild prey, means of livestock protection, density of predators and body-size of predator relative to that of prey. The literature review highlights the role of incentives in economic decision-making at community level, and raises the issue of how rural communities can conserve the very predators that threaten their economic well-being and ultimate survival. Current initiatives to devolve the management of wildlife and benefits

accruing therefrom in wildlife areas in southern Africa, including Botswana's NRMP, have been investigated.

Personal interviews with randomly selected heads of households provided data which related livestock losses to livestock sales and to total livestock endowment. Records on livestock predation incidences for Khumaga were obtained from the Khumaga DWNP office, and those for Gweta from the Franscistown DWNP office. The two-year time frame covered by this data set established trends and patterns in predator-livestock interactions. Participant observations revealed the utility status of the different livestock types and predator control system. The Mann-Whitney test was used to identify seasonal differences in livestock predation. Regression analysis was used to determine the degree of interdependence between livestock predation and endowment, and livestock sale and endowment.

In Khumaga, 90 cattle, 136 goats, 4 sheep, 57 donkeys and 6 horses were taken by different species of predators over 1994-96. All livestock types were preyed on more during the wet than dry seasons. Lion preyed on all livestock types but preyed more on goats during the wet seasons. This increase was associated with the emigration of zebra and wildebeest to northern and eastern parts of MPNP, including the northern fringes of Makgadikgadi salt pan. Crocodile preyed consistently on goats and only marginally on cattle during the wet season. This was due to their increased metabolism and food consumption during warm weather. Spotted hyena preyed on cattle, goats and donkeys consistently, and black-backed jackal on goats. Leopard preyed on cattle, goats and donkey, but took only goats during the dry season. A reduction amounting to over 8% of annual returns from livestock sales is attributed to livestock predation. An additional loss of over US$82,000 is represented by pending compensation claims. Predation on cattle increased with increasing livestock endowment but loss of utility was most experienced at lower livestock endowment systems because of high dependence on few stock for milk and draught power.

In Gweta, 91 cattle, 107 goats, 43 sheep, 33 donkeys and 14 horses were preyed on by different species of predators over 1994-96. All livestock types were taken more during the dry than wet seasons. Lion preyed on all livestock types but preyed more on cattle, goats and horses during the dry seasons. This increase coincided with the emigration of zebra and

wildebeest to the Boteti river. Spotted hyena preyed on cattle, goats, sheep and donkeys but more on cattle and goats during the dry seasons. Black-backed jackal preyed only on goats but did so more during the dry seasons. Leopard preyed on cattle and sheep with no seasonally-induced changes. A reduction amounting to over 3% of annual returns from livestock sales is attributed to livestock predation. An additional loss of over US$24,000 is represented by pending compensation claims. Predation on cattle increased with increasing livestock endowment but, for Khumaga, loss of utility was most experienced at lower livestock endowment systems because of high dependence on few stock.

Livestock predation was higher at Khumaga than at Gweta for goats and donkeys. Highest predation occurred during the wet seasons at Khumaga and during the dry seasons at Gweta. Availability of wild herbivore prey contributed to changes in predation on domestic herbivores especially for lion. Crocodile account for increased goat predation at Khumaga, hence the wider margins between goat predation in Khumaga and Gweta. Losses of revenue from pending claims and due to reduction in sales were more pronounced at Khumaga than at Gweta. Management of perishable trophies by DWNP leads to loss of revenue through reduced market value of the trophies. The following are main observations and recommended actions;

- Centralisation of PAC commits GoB to high costs for PAC activities and compensation.
- Data to plan adaptive management is lacking, but evidence available indicates that the current system of PAC is ineffective in reducing losses, compensating for losses or reducing discontent among farmers and the value of trophies is wasted.
- Vehicle operation, personnel effort and equipment should be re-directed to meet seasonal changes in demand for predator control, prompt response to reports from farmers and timely processing of compensation claim forms.
- PAC needs to be reinstated as part of CBNRM initiatives, with ownership of predators returned to communities. Safari hunting as an option, would reduce costs to GoB and should reduce costs to farmers. It may also provide net economic gains hence acting as an incentive to conserve predators.
- There needs to be a predator management policy agreed by all interested parties. It is to entail the objectives of predator management (off-take, trophies and benefits).

REFERENCES
(alphabetical order)

Aboud, A. A. (1989) The Role of Public Involvement in Wildlife-Livestock Conflicts: The Case of Narok Ranchers in Kenya. *Society and Natural Resources.* **2.** (4) p.319-328.

Adams, J. S. & M^{c}Shane, T. O. (1992) *The Myth of Wild Africa - Conservation Without Illusion.* W. W. Norton & Company. London.

Babbie, E. (1992) *The Practice of Social Research.* Wadsworth Publishing Company. 6th ed. California.

Barbier, E. B. (1992) Community-Based Development in Africa. *In*: Swanson, T. M. & Barbier, E. B. (Eds.) *Economics for the Wilds; Wildlife, Diversity and Development.* p.103-135. Island Press. Washington, D.C.

Barbier, E. B. (1992) Economics for the Wilds. *In*: Swanson, T. M. & Barbier, E. B. (Eds.) *Economics for the Wilds; Wildlife, Diversity and Development.* p.15-33. Island Press. Washington, D.C.

Barnes, J. & Pearce, D. W. (1991) *The Mixed Use of Habitats.* Centre for Social and Economic Research on Global Environment. University College of London. London.

Behnke, R. (1982) *Cattle Accumulation and the Commercialisation of the Traditional Livestock Industry in Botswana.* Rural Sociology Unit - Ministry of Agriculture. Gaborone, Botswana.

Behnke, R. (1984) Fenced and Open-range Ranching: The Commercialisation of Pastoral Land and Livestock in Africa. *In:* Simpson, J. & Evangelou, P. (Eds.) *Livestock Development in Subsaharan Africa: Constraints, Prospects, Policy.* p.261-284. Westview Press. Boulder.

Beinart, W. & Coates, P. (1995) *Environment and History: The Taming of Nature in USA and South Africa.* Routledge Publishers. London.

Bell, R. H. V. (1985) *Crop Damage by Elephants in Malawi.* (Unpublished Report). Lilongwe.

Bell, R. H. V. (1987) Conservation with a Human Face: Conflict and Reconciliation in African Land-use Planning. *In*: Anderson, D. & Grove, R (Eds.) *Conservation in Africa, Policies and Practice.* p.79-101. Cambridge University Press. Cambridge.

Bembridge, T. J. (1979) *Problems of Livestock Production in the Black Sates in Southern Africa and Future Strategy.* Published Paper: Annual Conference of Southern African Society for Animal Production. Johannesburg.

Bertram, B. C. (1978) *Pride of Lions.* J. M. Dent & Sons Ltd. London.

Blair-Rains, A. & M^{c}Kay, A. D. (1968) *The Northern State Lands, Botswana Land Resources Division*. Tolworth. Surrey, England.

Bothma, J. & Le Riche, E. A. N. (1982) Prey Preferences and Hunting Efficiency of the Khalahari Desert Leopard (*Panthera pardus*). *In*: Miller, S. D. & Everette, D. D. (Eds.) *Cats of the World: Biology, Conservation and Management*. p.389-414. National Wildlife Federation. Washington, D.C.

Botswana Outfitters and Professional Hunters Association (1997) *The Role of safari Hunting in Problem Animal Control*. (Unpublished Paper). Maun, Botswana.

Botswana Wildlife Training Institute. (1995) *Mission Statement - Botswana Wildlife Training Institute*. (Unpublished) Maun, Botswana.

Bowland, A. E., Mills, M. G. L. & Lawson, D. (1991) *Predators and Farmers*. Endangered Wildlife Trust. Johannesburg.

Brown, L. H. (1971) The Biology of Pastoral Man as a Factor in Conservation. *Wildlife Conservation*. **3.** (2) p.93-100.

Burney, D. A. (1980*) The Effects on Human Activities on Cheetahs (Acinonyx jubatus) in the Mara Region on Kenya*. MSc. Thesis. University of Nairobi. Nairobi.

Campbell, A. (1990) *The Nature of Botswana - A Guide to Conservation and Development.* International Union for the Conservation of Nature. Gland, Switzerland.

Carl Bro International (1982) An Evaluation ofLivestock Management and Production in Botswana (with special reference to communal areas). Govenment of Botswana - Commission of the European Communities. Gaborone, Botswana.

Caro, T. M. & Collins, D. A. (1987) Male Cheetah Social Organization and Territoriality. *Ethology*. **74.** (1) p.52-64.

Central Statistics Office (1992). *Population of Towns, Villages and Associated Localities*. Government Printers, Gaborone.

Child, D. I. (1968) *An Ecological Survey of North-eastern Botswana*. Food and Agricultural Organisation. Rome.

Child, G. (1984) Managing Wildlife for the People of Zimbabwe. *In:* McNeely, J. & Miller, K. (Eds.) *National Park, Conservation & Develpment*. Smithsonian Institute. Washington, DC.

Child, G. (1995) *Wildlife and People: the Zimbabwean Success*. Wisdom Foundation. Harare, Zimbabwe.

Clark, A. & Lubbe, T. (1995) Namibia - Last Outpost for the Cheetah. *African Wildlife*. **49** (5) p.13-14.

Colvin, P.M. (1983) *Welfare Economics and African Pastoralism*. Institute of Natural Resources. Pietermaritzburg.

Cooper, S. M. (1990) The Hunting Behaviour of Spotted Hyeanas (Crocuta crocuta) in a Region Containing Both Sedentary and Migratory Populations of Herbivores. *African Journal of Ecology*. **28.** p.131-141.

Cozza, K., Fico. R., Maria-Luisa, B. & Rogers, E. (1996) The Damage-Conservation Interface Illustrated by Predation on Domestic Livestock in Central Italy. *Biological Conservation.* **78.** p.329-336.

Cumming, D. H. M. (1993) Conservation Issues and Problems in Africa. *In*: Carter, N. & Lewis, D. (Eds.) *Voices from Africa: Local Perspectives on Conservation*. p.23-47. World Wide Fund for Nature. Washington, D.C.

Danckwerts, J. P. (1974) *A Socio-economic Study of Veld Management in the Tribal Areas of Victoria-Province*. Unpublished Report: Department of Agriculture. University of Rhodesia.

Deloitte & Touché Tohmatsu International. (1996) *Financial and Economic Review of Livestock Sector in Botswana*. Government of Botswana-European Commission. Gaborone, Botswana.

Department of Wildlife & National Parks (1995) *Report of the Rations Committee*. (Unpublished Report Prepared for Evaluation of Ration Hunting). Maun, Botswana.

Department of Wildlife & National Parks (1995). *Problem Animal Control Manual: a manual for use by problem animal control officers*. (Unpublished Report) United States Agency for International Development. Gaborone, Botswana.

Department of Wildlife and National Parks. (1995*) Report on Numbers of Wildlife Killed in Protection of Human Life and Property* (Unpublished Report). Maun, Botswana.

Emlen, J. M. (1966) The Role of Time and Energy in Food Preferences. *The American Naturalist.* **100**. (916) p.611-617.

Fiallo, E. A. & Jacobson, S. K. (1995) Local Communities and Protected Areas: Attitudes of Rural Residents Towards Conservation and Machalilla National Park, Ecuador. *Environmental Conservation.* **22.** (3) p.241-249.

Field, D. I. (1978) *A Handbook on the Ecology for Range Management in Botswana*. Ministry of Agriculture. Gaborone, Botswana.

Fielder, R. J. (1973) The Role of Cattle in the Ila Economy. *African Social Research.* **15.** p.327-360.

Fuller, T. K. & Kat, P. W. (1990) Movements, Activity and Prey Relationships of African Wild dogs (*Lycaon pictus*) Near Aitong, Southwestern Kenya. *African Journal of Ecology.* **28.** p.330-350.

Fuller, T. K., Nicholls, T. H. & Kat, P. W. (1995) Prey and Estimated Food Consumption of African Wild Dogs in Kenya. *South African Journal of Wildlife Research.* **25.** (3) p.106-110.

Godoy, R. A. & Bawa, K. S. (1993) The Economic Value and Sustainable Harvest of Plants and Animals fron the Tropical Forest: Assumptions, Hypothesis and Methods. *Economic Botany.* **47.** (3) p.215-219.

Government of Botswana. (1968) *Tribal Land Act (Chapter 32:02) - Laws of Botswana.* Government Printers. Gaborone, Botswana.

Government of British Bechuanaland (1961). *Fauna Conservation Proclamation N°. 23 of 1961.* Cape of Good Hope.

Government of British Bechuanaland. (1891) *Game Law Amendment Act N°. 36 of 1886.* Cape of Good Hope.

