THE COST OF PREDATION ON SMALL LIVESTOCK IN SOUTH AFRICA BY MEDIUM-SIZED PREDATORS

by

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Submitted in partial fulfilment of the requirements for the degree
M.Sc. Agric.

in the
Department of Agricultural Economics
Faculty of Natural and Agricultural Sciences
University of the Free State
Bloemfontein

30 November 2010

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Acknowledgements

This study was made possible with the assistance, cooperation and patience of many individuals. I wish to thank everybody who contributed in some way towards this study, several whom I would like to mention by name.

My supervisor, Dr. Pieter Taljaard, for his guidance, faith, encouragement and time. My co-supervisors, Dr. Bennie Grové and special thanks to Prof. HO de Waal, for all his knowledge in the field of study. My colleagues in the Department of Agricultural Economics at the University of the Free State, with special thanks to Dirkie Strydom, Nicky Matthews, Willem Zwiegers, Esté van der Merwe; and the administrative staff namely Marie Engelbrecht and Louise Hoffman, for their assistance.

Mrs. Hester Linde, Department of Animal, Wildlife and Grassland Sciences for preparing and printing the final copy of the dissertation.

A special word of thanks to the livestock producers' organisations (RPO and NWGA) for providing funds to complete this study and to the farmers who were willing and helpful in completing the questionnaires.

The guidance and financial support provided by ALPRU under the guidance of Prof. HO de Waal at the University of the Free State is especially appreciated.

To my mother for her ongoing support on so many levels, encouragement and the fine example she has always set; without her none of this would have been possible.

Finally, and most importantly, I give thanks to Almighty GOD for giving me the talents, inner strength and wisdom to complete this study.

The cost of predation on small livestock in South Africa by medium-sized predators

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ABSTRACT

Farmers have been protecting their livestock for centuries by fencing and kraaling to prevent the risk of losses due to predators. The black-backed jackal (*Canis mesomelas*) and the caracal (*Caracal caracal*) are two important medium-sized predator species among the South African wildlife, but they have a negative impact on the livestock industry in South Africa, especially among sheep and goats.

A small number of studies have been done to estimate losses due to predators. Local producer organisations estimated a loss of 8% of small livestock per year. However, no countrywide study has been done to quantify the monetary impact of predation on the livestock industry. Predation losses are not the only direct economic losses because there are also additional direct and indirect costs involved.

The primary objective of this study was to quantify the economic losses due to predation on small livestock and further to analyse the effect of various managerial aspects on the occurrence and level of predation on small livestock farms.

The five major small livestock producing provinces (Eastern Cape, Northern Cape, Free State, Western Cape and Mpumalanga) were used to collect primary data on predation. Telephonic interviews were used to collect data from 1 424 farmers in the five major small livestock producing provinces. The questionnaire included questions on farm name, location and size, flock size, topography, surrounding land uses, livestock losses due to predators, predator control and various managerial aspects.

The majority of losses in these five provinces were small livestock younger than one month, where the black-backed jackal was responsible for the majority of the predation. Losses due to caracal were not as high compared with black-backed jackal. This is mainly ascribed to lower population levels of caracals and also that these damage-causing animals are not found in every region within a province. Losses due to caracal were associated with lambs or kids older than a month, as well as older small livestock.

Predation losses due to predators was estimated at R 1 390 453 062 when extrapolating predation losses for the five provinces to the rest of South Africa. The Northern Cape Province reported the highest predation losses, namely R 540 847 496. The reported predation losses for the other four provinces were R 412 810 143 for the EC province, R 247 141 016 for the FS province, R 84 673 440 for the MP province and R 104 980 967 for the WC province. The physical monetary value attached to predation in this study was only the direct cost of predation and do not include indirect cost of controlling damage-causing animals.

The monetary losses as presented previously were based on biological information provided by respondents for the five major small livestock producing provinces. For example in the NC province 426 farmers were surveyed, representing 6.9% of commercial farmers in the province. These farmers were farming on 3 290 790 ha and lost on average 6.14% of their total small livestock and 13% of production animals (lambs between 0 – 6 months). The majority of losses were associated with predation by the black-backed jackal (65%) and to a lesser extent predation by the caracal (30%). Other losses experienced on farms were attributed to stock theft (3%) and vagrant dogs (1%).

There are a number of variables affecting predation in small livestock producing areas in South Africa. These variables differ between provinces according to the main agricultural practices in the area and the management practices used.

It was hypothesised that the variables affecting the occurrence of predation and the variables that affected the level of predation was not the same, therefore, it was necessary to use the Probit and Truncated regression models. It was assumed that factors affecting the occurrence of predation are usually associated with management aspects and normally will be negatively correlated with predation losses. Variables affecting the level of predation can be seen as factors reducing the level of predation and these factors will usually include non-lethal and lethal control methods. The non-lethal control methods usually do not stop predation, but will reduce the level of predation on a farm. However, when success is associated with a certain control method, this variable will be significant in effecting the occurrence of predation on a farm and at a specific point in time.

The information collected in this study showed that predation is a serious problem for the South African small livestock sector and there is also no indication that the level of predation is decreasing. This study does not answer all questions on predation, but provides valuable information in understanding the magnitude or extent of predation and some of the factors influencing predation on farms. The information collected can be used to select, evaluate and focus intensively on smaller areas in their efforts to manage predation and develop strategies to reduce the impact.

Declaration

I hereby declare that this dissertation submitted by me to the University of the Free State for the degree MAGISTER SCIENTIAE AGRICULTURAE (M.Sc. Agric.) Agricultural Economics is my own independent work and has not previously been submitted by me to any other university. I furthermore cede copyright of the dissertation in favour of the University of the Free State.

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Bloemfontein
November 2010

1. Background and motivation

Farmers have been protecting their livestock for centuries by kraaling and fencing animals to prevent the risk of predation losses. The black-backed jackal (*Canis mesomelas*) and the caracal (*Caracal caracal*) are important medium-sized predator species among the South African wildlife, but they also have a negative impact on the livestock and wildlife industries, especially small livestock like sheep and goats (Hall-Martin & Botha, 1980; De Waal *et al*., 2006). These two predators are found in most parts of Southern Africa (Skinner & Chimimba, 2005). Although the diet of the black-backed jackal and the caracal normally consists of smaller mammals, rodents and birds (Cillie, 1997), they also prey on small livestock. Analysis of the stomach content showed the abundance of small and larger game species (Rowe-Rowe, 1983) and small livestock found in the stomachs of black-backed jackal and caracal (Hall-Martin & Botha, 1980; Moolman, 1984).

Until the early 1990's the official system of predator control in South Africa was conducted by predator hunting clubs, with active farmer participation (Stadler, 2006; Gunter, 2008; De Waal, 2009). Since the mid 1990's most of the official predator hunting clubs were phased out and the government returned the primary responsibility to safeguard livestock to the farmers, while the government retained the responsibility of providing training in predator control techniques.

The longstanding bitterness by livestock farmers towards predators is understandable. The animosity of livestock farmers specifically towards the black-backed jackal and the caracal has also created distrust between neighbouring farmers and increasingly between livestock farmers and nature conservation authorities (De Waal *et al*., 2006). Thus, many livestock farmers feel that they have been abandoned by authorities, leaving them to their own means and devices in dealing with animal damage control (De Waal *et al*., 2006; Gunter, 2008; Strauss, 2010).

The problem of predation is an age-old problem for small livestock producers and having to cope with the economic potential or opportunity cost of the livestock being lost. Recently, Strauss (2010) reported on the big impact that black-backed jackal had on the Merino and Dorper flocks at the Glen Agricultural Institute, namely accounting for 70% of the 730 postweaning sheep losses from 2003 until 2007. Furthermore, the losses ascribed to predation contributed to 72% of the total annual financial losses, diseases 2%, metabolic disorders or accidental mortalities 20% and stock theft only 6% (Strauss, 2010). It was therefore concluded by Strauss (2010) that the financial impact ascribed to predation at an average of R129 562/year overshadowed the losses due to diseases (average R4 337/year), metabolic disorders or accidents (average R35 299/year) and stock theft (average R9 843/year) by a considerable margin. Clearly, this scale of direct financial losses due to predation can not be sustained in the long run (Strauss, 2010).

Very few studies have been done to estimate the extent and value of the predation problem. The National Wool Growers' Association (NWGA) has estimated a loss of 8% of livestock per year for South Africa, losses being mostly small livestock such as young lambs before weaning (NWGA, as cited by De Waal, 2007). There is no evidence that the problem of predation is decreasing in South Africa and livestock losses have not declined (Canis-Caracal Programme, 2006). In addition to the widely publicised losses among sheep and goats, it would appear that cattle producers and wildlife ranchers are also increasingly experiencing losses as a result of these two predators (De Waal, 2007).

According to Shwiff and Bodenchuk (2004) predation management is a controversial and often misunderstood reality of livestock management. There are specific benefits to be derived from predation management, namely direct, spill over and intangible benefits of predation management (Shwiff & Bodenchuk, 2004). Furthermore the authors stated that, the cost or impact of predation is not only measured in the direct losses of livestock, but also other cost elements must also be considered such as the indirect cost to the farming enterprise to apply preventive or control methods and other management expenses.

The gross farm income from all agricultural products in South Africa was estimated at R89 005 million for the year ending June 2007. This is 4.9% higher than the previous corresponding period. Income from animal products amounted to R 44 417 million. The total gross income from sheep slaughtered in South Africa exceeds R 2 301 million (NDA, 2006/07). A loss of 8% of small livestock numbers as a result of predation would have a marked impact on the profitability of livestock farming.

Given the paucity of more recent information regarding the impact of predation on livestock, efforts to quantify the economic losses caused by predation should be given priority to assist in creating a coordinated system of predation management in South Africa.

1.1 Problem statement

Despite the wide distribution of these two medium-sized predator species in southern Africa, very little is known about their current status, current distribution and their impact on the small livestock industry. The impact of these medium-sized predator species should not only be calculated in terms of the direct losses to predation on livestock, but also the additional losses to predation which include additional costs such as active measures to prevent or reduce predation, including methods such as hunting, trapping, specialised infrastructure, and labour (Arnold, 2001).

In South Africa little recent research has been done on predation by the black-backed jackal and caracal and especially the factors affecting the scale of predation (Herselman, 2004; 2005; Gunter, 2008; Strauss, 2010). It is important that the small livestock industry should know the extent of the impact of predation in order to develop effective strategies to reduce the impact of predation by specifically these two medium-sized predators.

1.2 Objectives

The primary objective of this study is to quantify the economic losses due to predation on small livestock in the major small livestock producing areas of South Africa, specifically the Eastern Cape, Free State, Northern Cape, Mpumalanga and Western Cape provinces.

More specifically, the secondary objectives are to determine the factors affecting predation on small livestock farms in South Africa. These latter aspects include different ways to control problem animals (non-lethal and lethal methods), topographical differences of South Africa and certain aspects of management. The latter include time of lambing season, number of lambing seasons per year, small livestock breeds, and other management aspects.

1.3 Outline of this study

This study consists of five chapters. Background and a better understanding of the problem of predation worldwide and more particular predation in South Africa by medium-sized predators, will be discussed in the early parts of Chapter 2. This will also include effective ways in valuing losses and principles of predator control. Thereafter follows a short history of black-backed jackal and caracal in South Africa and managing predator populations. The Chapter 2 concludes with the effectiveness of predator management at farm level and different factors affecting predation on a farm in South Africa. The data that are used in this study is briefly discussed in the early parts of Chapter 3 after which a description follows of the procedures that is used to analyse the data on predation in South Africa. The results of predation in South Africa is presented in Chapter 5, this includes descriptive analyses of each province, factors affecting predation and the cost of predation in each province. Finally the conclusions and recommendations drawn from the study are presented in Chapter 5.

2. Literature Review

2.1 Introduction

This chapter focuses on the implications that predators have on farmers across the world, more particularly, losses incurred as a result of predation by black-backed jackal (*Canis mesomelas*) and caracal (*Caracal caracal*). The factors affecting predation and the value of the losses play an important role in accurately evaluating the problem of predation in South Africa.

2.2 Predation worldwide

According to Shwiff and Bodenchuk (2004) predation management is a controversial and often misunderstood reality of livestock management. There are specific benefits to be derived from predation management, namely direct, spillover, and intangible benefits of predation management (Shwiff & Bodenchuk, 2004).

Predation on livestock by predators is a problem for livestock farmers across the world. For example, coyotes *(Canis latrans*) kill sheep (Conner *et al.*, 1998) and goats (Windberg, 1997) in parts of the USA and Canada (Dorance & Roy, 1976), wolverines *(Gulo gulo L.)* kill sheep and domestic reindeer *(Rangifer tarandus L.)* in Norway (Landa *et al.*, 1999), jackals *(Canis aureus L.)* kill cattle in Israel (Yom-Toy *et al.,* 1995) and wolves *(Canis lupus L.)* kill livestock in southern Europe (Meriggi & Lovari, 1996). In Spain, brown bears *(Ursus arctos)* appeared to be opportunists and do not take particular species or age classes of domestic animals, but instead preyed upon those that were most common.

A study done by Landa *et al.* (1999) found that wolverines played an important role in predating on domestic animals in the Northern parts of Norway. However, different sheep breeds vary in awareness and anti-predator strategies that were used in trials. This implies that wolverine predation on sheep could be expected to vary among the different sheep breeds and an abundance of prey can influence the depredation behaviour of predators. For example, Lugton (1993) showed that red foxes *(Vulpes vulpes)* began to kill and eat sheep when their natural food items were in short supply or when the population density of foxes becomes high and old foxes dominate the population. A reduction in the wolverine population will, on the other hand, be expected to result in a reduction in the number of sheep killed by wolverines. According to the research done by Lugton (1993) showed that 50-85% of the dead sheep that were found could be identified as having been killed by wolverines. Lugton (1993) reported that the total number of lambs that were reported to have disappeared while grazing was used to analyse the variation in losses among the various sheep breeds. The killing of wolverines led to fewer lambs being lost in the same year that the wolverine killing took place, but the effect quickly declined, implying a rapid re-establishment of wolverines in the local area. The lambs were more vulnerable to wolverine predation than ewes, and losses were higher in wolverine cub-rearing areas than in the area as a whole. Landa *et al.* (1999) stated in similar studies done on predators, that control programmes have little long-term effect in reducing predation losses, unless predators are eradicated or severely reduced in numbers.