HaBarad, J., Dikobe, L. & Gaboiphiwe, J. (1995) Understanding Community Dynamics: Participatory Rural Appraisal and Other Tools for Social Analysis. *In*: Rihoy, L. (Ed.). *The Commons Without the Tragedy - Strategies for Community based Natural Resource Management in Southern Africa (Proceedings of the 1995 Regional NRMP Annual Conference; Kasane; Botswana).* p.128-130. SADC Wildlife Technical Co-ordination Unit. Malawi.

Hall, M. (1987) *The Changing Past: Farmers, Kings and Traders in Southern Africa, 200 - 1860.* David Philip. Cate Town.

Hamilton, P. H. (1982) Status of Cheetah (*Acinonyx jubatus*) in Kenya, with Reference to Sub-Saharan Africa. *In*: Miller, S. D. & Everette, D. D. (Eds.) *Cats of the World: Biology, Conservation and Management.* p.65-76. National Wildlife Federation. Washington, D.C.

Harestad, A. S. & Bunnel, F. L. (1979) Home-range and Body-weight; A Re-evaluation. *Journal of Ecology.* **60** (2). p 389 - 402.

Henschel, J. R. & Skinner, J. D. (1990) The Diet of Spotted Hyaenas *Crocuta crocuta* in Kruger National Park. *African Journal of Ecology.* **28.** p.69-82.

Hetch, S., Norgaard, R. & Possio, G (1988) The Economics of Cattle Ranching in East Amazonia. *Interciencia.* **13.** (15) p.233-239.

Hoare, R. E. & Mackie, C. S. (1993) *Problem Animal Assessment and the Use of Fences to Manage Wildlife in the Communal Lands of Zimbabwe - WWF Multispecies Project Paper No 39.* World Wide Fund for Nature. Harare.

Hoare, R. E. (1992) Present and Future Use of Fencing in the Management of Larger African Mammals. *Environmental Conservation.* **19.** (2) p.160-164.

Hofer, H., East, M. L. & Campbell, K. L. I. (1993) Snares, commuting hyenas and migratory herbivores: humans as predators in the Serengeti. *In*: Dunston, N. & Gorman M. L. (Eds.) *Mammals as Predators: The Proceedings of a Symposium held by The Zoological Society of London and The Mammal Society: London, 22nd and 23rd November 1991.* p.347-366. Claredon Press. Oxford.

Homma, A. K. O. (1992) The Dynamics of Extraction in Amazonia: A Historical Perspective. *In*: Nepstad, D. C. & Schwartzman, S. (Eds.) *Non-Timber Products from Forest Evaluation of a Conservation and Development Strategy.* p.23-33. The New York Botanical Garden. New York.

Hutton, J. M. (1989) Movements, Home Range, Dispersal and the Seperation of Size Classes in Nile Crocodiles. *American Zooligist.* **29**. p.1033-1049.

Hutton, J. M. (1987) Growth and Feeding Ecology of the Nile Crocodile (*Crocodylus niloticus*) at Ngezi, Zimbabwe. *Journal of Animal Ecology.* **56**. p.25-38.

Infield, M. (1988) Attitudes of a Rural Community Towards Conservation and a Local Conservation Area in Natal, South Africa. *Biological Conservation.* **4.** p.21-46.

Infield, M. M. (1986) *Wildlife Utilisation and Attitudes Towards Conservation: A Case Study of the Hluhluwe and Umfolozi Game Reserves in Natal/KwaZulu,* MSc. Thesis, p42. University of Natal, Pietermaritzburg.

Inglis, J. M. (1976) Wet Season Movements of Individual Wildebeests of the Serengeti Migratory herd. *East African Wildlife Journal.* **14**. p 17 - 34.

International Fund for Agricultural Development. (1995) *Common Property Resources and the Rural Poor in Sub-Saharan Africa.* International Fund for Agricultural Development (Special Programme for Sub-Saharan African Countries Affected by Drought and Dessertification). Amsterdam.

International Union for Conservation of Nature. (1992) *The IUCN Review of the Southern Okavango Integrated Water Development Project; Final Report..* International Union for Conservation of Nature and Natural Resources. Gland, Switzerland.

International Union for Conservation of Nature. (1995) *Makgadikgadi Pans Management Plan - Incorporating Makgadikgadi Pans National Park, Nxai Pan National Park and Neighbouring Community Areas and Wildlife Management Areas.*(Unpublished Report) United States Agency for International Development. Gaborone, Botswana.

Kgathi, D. K. & Kalikawe, M. C. (1993) Seasonal Distribution of Zebra and Wildebeest in Makgadikgadi Pans Game Reserve, Botswana. *African Journal of Ecology.* **31**. p.210-219.

Kofron, C. P. (1993) Behaviour of Nile Crocodiles in a Seasonal River in Zimbabwe. *Copeia.* (2) p.463-469.

Kruuk, H. & Turner, M. (1967) Comparative Notes on Predation by Lion, Lepard, Cheetah and Wild dog in the Serengeti Area, East Africa. *Mammalia.* **31.** p.1-27.

Kruuk, H. (1972) *The Spotted Hyeana (Crocuta crocuta): A Study of Predation and Social behaviour.* University of Chicago Press. Chicago.

Kruuk, H. (1975) *Hyeana.* Oxford University Press. London.

Kruuk, H. (1982) Interactions Between Felidae and Their Prey Species: A Review. *In*: Miller, S. D. & Everette, D. D. (Eds.) *Cats of the World: Biology, Conservation and Management.* p.353-374. National Wildlife Federation. Washington, D.C.

Lawson, D. (1987) *A Survey of the Effects of Predators on Sheep Farming in Natal.* PhD. Thesis. University of Natal - Pietermaritzburg. Pietermaritzburg.

Le Roux, P. G. & Skinner, J. D. (1989) A Note on the Ecology of the Leopard (*Panthera pardus* Linnaeus) in the Londolozi Game Reserve, South Africa. *African Journal of Ecology.* **27**. p.67-171.

Little, P. D. (1984) Critical Socio-Economic Variables in African Pastoral Livestock Development: Toward a Comparative Framework. *In*: Simpson, J. R. & Evangelou, P. (Eds.) *Livestock Development in Sub-Saharan Africa: Constraints, Prospects and Policy.* p.201-214. Westview Press Inc. Colorado.

Little, P. D. (1985) Absentee Herd-owners and Part-time Pastoralists: The Political Economy of Resource Use in Norther Kenya. *Human Ecology.* **13.** (2) p.131-151.

Ludbrook, S. (1995) Problem Animal Control: A Closer Look at the Issues. *In*: Rihoy, L. (Ed.). *The Commons Without the Tragedy - Strategies for Community based Natural Resource Management in Southern Africa (Proceedings of the 1995 Regional NRMP Annual Conference; Kasane; Botswana)*. p.144-145. SADC Wildlife Technical Co-ordination Unit. Malawi.

Mason, R. (1981) Early Iron Age Settlement in Boederstroom 24/73, Transvaal, South Africa. *South African Journal of Science*. **77.** pp.401-416.

Mazonde, I. N. (Undated) *The Economics of Cattle in Botswana - Who Benefits?* National Institute of Development Research and Documentation - University of Botswana. Gaborone.

Mazonde, I. N. (1988) The Inter-Relationship Between Cattle and Politics in Botswana's Economy. *In*: Stone, J. C. (Ed.) *The Exploitation of Animals in Africa: Proceedings of a Colloquium at the University of Aberdeen - March 1987*. p.345-356. Aberdeen University African Studies Group. Aberdeen.

McNab, B. K. (1963) Biogernetics and the Determination of Home Range Size. *The American Naturalist.* **97** (6). p 133 - 140.

McNeely, J. A. (1988). *Economics and Biological Diversity: Developing and Using Economic Incentives to Conserve Biological Resources*. International Union for Conservation of Nature and Natural Resources. Gland, Switzerland.

M°Nutt, J. W. (1995*) Distribution and Behaviour of Wild Dog (Lycaon pictus) in Moremi Game Game Reserve, Botswana.* Unpublished Report. Maun.

Mientjies, H. (1995) *Trends in Natural Resource Management Policy and Practice in South Africa: Working Paper # 22*. Land and Agricultural Policy Centre. Johannesburg, South Africa.

Mills, M. G. L. & Biggs, H. C. (1993) Prey Apportionment and Related Ecological Relationships Between Large Carnivores in Kruger National Park. *In*: Dunston, N. & Gorman M. L. (Eds.). *Mammals as Predators: The Proceedings of a Symposium held by The Zoological Society of London and The Mammal Society: London, 22nd and 23rd November 1991.* p.253-268. Claredon Press. Oxford.

Mills, M. G. L. (1987) Behavioural Adaptations of Brown and Spotted Hyaenas in Southern Khalahari. *South African Journal of Science.* **3.** (10) p.595-598.

Mizutani, F. (1993) Home Range of Leopards and Their Impact on Livestock on Kenyan Ranches. *In*: Dunston, N. & Gorman M. L. (Eds.). *Mammals as Predators: The Proceedings of a Symposium held by The Zoological Society of London and The Mammal Society: London, 22nd and 23rd November 1991.* p.425-439. Claredon Press. Oxford.

Molamu, L., Monu, E. & Painter, M. (1995) *Findings of a Socio-Economic Study of the Settlement of Zutshwa, North Kgalagadi Sub-district.* United States Agency for International Development. Gaborone, Botswana.

Murombedzi, J. C. (1992) The Need for Appropriate Local Level Common Property Resource Management Institutions in Communal Tenure Regimes. *In*: Cousins, B. (Ed.) *Institutional Dynamics on Communal Grazing Regimes in Southern Africa: Proceedings of a Workshop Held at the University of Zimbabwe, 10th to 12th December, 1990.* p.39-58. Centre for Applied Social Sciences. Harare.

Murphree, M. (1994) Incorporating Human and Social Imperatives in Effective Policy. *In*: Melkamu, A., Croll, P. & Matowanyika, J. Z. Z. (Eds.) (1995). *Human and Social Imperatives for Environmental and Natural Resource Management in Southern Africa. - Proceedings of a Roundtable Conference, Kwa Maritane, Pilanesburg National Park, North West Province, South Africa.* p.41-46. IUCN - ROSA, Harare, Zimbabwe.

Murphree, M. W. (1993) *Communities as Resource Management Institutions* - Gatekeeper Series N°36. International Institute for Environment and Development. London.

Murphree, M. W. (1993) Decentralising Proprietorship of Wildlife Resources in Zimbabwe's Communal Lands. *In*: Carter, N. & Lewis, D. (Eds.) *Voices from Africa: Local Perspectives on Conservation.* p.133-145. World Wide Fund for Nature. Washington, D.C.

Murphree, M. W. (1995) Optimal Principles and Pragmatic Strategies: Creating an Enabling Environment for Community-Based Natural Resource Management (CBNRM). *In*: Rihoy, E. (Ed.) *The Commons Without Tragedy: Strategies for Community-Based Natural Resources Management in Southern Africa. Proceedings of the Regional Natural Resources Management Programme Annual Conference.* p.47-52. SADC Wildlife Technical Coordination Unit. Lilongwe, Malawi.

Natural Resource Management Programme. (1996) *Annual Plenary Session.* United States Agency for International Development - Botswana. Gaborone.

Nepal, S. J. & Weber, K. E. (1995) The Quandary of Local People - Park Relations in Nepal's Royal Chitwan National Park. *Environmental Management.* **19.** (6) p.853-866.

Nsanjama, H. (1993). Introduction. *In*: Carter, N. & Lewis, D. (Eds.) *Voices from Africa: Local Perspectives on Conservation.* p.1-6. World Wide Fund for Nature. Washington, D.C.

Oli, M. K., Taylor, R. I. & Rogers, M. E. (1994) Snow Leopard *Panthera uncia* Predation of Livestock: An Assessment of Local Perceptions in the Annapurna Conservation Area, Nepal. *Biological Conservation.* **68.** p.63-68.

Parry, D. & Campbell, B. (1992) Attitudes of Rural Communities to Animal Wildlife and its Utilization in Chobe Enclave and Mababe Depresion, Botswana. *Environmental Conservation.* **19.** (3) p.245-252.

Pearce, D. (1993) *Economic Values and the Natural World.* Earthscan Publishing Ltd. London.

Pearce, D. W. & Morran, D. (1994) *The Economic Value of Biodiversity.* International Union for Conservation of Nature and Natural Resources. London.

Pfister, J. A., Mueller-Schwarze, D. & Balph, D. F. (1990) Effects of Predator Fecal Odors on Feed Selection by Sheep and Cattle. *Journal of Chemical Ecology.* **16.** (2) p.573-583.