Greentree *et al.* (2000) focussed on the South Eastern parts of Australia where foxes prey upon lambs. The main agricultural enterprises in the region are Merino wool, fat lamb, beef cattle production and winter cereal cropping. The study used a factorial experimental design with fox control (poisoning) as a fixed factor and years and replicates as random factors. There were three levels of fox control (zero, once per year and three times per year). The three levels of fox control were used for the following reasons: (1) the zero fox control was the experimental control; (2) fox control once per year simulated the typical management practice and (3) poisoning against foxes just prior to lambing. Fox control three times per year was considered a likely maximum level of fox control that would be used by land managers. The effects of fox control and years were examined in a repeated measures analysis. Fox control was a fixed factor and years and replicates were random factors. This experimental study demonstrates that lamb production was not significantly affected by fox control. Fox predation of lambs occurred in the presence and absence of fox control. There were significant changes in the estimated incidence of predation by foxes. However, with predation being reduced with greater fox control, fox predation was the probable cause of lamb deaths for a minimum of 0.8% and a maximum of 5.3% of 1 321 lamb carcasses found. Fox control significantly reduced the minimum percentage of lamb carcasses classified as being killed by foxes from 1.5% (no fox control) to 0.9% (fox control once per year) or 0.2% (fox control three times per year). Fox control also significantly reduced the maximum percentage of lamb carcasses classified as killed by foxes from 10.2% (no fox control) to

6.5% (fox control once per year) or 3.7% (fox control three times per year). Poisoning did not affect fox abundance in spring as found by Greentree *et al.* (2000).

About 15% of the European wolf *(Canis lupus L.)* population is found in southern Europe. Wolf populations are fragmented and often comprise fewer than 500 individuals. In Northern and Eastern Europe, wolves feed mainly on wild herbivores. According to Meriggi & Lovari (1996), in southern Europe, these animals have adapted to feed also on fruit, rubbish and livestock, as well as small and medium-size mammals. The main conservation problem in these areas lies with predation on domestic animals, which leads to extensive killing of wolves. The reintroduction of large wild animals in the areas has been done to reduce the level of attacks on livestock, but predation may remain high if domestic animals are in a high level of abundance in a specific location. The selection of wild and domestic animals was influenced mainly by their local abundance, but also by their accessibility. Meriggi *et al.* (1996) concluded that the reintroduction of wild animal species is likely to reduce predation on livestock and may be one of the most effective conservation measures.

Ciucci and Boitani (1998) investigated wolf and dog predation on livestock and the cost of compensation in Italy. Most depredations involved sheep, with a mean (± SD) annual loss of 2 550 (±730) sheep representing 0.35% of the regional livestock. Sheep lost to predators by province were correlated with sheep density within areas containing wolves. The highest levels of predation were observed in provinces at the border of the regional wolf range where livestock was left unattended most of the year and sheep density reached its highest regional levels. Most of the sheep predation occurred during the night, in pastures with a abundance of wood or vegetative cover and involved free-ranging flocks unattended by either shepherds or guard dogs. High levels of predation occurred in localized areas of intensive sheep production; 6% of the affected farms and 8% of the affected municipalities accounted for 32% of the sheep lost to both wolves and dogs at the regional level. Ciucci *et al.* (1998) recommended that a compensation programs were not effective in reducing the conflict or in preventing illegal, private efforts to control wolf numbers. Ciucci *et al.* (1998) also stated that an improved husbandry practices should be encouraged and facilitated through financial incentives and public education as form of predation management.

2.3 Predator (damage-causing animal) management

Wildlife management implies the stewardship of a population and may be an attempt to make it increase, decrease or harvest it for a continuing yield (Caughley & Sinclair, 1994). In the case of vertebrate pests, it is usually the second of these (or holding the population at a reduced level) that is the aim. The concept of a pest is difficult to define and the issues involved in deciding whether an animal is termed a pest are both scientific and social (Hone, 1994; Moberly, 2002). A general definition is: “A species that conflicts with human interests, having implications for economic systems or human health” (Hone, 1994; Moberly 2002). It is the damage that vertebrate pests cause that justifies their control, however, pest management is frequently carried out in an *ad hoc* fashion and correctness of management is rarely assessed (Shea *et al.,* 2000; Moberly, 2002).

Economics is often experienced as the discipline that measures in monetary units, while other disciplines use physical units. However, this view is too simplistic and even inappropriate because economics is not concerned principally with money but with making rational choices and decisions in the allocation of scarce resources and competing alternatives. The conceptual models underlying economic analyses include three major components: people, products and resources (Mclnerney, 1987; Otte & Chilonde, 2001). It is people who want certain products and make decisions, products are goods and services that satisfy people’s wants, and resources are the physical factors and services that are the basis for generating the products, and as such the starting point of economic activity (Otte & Chilonde, 2001).

According to Caughley and Sinclair (1994) and Moberly (2002) one of the criteria for determining whether control of predators is an appropriate management action, is whether the benefit of carrying out control exceeds the cost and this should be determined before a control program is instigated in order to prevent unnecessary or uneconomic control actions

In some parts of the world there are no predators roaming freely and many animal species have been able to flourish in abundance, competing with the interests of farmers, hence livestock and food production. These species, thus, gained the label of “pest”. The analysis of pest control is not only important in economic and financial terms, but also needs to be acceptable to moral principles (Andrew & Robotton, 2000). According to Andrew *et al.* (2000) and Braysher (1993) managing vertebrate pest strategies is to find the best possible, humane, scientifically based guidelines for pest management. These conditions must be ethical and acceptable to humanity, however, these are an important aspects which are not considered in this study.

The management of wildlife as pests involves making choices that determine how much the control will cost and the benefit likely to be achieved. In order to make these choices acceptable, the effect that alternate actions will have on how costs and benefits of pest control accrue should ideally be understood. The understanding of how benefits and costs vary among different pest management strategies and the biological and management components of pest-resource system must be linked so that its economic input and output can be estimated and compared (Choquenot & Hone, 2002).

Aerial hunting is commonly used by agricultural agencies as a management strategy to reduce predation in the Intermountain West of the United State of America to reduce coyote *(Canis latrans)* predation on domestic sheep (Wagner & Conover, 1999). The authors assessed the effect of aerial hunting of coyotes on sheep losses due to coyotes, and the need for corrective predation management on the same pastures when sheep arrived for the subsequent summer grazing season. Comparisons were made between paired pastures with and without winter aerial hunting from helicopters. The numbers of dead lambs located and confirmed killed by coyotes was statistically significant less in treated pastures than in untreated pastures. To estimate total lamb losses to coyotes, Wagner and Conover (1999) multiplied the proportion of known lamb deaths that were confirmed coyote kills by the number of missing lambs and added the resulting figure of confirmed kills. Based on values for 1995 regarding Utah lambs and labour, winter aerial hunting of coyotes had a benefit:cost ratio of 2.1:1.

2.3.1 Valuing losses

Livestock losses represent a cost to farmers, as do the opportunity cost of actions that are used to prevent them. The profit of a small livestock farmer is a function of the number of lambs born and lamb losses between birth and weaning. As lamb losses are made up of predation losses to predators and losses to other causes (including diseases and theft), it can be assumed that a sheep farmer aims to minimise lamb losses to predators per ewe in the total lambing flock so far as possible (Moberly *et al.*, 2003b; Skonhoft, 2005; Strauss, 2010).

Therefore the cost of livestock mortality should take into account both the loss, or reduction in output, and the expenditure on extra inputs, including control and prevention costs (Mclnerney *et al.,* 1992; Strauss, 2010). Total cost figures alone are of limited use in determining what management actions should be taken to help improve a wildlife or disease problem and an economic analysis of predator control should consider how the marginal benefits of preventive and treatment measures compare with their costs in order to find the most efficient solution to the problem in terms of resource allocation (Mclnerney *et al.,* 1992).

There are several ways of valuing the costs of livestock mortality. One approach is to use the output loss, the loss as "finished products" or the value of the animal when it is lost (Mclnerney, 1987; Moberly, 2002). The value is difficult to estimate if the animal is not at a point of sale, as in contrast to when a "finished product" is lost. Losses are determent according to Otte and Chilonda (2002) and Mclnerney *et al.* (1992) as the total cost (C), the loss of the animal (L), plus the direct and indirect expenditure cost and control expenditure (E). This estimates the total cost to farmers based on the market price of an animal multiplied by the number of losses.

2.3.2 Approaches to analysis of losses

The resources spent on preventing livestock losses to predators are likely to be traded off against the cost of these losses. Therefore it is not just the total cost of losses and preventive and treatment measures that should be considered in an economic analysis of predation, but how these relate to one another and consequently, what is the most efficient point in terms of resource allocation. A number of approaches could be used to analyse the costs of predation in an economic framework (Moberly, 2002).

Many techniques exist in assessing the problem of pest control, one of which is the decision theory. A farmer has to decide what strategy or level of pest control or preventive measure to use before the economic impact of the pest is known. If there is uncertainty about what level of pest attack will occur, but the probability of any particular level of attack occurring is known, the expected outcome of alternative strategies can be determined. An alternative to risk decision models is the use of marginal analysis, where the cost of preventive measures and control are compared with the benefits of reduced losses due to the control effort. Taylor *et al.* (1979) suggested that the production function approach should be used to estimate the optimum rates of predator control and the predator density, which is socially, economically and ecologically acceptable for predation of lambs by coyotes in Utah (USA), where there is a 10% annual decrease in Utah's sheep numbers.

The production function approach has been used by environmental economists to value environmental or resource quality for which there is no direct market value. Whilst more direct market or resource-based approaches can be used for valuing livestock mortality due to predation, the approach illustrates how environmental resources can be included in production functions, which could then be used for more detailed analysis, including assessing optimal levels of use of preventive measures (Moberly, 2002). As predation affects losses directly, we can also consider the cost rather than the production side of an operation.

The principle of marginal returns was used by Otte and Chilonda (2001) to estimate the cost of animal diseases. In a relationship between production losses and control expenditure, i.e. higher treatment and prevention expenditures, this should result in lower losses. In most cases these relationships between losses and expenditure will be non-linear reflecting the non-linear nature of the typical production function. According to the law of diminishing marginal returns, the additional return per additional unit of input will decrease as the amount of inputs increases. Therefore, the maximum use of inputs will not lead to the maximum revenue (in the case of predation, less sheep caught). For any variable input, the optimum level of its use occurs when the extra return just equals the extra cost per unit. Thus, there is an "economic optimum" amount of input use for a desirable outcome (Otte & Chilonda, 2001).

Mclnerney (1996) used basically the same concept, arguing that the economic optimal position of disease control occurs where there is an additional unit of currency spent. This defines the part where the cost of the disease is minimised, if the cost is defined as the loss plus expenditures. At this point, the marginal costs of control equal the marginal benefits of control. In the case of predation, benefits are defined as the reduction in livestock losses due to control (Mclnerney *et al.*, 1992; Moberly, 2002).

2.3.3 Principles of predator control

A number of researchers found a positive relationship between abundance of predators and damages. Hone (1994) points out that there is a positive relationship between pest abundance and damage. Damages are unlikely and unusual because the extent of damage depends on a number of variables other then the pest abundance. Moberly *et al.* (2003a,b) also found a positive relationship between fox abundance with perceived predation and that fox predation was more likely to occur on larger farms, but, when it did, fewer lambs were perceived lost per ewe. Landa *et al.* (1999) found that the killing of wolverines led to fewer lambs being lost in the same year that the wolverine killing took place; also that population is positively correlated with predation.

Predator control or management cuts across the field of wildlife ecology and management; decisions for control are inseparable from other resource plans and decisions. Carnivores, omnivores, herbivores, and scavengers sometimes develop predatory tendencies and require control (Berryman, 1972). Predator control should be practiced only when it is essential to accomplish planned management objectives including disease suppression, wildlife protection and domestic animal protection. Planning for control requires that control decision is not to be made independently. Planning should rather involve several agencies and interdisciplinary talent and that an input of accurate data be assured. The criteria for determining needs include a combination of social, economic, political and administrative considerations. Control measures should be applied at a time, point and place when the organism is most vulnerable with the least risk of side effects. Control methods should be applied in combination to achieve flexibility and selectivity (Berryman, 1972).

2.3.4 Arguments for managing predator populations in South Africa

Despite the wide distribution ranges of these two predator species in South Africa, their well-known status as damage-causing animals and their impact on small livestock, very little research has been done on the black-backed jackal and the caracal, in particular losses incurred as a result of predation. The impact of problem animals is not only the predation on livestock, but the economic impact of the losses in small livestock.

The losses due to predation is not the only economic loss, there is an additional cost in preventing predation, these methods include hunting, fences, poisons and traps etc. (Arnold, 2001). The financial impact that the jackal and caracal poses is believed to be more than losses due to theft in South Africa. Losses due to theft are approximate R300 million per annum (De Waal *et al.*, 2007); the annual losses to predation in South Africa is estimated at 2.8 million head of small livestock, according to the National Wool Growers' Association (NWGA, 2007).

Studies have been done to estimate the problem; the NWGA estimated a loss of 8% of livestock per year, the losses are mostly small livestock, especially young lambs before weaning (De Waal, 2007). Brand (1993) calculated that losses from black-backed jackal range from 3.9% to 18% in certain areas, which entail a high economic loss to farmers. However, although these studies by the NWGA (2007) and Brand (1993) are very important, there is a paucity of economic information on predation losses by these two damage-causing animals.

These studies only focused on high predation areas and farmers how encountered losses. Thus there was a need for a nation wide study on predation to collect information on predation losses for economic analyse. It was also necessary to have a representative sample of farmers which include farmers incurring no predation losses in areas with high predation losses.