Pienaar, U. De V. (1969) Predator-Prey Relationships Amongst the Larger Mammals of the Kruger National Park. *Koedoe.* **12.** p.108-176.

Polet, G. (1989) *The Chobe Enclave.* Msc. Thesis, University of Utrecht. The Netherlands.

Pooley, A. C. (1962) The Nile Crocodile, *Crocodile niloticus. Lammergeyer.* **2.** (1) p.1-55.

Pooley, A. C. (1982) *The Ecology of the Nile Crocodile (Crocodilus niloticus) in Zululand.* Thesis (Msc in Zoology) University of Natal. Pietermaritzburg.

Principe, P. (1989). The Economic Significance of Plants and their Constituents as Drugs. *Economic and Medical Plant Research.* **3.** p.1-17.

Prins, H. H. T. (1992) The Pastoral Road to Extinction: Competition Between Wildlife and Traditional Pastoralism in East Africa. *Environmental Conservation.* **19** (2) p.117-123.

Republic of Botswana (1992) *Wildlife Conservation and National Parks Act 28 of 1992.* Government Printers. Gaborone

Republic of Botswana, (1971*) Amendment Fauna Conservation Proclamation Schedules - Statutory Instrument N°. 31.* Gaborone.

Ritter, R. (1993) *Behaviour and Land Usage of Water-dependent Herbivores in Arid Grasslands.* PhD Thesis. St. John's College. USA.

Roberts, D. H. (1996) Determination of Predators Responsible for Killing Small Stock. *South African Journal of Wildlife Research.* **16.** (4). p.150-152.

Rowe-Rowe, D. T. (1983) Killing and Feeding Methods of Some Carnivores. *Wildlife Management Technical Guides for Farmers.* **4** Natal Parks Board. p2.

Sandford, S. (1982) *Livestock in the Communal Areas of Zimbabwe*, Ministry of Lands, Resettlement and Rural Development. Zimbabwe.

Sandford, S. (1982) Pastoral Strategies and Desertification: Opportunism and Conservatism in Dry Lands. *In*: Spooner, B. & Mann, H. (Eds.) *Desertification and Development: Dryland Ecology in Social Perspective*. p.61-80. Academic Press. London.

Schneider, H. K. (1974) Economic Development and Economic Change: The Case of East African Cattle. *Current Anthropology* **15.** p.259-276.

Semple, A. T. (1971) Grassland Improvement in Africa. *Biological Conservation.* **3.** p.173-180.

Sheldon, J. W. (1992) *Wild Dogs - The Natural History of the Nondomesticated Canidae.* Academic Press Inc. California.

Spinage, C. A. (1991) *History and Evolution of Fauna Conservation Laws of Botswana.* The Botswana Society. Gaborone, Botswana.

Tisdell, C. A. (1995) Issues of Biodiversity Conservation Including the Role of Local Communities. *Environmental Conservation.* **22.** (3) p.216-222.

Van Orsdol, K. G. (1982) Feeding Behaviour and Food Intake of Lion (*Panthera leo*) in Ruwenzori National Park, Uganda. *In*: Miller, S. D. and Everette, D. D. (Eds.) *Cats of the World: Biology, Conservation and Management.* p.337-388. National Wildlife Federation. Washington, D.C.

Veck, A. (1995) *The Economics of Natural Resources: Working Paper N°. 23.* Land and Agricultural Policy Centre. Johannesburg, South Africa.

Viljoen, P. C. (1993). Effects of Changes in Prey Availability on Lion Predation in a Large Natural Ecosystem in Northern Botswana. *In*: Dunston, N. & Gorman M. L. (Eds.) *Mammals as Predators: The Proceedings of a Symposium held by The Zoological Society of London and The Mammal Society: London, 22nd and 23rd November 1991.* p.193-213. Claredon Press. Oxford.

Wa-Githinji Mwangi & Perrings C. (1993) Social and Ecological Sustainability in the Use of Biotic Resources in Sub-Saharan Africa. *Ambio.* **22.** (2-3) p.110-116.

Wade, D. A. & Bowns, J. E. (1980) Procedure for Evaluating Predation on Livestock and Wildlife. Texas Agricultural Extension Service - Texas A & M University - United States Fish and Wildlife Service. USA.

Weiss, N. & Hassett, M. (1982) *Introductory Statistics*. Addison-Wesly Publishing Company. London.

Wilcox, R. R. (1996) *Statistics for the Social Sciences*. Academic Press, London.

Winer, N (1996) Regional Roundup: Botswana Breaks Up! *Resource Africa.* **1.** (1) p.6.

Wood, A. D. (1988) Cattle and Development in Western Zambia. *In*: Stone, J. C. (Ed.) *The Exploitation of Animals in Africa: Proceedings of a Colloquium at the University of Aberdeen - March 1987.* p.317-343. Aberdeen University African Studies Group. Aberdeen.

World Conservation Monitoring Centre. (1996) *Assessing Biodiversity Status and Sustainability.* Groombridge, B. & Jenkins, M. D. (Eds.) World Conservation Press. Cambridge, United Kingdom.

Yalden, D. W. (1993). The Problems of Re-Introducing Predators. *In*: Dunston, N. & Gorman M. L. (Eds.) *Mammals as Predators: The Proceedings of a Symposium held by The Zoological Society of London and The Mammal Society: London, 22nd and 23rd November 1991.* p.289-306. Claredon Press. Oxford.

REFERENCES

(Chronological Order)

[1] Beinart, W. & Coates, P. (1995) *Environment and History: The Taming of Nature in USA and South Africa.* Routledge Publishers. London.

[2]Bell, R. H. V. (1985) *Crop Damage by Elephants in Malawi.* (Unpublished Report). Lilongwe.

[3]Hall, M. (1987) *The Changing Past: Farmers, Kings and Traders in Southern Africa, 200 - 1860.* David Philip. Cate Town.

[4]Mason, R. (1981) Early Iron Age Settlement in Boederstroom 24/73, Transvaal, South Africa. *South African Journal of Science.* **77.** pp.401-416.

[5]Nsanjama, H. (1993). Introduction. *In*: Carter, N. & Lewis, D. (Eds.) *Voices from Africa: Local Perspectives on Conservation.* p.1-6. World Wide Fund for Nature. Washington, D.C.

[6]Mientjies, H. (1995) *Trends in Natural Resource Management Policy and Practice in South Africa: Working Paper # 22.* Land and Agricultural Policy Centre. Johannesburg, South Africa.

[7]Spinage, C. A. (1991) *History and Evolution of Fauna Conservation Laws of Botswana.* The Botswana Society. Gaborone, Botswana.

[8]International Union for Conservation of Nature. (1995) *Makgadikgadi Pans Management Plan - Incorporating Makgadikgadi Pans National Park, Nxai Pan National Park and Neighbouring Community Areas and Wildlife Management Areas.*(Unpublished Report) United States Agency for International Development. Gaborone, Botswana.

[9]Department of Wildlife & National Parks (1995). *Problem Animal Control Manual: a manual for use by problem animal control officers.* (Unpublished Report) United States Agency for International Development. Gaborone, Botswana.

[10]Parry, D. & Campbell, B. (1992) Attitudes of Rural Communities to Animal Wildlife and its Utilization in Chobe Enclave and Mababe Depresion, Botswana. *Environmental Conservation.* **19.** (3) p.245-252.

[11]Government of British Bechuanaland. (1891) *Game Law Amendment Act N°. 36 of 1886.* Cape of Good Hope.

[12]Government of British Bechuanaland (1961). *Fauna Conservation Proclamation N°. 23 of 1961.* Cape of Good Hope.

[13]Republic of Botswana, (1971*) Amendment Fauna Conservation Proclamation Schedules - Statutory Instrument N°. 31.* Gaborone.

[14]Republic of Botswana (1992) *Wildlife Conservation and National Parks Act 28 of 1992.* Government Printers. Gaborone

[15]Department of Wildlife and National Parks. (1995*) Report on Numbers of Wildlife Killed in Protection of Human Life and Property* (Unpublished Report). Maun, Botswana.

[16]HaBarad, J., Dikobe, L. & Gaboiphiwe, J. (1995) Understanding Community Dynamics: Participatory Rural Appraisal and Other Tools for Social Analysis. *In*: Rihoy, L. (Ed.). *The Commons Without the Tragedy - Strategies for Community based Natural Resource Management in Southern Africa (Proceedings of the 1995 Regional NRMP Annual Conference; Kasane; Botswana).* p.128-130. SADC Wildlife Technical Co-ordination Unit. Malawi.

[17]Ludbrook, S. (1995) Problem Animal Control: A Closer Look at the Issues. *In*: Rihoy, L. (Ed.). *The Commons Without the Tragedy - Strategies for Community based Natural Resource Management in Southern Africa (Proceedings of the 1995 Regional NRMP Annual Conference; Kasane; Botswana).* p.144-145. SADC Wildlife Technical Co-ordination Unit. Malawi.

[18]Botswana Wildlife Training Institute. (1995) *Mission Statement - Botswana Wildlife Training Institute.* (Unpublished) Maun, Botswana.

[19]Natural Resource Management Programme. (1996) *Annual Plenary Session.* United States Agency for International Development - Botswana. Gaborone.

[21]Murphree, M. (1994) Incorporating Human and Social Imperatives in Effective Policy. *In*: Melkamu, A., Croll, P. & Matowanyika, J. Z. Z. (Eds.) (1995). *Human and Social Imperatives for Environmental and Natural Resource Management in Southern Africa. - Proceedings of a Roundtable Conference, Kwa Maritane, Pilanesburg National Park, North West Province, South Africa.* p.41-46. IUCN - ROSA, Harare, Zimbabwe.

[22]Bowland, A. E., Mills, M. G. L. & Lawson, D. (1991) *Predators and Farmers.* Endangered Wildlife Trust. Johannesburg.

[23]Colvin, P.M. (1983) *Welfare Economics and African Pastoralism.* Institute of Natural Resources. Pietermaritzburg.

[24]Schneider, H. K. (1974) Economic Development and Economic Change: The Case of East African Cattle. *Current Anthropology* **15.** p.259-276.

[25]Sandford, S. (1982) *Livestock in the Communal Areas of Zimbabwe*, Ministry of Lands, Resettlement and Rural Development. Zimbabwe.

[26]Bembridge, T. J. (1979) *Problems of Livestock Production in the Black Sates in Southern Africa and Future Strategy.* Published Paper: Annual Conference of Southern African Society for Animal Production. Johannesburg.

[27]Fielder, R. J. (1973) The Role of Cattle in the Ila Economy. *African Social Research.* **15.** p.327-360.

[28]Danckwerts, J. P. (1974) *A Socio-economic Study of Veld Management in the Tribal Areas of Victoria-Province.* Unpublished Report: Department of Agriculture. University of Rhodesia.

[29]Behnke, R. (1982) *Cattle Accumulation and the Commercialisation of the Traditional Livestock Industry in Botswana.* Rural Sociology Unit - Ministry of Agriculture. Gaborone, Botswana.

[30]Sandford, S. (1982) Pastoral Strategies and Desertification: Opportunism and Conservatism in Dry Lands. *In*: Spooner, B. & Mann, H. (Eds.) *Desertification and Development: Dryland Ecology in Social Perspective.* p.61-80. Academic Press. London.

[31]Bell, R. H. V. (1987) Conservation with a Human Face: Conflict and Reconciliation in African Land-use Planning. *In*: Anderson, D. & Grove, R (Eds.) *Conservation in Africa, Policies and Practice.* p.79-101. Cambridge University Press. Cambridge.

[32]Little, P. D. (1984) Critical Socio-Economic Variables in African Pastoral Livestock Development: Toward a Comparative Framework. *In*: Simpson, J. R. & Evangelou, P. (Eds.) *Livestock Development in Sub-Saharan Africa: Constraints, Prospects and Policy.* p.201-214. Westview Press Inc. Colorado.

[33]Government of Botswana. (1968) *Tribal Land Act (Chapter 32:02) - Laws of Botswana.* Government Printers. Gaborone, Botswana.

[34]Caro, T. M. & Collins, D. A. (1987) Male Cheetah Social Organization and Territoriality. *Ethology.* **74.** (1) p.52-64.

[35]Mizutani, F. (1993) Home Range of Leopards and Their Impact on Livestock on Kenyan Ranches. *In*: Dunston, N. & Gorman M. L. (Eds.). *Mammals as Predators: The Proceedings of a Symposium held by The Zoological Society of London and The Mammal Society: London, 22nd and 23rd November 1991.* p.425-439. Claredon Press. Oxford.