2.4 Predation in South Africa

Predators attacked livestock of the European settlers from the time of the first Dutch settlement. The most effective way was to keep sheep and other livestock in enclosure at night. The most well known small livestock predator in the 1900's was the black-backed jackal, widespread threw out the southern and eastern parts of Africa (including the majority of South Africa) (Cillie, 1997), especially in more open semi-arid and grassland habitats which are also preferred for small livestock farming. Black-backed jackal and other small predators were not known to attack humans, but they became a pest to small livestock farmers. Their adaptability came into full play when both small livestock and game diminished to such an extent that they began to depend more heavily on small livestock. Predation tended to be worse during droughts, when other food sources diminished and sheep were negatively affected and weakened by the drought conditions. Records of sporadic rewards (bounties) offered for skins are one indication that predators were initially overshadowed as predators by larger species (Bleinart, 1998).

Beinart (1998) suggested that, once the adaptation had been made, sheep killing was much easier and the meat perhaps more appetizing than that of animals of the veld. The growing problem that small livestock farmers have with problem animals is a problem that has been accumulating over time.

During the early 1990's the official systems of predator control was the predator hunting clubs and farmers voluntarily participated (De Waal, 2009). It was widely believed that government intervention by subsidising predator control activities influenced farmers to assume the primary responsibilities in being vigilant and warding off predators. The government returned the primary responsibility to the farmers during the mid 1990's, with the government retaining the responsibility of providing training in predator control techniques. The longstanding bitterness by livestock farmers towards predators is understandable; the ill feeling towards the black-backed jackal and the caracal has also created distrust between neighbouring farmers and increasingly between livestock farmers and nature conservation authorities (De Waal, 2006).

Problem animals are defined as animals interacting with human activities and causing losses of livestock (De Waal, 2007). The government defined the black-backed jackal and caracal as damage-causing animals in the early nineteen-hundreds. It was legalized to kill damage-causing animals and government subsidized such activities (Stadler, 2006). Currently the black-backed jackal and caracal are still defined as damage-causing animals and may still be killed if the problem occurs. Under the National Biodiversity Act No. 10 of South Africa the black-backed jackal and caracal are not protected species and can be killed when needed (Department of Tourism, Environmental and Economic Affairs, 2008).

2.4.1 General information on the black-backed jackal and caracal

According to De Waal (2009), farmers suggest that the social and food habits of the present-day black-backed jackal, a typical dog, may not conform anymore to the type descriptions found in textbooks about the species. Black-backed jackal form pairs and mate for life or until one mate of the breeding pair is killed. Young black-backed jackal disperse by finding their own mates by occupying new or vacant areas that meet their food and social requirements to breed and successfully raise pups.

The black-backed jackal is a medium-sized predator and manifests itself as an opportunistic scavenger of carrion and vegetable matter and a hunter of small mammals, insects and birds (Cillie, 1997). However, at some point animals may be introduced to predation on sheep, lambs and goats. These easier prey types may set a lifetime habit which cannot be changed or get rid of again easily (De Waal, 2009).

The caracal is a typical cat and the territory of a male caracal overlaps with the territories of several neighbouring females (De Waal, 2009). In addition to patrolling and keeping individuals of the same sex out of their territories, both sexes are also very familiar with the natural food sources in their respective territories. Individuals of both sexes are rarely seen together, except when mating or in the case of a female with larger kittens. The caracal is a very successful hunter of small mammals and birds. It will not readily take carrion except when it may return to a carcass of prey that it recently caught. Before they settle as young adults in territories of their own, the young cats have to keep out of harm's way by avoiding resident territorial adult cats of both sexes. It is suspected that during this stressful period in their lives young cats may also predate on easy prey.

2.4.2 History of predator control in South Africa

Predators (including large and small predators) was hunted and killed for centuries by Khoikhoi, Africans and settlers to protect their livestock. The Khoikhoi had eaten some of the predators (jackal) whereas some Africans made use of its pelt. Although there was an occasional market for skins, settlers killed it primarily as a pest, because they preyed on livestock. Jackal and other predators (hyeana, leopard caracal) were exempt from the hunting restrictions imposed during the nineteenth century and consolidated in the Cape's Game Law Amendment Act of 1886.

Shooting black-backed jackal and caracal is difficult because they are nocturnal animals; other strategies of reducing predators include poisoning, traps and dogs. Lairs or dens are the main target for black-backed jackal, especially during the main breeding season in spring

(August to October), also during lambing season, when most of the predators were most active. In the previous century jackal-proof fencing was available to farmers and it was subsidized by the government. This was helpful in keeping sheep in and was just as helpful in keeping predators out. During the 1890's, Cape bounty increased to a flat rate of 7s per tail for damage-causing animals. The total paid out annually by the government rose quickly to a peak of £28 000 in 1898-99. The jackal was the predominant species killed in the northern districts; in the midlands, baboons, caracals, wild cats and monkeys suffered in large numbers, over 50 000 predators were killed for reward in the same year (Beinart, 1998).

2.5 Managing predator populations

There is no nationwide strategy to reduce predation in South Africa. Control and management practises differ between individual farmers, and often there is no specific plan or goal, just to reduce losses due to predation (De Waal, 2009). A range of different methods are used to reduce predation. These methods are divided into lethal and non-lethal methods, lethal methods kills the predator and the non-lethal methods is a means of reducing predation without killing the predator. Methods include lamping with rifles, shooting by day, hunting with dogs, snares, traps, poisoning whereas non-lethal methods include kraaling of small livestock or indoor housing, sheep herders, lights, guard dogs and king collars (Burns *et al.*, 2000; Moberly, 2002; Arnold, 2001; Van Deventer, 2008). Very little research has been done on the predation of small livestock in South Africa by the jackal and caracal and specifically also on the methods used to stop predation by these animals.

2.5.1 Effectiveness of management

In all areas of science, integration across disciplines is an important source of ideas, leading to new avenues for theoretical sources of ideas, leading to new theoretical and experiential investigations. In management situations, such an integrative approach can be especially useful. By developing common conceptual perspectives for ostensibly different management problems, it is possible to see previously unobserved patterns, to understand the processes shaping these patterns more clearly and to use them as a broad basis for decision-making (Shea *et al.*, 2000).

According to McAdoo *et al.* (2000) proper sheep management is just as important for protection of sheep herds as a predator control program. Predation has been cited as one of the economic factors blamed for the decline of the American sheep industry during the last three decades (1970-2000), with many ranchers having sold their operations. In the state of Nevada, sheep numbers have decreased from 300 000 in 1972 to 80 000 in 1998. McAdoo *et al.* (2000) believed that most ranchers could alleviate much of their losses to predators by changing and/or implementing various sheep management techniques. The techniques used by ranchers already, consist of: season of lambing, shed or indoor lambing, herders as guardians, bedding sheep near camp and guard dogs. Employing one or more of these or other management practices will discourage predation. No one method of control or management will ever be the solution, but is a good starting point (McAdoo *et al.* 2000).

In South Africa one of the ways of managing predation is the use of guard dogs (Anatolian shepherd dogs for example). The use of livestock guard dogs is a proven technique in other parts of the world and is now a growing managing technique in South Africa (Herselman, 2004; 2005). A study done by Herselman (2005) illustrated that on 10 farms where livestock guard dogs were introduced during 2004, the percentage of lambs caught before weaning, decreased from 7.6% in 2003 to 2.6% in 2005. After weaning, the percentage of lambs caught decreased from 2.9% to 0.6% from 2003 to 2005.

A variety of opinions exists of various predator control methods (McAdoo *et al.*, 2000). Scientists and farmers disagree about the relative effectiveness of poisons, trapping, aerial hunting and other methods. Criticism from environmentalists has resulted in greater consideration being given to the selectivity, specificity, environmental and human safety and humaneness of various methods.

Vast areas of South Africa are devoted to small livestock farming, with the natural pastures also being habitat to indigenous fauna. These farming areas engulf the comparatively small and scattered nature reserves and are very important for the conservation of South Africa’s biodiversity. The primary objective of small livestock farmers is to sustain a livelihood from domestic animals, but biodiversity is also conserved on privately owned properties. According to De Waal and Avenant (2008) South African small livestock producers are currently face three major threats to their enterprises, namely drought, theft, and predators. There is government support for drought and theft, but none to assist in the management of predators. Individual farmers in the Western, Eastern and Northern Cape, the Free State and Mpumalanga provinces are reporting losses of between 5.3 and 11.3% of their total livestock per year due to predation by the black-backed jackal and caracal.

According to De Waal (2009) desperation has played a major role in indiscriminate blanket-control and even poisoning practices to multiply over large areas in southern Africa. This is placing small livestock farmers and farming areas under constant threat of predation, while small livestock losses do not decline. As with many other predators, black-backed jackal and caracal numbers seem to recover and increase with the increase in non-selective hunting efforts or immediately after predator removal. For example, black-backed jackal and caracal females now carry foetuses at a younger age, while black-backed jackal litter sizes of six to seven foetuses have become common. Previously females seldom carried more than four foetuses. In many areas, farmers claim that the situation is now worse than ever (De Waal & Avenant, 2008). Managing the black-backed jackal and caracal will only succeed if effective management is used to help farmers with the problem at hand.

2.6 South African studies

A study done by Stannard (2003), estimated the effectiveness of different problem animal control methods (mainly Anatolian shepherd dogs) in the small livestock producing areas of South Africa. This study surveyed approximately one hundred farmers across fifty-six districts throughout South Africa. Each farmer completed an annual questionnaire in which particulars of his farming enterprise, neighbouring farms, as well as livestock numbers, were requested. Losses of livestock and predators killed were recorded through a monthly telephonic questionnaire.

The total number of livestock owned by the farmers represents 1%, 4% and 1% of the total sheep, Angora goat and Boer goat populations respectively of South Africa. Stannard (2003) found losses due to livestock theft appeared to be relative small when compared to the predation on small livestock. Topography and surrounding farm practice also played an important role in the number of animals lost. The preliminary conclusions were made that individual cases of extremely high livestock losses occur; the extent of the predator problem appears not to be a general threat to small livestock production in South Africa. The data collected, indicate that predators kill approximately 4% of all lambs (2004).

In 2007 a survey was conducted in the Western Cape province of South Africa to estimate the extent of predation in this area by Agri Western Cape. A structured questionnaire was sent out to local agricultural unions and district agricultural unions. In total, 125 questionnaires were sent out with a 32% (i.e. 40 questionnaires) response rate with the majority of the responses out of small livestock producing areas of the Western Cape province. The questionnaire includes questions on methods of hunting, type of predator and losses of livestock and game. Results from the survey indicated that the black-backed jackal and caracal are responsible for more than 50% of the losses. Other losses include losses from leopards, baboons, crows and vagrant dogs. This study concluded that there is a difference in the effectiveness of control methods. The use of cage traps proved to be more effective than hunting. The quantification was made that there is a loss of R 9.96 million due to predators in the Western Cape province of South Africa.

The longstanding bitterness by livestock farmers towards predators is understandable. The animosity of livestock farmers specifically towards the black-backed jackal and the caracal has also created distrust between neighbouring farmers and increasingly between livestock farmers and nature conservation authorities (De Waal *et al*., 2006). Thus, many livestock farmers feel that they have been abandoned by authorities, leaving them to their own means and devices in dealing with animal damage control (De Waal *et al*., 2006; Gunter, 2008; Strauss, 2010).

2.7 Factors affecting predation in South Africa

Factors affecting predation are divided into three categories; namely topography, control methods and managerial practices (farm management or animal husbandry). If these categories are correctly defined and interpreted, a clear perception can be drawn about the situation of predation in South Africa.

2.7.1 Topography

South Africa has a total surface area of 105 207 300 ha of which 81% is utilized for farming and of which 68.4% is used for extensive grazing purposes (NDA, 2009). These grazing areas include sheep, goat, game as well as cattle farming. Not all areas of South Africa are suitable for small livestock production. Certain areas are more suitable for large livestock and others for small livestock; in some areas there is an optimal combination of both. The unusual vegetation of the Karoo region makes livestock farming and other enterprises more challenging in the Karoo than in other parts of South Africa. It is also known that areas with lower rainfall are more suitable for small livestock farming. The extensive grazing systems of the Karoo, Northern and North-Western Cape Provinces, southern and western parts of Namibia, Botswana and the Kalahari all have certain characteristics such as low rainfall, sparse vegetation and a desert-type climate. Under correct extensive grazing systems a number of small livestock can be produced in these areas (Maree & Casey, 1993). Small livestock farming is restricted to certain parts of South Africa and for which predators have a physical and topographical preference.

The black-backed jackal is found in a variety of habitats in South Africa (Cillie, 1997). These areas include arid savannah, open savannah, woodland savannah mosaics. In general, black-backed jackals show a preference for open habitats, thus tending to avoid dense vegetation. In KwaZulu-Natal, they are recorded from sea level to more than 3 000 m above sea level in the Drakensberg and in localities receiving more than 2 000 mm of rainfall. The trend is for black-backed jackal to use either the open grassland or wooded savannah (Loveridge & Nel, 2004). This illustrates that the black-backed jackal has preferred areas, but can adapt to most areas of South Africa.

Caracals are found in dry savannah and woodland areas, scrubland and rugged terrain in mountainous regions even as high as 3 000 m above sea level (Cillie, 1997). Like other cats that are found in dry, arid or semi- dessert locations, the caracal can survive for long periods without water by obtaining its requirement from the metabolic moisture of its prey.

2.7.2 Control methods

Because of the learning ability of these damage-causing animals, it is important to use as many different control methods as possible. Operators that promote shooting or poison or leg hold traps as the method that will solve the problem and invest heavily in the chosen direction, all lack the depth to eventually solve problems in the long term. When an animal learns from the death of its partner, only a different method will eliminate that animal. Any operator therefore, that wants to actually solve problems, must have a variation of methods that they master (De Wet, undated). Control methods can be divided into two categories; lethal and non-lethal methods. These methods include hunting at night with rifles, hunting with dogs, snares, traps, poisoning and the non-lethal methods include kraaling of small livestock or indoor housing, sheep herders, lights, guard dogs and King Collars (Burns *et al.,* 2000; Moberly, 2002; Arnold, 2001; Van Deventer, 2008; De Waal, 2009). There are many methods available to word off and kill predators, but very little information exists on which methods are working effectively and efficiently. However, these non-lethal preventive measures' do not give permanent relief of damage. These methods are usually expensive with no guarantee that the chosen method will work effectively.