[36]Bothma, J. & Le Riche, E. A. N. (1982) Prey Preferences and Hunting Efficiency of the Khalahari Desert Leopard (*Panthera pardus*). *In*: Miller, S. D. & Everette, D. D. (Eds.) *Cats of the World: Biology, Conservation and Management.* p.389-414. National Wildlife Federation. Washington, D.C.

[37]Le Roux, P. G. & Skinner, J. D. (1989) A Note on the Ecology of the Leopard (*Panthera pardus* Linnaeus) in the Londolozi Game Reserve, South Africa. *African Journal of Ecology.* **27.** p.67-171.

[38]Kruuk, H. & Turner, M. (1967) Comparative Notes on Predation by Lion, Lepard, Cheetah and Wild dog in the Serengeti Area, East Africa. *Mammalia.* **31.** p.1-27.

[39]Kruuk, H. (1982) Interactions Between Felidae and Their Prey Species: A Review. *In*: Miller, S. D. & Everette, D. D. (Eds.) *Cats of the World: Biology, Conservation and Management.* p.353-374. National Wildlife Federation. Washington, D.C.

[40]Sheldon, J. W. (1992) *Wild Dogs - The Natural History of the Nondomesticated Canidae.* Academic Press Inc. California.

[41]Mills, M. G. L. & Biggs, H. C. (1993) Prey Apportionment and Related Ecological Relationships Between Large Carnivores in Kruger National Park. *In*: Dunston, N. & Gorman M. L. (Eds.). *Mammals as Predators: The Proceedings of a Symposium held by The Zoological Society of London and The Mammal Society: London, 22nd and 23rd November 1991.* p.253-268. Claredon Press. Oxford.

[42]Cooper, S. M. (1990) The Hunting Behaviour of Spotted Hyeanas (Crocuta crocuta) in a Region Containing Both Sedentary and Migratory Populations of Herbivores. *African Journal of Ecology.* **28.** p.131-141.

[43]Mills, M. G. L. (1987) Behavioural Adaptations of Brown and Spotted Hyaenas in Southern Khalahari. *South African Journal of Science.* **3.** (10) p.595-598.

[44]Pienaar, U. De V. (1969) Predator-Prey Relationships Amongst the Larger Mammals of the Kruger National Park. *Koedoe.* **12.** p.108-176.

[45]Emlen, J. M. (1966) The Role of Time and Energy in Food Preferences. *The American Naturalist.* **100.** (916) p.611-617.

[46]Roberts, D. H. (1996) Determination of Predators Responsible for Killing Small Stock. *South African Journal of Wildlife Research.* **16.** (4). p.150-152.

[47]Fuller, T. K. & Kat, P. W. (1990) Movements, Activity and Prey Relationships of African Wild dogs (*Lycaon pictus*) Near Aitong, Southwestern Kenya. *African Journal of Ecology.* **28.** p.330-350.

[48]Kruuk, H. (1975) *Hyeana.* Oxford University Press. London.

[49]Pooley, A. C. (1982) *The Ecology of the Nile Crocodile (Crocodilus niloticus) in Zululand.* Thesis (Msc in Zoology) University of Natal. Pietermaritzburg.

[50]Yalden, D. W. (1993). The Problems of Re-Introducing Predators. *In*: Dunston, N. & Gorman M. L. (Eds.) *Mammals as Predators: The Proceedings of a Symposium held by The Zoological Society of London and The Mammal Society: London, 22nd and 23rd November 1991.* p.289-306. Claredon Press. Oxford.

[51]Oli, M. K., Taylor, R. I. & Rogers, M. E. (1994) Snow Leopard *Panthera uncia* Predation of Livestock: An Assessment of Local Perceptions in the Annapurna Conservation Area, Nepal. *Biological Conservation.* **68.** p.63-68.

[52]Pfister, J. A., Mueller-Schwarze, D. & Balph, D. F. (1990) Effects of Predator Fecal Odors on Feed Selection by Sheep and Cattle. *Journal of Chemical Ecology.* **16.** (2) p.573-583.

[53]Viljoen, P. C. (1993). Effects of Changes in Prey Availability on Lion Predation in a Large Natural Ecosystem in Northern Botswana. *In*: Dunston, N. & Gorman M. L. (Eds.) *Mammals as Predators: The Proceedings of a Symposium held by The Zoological Society of London and The Mammal Society: London, 22nd and 23rd November 1991.* p.193-213. Claredon Press. Oxford.

[54]Van Orsdol, K. G. (1982) Feeding Behaviour and Food Intake of Lion (*Panthera leo*) in Ruwenzori National Park, Uganda. *In*: Miller, S. D. and Everette, D. D. (Eds.) *Cats of the World: Biology, Conservation and Management.* p.337-388. National Wildlife Federation. Washington, D.C.

[55]Fuller, T. K., Nicholls, T. H. & Kat, P. W. (1995) Prey and Estimated Food Consumption of African Wild Dogs in Kenya. *South African Journal of Wildlife Research.* **25.** (3) p.106-110.

[56]Henschel, J. R. & Skinner, J. D. (1990) The Diet of Spotted Hyaenas *Crocuta crocuta* in Kruger National Park. *African Journal of Ecology.* **28.** p.69-82.

[57]Pooley, A. C. (1962) The Nile Crocodile, *Crocodile niloticus. Lammergeyer.* **2.** (1) p.1-55.

[58]Hutton, J. M. (1987) Growth and Feeding Ecology of the Nile Crocodile (*Crocodylus niloticus*) at Ngezi, Zimbabwe. *Journal of Animal Ecology.* **56.** p.25-38.

[59]Hamilton, P. H. (1982) Status of Cheetah (*Acinonyx jubatus*) in Kenya, with Reference to Sub-Saharan Africa. *In*: Miller, S. D. & Everette, D. D. (Eds.) *Cats of the World: Biology, Conservation and Management.* p.65-76. National Wildlife Federation. Washington, D.C.

[60]Bertram, B. C. (1978) *Pride of Lions.* J. M. Dent & Sons Ltd. London.

[61]Burney, D. A. (1980*) The Effects on Human Activities on Cheetahs (Acinonyx jubatus) in the Mara Region on Kenya.* MSc. Thesis. University of Nairobi. Nairobi.

[62]Kruuk, H. (1972) *The Spotted Hyeana (Crocuta crocuta): A Study of Predation and Social behaviour.* University of Chicago Press. Chicago.

[63]Clark, A. & Lubbe, T. (1995) Namibia - Last Outpost for the Cheetah. *African Wildlife.* **49** (5) p.13-14.

[64]M^{c}Nutt, J. W. (1995*) Distribution and Behaviour of Wild Dog (Lycaon pictus) in Moremi Game Game Reserve, Botswana.* Unpublished Report. Maun.

[65]Hoare, R. E. (1992) Present and Future Use of Fencing in the Management of Larger African Mammals. *Environmental Conservation.* **19.** (2) p.160-164.

[66]Kgathi, D. K. & Kalikawe, M. C. (1993) Seasonal Distribution of Zebra and Wildebeest in Makgadikgadi Pans Game Reserve, Botswana. *African Journal of Ecology.* **31.** p.210-219.

[67] Inglis, J. M. (1976) Wet Season Movements of Individual Wildebeests of the Serengeti Migratory herd. *East African Wildlife Journal.* **14.** p 17 - 34.

[68] Harestad, A. S. & Bunnel, F. L. (1979) Home-range and Body-weight; A Re-evaluation. *Journal of Ecology*. **60** (2). p 389 - 402.

[69] McNab, B. K. (1963) Biogernetics and the Determination of Home Range Size. *The American Naturalist.* **97** (6). p 133 - 140.

[70] Ritter, R. (1993) *Behaviour and Land Usage of Water-dependent Herbivores in Arid Grasslands*. PhD Thesis. St. John's College. USA.

[71]Kofron, C. P. (1993) Behaviour of Nile Crocodiles in a Seasonal River in Zimbabwe. *Copeia.* (2) p.463-469.

[72]Hutton, J. M. (1989) Movements, Home Range, Dispersal and the Seperation of Size Classes in Nile Crocodiles. *American Zooligist.* **29**. p.1033-1049.

[73]Wood, A. D. (1988) Cattle and Development in Western Zambia. *In*: Stone, J. C. (Ed.) *The Exploitation of Animals in Africa: Proceedings of a Colloquium at the University of Aberdeen - March 1987.* p.317-343. Aberdeen University African Studies Group. Aberdeen.

[74]Carl Bro International (1982) An Evaluation ofLivestock Management and Production in Botswana (with special reference to communal areas). Govenment of Botswana - Commission of the European Communities. Gaborone, Botswana.

[75]Polet, G. (1989) *The Chobe Enclave.* Msc. Thesis, University of Utrecht. The Netherlands.

[76]Lawson, D. (1987) *A Survey of the Effects of Predators on Sheep Farming in Natal.* PhD. Thesis. University of Natal - Pietermaritzburg. Pietermaritzburg.

[77]Pearce, D. (1993) *Economic Values and the Natural World.* Earthscan Publishing Ltd. London.

[78]Pearce, D. W. & Morran, D. (1994) *The Economic Value of Biodiversity*. International Union for Conservation of Nature and Natural Resources. London.

[79]Barbier, E. B. (1992) Economics for the Wilds. *In*: Swanson, T. M. & Barbier, E. B. (Eds.) *Economics for the Wilds; Wildlife, Diversity and Development.* p.15-33. Island Press. Washington, D.C.

[80]Tisdell, C. A. (1995) Issues of Biodiversity Conservation Including the Role of Local Communities. *Environmental Conservation.* **22.** (3) p.216-222.

[81]McNeely, J. A. (1988). *Economics and Biological Diversity: Developing and Using Economic Incentives to Conserve Biological Resources.* International Union for Conservation of Nature and Natural Resources. Gland, Switzerland.

[82]Hofer, H., East, M. L. & Campbell, K. L. I. (1993) Snares, commuting hyenas and migratory herbivores: humans as predators in the Serengeti. *In*: Dunston, N. & Gorman M. L. (Eds.) *Mammals as Predators: The Proceedings of a Symposium held by The Zoological Society of London and The Mammal Society: London, 22nd and 23rd November 1991.* p.347-366. Claredon Press. Oxford.

[83]Child, G. (1995) *Wildlife and People: the Zimbabwean Success.* Wisdom Foundation. Harare, Zimbabwe.

[84]Principe, P. (1989). The Economic Significance of Plants and their Constituents as Drugs. *Economic and Medical Plant Research.* **3.** p.1-17.

[85]Hetch, S., Norgaard, R. & Possio, G (1988) The Economics of Cattle Ranching in East Amazonia. *Interciencia.* **13.** (15) p.233-239.

[86]Barnes, J. & Pearce, D. W. (1991) *The Mixed Use of Habitats.* Centre for Social and Economic Research on Global Environment. University College of London. London.

[87]Cozza, K., Fico. R., Maria-Luisa, B. & Rogers, E. (1996) The Damage-Conservation Interface Illustrated by Predation on Domestic Livestock in Central Italy. *Biological Conservation.* **78.** p.329-336.

[88]World Conservation Monitoring Centre. (1996) *Assessing Biodiversity Status and Sustainability.* Groombridge, B. & Jenkins, M. D. (Eds.) World Conservation Press. Cambridge, United Kingdom.

[89]Cumming, D. H. M. (1993) Conservation Issues and Problems in Africa. *In*: Carter, N. & Lewis, D. (Eds.) *Voices from Africa: Local Perspectives on Conservation.* p.23-47. World Wide Fund for Nature. Washington, D.C.

[90]Nepal, S. J. & Weber, K. E. (1995) The Quandary of Local People - Park Relations in Nepal's Royal Chitwan National Park. *Environmental Management.* **19.** (6) p.853-866.

[91]Veck, A. (1995) *The Economics of Natural Resources: Working Paper N°. 23.* Land and Agricultural Policy Centre. Johannesburg, South Africa.

[92]Mazonde, I. N. (1988) The Inter-Relationship Between Cattle and Politics in Botswana's Economy. *In*: Stone, J. C. (Ed.) *The Exploitation of Animals in Africa: Proceedings of a Colloquium at the University of Aberdeen - March 1987.* p.345-356. Aberdeen University African Studies Group. Aberdeen.

[93]Barbier, E. B. (1992) Community-Based Development in Africa. *In*: Swanson, T. M. & Barbier, E. B. (Eds.) *Economics for the Wilds; Wildlife, Diversity and Development.* p.103-135. Island Press. Washington, D.C.

[94]Adams, J. S. & M°Shane, T. O. (1992) *The Myth of Wild Africa - Conservation Without Illusion.* W. W. Norton & Company. London.

[95]Murphree, M. W. (1995) Optimal Principles and Pragmatic Strategies: Creating an Enabling Environment for Community-Based Natural Resource Management (CBNRM). *In*: Rihoy, E. (Ed.) *The Commons Without Tragedy: Strategies for Community-Based Natural Resources Management in Southern Africa. Proceedings of the Regional Natural Resources Management Programme Annual Conference.* p.47-52. SADC Wildlife Technical Coordination Unit. Lilongwe, Malawi.

[96]Murphree, M. W. (1993) *Communities as Resource Management Institutions* - Gatekeeper Series N°36. International Institute for Environment and Development. London.

[97]Homma, A. K. O. (1992) The Dynamics of Extraction in Amazonia: A Historical Perspective. *In*: Nepstad, D. C. & Schwartzman, S. (Eds.) *Non-Timber Products from Forest Evaluation of a Conservation and Development Strategy.* p.23-33. The New York Botanical Garden. New York.

[98]Godoy, R. A. & Bawa, K. S. (1993) The Economic Value and Sustainable Harvest of Plants and Animals fron the Tropical Forest: Assumptions, Hypothesis and Methods. *Economic Botany.* **47.** (3) p.215-219.

[99]Prins, H. H. T. (1992) The Pastoral Road to Extinction: Competition Between Wildlife and Traditional Pastoralism in East Africa. *Environmental Conservation.* **19** (2) p.117-123.

[100]Brown, L. H. (1971) The Biology of Pastoral Man as a Factor in Conservation. *Wildlife Conservation.* **3.** (2) p.93-100.

[101]Semple, A. T. (1971) Grassland Improvement in Africa. *Biological Conservation.* **3.** p.173-180.

[102]Murombedzi, J. C. (1992) The Need for Appropriate Local Level Common Property Resource Management Institutions in Communal Tenure Regimes. *In*: Cousins, B. (Ed.) *Institutional Dynamics on Communal Grazing Regimes in Southern Africa: Proceedings of a Workshop Held at the University of Zimbabwe, 10th to 12th December, 1990.* p.39-58. Centre for Applied Social Sciences. Harare.

[103]Wa-Githinji Mwangi & Perrings C. (1993) Social and Ecological Sustainability in the Use of Biotic Resources in Sub-Saharan Africa. *Ambio.* **22.** (2-3) p.110-116.

[104]Murphree, M. W. (1993) Decentralising Proprietorship of Wildlife Resources in Zimbabwe's Communal Lands. *In*: Carter, N. & Lewis, D. (Eds.) *Voices from Africa: Local Perspectives on Conservation.* p.133-145. World Wide Fund for Nature. Washington, D.C.

[105]International Fund for Agricultural Development. (1995) *Common Property Resources and the Rural Poor in Sub-Saharan Africa.* International Fund for Agricultural Development (Special Programme for Sub-Saharan African Countries Affected by Drought and Dessertification). Amsterdam.

[106]Little, P. D. (1985) Absentee Herd-owners and Part-time Pastoralists: The Political Economy of Resource Use in Norther Kenya. *Human Ecology.* **13.** (2) p.131-151.

[107]Behnke, R. (1984) Fenced and Open-range Ranching: The Commercialisation of Pastoral Land and Livestock in Africa. *In:* Simpson, J. & Evangelou, P. (Eds.) *Livestock Development in Subsaharan Africa: Constraints, Prospects, Policy.* p.261-284. Westview Press. Boulder.

[108]Hoare, R. E. & Mackie, C. S. (1993) *Problem Animal Assessment and the Use of Fences to Manage Wildlife in the Communal Lands of Zimbabwe - WWF Multispecies Project Paper No 39.* World Wide Fund for Nature. Harare.

[109]Fiallo, E. A. & Jacobson, S. K. (1995) Local Communities and Protected Areas: Attitudes of Rural Residents Towards Conservation and Machalilla National Park, Ecuador. *Environmental Conservation.* **22.** (3) p.241-249.

[110]Infield, M. (1988) Attitudes of a Rural Community Towards Conservation and a Local Conservation Area in Natal, South Africa. *Biological Conservation.* **4.** p.21-46.

[111]Aboud, A. A. (1989) The Role of Public Involvement in Wildlife-Livestock Conflicts: The Case of Narok Ranchers in Kenya. *Society and Natural Resources.* **2.** (4) p.319-328.

[112]Central Statistics Office (1992). *Population of Towns, Villages and Associated Localities.* Government Printers, Gaborone.

[113]International Union for Conservation of Nature. (1992) *The IUCN Review of the Southern Okavango Integrated Water Development Project; Final Report..* International Union for Conservation of Nature and Natural Resources. Gland, Switzerland.

[114]Deloitte & Touché Tohmatsu International. (1996) *Financial and Economic Review of Livestock Sector in Botswana.* Government of Botswana-European Commission. Gaborone, Botswana.

[115]Campbell, A. (1990) *The Nature of Botswana - A Guide to Conservation and Development.* International Union for the Conservation of Nature. Gland, Switzerland.

[116]Mazonde, I. N. (Undated) *The Economics of Cattle in Botswana - Who Benefits?* National Institute of Development Research and Documentation - University of Botswana. Gaborone.

[117]Winer, N (1996) Regional Roundup: Botswana Breaks Up! *Resource Africa.* **1.** (1) p.6.

[118]Blair-Rains, A. & M^{c}Kay, A. D. (1968) *The Northern State Lands, Botswana Land Resources Division.* Tolworth. Surrey, England.

[119]Field, D. I. (1978) *A Handbook on the Ecology for Range Management in Botswana.* Ministry of Agriculture. Gaborone, Botswana.

[120]Child, D. I. (1968) *An Ecological Survey of North-eastern Botswana.* Food and Agricultural Organisation. Rome.

[121]Molamu, L., Monu, E. & Painter, M. (1995) *Findings of a Socio-Economic Study of the Settlement of Zutshwa, North Kgalagadi Sub-district.* United States Agency for International Development. Gaborone, Botswana.

[122]Infield, M. M. (1986) *Wildlife Utilisation and Attitudes Towards Conservation: A Case Study of the Hluhluwe and Umfolozi Game Reserves in Natal/KwaZulu,* MSc. Thesis, p42. University of Natal, Pietermaritzburg.

[123]Babbie, E. (1992) *The Practice of Social Research.* Wadsworth Publishing Company. 6th ed. California.

[124]Wilcox, R. R. (1996) *Statistics for the Social Sciences.* Academic Press, London.

[125]Weiss, N. & Hassett, M. (1982) *Introductory Statistics.* Addison-Wesly Publishing Company. London.

[126]Rowe-Rowe, D. T. (1983) Killing and Feeding Methods of Some Carnivores. *Wildlife Management Technical Guides for Farmers.* **4** Natal Parks Board. p2.

[127]Wade, D. A. & Bowns, J. E. (1980) Procedure for Evaluating Predation on Livestock and Wildlife. Texas Agricultural Extension Service - Texas A & M University - United States Fish and Wildlife Service. USA.

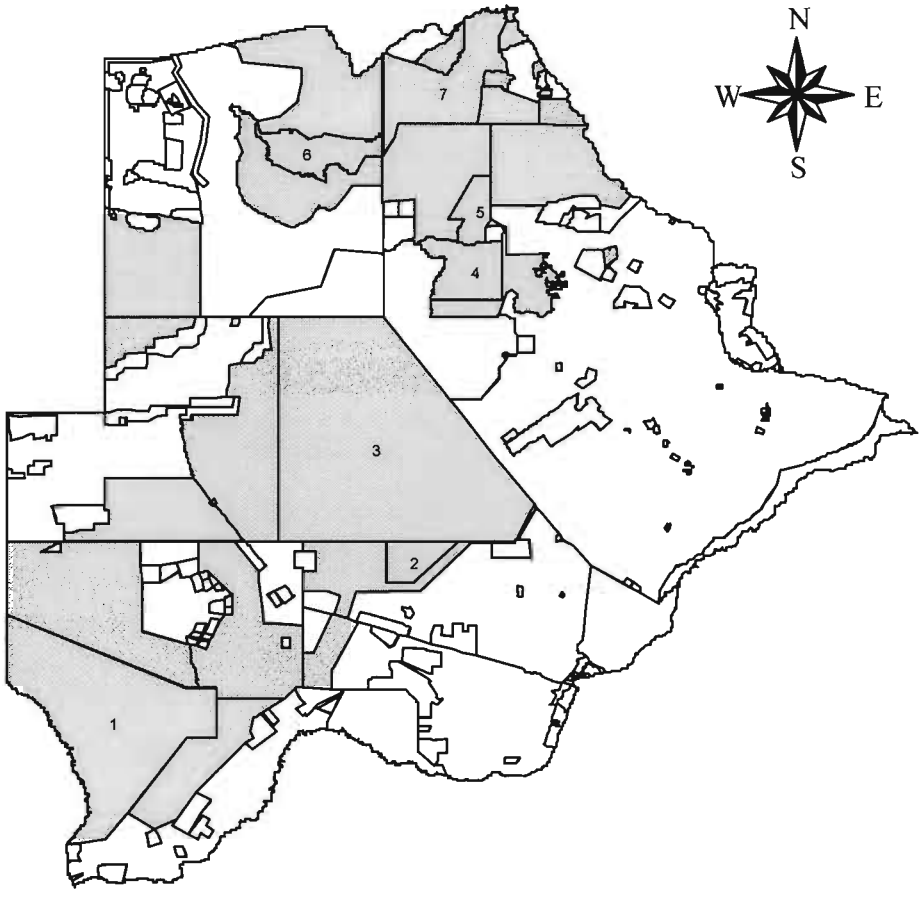
[128]Department of Wildlife & National Parks (1995) *Report of the Rations Committee.* (Unpublished Report Prepared for Evaluation of Ration Hunting). Maun, Botswana.

[129]Botswana Outfitters and Professional Hunters Association (1997) *The Role of safari Hunting in Problem Animal Control.* (Unpublished Paper). Maun, Botswana.

[130]Child, G. (1984) Managing Wildlife for the People of Zimbabwe. *In:* McNeely, J. & Miller, K. (Eds.) *National Park, Conservation & Develpment.* Smithsonian Institute. Washington, DC.

APPENDICES

Appendix 1: Botswana's protected-area network (including Controlled Hunting Areas).



KEY:

Protected Area

National Parks and Game Reserves have been numbered as:

1. Gemsbock National Park
2. Kutse Game Reserve
3. Central Kgalagadi Game Reserve
4. Makgadikgadi Pans National Park
5. Nxai Pan Nnational Park
6. Moremi Game Reserve
7. Chobe National park

Source: Department of Wildlife & National Parks GIS Data-base.

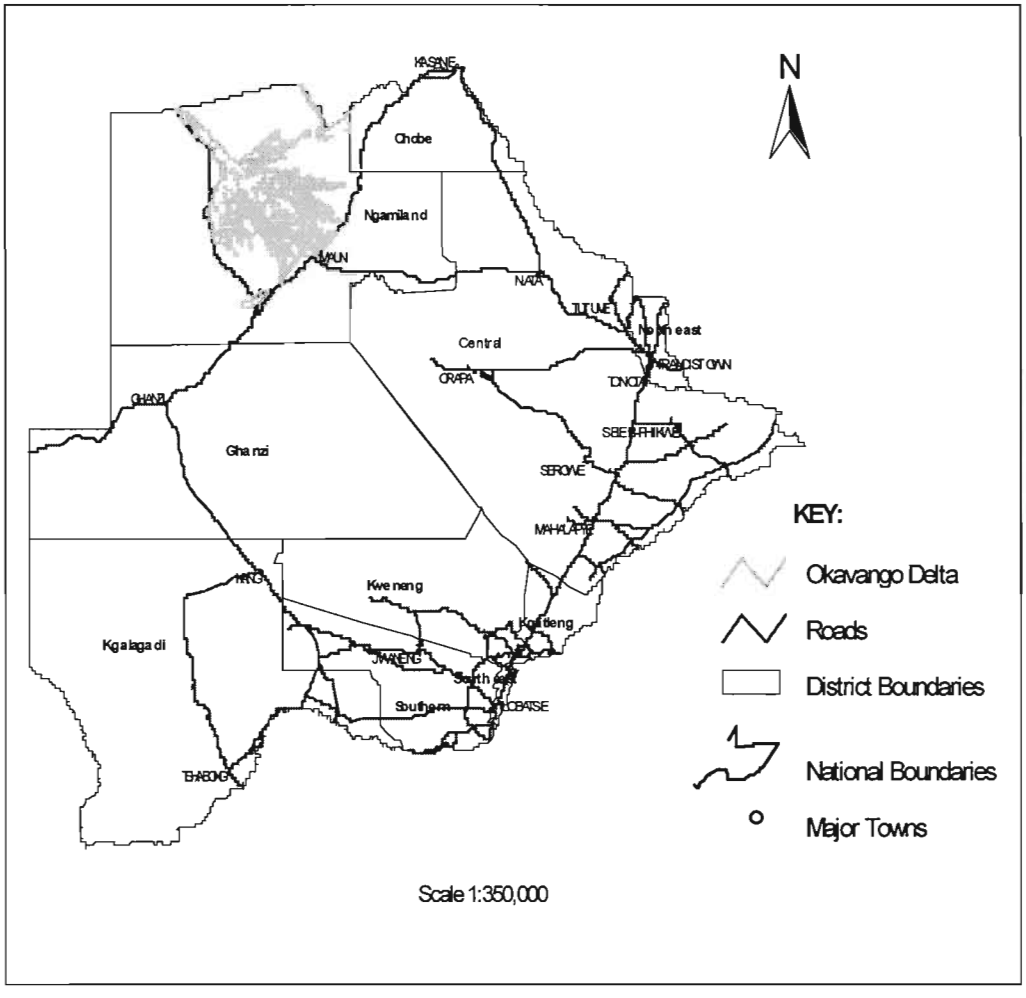
Appendix 2 : Direct government recurrent expenditure on livestock production sector, 1990/91 to 1994/95 (adapted from Deloitte & Touche[114]).