2.7.2.1 Lethal methods

Lethal methods consist of hunting at night with rifles, hunting with dogs, snares, traps, poisoning. Great success is associated with these methods, however most these methods are non-selective methods in controlling predators (Burns *et al.*, 2000; Moberly 2002; Arnold 2001; Van Deventer, 2008; De Waal, 2009).

2.7.2.1.1 Hunting

Hunting damage-causing animals is one of the most effective ways to reduce the predation. Hunting has been used since the early 1870's in South Africa by settlers to protect their livestock against predators (Beinart, 1996). This method is also used in other countries to reduce predation on livestock (Goldberg, 1996). Aerial hunting is commonly used by agriculture agencies in the USA (Wagner *et al.,* 1999); whereas in Australia and the United Kingdom (UK) shooting predators is frequently used to reduce fox populations (Gentle, 2006; Moberly *et al.*, 2002). This is most often done at night with the aid of a spotlight and calling equipment. Shooting at night can be very selective and solve problems within a short timeframe and with little ecological effects (De Waal, 2009).

2.7.2.1.2 Poisoning

Poisoning is another method often used to kill problem-causing animals out of the predator populations; poisons are used worldwide to control problem animals. In Australia, the introduced red fox (*Vulpes vulpes)* represents a continuing threat to livestock farmers, these problems are however, managed by setting ground-level baits impregnated with poison such as for example compound 1080 (sodium monofluoroacetate). The effectiveness of control programs lies in a proper managed management program to achieve long term goals. In South Africa only three toxins or poisons may be used; sodium cyanide, strychnine and sodium monofluoroacetate may be used in meat baits and then only with a permit. The method has been used by farmers to poison carcases or in poisoned baits to kill predators, the reason this method is so frequently used, is because it is cheap and very effective. The only drawback is that non-targeted animals might also get killed (Snow, 2006).

2.7.2.1.3 Trapping

Trapping problem animals is a method used to reduce predation on farms. The only factor influencing trapping is the potential to cause some injury or distress to the target and non-target animals without killing it and thereby causing suffering and pain to these animals. Gin traps, jaw-traps or "slagysters" may be effective, provided that they are correctly sited and set. Steel-jawed gin-traps without padding between the jaws are mostly used in South Africa, but cause severe injury to the animal. Cage traps are usually preferred in certain areas, since non-target animals can be released easily. Trapping is not always the most effective way of control, but it is a cost- effective way. Gin-traps are mostly used and are more effective for black-backed jackal, while cage traps are preferred for caracal (Snow, 2006).

2.7.2.1.4 Coyote getters

The original American coyote getter or the later development, namely the M44 is no longer obtainable in South Africa, but similar locally-made devices, called "Fox Busters" are available. These are mechanical devices which function similarly to the trigger mechanism of a gun. The device consists of a ground peg which holds the device in position. The trigger portion clips into the ground peg and its bait head, which contains a .38 Special cartridge loaded with sodium cyanide, screws onto the trigger portion. When bitten and pulled by an animal, the cartridge fires and sodium cyanide is propelled into the animal's mouth. These devices are very dangerous and need a lot of experience to operate (Snow, 2006).

2.7.2.1.5 Hunting with dogs

Hunting predators with hunting dogs is an effective way of controlling these problem animals. These hunt packs or “hunt clubs” are very effective, but only when used and managed properly. It must be stressed that they are only as effective as their management and a poorly run dog pack is a recipe for disaster, according to Snow (2006). There are advantages; it is a quick and effective way of targeting specific animal; however, when hunting dogs are used, it is not recommended to use poisons and leg hold traps. The only limiting factor is that the upkeep of these animals is expensive and it is time-consuming.

2.7.2.2 Non-lethal methods

There are many methods available to word off and kill predators, but very little information exists on which methods are working effectively and efficiently. However, these non-lethal preventive measures’ do not give permanent relief of damage. These methods are usually expensive with no guarantee that the chosen method will work effectively (Burns *et al*., 2000; Moberly 2002; Arnold, 2001; Van Deventer, 2008; De Waal, 2009)..

2.7.2.2.1 King collars

These simple and relative inexpensive devices can be very effective for black-backed jackal control, but not so effective for caracal and vagrant dogs. These collars are wide, adjustable PVC collars which are fitted to the entire flock. During the rainy season the collars cannot be fitted permanently as maggots tend to attack the neck of the sheep under the collars. The black-backed jackal over time learns to attack the sheep from the back and thereby does not kill as effectively as they normally do, causing trauma and mutilated sheep as a result (Snow, 2006).

2.7.2.2.2 Fencing

Fencing can be divided into two groups of control; electric and jackal-proof fencing. Predator-proof enclosure protects animals all the time, providing there is no predator within the enclosed area. Jackal-proof and electrical fencing is quite an expensive capital investment. When the fences have to be medium-sized predator-proof, the labour cost usually more than doubles. This is due to the process of having to attend to and blocking all possible entry spots for the animals. For these fences to be efficient, maintenance is critical. Porcupine and warthog can easily dig under such fences thereby cause the fence to be ineffective. This means that fences must be checked frequently, this is however, very expensive and time-consuming (Snow, 2006).

During the previous century, farmers received official subsidies to assist in enclosing large tracts of farmland with jackal-proof fences to protect their sheep and goats. Most of these original jackal-proof fences have exceeded their effective lifespan and unless they have been maintained or replaced since at the farmers' own expense, these fences are not effective anymore.

2.7.2.2.3 Livestock guarding animals

Several forms of livestock guard animals have been tried with varying degrees of success. These include donkeys, zebras, ostriches and Anatolian dogs. The use of guard dogs to protect sheep has become popular in the last decade. Some have proclaimed it as the solution to reduce predation problems, thereby eliminating the need for various lethal control techniques (Jeffrey *et al.*, 1984). In the USA guard dogs have been successful in approximately two-thirds of the trials where they have been tested for their ability to protect sheep from predators in fenced or open range grazing conditions. The use of Anatolian Shepherd livestock guard dogs is a proven technique across the world and is gaining popularity in some parts of South Africa. Predator problems are usually associated with lambs that are still suckling, this is where guard dogs can provide great relief (Herselman, 2005). However, these guard dogs are not totally effective everywhere. They are not the industry wide solution to the predator problem as Green *et al.* (1984) stated. Unfortunately there are a few disadvantages, the cost of guard animals is high and the method might reduce losses, but may not prevent them entirely (Snow, 2006).

2.7.2.2.4 Other methods

Bell collars and scent collars can confuse predators and discourage them because of the unnatural noise they make; or the human-associated scent they exude; provided they are used inconsistently and in conjunction with other methods. It must be stressed that these should be used intermittently at times when the risk of predation is at its highest, particularly at lambing times; otherwise predators become used to them and unafraid. Lanterns might be used to light up night enclosures and radios can be played, but these should also be used with discretion as they may attract human thieves (Snow, 2006).

2.7.3 Management

McAdoo *et al.* (2000) and Shivik (2004) illustrated that with good management practices a farmer can reduce predation. McAdoo *et al.* (2000) believe that most small livestock farmers could alleviate much of their predation by changing or implementing various small livestock management techniques. These techniques consist of: season of lambing, shed or indoor lambing, herders as guardians, bedding sheep near camp and guard dogs. By using a combination of management practices, small livestock owners can decrease predation.

2.7.3.1 Season of lambing

Predators are often more likely to kill livestock at specific times of the year than at others, killing lambs often coincides with the need to provision for their offspring (Shivik, 2004). This specific season sometimes coincides with that which most farmers use to lamb their small livestock. In Table 2.1 an illustration is provided of the seasonality of the black-backed jackal.

Table 2.1 Seasonality of the black-backed jackal

Time of year	Period
January - April	Social time
May - July	Breeding time
August	Breeding and bedding time
September - October	Puppies born in dens
November - December	Puppies out of dens with adults

Source: Snow, 2006

In the social period and when the pups are born, the black-backed jackal is generally known to kill livestock. In most parts of South African farmers also lamb their livestock during this time of year. However, this is also the biological seasonality of small livestock. If small livestock are bred earlier in the season, they may have time to grow out and may be less vulnerable to predators during their whelping time. This is not always possible due to limitations such as biological limits to the alteration of lambing seasons and increased cost involved with altering reproductive cycles. Caracals are not seasonal and can reproduce year round, this means that farmers must practice year-round caracal control (De Waal, 2009).

2.7.3.2 Breeds

Greentree *et al.* (2000) highlighted the fact that small livestock losses due to predators can vary between individual flocks or areas in a country. Reviewing a couple of studies carried out in Australia where high losses were associated with a particular sheep breeds and the proximity of optimal fox habitat (Moore *et al.*, 1966; Coman, 1985). They also drew attention to the limited evidence that suggests that individual foxes become habituated to the killing of small livestock (Rowley, 1970) and can cause serious losses in an individual flock.

In South Africa there is little information on which small livestock breed is preferable or more affected by predators, but mostly a case of availability and poor mothering ability.

2.7.3.3 Problem areas

Predation can be reduced simply by avoiding problem areas within a range allotment. According to Shivik (2004), there can be areas that predators prefer to others. These “hot spots” of predation must be avoided to reduce predation on a farm Intense predation may be due to some intrinsic aspect of the topography, it may have a nearby rendezvous site with cover and prey that attracts predators. Sometimes, it may be possible to not use a particular area for grazing and it may be economically advantageous to do so if predation pressures are high.

In rotational grazing schemes, incorporating probability of predation into management plans might be useful. When grazing areas are most beneficial to livestock, they may also be most attractive to predators, so simply altering timing or use of land may not be feasible economically or logistically. Moving livestock around repeatedly can cause additional stress and is not always possible (Shivik, 2004).

2.7.3.4 Buffer species

Small antelopes and small game such as rabbits, springhares, guinea fowls and game birds are buffer species, being the preferred prey animals of predators on farmland. Unsustainable hunting of these species creates food shortages for the predators with the inevitable result that some resort to killing small livestock for survival. In addition, irresponsible use or abuse of chemicals can wipe out these buffer species that predators prey on (Snow, 2006).

2.7.3.5 Kraaling at night

This method is used in most parts of South Africa which implies that small livestock is kraaled every night. Kraaling of livestock implies that animals graze during the day-time and return to the kraal at night-time. This method is highly effective, but is not always possible for large small livestock farms or mountainous terrain. This method is also labour-intensive and uneconomical for large-scale small livestock framing.

3. Research methodology

3.1 Introduction

This chapter focuses on the research methods used to analyse the factors affecting predation on farms in the five major small livestock producing provinces in South Africa. Specific research tools were used, which included the survey design and the analytical framework. Factors associated with predation were identified using certain logistic regression analyses.

3.2 The study area

The study area includes the five major small livestock producing provinces of South Africa. These five provinces (Eastern Cape, Free State, Northern Cape, Mpumalanga and Western Cape) comprise over 85% of the national sheep and goat flock of South Africa (Figure 3.1). The five provinces used in the study represented more than 90% of the estimated sheep and more than 55% of the goat populations' estimates of South Africa. The estimated sheep and goat distributions in South Africa are illustrated in Figure 3.2 and Figure 3.3. In total, 74% of South Africa's grazing land is covered by the five provinces, including a large range of different topographical areas (NDA, 2008).

A sample size of 1 500 farmers was used to collect data from the five provinces. The sample of farmers drawn from each province was based on the percentage that each of the different magistrate districts per province contributed to the total small livestock populations (sheep and goat) of South Africa.

3.2.1 Sample specification and sample size

Sampling requires the sample size to be representative enough with a view to conduct reliable statistical analysis. Sample size depends largely on the degree to which the sample population approximates the characteristics and qualities resident in the general population (De Vos *et al.*, 2002). According to Scheaffer *et al.* (1990) a sample is defined as a collection of sampling unit drawn from the sampling frame. In short, a sample is a finite part of a statistical population whose properties are studied to gain information about the population as a whole.

Representative means that the sample selected should have approximately the same characteristics as the population relevant to the research in question (De Vos *et al.*, 2002).

Figure 3.1 Map of South Africa showing the nine provinces.

Source: Family Travel SA (http://www.familytravel.co.za)

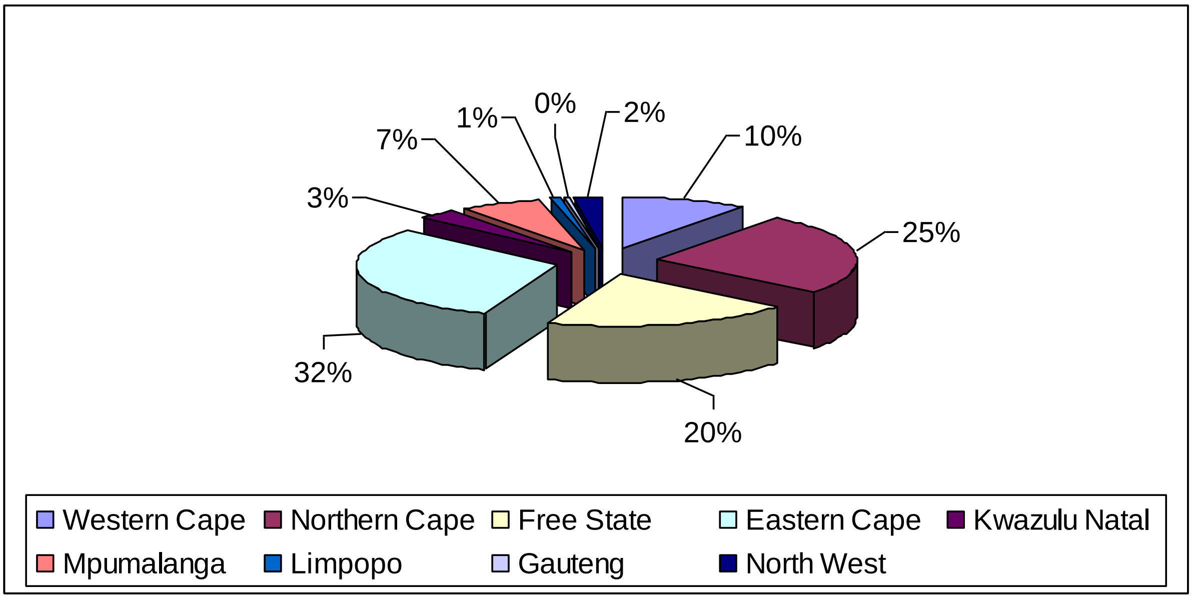

Figure 3.2 Estimated distribution of sheep per province in South Africa.

Source: NDA, 2006

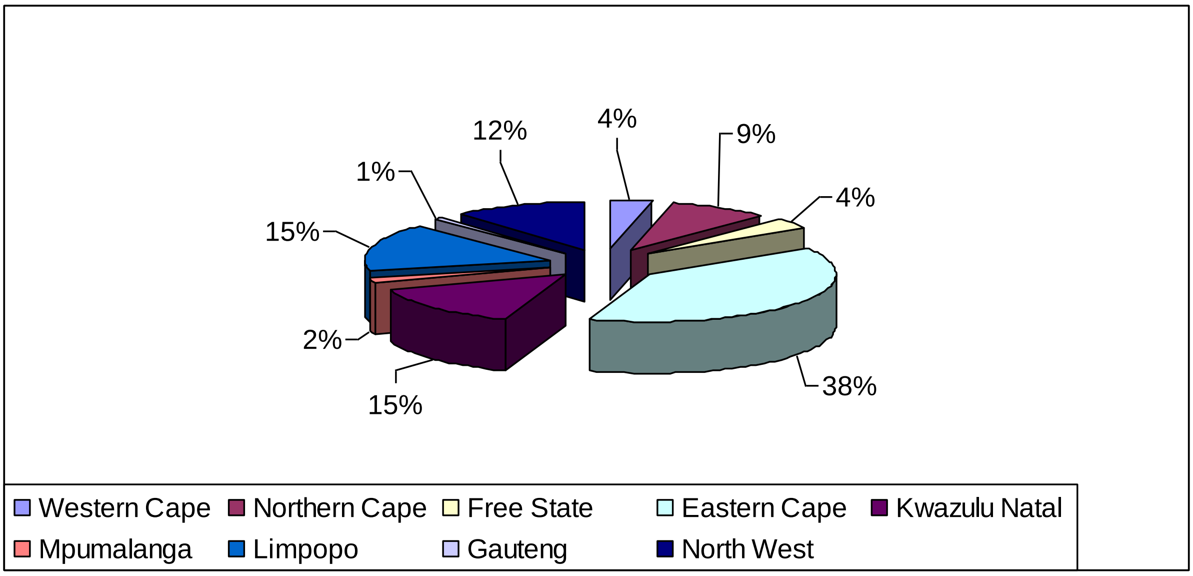

Figure 3.3 Estimated distribution of goats per province in South Africa.
Source: NDA, 2006

A sample becomes inaccurate mainly due to human factor/bias and distortion due to the selection systems. In the most general sense, the components of the sample are chosen from the population universe by a process known as randomization (Montshwe, 2006). According to Babbie (2001), randomization means selecting a part of the whole population in such a way that the characteristics of each of the units of the sample approximate the board characteristics inherent in the total population. The larger the sample utilised in the survey procedure, the more accurate and closer the actual results would be to that of the entire population. Leedy (1996) explained that the larger the population, the smaller the proportionate sample size required. Leedy (1996) also illustrates that at a specific population size it becomes irrelevant to increase the sample size any further. Gay (1996, cited by Leedy, 1996) argued that for a total population in excess of 5000 a sample of 400 would be adequate to reflect a representative of the total population.

The total population of farmers in the five provinces is estimated at 31 310 (NDA, 2008) (Table 3.1). Therefore, a sample size of 1 500 respondents is deemed adequate for this study. Contact details of small livestock producers were obtained from the Red Meat Producers' Organization (RPO) and Cape Wools SA for the study. Not all respondents were used in the analysis; only 1 424 respondents were included.

3.2.2 Probability sampling

Probability sampling is based on random selection. Each sample from the population of interest has a known probability of selection under a given sampling scheme. Probability sampling consists of simple random sampling, stratified random sampling, cluster sampling, and quota sampling. The stratified random sample suited the purpose of this study the best, due to the fact that all the respondents are active small livestock framers (Leedy, 1996; De Vos *et al.*, 2002).

Stratified random sampling was used because only sheep and goat farmers were selected from the data bases for this study. A random sample of farmers was selected from each province according to how much each province contributed to the estimated small livestock population of the study area. Provinces were divided into their different magisterial districts and further divided into smaller local municipalities. The reason is to give an equal distribution of farmers throughout the provinces. Sample size and estimated sheep distribution of the targeted provinces are shown in Table 3.1. The number of farmers (Table 3.1) includes only commercial agriculture; for further detail of each province.

Table 3.1 Sample size and estimated distribution of sheep per province (2008)

Province	Farmers	Sheep	Proportion of small livestock population (%)	Farmers sampled per province
Eastern Cape	4 376	5 062 299	25	371
Free State	8 531	4 840 515	22	355
Northern Cape	6 114	6 342 900	31	465
Mpumalanga	5 104	1 681 233	8	123
Western Cape	7 185	2 545 496	11	187
Total	31 310	20 472 443	100	1 500

Source: NDA (2008)

3.2.3 Development of the questionnaire

A questionnaire was developed to obtain relevant information on predation for farms in South Africa. This questionnaire was designed to be used during short telephonic interviews. The questionnaire was designed on the same principals as suggested by Moberly (2002) and a questionnaire used by African Large Predator Research Unit (ALPRU) in South Africa.

There are different ways in which a questionnaire can be administered. The methods include self-administered questionnaire, face-to-face interview and telephone survey. Telephonic interviews were considered the relevant method for quick and accurate data collection in this study, because of the large sample size and the fact that farmers are reluctant to complete self-administered questionnaires. The majority of the telephonic interviews for the questionnaires were made in the late afternoons and early evenings, when farmers have completed most of their daily farming activities.

Although criticism is often voiced at the use of telephonic surveys, it provides the largest amount of information for the time and effort expended (Knowlton *et al*., 1999). However, telephonic surveys are also subject to the same biases as for other types of surveys, namely the degree to which producers locate missing animals and accurately identify and report causal agents (Knowlton *et al*., 1999).

Data collection covered a period of two years (2006/2007), which included two lambing seasons or farmers who used three lambing seasons in two years. Questions were included on losses, management, control methods and topography. Management questions were asked to identify whether certain management practices can lead to a decline in losses due to predators. The management questions were asked on certain farming practices such as the frequency which a farmer counted his livestock, where does the small livestock lamb as well as identification methods. The various control methods were also enquired, as well as the cost of different methods and the number of predators killed by different methods.

3.3 Methodology

The methodology used in this study consists of quantification of predation losses to set a fiscal economic value to predation losses in five major small livestock producing areas of

South Africa. The factors affecting predation of farms in South Africa were also investigated using regression analyses.

3.3.1 Quantification of predation losses

The primary objective of this study was to quantify the economic loss due to damage-causing animals in major small livestock producing areas in South Africa. Quantification was done by multiplying the market price of an animal by the number of animals lost, however this is difficult when this animal is not at a point of sale. The National Wool Growers' Association valued one unit (animal lost) in earlier estimates at R 600, this was a very low estimate for a unit lost. The National Livestock Theft Forum is currently (2010) valuing one small livestock (sheep) unit at R 1 200 and one small livestock (goat) unit at R 1 400. By using the value used by the National Livestock Theft Forum (2010) an overestimation is possible.

Therefore, for the purpose of this study a value of R 600 was used for one unit (sheep and goat) younger than six months and a value of R 1 000 for one unit (sheep and goat) older than six months. However, this only illustrates the direct cost of predation and does not reflect the additional indirect cost of preventing predation on a farm. The cost of prevention includes among other cost; the cost of a professional predator hunter, fencing (jackal proof and electrical) and management input. Although some of these methods is a once-off expense, the methods are very expensive and therefore not a viable option to all farmers. Other methods like poison and the use of professional hunters or the farmer hunting himself represent a continuous cost to farmers.

3.3.2 Identifying factors affecting predation

The secondary objective of this study was to determine the factors affecting predation on farms in South Africa. It was hypothesised that the variables affecting the occurrence of predation and variables affecting the level of predation on a farm is not the same.

In this study the model on factors affecting predation cover two aspects: whether or not predation will occur and, if predation occurs, what level of predation will occur. An important factor that must be considered is the fact that a small number of farmers incurred no losses on their farms (over 80% of farmers incurred losses). According to Aramyn *et al.*

(2007) excluding observation with zero predation can lead to the sample being bias and biased regression parameters. It is however important to include these observations in the regression, because it is possible that no predation occurred during the two year when data was collected or management and control methods (lethal and non-lethal) is of that nature that no predation occurs. Therefore it is important to include these observations when estimating factors affecting predation.

The Tobit regression model is frequently used when dealing with zero observations (Gujarati, 2003; Tobin, 1958; Aramyn *et al.,* 2007). A problem occurs that the Tobit model is very restrictive, according to Aramyn *et al.* (2007). For example, any variable that increases the probability that predation will occur increases the level of predation on a farm. In the Tobit regression model, a variable that increases the probability of predation will also have a higher influence on the level of predation (Lin & Schmidt, 1984, cited by Katchove & Miranda, 2004; Jordaan & Grové, 2010). Thus, the same variables will affect the probability that predation will occur as well as the level of predation. Therefore the Tobit regression model alone would be insufficient in some cases. The Cragg's model is an alternative for the Tobit model and allows one set of parameters to determine the probability that predation will occur and the second set of parameters to determine the level of predation.

The Cragg model is based on the fact that the Tobit model arises when the occurrence of predation (whether or not predation will occur on a farm), is represented by the Probit model (Katchove & Miranda 2004) in Equation 3.1:

$$P(\alpha_i = 0) = \Phi\left(-\frac{\beta_\alpha^{'} x_i}{\sigma}\right) \tag{3.1}$$

And the level of predation on a farm is represented by the Truncated regression model in Equation 3.2:

$$f\left(\alpha_i : \alpha_i > 0\right) = \frac{f(\alpha_i)}{P(\alpha_i > 0)} = \frac{\frac{1}{\sigma}\Phi\left(\frac{\alpha_i - \beta_\alpha^{'} x_i}{\sigma}\right)}{\Phi\left(\frac{\beta_\alpha^{'} x_i}{\sigma}\right)} \tag{3.2}$$

When the same variable significantly affects the occurrence of predation (Probit) and the level of predation (Truncated) the specification of the Tobit model is appropriate. However, when the variables affecting the probability that predation will occur or not and variables affecting the level of predation is not the same variables, specification of the Gragg model is more appropriate.

The Gragg test is based on a comparison between the likelihood ratios (Conte & Vivarelli, 2007; Lin & Schmidt, 1984). The Cragg's model with a log-likelihood function is illustrated in Equation 3.3 as given by Katchove and Miranda (2004) and furthermore explained by Conte and Vivarelli (2007), Lin and Schmidt (1984) and Zhang *et al.* (2006). The log-likelihood in Cragg's model is a sum of the log-likelihood of the Probit model (the first two terms) and the log-likelihood of the Truncated regression model (the second two terms).

$$\ln L = \sum_{c_i=0} \ln \Phi(-\gamma' z_i) + \sum_{\alpha_i>0} \left\{ \ln \Phi(\gamma' z_i) + \ln\left[\frac{1}{\sigma}\Phi\left(\frac{\alpha_i - \beta_\alpha^{'} x_i}{\sigma}\right)\right] - \ln \Phi\left(\frac{\beta_\alpha^{'} x_i}{\sigma}\right)\right\} \qquad (3.3)$$

All the regression models used to analyse data on predation were done by using NLOGIT 4.0 statistical software.

The variables affecting the probability that predation will occur on a farm is modelled by the Pobit regression model. The dependent variable takes the form of a dummy variable, coded zero for no losses and one if predation incurs on a farm. The variables affecting the level of predation on a farm is modelled by the Truncated regression model. The dependent variable takes the form of a continuous variable, where the reported losses to predators is divided by the total number of ewes/does and lambs/kids on a farm.

3.4 Hypothesised variables

A summary of hypothesised variables, a short description of variables as well as expected influence of predation on farms in South Africa is shown in Table 3.2. Not all variables were included in regressions of provinces. Variables vary vastly between provinces according to the different management and agricultural practices of that specific province.

Table 3.2 Variables affecting predation on farms and expected influence of variable on predation.