	1990/91	1991/92	1992/93	1993/94	1994/95
Ministry of Agriculture	Million Pula				
Animal Health & Production					
Emoluments	33.20	38.76	48.02	58.74	44.59
Diseases Control	3.52	5.80	3.17	6.52	6.02
Internal Subsistence & Transport	3.12	4.01	4.19	5.67	13.79
Material & Requisites for Re-sale	10.43	10.50	9.05	6.69	8.14
Other	3.38	4.36	4.70	6.24	6.99
Total	54.10	63.43	69.13	83.86	79.53
Other Departments with Livestock Components					
Headquarters (i)	5.85	6.78	10.45	12.49	13.72
Dept. of Agricultural Research	8.85	9.53	1,047.00	13.44	14.64
Dept. of Co-operative Devt.	2.77	3.05	4.02	5.00	4.92
Botswana College of Agric.	3.45	4.36	10.17	13.85	16.29
Total	*20.94*	*23.72*	*35.65*	*44.78*	*49.57*
Share Attributed to Livestock (ii)	13.67	16.54	23.83	30.72	31.29
Ministry of Mineral Resources & Water Affairs					
Borehole Repairs Service (iii)	1.59	2.50	1.74	1.78	1.69
Total Livestock Expenditure	*69.36*	*82.47*	*94.70*	*116.36*	*112.51*
MoA	103.80	114.72	139.07	167.03	175.54
Total Government	*3,418.86*	*3,116.63*	*4,178.59*	*4,078.99*	*4,885.78*
(i) Excluding Botswana Agricultural marketing Board (BAMB) subsidies and Botswana College of Agriculture					
(ii) Based on relative importance of expenditure by DAHP compared with Department of Crop Production & Forestry plus BAMB subsidies.					
(iii) Based on Government Direct Revenue from livestock (1990/91 - 1994/95) and assuming that service is subsidised by 61% (Department of Water Affiars calculations).					

Appendix 3: Direct government development expenditure on livestock sector, 1991/92 - 1994/95 (adapted from Deloitte & Touche[114]).

	1991/92	1992/93	1993/94	1994/95
Ministry of Agriculture	Million Pula			
Headquarters				
Livestock Water Development	3.16	3.08	20.20	2.84
National Land Management & Livestock Projec	7.11	3.91	1.26	0.96
Dairy Development	0.01	0.03	0.02	0.23
Total	10.28	7.02	3.30	4.03
Other Departments with Livestock Components				
Animal Diseases Emergency Control	-	0.93	0.18	3.00
Improvements to Disease Control	1.96	1.77	1.54	1.50
Veterinary Laboratories	0.03	-	0.45	3.07
Artificial Insemination Service	0.41	0.37	0.09	0.04
Sheep & Goat Development	-	0.18	0.82	1.00
Services to Livestock Owners	0.96	0.02	0.59	0.48
Total	3.36	3.28	3.67	9.09
Other Departments				
Range Research	-	-	-	-
Total Livestock Expenditure	13.64	10.30	6.97	13.14
Other MoA Projects with Livestock Component				
Research Programme Support	0.03	0.09	0.04	0.02
Agricultural Research Stations	0.29	0.21	0.78	2.00
Botswana College of Agricultural	0.94	5.44	12.83	12.96
Total	*1.26*	*5.74*	*13.65*	*14.98*
Total Government Development Expenditure				
MoA	31.48	52.88	89.16	104.36
Total Government	*1,097.98*	*1,206.97*	*1,558.25*	*1,662.58*

Appendix 4: Botswana - showing major population centres, roads and district boundaries.



Source: Department of Wildlife & National Parks GIS Data-base.

Appendix 5: Questionnaire for socio-economic data.

---

1. HOUSEHOLD NO. .....

2. STATUS OF RESPONDENT: Husband..... Housewife..... Other (specify).....

3. LIVESTOCK KEPT AND NUMBERS

   a) Cattle:..... b) Horses: ..... c) Goats:..... d) Sheep:..... d) Donkeys:.....

4. TYPE OF PROTECTIVE BARRIER:

   a) Pole kraal:..... b)Thorn bush kraal:..... c) Others (specify):..... d) None:....

5. HERDING METHODS:

   a) Full-time:..... b) Seasonal attention:..... c) Others (specify):..... d) None:.....

6. PREDATION LEVELS (NO. OF LIVESTOCK LOST TO PREDATORS)

Type of Livestock	Numbers	Month	Predator	Compensation Received
.....	.....	.....	.....	.....
.....	.....	.....	.....	.....
.....	.....	.....	.....	.....

7. INCOME GENERATED FROM LIVESTOCK

7.1 Cattle

   a) No. sold since beginning of year (1996): .....

b) Centre of Sale: .....

7.2 Horse

a) No. sold since beginning of year (1996): .....

b) Centre of Sale: .....

7.3 Sheep

a) No. sold since beginning of year (1996): .....

b) Centre of Sale: .....

7.4 Goat

a) No. sold since beginning of year (1996): .....

b) Centre of Sale: .....

7.5 Donkey

a) No. sold since beginning of year (1996): .....

b) Centre of Sale: .....

9. PAST PREDATOR CONTROL SYSTEMS

a) What did we do in the past?

.....

.....

.....

c) Can we improve the situation by using some of these methods?

.....

.....

Appendix 6: Price per animal at different centres of livestock sale for Khumaga and Gweta (in US$).

Centres of Sale	Type of Livestock				
	Cattle	Horse	Sheep	Goat	Donkey
BLDC-G	168.00	0.00	0.00	0.00	0.00
BLDC-T	168.00	0.00	0.00	0.00	0.00
BMC-F	173.60	0.00	0.00	0.00	0.00
BMC-M	184.80	0.00	0.00	0.00	0.00
Coop-G	154.00	0.00	0.00	0.00	0.00
Coop-K	145.60	0.00	0.00	0.00	0.00
Coop-T	140.00	0.00	0.00	0.00	0.00
Local-G	229.60	336.00	49.00	47.60	28.00
Local-K	196.00	277.20	44.80	44.80	28.00
Local-T	249.20	392.00	50.40	53.20	28.00

Appendix 7: Diary of livestock predation incidences for Khumaga.

Date	Livestock type	Livestock No.s	Predator type	Predator No.s	Location	Region	Season
17/8/94	Cow	1	Hyena	1	Dikwalo	Khumaga	dry
30/8/94	Goat	2	Crocodile	1	Bosobea	Khumaga	dry
30/8/94	Cow	1	Lion	1	Gwaraga	Khumaga	dry
31/8/94	Calf	1	Lion	1	Dikwalo	Khumaga	dry
1/9/94	Goat	1	Leopard	1	Gwaraga	Khumaga	dry
1/9/94	Cow	1	Lion	1	Dikwalo	Khumaga	dry
3/9/94	Cow	1	Lion	1	Gwaraga	Khumaga	dry
4/9/94	Heifer	1	Lion	1	Khumaga	Khumaga	dry
5/9/94	Cow	1	Lion	1	Marotobolo	Khumaga	dry
5/9/94	Ox	1	Lion	1	Menoakwena	Khumaga	dry
8/9/94	Donkey	1	Hyena	1	Marotobolo	Khumaga	dry
26/9/94	Cow	1	Lion	2	Dikwalo	Khumaga	dry
29/9/94	Donkey	1	Lion	3	Gwaraga	Khumaga	dry
3/10/94	Goat	3	Jackal	2	Menoakwena	Khumaga	dry
13/10/94	Goat	1	Jackal	1	Senagomo	Khumaga	dry
15/10/94	Goat	1	Crocodile	1	Khumaga	Khumaga	dry
20/10/94	Goat	1	Jackal	1	Menoakwena	Khumaga	dry
24/10/94	Cow	1	Lion	2	Dikwalo	Khumaga	dry
4/4/95	Cow	1	Lion	2	Dikwalo	Khumaga	dry
5/4/95	Cow	1	Lion	1	Menoakwena	Khumaga	dry
6/4/95	Cow	1	Lion	1	Menoakwena	Khumaga	dry
8/4/95	Donkey	3	Lion	3	Gwaraga	Khumaga	dry
11/4/95	Calf	1	Lion	1	Menoakwena	Khumaga	dry
11/4/95	Donkey	1	Lion	4	Nxwee	Kumaga	dry
11/4/95	Foal	1	Lion	2	Marotobolo	Kumaga	dry
13/4/95	Cow	1	Lion	1	Nxwee	Kumaga	dry
14/4/95	Cow	1	Lion	1	Dikwalo	Kumaga	dry
14/4/95	Cow	1	Lion	1	Menoakwena	Kumaga	dry
14/4/95	Calf	1	Lion	1	Nxwee	Kumaga	dry
21/4/95	Goat	1	Leopard	1	Gwaraga	Kumaga	dry
21/4/95	Goat	1	Crocodile	1	Gwaraga	Kumaga	dry
25/4/95	Donkey	1	Lion	3	Kumaga	Kumaga	dry
26/4/95	Goat	1	Crocodile	1	Nxwee	Kumaga	dry
28/4/95	Goat	1	Crocodile	1	Gwaraga	Kumaga	dry
7/5/95	Goat	2	Crocodile	1	Bosobea	Kumaga	dry
7/5/95	Cow	1	Lion	2	Dikwalo	Kumaga	dry
10/5/95	Bull	1	Lion	2	Kumaga	Kumaga	dry
13/5/95	Cow	1	Hyena	1	Nxamisane	Kumaga	dry
14/5/95	Ox	1	Lion	1	Menoakwena	Kumaga	dry
24/5/95	Goat	1	Crocodile	1	Bosobea	Kumaga	dry
24/5/95	Donkey	1	Lion	1	Bosobea	Kumaga	dry
24/5/95	Cow	1	Lion	1	Bosobea	Kumaga	dry
26/5/95	Donkey	1	Hyena	1	Menoakwena	Kumaga	dry
29/5/95	Goat	2	Hyena	1	Dikwalo	Kumaga	dry
28/6/95	Calf	1	Lion	1	Gwaraga	Kumaga	dry
28/7/95	Donkey	1	Lion	1	Gwaraga	Kumaga	dry
4/8/95	Goat	1	Crocodile	1	Kumaga	Kumaga	dry
7/8/95	Cow	1	lion	1	Dikwalo	Kumaga	dry
8/8/95	Cow	1	Lion	1	Gwaraga	Kumaga	dry
11/8/95	Cow	1	Hyena	2	Menoakwena	Kumaga	dry
14/8/95	Goat	1	Crocodile	1	Gwaraga	Kumaga	dry
4/9/95	Goat	1	Leopard	1	Menoakwena	Kumaga	dry
19/9/95	Cow	1	Hyena	2	Menoakwena	Kumaga	dry
23/9/95	Goat	1	Jackal	3	Gwaraga	Kumaga	dry
23/9/95	Donkey	3	Lion	4	Gwaraga	Kumaga	dry
28/9/95	Goat	2	Crocodile	2	Kumaga	Kumaga	dry
29/9/95	Donkey	2	Lion	4	Gwaraga	Kumaga	dry
29/9/95	Calf	1	Lion	2	Kumaga	Kumaga	dry
6/10/95	Donkey	1	Lion	3	Gwaraga	Kumaga	dry
6/10/95	Donkey	1	Lion	3	Gwaraga	Kumaga	dry
10/10/95	Goat	1	Crocodile	1	Kumaga	Kumaga	dry
15/10/95	Foal	1	Lion	4	Menoakwena	Kumaga	dry
15/10/95	Calf	3	Lion	4	Menoakwena	Kumaga	dry
18/10/95	Goat	1	Hyena	2	Sesanasamotswere	Kumaga	dry
23/10/95	Calf	1	Lion	2	Tsoi	Kumaga	dry
15/4/96	Cow	1	Lion	2	Nxwee	Kumaga	dry
15/4/96	Donkey	1	Hyena	1	Sesanasamotswere	Kumaga	dry
18/4/96	Goat	1	Crocodile	1	Bosobea	Kumaga	dry

Date	Livestock type	Livestock No.s	Predator type	Predator No.s	Location	Region	Season
18/4/96	Donkey	5	Lion	1	Nxamisane	Kumaga	dry
18/4/96	Goat	2	Lion	1	Menoakwena	Kumaga	dry
4/6/96	Cow	1	Lion	2	Gwaraga	Kumaga	dry
9/6/96	Cow	1	Lion	2	Bosobea	Kumaga	dry
10/6/96	Donkey	1	Lion	1	Kumaga	Kumaga	dry
18/6/96	Cow	1	Lion	1	Kumaga	Kumaga	dry
24/6/96	Heifer	1	Lion	1	Kumaga	Kumaga	dry
2/11/94	Goat	1	Jackal	2	Senagomo	Kumaga	wet
4/11/94	Cow	1	Lion	1	Nxwee	Kumaga	wet
7/11/94	Goat	1	Jackal	1	Senagomo	Kumaga	wet
8/11/94	Cow	1	Crocodile	1	Gwaraga	Kumaga	wet
12/11/94	Goat	3	Jackal	1	Marotobolo	Kumaga	wet
12/11/94	Goat	1	Jackal	1	Menoakwena	Kumaga	wet
13/11/94	Goat	2	Crocodile	1	Gwaraga	Kumaga	wet
13/11/94	Goat	1	Jackal	1	Menoakwena	Kumaga	wet
23/11/94	Tolly	1	Hyena	1	Marotobolo	Kumaga	wet
24/11/94	Horse	1	Lion	2	Bosobea	Kumaga	wet
25/11/94	Cow	1	Lion	3	Beexhana	Kumaga	wet
28/11/94	Donkey	1	Hyena	1	Kumaga	Kumaga	wet
29/11/94	Goat	1	Crocodile	1	Mozikiya	Kumaga	wet
2/12/94	Cow	1	Lion	1	Menoakwena	Kumaga	wet
3/12/94	Cow	1	Lion	1	Menoakwena	Kumaga	wet
3/12/94	Goat	1	Crocodile	1	Kumaga	Kumaga	wet
8/12/94	Ox	1	Lion	3	Menoakwena	Kumaga	wet
28/12/94	Donkey	2	Lion	1	Bosobea	Kumaga	wet
29/12/94	Cow	1	Lion	1	Bosobea	Kumaga	wet
4/1/95	Bull	1	Lion	1	Kumaga	Kumaga	wet
4/1/95	Calf	2	Lion	2	Menoakwena	Kumaga	wet
8/1/95	Cow	1	Lion	1	Kumaga	Kumaga	wet
8/1/95	Goat	1	Crocodile	1	Bosobea	Kumaga	wet
8/1/95	Goat	1	Crocodile	1	Bosobea	Kumaga	wet
11/1/95	Donkey	1	Lion	1	Bosobea	Kumaga	wet
13/1/95	Donkey	1	Lion	1	Bosobea	Kumaga	wet
24/1/95	Cow	1	Lion	1	Menoakwena	Kumaga	wet
27/1/95	Ox	1	Lion	1	Gwaraga	Kumaga	wet
28/1/95	Goat	1	Crocodile	1	Gwaraga	Kumaga	wet
28/1/95	Tolly	1	Hyena	1	Nxamisane	Kumaga	wet
1/3/95	Cow	1	Lion	2	Senagomo	Kumaga	wet
1/3/95	Calf	1	Crocodile	1	Nxwee	Kumaga	wet
5/3/95	Calf	1	Lion	1	Dikwalo	Kumaga	wet
5/3/95	Cow	1	Lion	3	Bosobea	Kumaga	wet
7/3/95	Donkey	1	Lion	2	Marotobolo	Kumaga	wet
7/3/95	Goat	1	Crocodile	1	Nxwee	Kumaga	wet
9/3/95	Donkey	1	Lion	4	Marotobolo	Kumaga	wet
14/3/95	Goat	2	Leopard	1	Gwaraga	Kumaga	wet
17/3/95	Goat	2	Crocodile	1	Nxwee	Kumaga	wet
18/3/95	Goat	1	Leopard	1	Gwaraga	Kumaga	wet
18/3/95	Goat	1	Leopard	1	Gwaraga	Kumaga	wet
18/3/95	Cow	1	Lion	1	Gwaraga	Kumaga	wet
21/3/95	Goat	1	Crocodile	1	Gwaraga	Kumaga	wet
21/3/95	Goat	1	Crocodile	1	Bosobea	Kumaga	wet
27/3/95	Cow	1	Lion	1	Nxwee	Kumaga	wet
28/3/95	Goat	1	Leopard	1	Nxamisane	Kumaga	wet
1/11/95	Donkey	1	Lion	2	Kumaga	Kumaga	wet
3/11/95	Goat	2	Lion	1	Bosobea	Kumaga	wet
3/11/95	Goat	1	Jackal	1	Menoakwena	Kumaga	wet
5/11/95	Ox	1	Lion	1	Gwaraga	Kumaga	wet
9/11/95	Goat	1	Crocodile	1	Kumaga	Kumaga	wet
12/11/95	Donkey	1	Lion	2	Gwaraga	Kumaga	wet
12/11/95	Donkey	1	Lion	2	Gwaraga	Kumaga	wet
18/11/95	Goat	2	Jackal	2	Menoakwena	Kumaga	wet
21/11/95	Goat	2	Lion	3	Dikwalo	Kumaga	wet
21/11/95	Sheep	3	Lion	3	Dikwalo	Kumaga	wet
24/11/95	Donkey	2	Lion	8	Kumaga	Kumaga	wet
25/11/95	Cow	1	Lion	1	Bosobea	Kumaga	wet
25/11/95	Calf	1	Lion	2	Bosobea	Kumaga	wet
27/11/95	Donkey	2	Lion	5	Marotobolo	Kumaga	wet
29/11/95	Donkey	1	Lion	5	Marotobolo	Kumaga	wet

Date	Livestock type	Livestock No.s	Predator type	Predator No.s	Location	Region	Season
30/11/95	Donkey	1	Lion	5	Marotobolo	Kumaga	wet
1/12/95	Donkey	1	Lion	5	Kumaga	Kumaga	wet
1/12/95	Donkey	1	Lion	8	Kumaga	Kumaga	wet
1/12/95	Donkey	1	Lion	3	Marotobolo	Kumaga	wet
14/12/95	Goat	8	Lion	4	Kumaga	Kumaga	wet
16/12/95	Cow	1	Lion	1	Kumaga	Kumaga	wet
18/12/95	Cow	1	Lion	2	Kumaga	Kumaga	wet
18/12/95	Donkey	1	Lion	2	Marotobolo	Kumaga	wet
18/12/95	Cow	1	Hyena	4	Nxamisane	Kumaga	wet
18/12/95	Calf	1	Hyena	4	Nxamisane	Kumaga	wet
18/12/95	Donkey	1	Lion	1	Mangana	Kumaga	wet
20/12/95	Goat	4	Lion	5	Marotobolo	Kumaga	wet
20/12/95	Horse	1	Lion	1	Menoakwena	Kumaga	wet
21/12/95	Ox	1	Lion	1	Menoakwena	Kumaga	wet
21/12/95	Ass	1	Leopard	1	Gwaraga	Kumaga	wet
22/12/95	Calf	1	Lion	1	Bosobea	Kumaga	wet
22/12/95	Ox	1	Lion	1	Marotobolo	Kumaga	wet
24/12/95	Donkey	1	Hyena	3	Nxamisane	Kumaga	wet
24/12/95	Goat	17	Lion	4	Gwaraga	Kumaga	wet
24/12/95	Donkey	1	Lion	2	Nxwee	Kumaga	wet
26/12/95	Cow	1	Lion	1	Bosobea	Kumaga	wet
28/12/95	Cow	1	Lion	2	Nxwee	Kumaga	wet
28/12/95	Calf	1	Lion	2	Nxwee	Kumaga	wet
29/12/95	Goat	2	Lion	2	Marotobolo	Kumaga	wet
30/12/95	Goat	2	Lion	2	Kumaga	Kumaga	wet
30/12/95	Cow	1	Lion	2	Bosobea	Kumaga	wet
31/12/95	Donkey	1	Lion	2	Menoakwena	Kumaga	wet
31/12/95	Cow	1	Hyena	3	Nxamisane	Kumaga	wet
31/12/95	Goat	1	Lion	2	Kumaga	Kumaga	wet
2/1/96	Donkey	1	Lion	6	Nxwee	Kumaga	wet
2/1/96	Goat	2	Lion	4	Menoakwena	Kumaga	wet
8/1/96	Calf	1	Leopard	1	Menoakwena	Kumaga	wet
9/1/96	Goat	1	Crocodile	1	Bosobea	Kumaga	wet
9/1/96	Goat	5	Hyena	3	Nxamisane	Kumaga	wet
9/1/96	Tolly	1	Hyena	2	Nxamisane	Kumaga	wet
12/1/96	Horse	1	Lion	2	Marotobolo	Kumaga	wet
13/1/96	Cow	1	Hyena	3	Nxamisane	Kumaga	wet
13/1/96	Calf	1	Hyena	3	Nxamisane	Kumaga	wet
18/1/96	Calf	1	Lion	1	Marotobolo	Kumaga	wet
23/1/96	Cow	1	Lion	1	Nxamisane	Kumaga	wet
25/1/96	Cow	1	Lion	2	Gwaraga	Kumaga	wet
25/1/96	Goat	5	Lion	3	Nxamisane	Kumaga	wet
26/1/96	Goat	14	Lion	2	Tsoi	Kumaga	wet
26/1/96	Donkey	1	Lion	2	Tsoi	Kumaga	wet
26/1/96	Cow	1	Lion	2	Tsoi	Kumaga	wet
29/1/96	Donkey	1	Lion	2	Khweligcum	Kumaga	wet
6/2/96	Ox	1	Lion	1	Kumaga	Kumaga	wet
19/2/96	Cow	1	Lion	2	Nxamisane	Kumaga	wet
19/2/96	Goat	2	Hyena	2	Nxamisane	Kumaga	wet
19/2/96	Cow	1	Crocodile	1	Kumaga	Kumaga	wet
19/2/96	Goat	2	Hyena	2	Nxamisane	Kumaga	wet
19/2/96	Cow	1	Lion	2	Nxamisane	Kumaga	wet
19/2/96	Cow	1	Crocodile	1	Kumaga	Kumaga	wet
21/2/96	Goat	1	Lion	7	Kumaga	Kumaga	wet
28/2/96	Donkey	1	Lion	4	Bosobea	Kumaga	wet
29/2/96	Horse	1	Lion	3	Nxamisane	Kumaga	wet
1/3/96	Goat	6	Lion	3	Marotobolo	Kumaga	wet
5/3/96	Donkey	1	Lion	4	Dikwalo	Kumaga	wet
5/3/96	Donkey	1	Lion	4	Dikwalo	Kumaga	wet
6/3/96	Calf	1	Lion	2	Nxamisane	Kumaga	wet
6/3/96	Cow	1	Lion	2	Nxamisane	Kumaga	wet
8/3/96	Calf	1	Hyena	1	Sesanasamotswere	Kumaga	wet
22/3/96	Donkey	1	Lion	2	Kumaga	Kumaga	wet
28/3/96	Goat	3	Lion	3	Marotobolo	Kumaga	wet
28/3/96	Sheep	1	Lion	3	Marotobolo	Kumaga	wet
30/3/96	Donkey	1	Lion	2	Kumaga	Kumaga	wet

Source: Department of Wildlife and National Parks - Botswana.

Appendix 8: Diary of livestock predation incidences for Gweta.