Variable	Description	Expected influence
Region	Regions were single-digit coded for the five major small livestock producing areas in South Africa.	-/+
Farming size	Continuous variable (farming area in hectares).	-
Breeds	Dummy variable, coded 1 for farms with small livestock breed in question.	-/+
Lambing interval	Dummy variable, coded 1 for farms with 8 or 12 month lambing intervals, 0 otherwise.	-
Lambing months	Dummy variable, coded 1 for farms with lambing seasons in April-March, August-September, April-March and August-September and year round, 0 otherwise	-/+
Production ewes/does	Continuous variable, Number of ewes/does on a farm.	-
Counting of small livestock	Continuous variable, number of times per month small livestock is counted.	-
Identification of small livestock (Tagging)	Dummy variable, coded 1 for identification of small livestock, 0 otherwise.	-
Lambing in protected areas	Dummy variable, coded 1 for lambing small livestock in protected areas (kraaling during lambing), 0 otherwise.	-
Topography of farm	Dummy variable, coded 1 for different topographical regions on farms, 0 otherwise.	+
Frequency of predator control	Dummy variable, coded 1 for active control, when problem of predation occurs or before lambing, 0 otherwise.	+
Predator control carried out	Dummy variable, coded 1 for predator control carried out by professional hunter, farmer or hunting clubs, 0 otherwise	-/+
Lethal predator control methods	Dummy variable, coded 1 for hunting, poison, gin traps or hunting dogs, 0 otherwise.	+
Non-lethal control methods	Dummy variable, coded 1 for bells, King Collars, guarding animals, kraaling or jackal-proof fencing, 0 otherwise.	+
Combination of two or more non-lethal control methods	Dummy variable, coded 1 for farms using more than 2 non-lethal control methods, 0 otherwise.	-/+
Believed foundation of predation problems	Dummy variable, coded 1 for different surrounding practices that contributes to predation on farms (farmers view point), 0 otherwise.	+

The variables shown in Table 3.2 can be divided into two groups, namely management variables and control variables (lethal and non-lethal control methods). It is hypothesised that all management variables will have a negative effect on predation on farms. It is believed that a higher level of management will reduce predation losses on a farm (McAdoo, 2000). Management aspects will include time of lambing, flock size, breeds, lambing intervals, counting of small livestock, identification of small livestock and lambing months.

A positive sign is expected with all control methods including lethal and non-lethal methods. Lethal methods include hunting, poisons and gin traps. Non-lethal methods include electric fences, jackal-proof fencing, bells, King Collars and guarding dogs. According to De Waal (2009) non-lethal methods will only reduce the level of predation and will however not stop the occurrence of predation on a farm.

4. Results and discussion

4.1 Introduction

The Eastern Cape (EC), Free State (FS), Northern Cape (NC), Mpumalanga (MP) and Western Cape (WC) provinces are chosen as study area to collect data to determine the extent of predation by black-backed jackal and caracal on small livestock in South Africa. This study focused on the five major small livestock producing areas, but these provinces differ in terms of vegetation, topography, and farming practices. In total 1 424 farmers was surveyed out of the target sample of the 1 500 farmers; the reason for this being that not all farmers responded to the invitation to participate in the data collection process.

The NC province is the largest province in South Africa, where more than 94% of the farmland is used for extensive grazing purposes. This is followed by the EC province, where 92% of farming land is used for grazing. These two provinces are traditionally known for large and small livestock production and less for field crop production. In contrast, field crop production plays a larger role in the FS, MP and WC provinces, where livestock is utilising crop residues after harvesting, which reduces the effects of management aspects and thus reduces predation to some extent.

The data of each of the five provinces are analysed separately because of differences in farming practices, topography, vegetation and perceived predator density. The Tobit and Truncated regression models are used to analyse data on factors influencing predation according to the model specifications and tested with the Cragg’s model.

4.2 Eastern Cape (EC) province

4.2.1 Descriptive analyses of the EC province

The EC province comprises five District Municipalities (Figure 4.1). A total of 350 farmers were surveyed in the EC province and 96% of these farmers reported predation losses due to the black-backed jackal and caracal. In Table 4.1 a summary is provided of farmers surveyed, land utilization and small livestock numbers in the EC province. There are an estimated 5 670

469 head of small stock in the EC province (NDA, 2005/06), with the composition of small livestock numbers comprising of sheep (75%) and goats (25%), respectively. It is important to not that these sheep and goat numbers only refer to the commercial farming sector. More than 94% of the farming land is utilized for grazing land (NDA, 2008). In total 13.4% of the grazing land in the EC province was surveyed, with an average farm size of 5 400 ha.

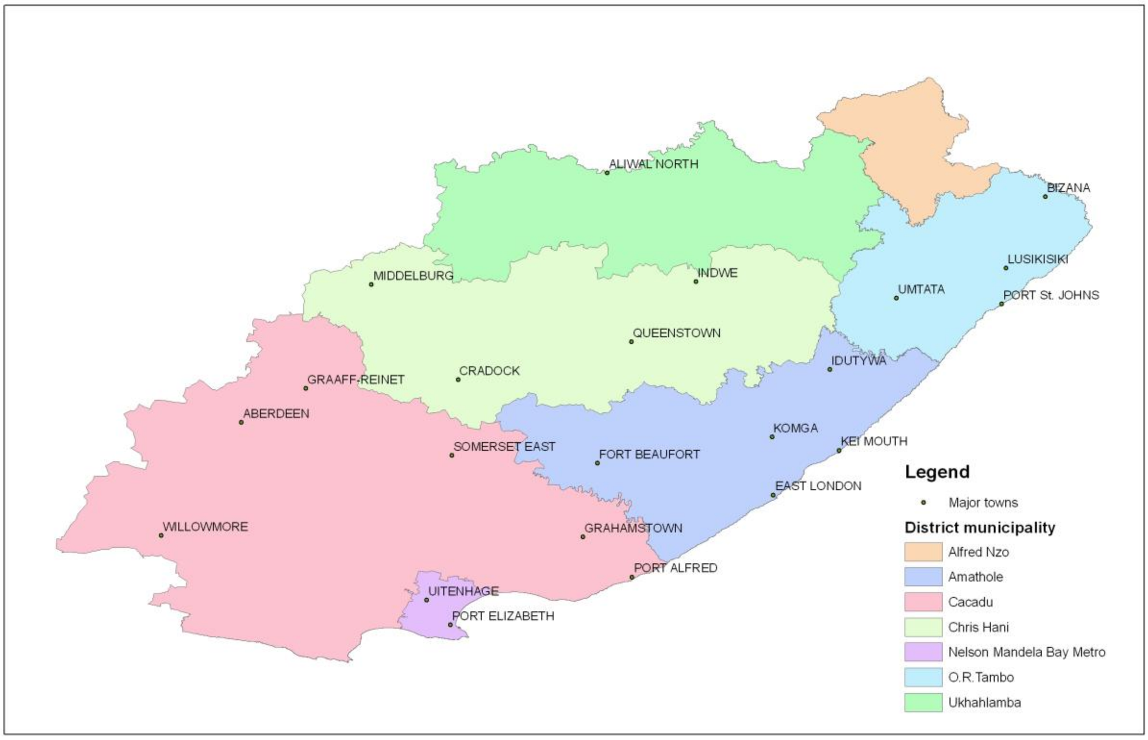

Figure 4.1 District Municipalities and towns in the EC province (MDB, 2009).

Table 4.1 Number of farmers surveyed, land utilization and small livestock numbers in the EC province

	Surveyed	EC province	Percentage
Farmers	350	4 376	7.9
Head of small livestock	794 028	5 670 469	13.4
Grazing land (ha)	1 822 825	13 644 822	13.3

Source: NDA, 2008

Production of wool, Mohair, Angora goats and lamb production are important agricultural activities in the EC province. The different small livestock breeds in the EC province are presented in Figure 4.2. Farmers that were contacted indicated that certain small livestock breeds are more likely to be killed by predators, for example higher losses were associated with Angora goats, and other goat breeds.

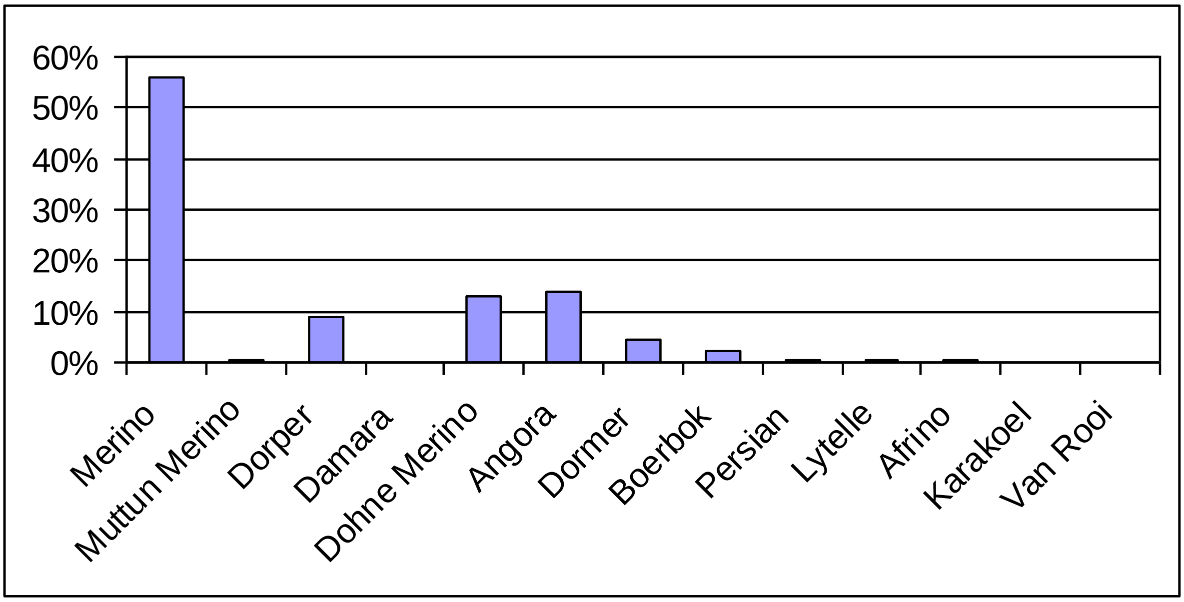

Figure 4.2 Small livestock breeds reported by the farmers surveyed in the EC province.

Time of lambing plays an important role in predation and higher losses are associated with lambing during certain seasons. The preferred lambing seasons for farmers include August-September season and March-April seasons. During August to September predators kill more sheep, because it coincides with the breeding seasons of specifically black-back jackal when their pups are born and reared. The majority of farmers is lambing their small livestock once a year in the April and August lambing seasons and 9% of farmers are lambing their small livestock three times every two years, as seen in Table 4.2. If farmers use three lambing seasons in two years, the lambing months differ and the losses are minimized.

Table 4.2 Lambing seasons (%) reported by responding farmers in the EC province

Lambing season	March-April	August-September	March-April and August-September	Year round (3 lambing seasons in 2 years)
	15.5	32.5	43	9

4.2.1.1 Small livestock losses

Losses associated with predation are shown in Table 4.3 with fewer losses attributed to caracal than for black-backed jackals.

Table 4.3 Classes of small stock losses reported for two consecutive years in the EC province

	2006		2007	
Losses	Black-backed jackal	Caracal	Black-backed jackal	Caracal
Ewes/does	1 199	747	982	697
Lambs/kids 0-1 months	13 352	6 473	13 078	6 486
Lambs/kids 1-6 months	13 694	9 705	13 188	8 956
Total	28 245	16 925	27 248	16 139

On average for the two sample years (2006 and 2007), farmers in the EC province are losing 5.58% of total livestock. The majority of losses are associated with lambs and kids older than one month. Small livestock losses are divided into production animals lost, offspring lost and total losses. Losses as high as 30% of total livestock (total losses), and 75% of production were reported in the EC province. The total losses in the EC province are illustrated in Figure 4.3, showing black-backed jackal (57%) and caracal (35%) are responsible for the majority of the losses compared to stock theft (7%).

The largest predation losses occurred in the Cacadu District (see Table 4.4). This part of the EC province includes towns such as Aberdeen, Graaff-Reinet, Humansdorp, Pearston and Willowmore and is known for extensive sheep and goat farming (see Figure 4.1). Predation losses are almost equally attributed to black-backed jackal and caracal, possibly due to the fact that this part of the EC province meets the habitat requirements of both the black-backed jackal and caracal. In this part of the EC province, namely the Cacadu District, farmers feel that nature reserves and wildlife ranches play an important role in the level of predation on farms, by not controlling predators or by neglecting fences.

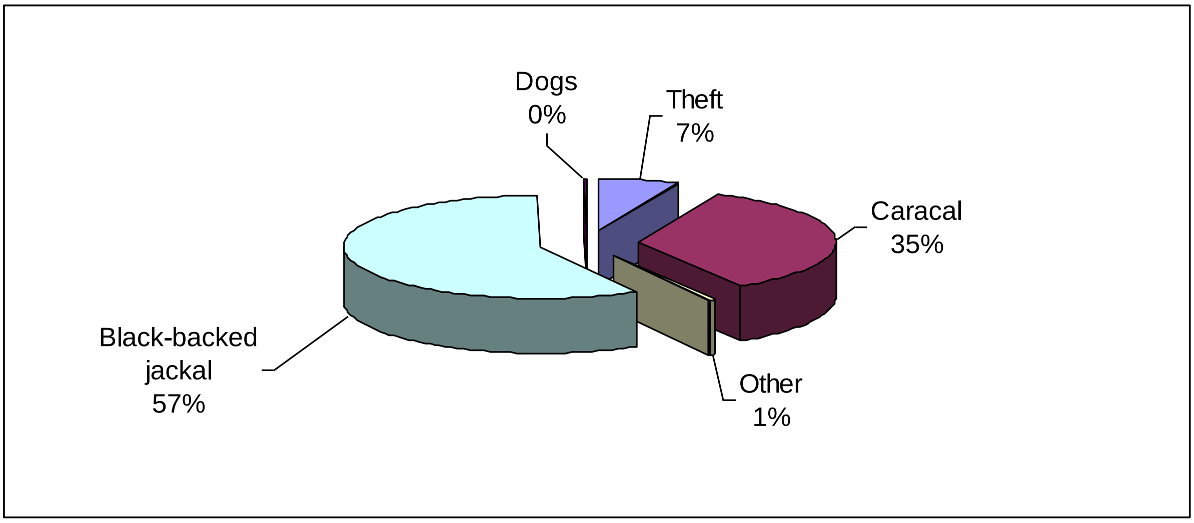

Figure 4.3 Reported causes of small livestock losses for two consecutive years (2006/07) in the EC province.

The Chris Hani District also experienced high predation losses and encountered the same problems as the Cacadu District. According to farmers in the Chris Hani District there are a number of so-called "empty" farms in the district; by "empty" meaning, weekend farmers, and solitary stock posts. Farmers have strong views that these "empty" farms are breeding areas for predators.

Table 4.4 Predation reported per district (%) over two consecutive years in the EC province

	2006		2007	
District Municipality	Black-backed jackal	Caracal	Black-backed jackal	Caracal
Cacadu	38	36	39	36
Amatole	8	12	15	11
Chris Hani	39	32	32	31
Ukhahlamba	12	19	12	20
Nelson Mandela	3	1	2	1
Total	100	100	100	100

The Nelson Mandela District reported the least losses to predation, because it is largely an urban part of the EC province and small livestock farming is practiced on a relatively small scale.

4.2.1.2 Control of predators in the EC province

From the 350 farmers interviewed in the EC province, 73% actively controls predators. The methods mostly used are hunting with rifles and hunting dogs whereas a small number of farmers use poison any longer. A general believe among farmers is that problem areas or breeding areas, namely the areas from which the problem of predation occurs, are mostly wildlife ranches and nature reserves. Non-lethal methods remain popular with 64% of farmers using these methods; jackal-proof fencing and King Collars being the most popular options (see Figure 4.4).

Non-lethal methods are expensive to use and there is no guarantee that these methods will work. A number of farmers in the EC province are using electric fences with great success. However, this method is also expensive and time consuming. According to some of the farmers interviewed, predation losses were kept to a minimum when non-lethal methods were used in combination or in rotation with one another.

Table 4.5 Methods used and predators killed in the EC province

	2006		2007	
Method used to kill predators	Black-backed jackal	Caracal	Black-backed jackal	Caracal
Soft Catch traps	645	355	621	420
Dogs	1 123	726	1 066	658
Cage traps	98	710	107	699
Hunting	2 288	621	2 318	569
Poison	160	29	156	31
Total	4 314	2 441	4 268	2 377

A great deal of success is associated with lethal control methods, especially when damage-causing animals are hunted. This is a very selective method and mostly only targeted animal are killed. The use of dogs is another method frequently used in the EC province, this method is not that selective. The use of non-lethal methods is gaining popularity, with the majority of farmers using jackal-proof fencing, bells and electrical fences.

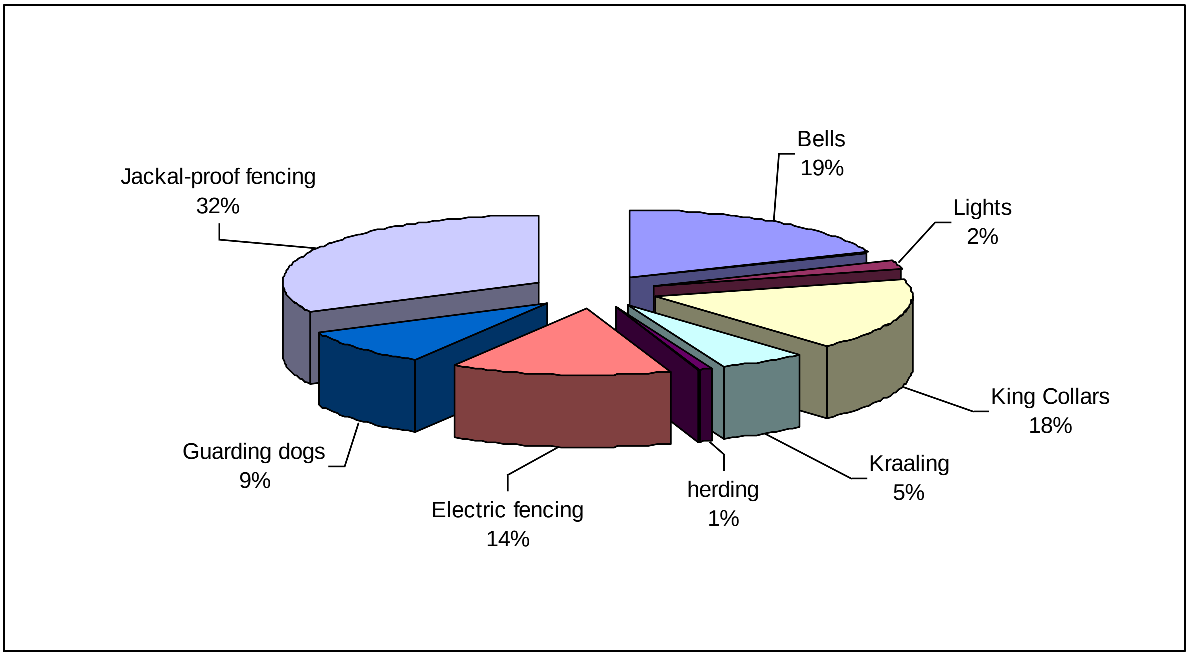

Figure 4.4 The non-lethal methods used to reduce predation in the EC province.

4.2.2 Factors associated with predation losses in the EC province

It was hypothesised that the variables influencing the occurrence of predation and the variables influencing the level of predation is not the same, thus it is necessary to use the Probit and Truncated regression models to differentiate between these factors. A backward linear regression was used to eliminate insignificant variables from the regression. The dependent variable in the Probit model indicated the occurrence of predation on a farm, with a value of zero indicating no losses occurred and a value of one if predation occurred. The dependent variable in the Truncated regression model for all the provinces is a continuous variable that measured the percentage loss of small livestock (the number of small livestock losses divided by the total number of animals on a farm).

The results of the analyses are shown in Table 4.6. Variables were kept the same for the specifications of the two models to test the specifications of the Cragg's model. The Probit model models the probability that predation will occur or not and the Truncated model models the level of predation on a farm. Variables were specifically selected at a statistical significant level of 0.15. The Cragg's model had a significant P value (P = 0.000; CHISQ = 69.905) and thus, the factors affection occurrence of predation were significantly different form the factors affecting the level of predation.

Table 4.6 Regression results for the Probit and Truncated models in the EC province

	Probit		Truncated	
Variables	Coefficient	P value	Coefficient	P value
Constant	1.493	0.000	0.029	0.302
Lambing interval	-0.069	0.038	-0.056	0.697
Number of ewes	-0.000	0.012	-0.379	0.000
Lambing in protected areas	-0.343	0.124	-0.708	0.343
Regular counting of small stock	-0.045	0.016	-0.005	0.037
Electric fences	-0.022	0.955	-0.042	0.067
Bells	-0.031	0.165	-0.053	0.021
Combination of non-lethal methods	0.172	0.629	0.069	0.001
Active hunting of predators	1.104	0.000	0.071	0.001
Planted pastures	0.062	0.055	0.091	0.018

In the Probit model a number of variables are significant in modelling the occurrence of predation in the EC province. These variables are mostly associated with managerial aspects such as lambing intervals (lambing once every year or twice in three years), number of ewes, lambing in protected areas, and regular counting of small livestock. A negative coefficient was expected for all managerial aspects, namely the more intensive the management, the less the occurrence of predation. In the EC province a higher level of management is associated with larger small livestock numbers on a farm (Probit, P = 0.012). Therefore, a higher level of management on a farm will probably lead to a reduction in predation losses. This principle can also be applied to the other management variables. Lambing interval (Probit, P = 0.038), lambing in protected areas (Probit, P = 0.124) and regular counting of small stock (Probit, P = 0.016) are all very important management practices used by farmers to detect a specific problem quickly and deal with it accordingly. However, to implement all the different management aspects on a farm is not always financially and physically possible.

Active hunting is significant as a control method in both the Probit and Truncated models (Probit, P = 0.000; Truncated, P = 0.001). The positive coefficients indicate that the more active hunting occurs, the more predation losses may increase. However, the perceived large population of damage-causing animals in the EC province makes active predator control necessary. Management practices and the use of non-lethal and lethal control methods differ between regions and provinces, but it does not necessarily mean that if a certain method is successful in one region or province, it will be successful on a farm in another region or province.

When a variable is affecting the level of predation it means it contributes either to a reduction or an increase in the level of predation. These factors will usually include non-lethal methods and lethal control methods to a certain extent. Bells, King Collars, jackal-proof fences and electric fences are examples of non-lethal methods used by farmers with varying success in regions and provinces. Non-lethal methods usually do not stop predation, but will only reduce the level of predation on a farm. This is why most non-lethal methods will only be significant in the Truncated model and have a negative coefficient. A great deal of success was experienced when non-lethal methods were used in combination or in rotation with one another (Truncated, P = 0.001), this is mainly due to the adaptability of predators. There is no real explanation regarding the reason for the positive coefficient, but it might be that when methods are used in a certain combination, it can as previously mentioned have the same effect as active hunting.

An interesting factor came to light in the EC province. A number of farmers use irrigated pastures (Probit, P = 0.055; Truncated, P = 0.018), which had an influence on whether predation occurred as well as increasing the level of predation. These pastures are small and mostly used for lambing and finishing of lambs. The higher level of predation might be due to at least two factors: firstly, small livestock is more concentrated in a specific area and secondly, higher levels of predation occur in that specific area of the EC province.

4.2.3 The cost of predation in the EC province

A number of methods exist to articulate the costs of predation. The frequently used method of illustrating the cost of predation is to use the market price of the animal lost and multiply it by the number of animals lost. The National Wool Growers' Association valued one unit (animal lost) in earlier estimates at R600, which was a very low estimate for a unit lost. At present (2010) the Stock Theft Forum is valuing one small stock (sheep) unit at R1 200, and one small stock (goat) unit at R1 400. By using the value used by Stock Theft Forum a over estimation is possible. For the purpose of this study it was decided to use a value of R600 for one unit (sheep and goat) younger than six months and a value of R1 000 for one unit (sheep and goat) older than six months. However, this only illustrates the direct cost of predation for the EC province and does not reflect the indirect cost of preventing predation on a farm. The cost of prevention includes among other cost the cost of a professional hunter, fencing (jackal proof and electrical) and management input. Although some of these methods is a once-off expense, the methods are very expensive and therefore not a viable option to all farmers. Other methods like poison and the use of professional hunters or the farmer hunting himself represent a continuous cost to farmers. The average direct cost to predation losses by damage-causing animals are shown of the EC province in Table 4.7.

Table 4.7 The direct cost of predation in the EC province

		Number of small livestock	Average predation losses (%)	Losses due to predators	Unit cost per animal (R)	Cost of predation (R)
Sheep	< 6 months	5 062 299	11.3	572 040	600	343 223 872
	> 6 months	5 062 299	0.5	25 311	1 000	25 311 495
Goats	< 6 months	608 170	11.3	68 723	600	41 233 926
	> 6 months	608 170	0.5	3 041	1 000	3 040 850
Total		5 670 469		669 115		412 810 143

It is difficult to estimate the indirect cost of predation. Management and farming activities differ between farmers and regions, but these costs have to be taken into account. The number of small stock (sheep and goats) is an estimate provided by the National Department of Agriculture (2005) for commercial farmers only.

4.3 Free State (FS) province

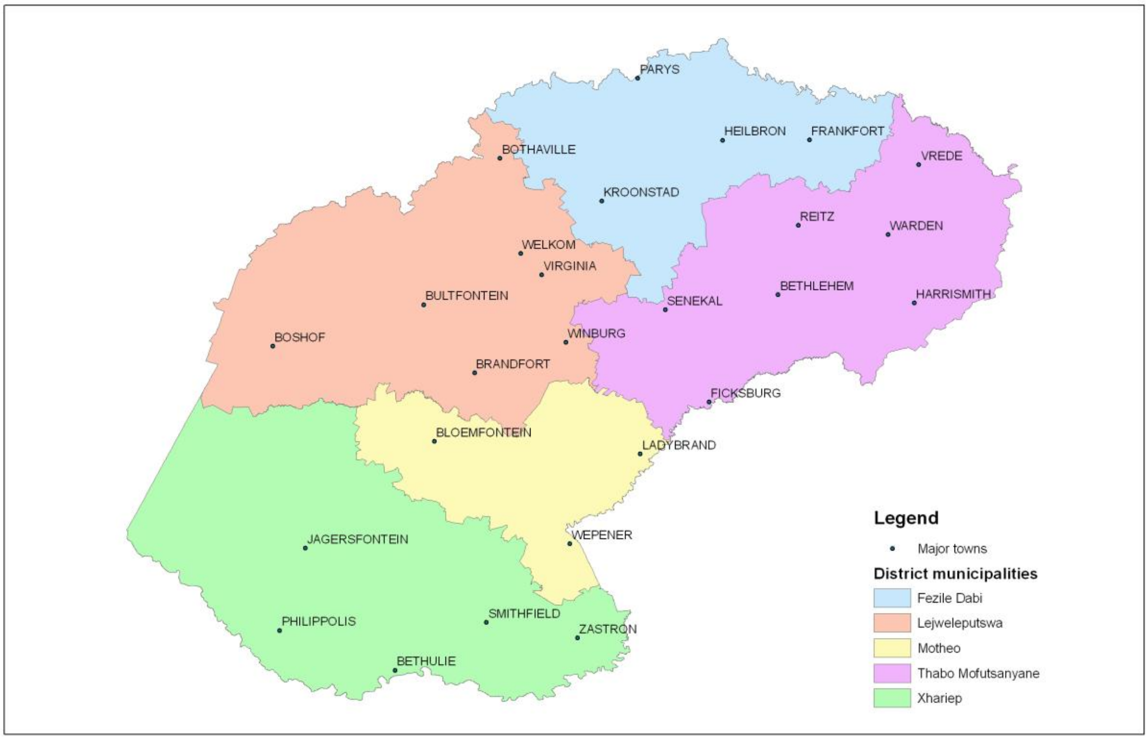

Figure 4.5 District Municipalities and towns in the FS province (MDB, 2009).

4.3.1 Descriptive analysis of the FS province

The FS province comprises five District Municipalities (see Figure 4.5). In the FS province a total of 343 farmers were surveyed and 90% of the farmers reported predation losses due to the black-backed jackal or caracal. In Table 4.8 a summary is provided of farmers surveyed, land utilization and small livestock numbers. There are an estimated 5 326 315 (NDA, 2005/06) head of small livestock in the FS province on commercial farms. In the FS province about 90.9% of the land is used for farming purposes and 58.2% is utilized as grazing land (NDA, 2008). In total 10% of the total area of the FS province was included in the survey, with an average farm size of 2 700 ha.