Date	Livestock type	Livestock No.s	Predator type	Predator No.s	Location	Region	Season
1/5/95	Ass	3	Hyena	1	Chaneo	Gweta	dry
24/6/95	Calf	2	hyena	6	Gcingcara	Gweta	dry
20/5/95	Calf	3	Hyena		Polanka	Gweta	dry
2/2/95	Calf	4	Hyena	1	Farm 5	Gweta	wet
21/9/94	Cow	1	Hyena		Kgaolasetlhako	Gweta	dry
27/4/95	Cow	3	Hyena		Ranch	Gweta	dry
2/9/95	Cow	2	Hyena	7	Kgaolasetlhako	Gweta	dry
31/7/95	Cow	3	Hyena		Gcingcara	Gweta	dry
1/5/96	Donkey	1	Hyena	1	Maronga	Gweta	dry
10/6/96	Cow	1	Hyena		Jinarwa	Gweta	dry
31/1/96	Donkey	1	Hyena	3	Gcingcara	Gweta	wet
3/4/96	Cow	1	Hyena	1	Gcingcara	Gweta	dry
11/6/96	Cow	1	Hyena	6	Gcingcara	Gweta	dry
19/10/94	Donkey	1	Hyena	1	Polanka	Gweta	dry
12/4/96	Donkey	1	Hyena		Polanka	Gweta	dry
4/5/96	Donkey	1	Hyena	2	Chaneo	Gweta	dry
15/8/94	Goat	4	Hyena		Chaneo	Gweta	dry
10/5/95	Goat	2	Hyena	1	Gweta	Gweta	dry
4/1/95	Goat	1	hyena	3	Chaneo	Gweta	wet
23/9/95	Goat	3	Hyena		Gcingcara	Gweta	dry
11/9/95	Goat	2	Hyena		Juna	Gweta	dry
7/10/95	Goat	1	Hyena		Maotomabe	Gweta	dry
6/4/96	Goat	3	Hyena	1	Polanka	Gweta	dry
4/8/96	Horse	1	Hyena		Chaneo	Gweta	dry
13/8/94	Ox	1	Hyena		Chaneo	Gweta	dry
5/12/94	Ox	1	Hyena		Polanka	Gweta	wet
5/6/95	Ox	2	Hyena	4	Kgaolasetlhako	Gweta	dry
22/2/95	Ox	1	Hyena	1	Gcingcara	Gweta	wet
16/7/96	Ox	1	Hyena	3	Chaneo	Gweta	dry
5/11/94	Sheep	3	Hyena		Tsokatshaa	Gweta	wet
12/4/95	Sheep	2	Hyena		Gweta	Gweta	dry
29/9/95	Sheep	2	Hyena		Kgaolasetlhako	Gweta	dry
3/3/96	Sheep	2	Hyena	1	Chaneo	Gweta	wet
18/6/96	Sheep	1	Hyena		Kgaolasetlhako	Gweta	dry
5/10/94	Tolly	3	Hyena		Kgaolasetlhako	Gweta	dry
25/9/96	Tolly	1	Hyena		Kgaolasetlhako	Gweta	dry
30/7/94	Goat	5	Jackal	1	Chaneo	Gweta	dry
8/9/94	Goat	3	Jackal	1	Chaneo	Gweta	dry
5/8/94	Goat	3	Jackal	2	Gcingcara	Gweta	dry
9/10/94	Goat	5	jackal	1	Polanka	Gweta	dry
5/10/94	Goat	3	Jackal		Gcingcara	Gweta	dry
31/5/94	Goat	4	Jackal		Gcingcara	Gweta	dry
22/9/94	Goat	1	Jackal		Gcingcara	Gweta	dry
25/9/94	Goat	1	Jackal	1	Kgaolasetlhako	Gweta	dry
7/5/95	Goat	3	Jackal		Gweta	Gweta	dry
8/5/95	Goat	2	Jackal		Gweta	Gweta	dry
14/5/95	Goat	1	Jackal	1	Xhoo	Gweta	dry
4/7/95	Goat	4	jackal	1	Polanka	Gweta	dry
12/6/95	Goat	1	Jackal	1	Polanka	Gweta	dry
4/7/95	Goat	4	Jackal	3	Chaneo	Gweta	dry
6/4/95	Goat	3	Jackal		Kgaolasetlhako	Gweta	dry
10/6/96	Goat	4	jackal	1	Kgaolasetlhako	Gweta	dry
17/5/96	Goat	4	Jackal		Polanka	Gweta	dry
26/1/96	Goat	3	Jackal		Xaa	Gweta	wet
19/11/96	Goat	2	Jackal		BLDC	Gweta	wet
5/5/95	Goats	1	Jackal		Gweta	Gweta	dry
6/5/95	Goats	4	Jackal		Gweta	Gweta	dry
12/8/95	Sheep	4	Jackal		Gcingcara	Gweta	dry
5/5/95	Sheep	2	jackal		Gcingcara	Gweta	dry
23/7/95	Sheep	1	Jackal		Kgaolasetlhako	Gweta	dry
4/4/96	Sheep	1	jackal	1	Chaneo	Gweta	dry
17/11/96	Sheep	1	Jackal		Chaneo	Gweta	wet
23/1/96	Sheep	2	Jackal		Chaneo	Gweta	wet
10/6/94	Calf	1	Leopard		Gcingcara	Gweta	dry
18/2/95	Calf	1	Leopard	1	Chaneo	Gweta	wet
4/5/96	Calf	1	Leopard	1	Gcingcara	Gweta	dry
4/11/96	Calf	3	Leopard	1	BLDC	Gweta	wet
10/9/95	Cow	1	Leopard		Chaneo	Gweta	dry

Date	Livestock type	Livestock No.s	Predator type	Predator No.s	Location	Region	Season
2/10/94	Sheep	2	Leopard		Gcingcara	Gweta	dry
19/9/94	Sheep	4	Leopard		Kgaolasetlhako	Gweta	dry
6/6/95	Sheep	1	Leopard		Kgaolasetlhako	Gweta	dry
22/4/95	Sheep	1	Leopard		Gcingcara	Gweta	dry
10/7/95	Sheep	3	Leopard		Polanka	Gweta	dry
14/3/96	Sheep	1	Leopard		Chaneo	Gweta	wet
29/12/96	Sheep	1	Leopard		Kgaolasetlhako	Gweta	wet
2/10/94	Cow	3	Lion		Gcingcara	Gweta	dry
13/1/96	Ass	1	Lion	1	Gcingcara	Gweta	wet
4/3/95	Bull	1	Lion	3	Polanka	Gweta	wet
28/9/94	Calf	1	Lion	2	Kgaolasetlhako	Gweta	dry
17/7/95	Calf	3	Lion	1	Polanka	Gweta	dry
2/5/95	Calf	2	Lion	1	Kgaolasetlhako	Gweta	dry
6/5/95	Calf	3	Lion		Chaneo	Gweta	dry
2/8/94	Cow	2	Lion	2	Polanka	Gweta	dry
25/10/94	Cow	3	Lion		Gcingcara	Gweta	dry
1/5/95	Cow	2	Lion	3	Chaneo	Gweta	dry
3/9/95	Cow	2	Lion		Gcingcara	Gweta	dry
30/8/95	Cow	1	Lion		Gcingcara	Gweta	dry
6/2/96	Cow	2	Lion	2	Xoo	Gweta	wet
20/11/96	Cow	1	Lion		Gweta	Gweta	wet
23/10/94	Donkey	3	Lion	1	Polanka	Gweta	dry
12/9/94	Donkey	2	Lion	1	Polanka	Gweta	dry
13/8/94	Donkey	1	Lion		Polanka	Gweta	dry
14/2/95	Donkey	2	Lion	5	Gcingcara	Gweta	wet
21/4/95	Donkey	3	Lion	1	Polanka	Gweta	dry
25/9/95	Donkey	1	Lion		Kgaolasetlhako	Gweta	dry
21/4/95	Donkey	0	Lion		Chaneo	Gweta	dry
26/6/95	Donkey	2	Lion		Gcingcara	Gweta	dry
9/7/95	Donkey	1	Lion		Chaneo	Gweta	dry
17/7/96	Donkey	1	Lion		Chaneo	Gweta	dry
20/11/94	Foal	1	Lion	1	Chaneo	Gweta	wet
8/10/95	Foal	3	Lion		Chaneo	Gweta	dry
18/4/96	Foal	3	Lion	4	Gcingcara	Gweta	dry
29/8/96	Foal	2	Lion		Gcingcara	Gweta	dry
20/11/94	Goat	1	Lion		Gweta	Gweta	wet
3/10/94	Goat	3	Lion	2	Gcincgara	Gweta	dry
25/5/94	Goat	3	Lion	1	Kgaolasetlhako	Gweta	dry
19/9/94	Goat	2	Lion	2	Kgaolasetlhako	Gweta	dry
20/12/94	Goat	1	Lion	2	Gweta	Gweta	wet
21/1/95	Goat	1	Lion		Gcingcara	Gweta	wet
7/7/95	Goat	1	Lion	2	Polanka	Gweta	dry
18/6/95	Goat	1	Lion	2	Chaneo	Gweta	dry
9/9/95	Goat	1	Lion		Gcingcara	Gweta	dry
9/10/95	Goat	3	Lion	3	Chaneo	Gweta	dry
4/7/95	Goat	1	Lion	1	Gcingcara	Gweta	dry
22/4/95	Goat	2	Lion	1	Magotlhong	Gweta	dry
15/6/96	Goat	1	Lion		Polanka	Gweta	dry
6/4/96	Goat	1	Lion		Chaneo	Gweta	dry
5/10/96	Goat	1	Lion		Polanka	Gweta	dry
3/5/95	Heifer	3	Lion		BLDC	Gweta	dry
2/10/94	Horse	1	Lion	3	Polanka	Gweta	dry
6/1/96	Horse	1	Lion	1	Gweta	Gweta	wet
6/2/96	Horse	2	Lion	2	Xoo	Gweta	wet
4/10/94	Ox	1	Lion	1	Kgaolasetlhako	Gweta	dry
30/12/94	Ox	1	Lion	1	Polanka	Gweta	wet
20/12/94	Ox	1	Lion	3	Gcingcara	Gweta	wet
20/12/94	Ox	1	Lion		Chaneo	Gweta	wet
3/7/95	Ox	2	Lion	1	Chaneo	Gweta	dry
18/9/95	Ox	2	Lion		Polanka	Gweta	dry
1/3/95	Ox	1	Lion	1	Gcingcara	Gweta	wet
27/9/96	Ox	1	Lion		Chaneo	Gweta	dry
4/3/96	Ox	1	Lion		Polanka	Gweta	wet
18/8/94	Sheep	4	Lion	3	Gcingcara	Gweta	dry
25/12/94	Sheep	1	Lion		Kgaolasetlhako	Gweta	wet
7/7/95	Sheep	3	Lion		Kgaolasetlhako	Gweta	dry
27/7/96	Sheep	1	Lion		Gcingcara	Gweta	dry
3/9/94	Tolly	3	Lion		Polanka	Gweta	dry

Date	Livestock type	Livestock No.s	Predator type	Predator No.s	Location	Region	Season
26/9/94	Tolly	1	Lion	1	Chaneo	Gweta	dry
4/9/94	Calf	1	Wilddog	5	Kgaolasetlhako	Gweta	dry
4/5/95	Cow	2	Wilddog		Tsokatshaa	Gweta	dry
12/5/95	Cow	6	Wilddog		Gweta	Gweta	dry
5/6/95	Cow	1	Wilddog		Kgaolasetlhako	Gweta	dry
12/7/96	Cow	1	Wilddog		Nxwauga	Gweta	dry
18/6/95	Donkey	1	Wilddog		Kgaolasetlhako	Gweta	dry
8/4/95	Donkey	1	Wilddog		Polanka	Gweta	dry
15/8/95	Donkey	1	Wilddog		Nxwauga	Gweta	dry
23/1/95	Donkey	2	Wilddog		Chaneo	Gweta	wet
19/11/95	Donkey	2	Wilddog		Chaneo	Gweta	wet
6/7/96	Donkey	1	Wilddog		Tsokatshaa	Gweta	dry
25/8/94	Goat	2	Wilddog		Gweta	Gweta	dry
5/8/95	Goat	2	Wilddog	1	Gcingcara	Gweta	dry
8/12/95	Goat	0	Wilddog		Nxwauga	Gweta	wet
20/12/95	Goat	1	Wilddog		Kgaolasetlhako	Gweta	wet
1/5/96	Goat	2	Wilddog		Juna	Gweta	dry
21/2/96	Goat	0	Wilddog	1	Maotomabe	Gweta	wet
12/4/95	Tolly	1	Wilddog		Kgaolasetlhako	Gweta	dry

Source: Department of Wildlife and National Parks - Botswana.