In the FS province field crop production, Merino wool and lamb production are some of the main agricultural practices. In Figure 4.6 an illustration is provided of the different small stock breeds surveyed in the FS province.

Table 4.8 Number of farmers surveyed, land utilization and small livestock numbers in the FS province

	Surveyed	FS province	Percentage
Farmers	343	8 531	4.0
Head of small livestock	743 337	5 326 315	13.9
Land (ha)	840 589	7 538 677	11.1

Source: NDA, 2008

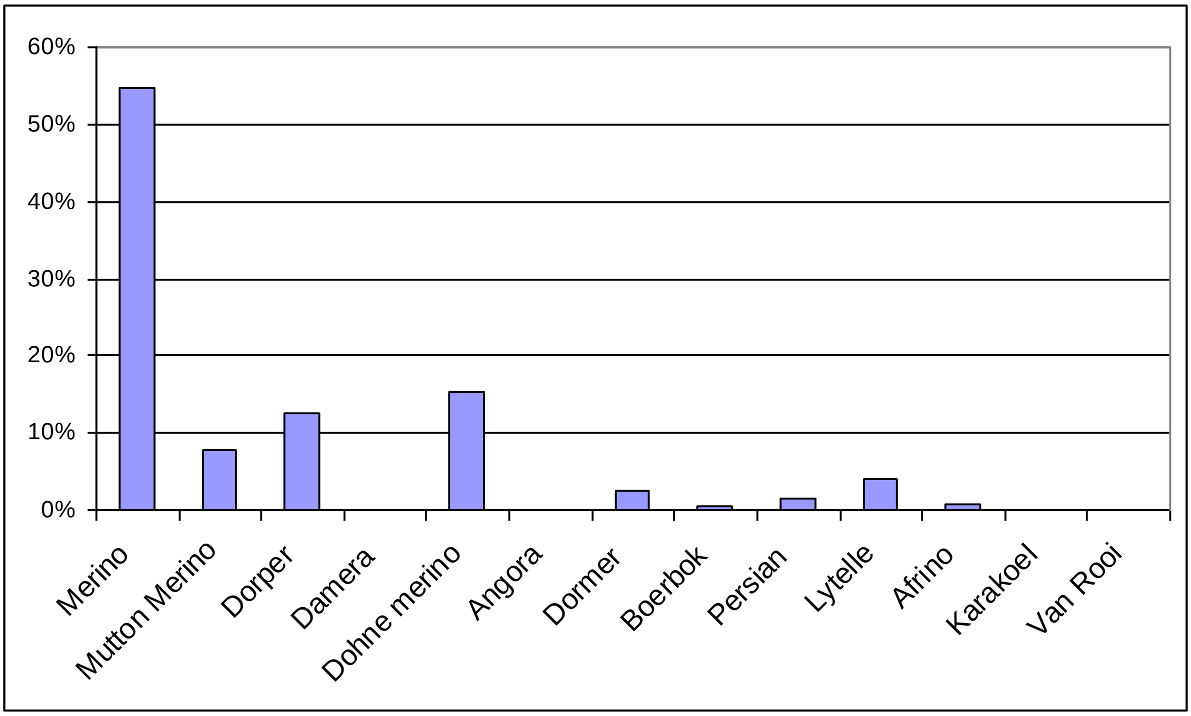

Figure 4.6 Small livestock breeds reported by the farmers surveyed in the FS province.

Time of lambing plays an important role in predation and higher losses are associated with lambing in certain seasons. These lambing seasons include August-September season and March-April seasons. In Table 4.9 the differences between lambing seasons are illustrated. Most farmers is lambing their small livestock once a year in the March-April and August-September lambing seasons and fewer are lambing their small stock three times in two years. If farmers use three lambing seasons in two years the lambing months differ and these farmers' losses are minimized.

Table 4.9 Lambing seasons reported by responding farmers in the FS province

Lambing season	March-April	August-September	March-April and August-September	Year round (3 lambing seasons in 2 years)
Percentage	8	18	57.14	16.62

4.3.1.1 Small livestock losses

Losses associated with predation in the FS province are shown in Table 4.10, with much fewer losses attributed to caracal than for black-backed jackal. The majority of losses is associated with lambs younger than one month in the case of black-backed jackal.

Table 4.10 Classes of small livestock losses reported for two consecutive years in the FS province

	2006		2007	
Losses	Black-backed jackal	Caracal	Black-backed jackal	Caracal
Ewes/does	193	408	236	539
Lambs/kids 0-1 months	9 351	1 848	10 791	2 182
Lambs/kids 1-6 months	10 846	5 241	10 104	4 897
Total	20 390	7 497	21 131	7 618

Although losses differ between farm and region, the majority of losses are associated with lambs older than one month. Small livestock losses are divided into production animals lost, offspring lost and total losses. The total losses in the FS province are shown Figure 4.7, with stock theft particularly high.

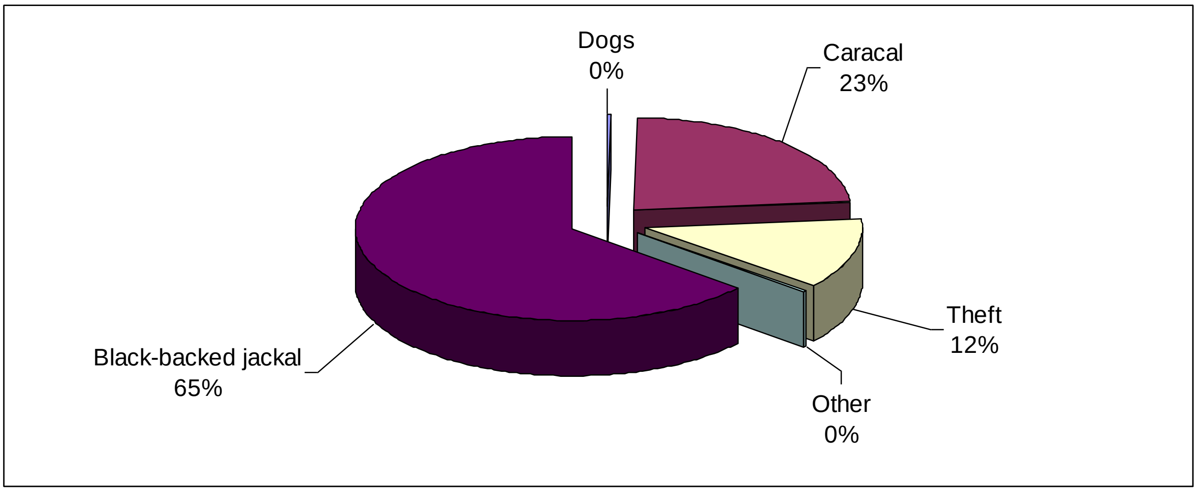

Figure 4.7 Reported causes of small livestock losses for two consecutive years (2006/07) in the FS province.

Table 4.11 Predation reported per district (%) over two consecutive years in the FS province

	2006		2007	
District Municipality	Black-backed jackal	Caracal	Black-backed jackal	Caracal
Xhariep	54	67	54	65
Motheo	8	4	7	6
Lejweleputswa	3	4	3	3
Fezile Dabi	19	16	20	18
Thabo Mofutsanyane	16	9	15	8
Total	100	100	100	100

The reason for the high predation losses in the Xhariep District, better known as the Southern Free State, is that this area is an well-known as a small livestock farming area. Regions includes amongst others towns such as Bethulie, Edenburg and Springfontein. Farmers in this area feel that nature reserves and wildlife ranchers contribute to the problem by not managing predators, by not controlling predation or fences that are inadequate to contain predators.

In the Lejweleputswa District (Bothaville, Hoopstad, Boshof, Hertzogville) predation is lower than the other districts, because these areas are more suitable for field crop production. However, there are a number of small stock farmers in this area. Small stock can utilize crop residues after harvesting, but because stock theft is high these animals must be kraaled every night.

The survey highlighted that there are a large number of "empty farms" or stock posts and weekend farmers in some parts of the FS province. Farmers surveyed feel that these farms are not managed efficiently and in certain circumstances are breeding areas for predators.

4.3.1.2 Control of predators in the FS province

Of the 343 farmers interviewed in the FS province, 68% actively controls predators. The methods mostly used are hunting with rifles, hunting dogs and gin traps, fewer farmers are using poisons as presented in Table 4.12.

Table 4.12 Methods used and predators killed in the FS province

	2006		2007	
Methods used to kill predators	Black-backed jackal	Caracal	Black-backed jackal	Caracal
Soft Catch traps	469	140	445	113
Dogs	350	117	329	53
Cage traps	80	222	81	228
Hunting	2 050	447	1 860	343
Poison	300	30	260	45
Total	3 249	956	2 975	782

In the FS province about 60% of farmers are using non-lethal methods, Jackal-proof fencing, kraaling and electric fences to reduce predation. In the FS province kraaling of stock at night is the highest of all the provinces surveyed. This reduces stock theft that is especially high in this province and thus also minimizes predation. However, these methods are very expensive and intensify management practices. Furthermore, due to the adaptability of these predators non-lethal methods can be used in rotation with one another to reduce familiarisation of the methods used. Different non-lethal methods are summarized in Figure 4.8, where jackal-proof fencing and kraaling at night was the non-lethal methods most used.

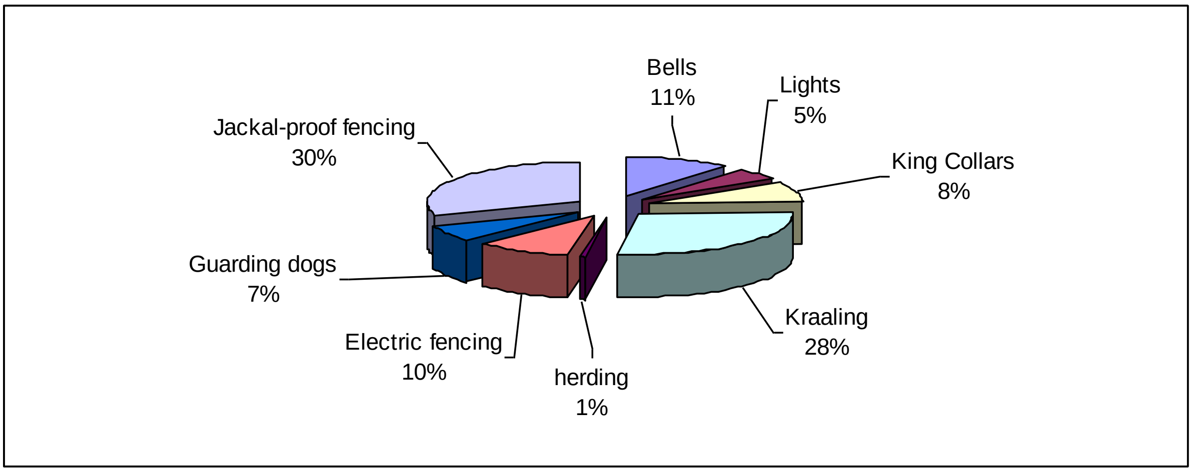

Figure 4.8 Non-lethal methods used to reduce predation in the FS province.

4.3.2 Factors associated with predation losses in the FS province

The results of the analyses of the FS province are shown in Table 4.13; the variables were kept the same for both the Probit (probability that predation will occur) and Truncated (level of predation) regression models to test the specifications of the Cragg's model. The Cragg's model had a significant P value (P = 0.000; CHISQ = 117.602), therefore, according to the Cragg's model it was necessary to use the Probit an Truncated models to analyse data on predation. The dependent variable in the Probit model indicated the occurrence of predation on a farm and the dependent variable in the Truncated model indicated the percentage of predation on a farm.

In the Probit model a number of variables were found to be significant (see Table 4.13). It was expected that management aspects should be significant in the Probit model and negatively correlated with the occurrence of predation. However, in the FS province it is more complex to interpret results, because this province has a high number of small livestock and predation losses is relatively low in comparison with other provinces. This is mainly due to the fact that a large number of farmers, mostly in the crop producing areas, have large number of small livestock feeding on crop residues after harvesting in combination with natural grazing. When these farming practices are used it increases management activities, with this increase of management activities predator management activities becomes more easer.

When small livestock is kraaled every night problems are detected much quicker. According to this not all management variables and coefficients was found to be as expected. For example, lambing intervals (lambing once every year or twice in three years) in the Probit (P = 0.620) and the positive coefficient in the number of ewes can be seen as an example. Lambing intervals move from being a factor influencing the occurrence of predation to a factor influencing the level of predation dew to changes in management activities.

Table 4.13 Regression results for the Probit and Truncated models in the FS province

	Probit		Truncated	
Variables	Coefficient	P value	Coefficient	P value
Constant	0.906	0.000	-0.034	0.216
Lambing interval	-0.114	0.620	0.031	0.063
Number of ewes	0.000	0.008	-0.205	0.010
Lambing in protected areas	-0.342	0.046	-0.015	0.309
Combination of non-lethal methods	0.016	0.947	0.032	0.059
Poison	0.542	0.150	0.026	0.150
Soft Catch traps	0.337	0.184	0.047	0.007
Hunting (using a professional hunter)	0.431	0.091	0.021	0.169
Nature reserves	1.167	0.011	0.028	0.102
Small stock farms	-1.481	0.000	-0.114	0.293

Although control methods reduce the level of predation, some of these methods will also play a roll in the occurrence of predation on a farm, for example the use of a professional hunter (Probit, P = 0.091) is one of these methods. This can be that a great deal of success is associated whit professional hunters in the FS province (by only eliminating the damage-causing animal or there are a relatively low concentration of predators in an area).

The reason for poison being effective in reducing the occurrence of predation can be that a great deal of success was associated with that method at that specific point in time in the FS province.

When a variable is affecting the level of predation it means it contributes either to a reduction or an increase in the level of predation. These factors will usually include non-lethal and lethal control methods to a certain extent. Variables are expected to be significant in the Truncated model and have a positive coefficient. In the FS province control method such as a combination of non-lethal methods (Truncated, P = 0.059) and the use of soft catch traps (Truncated, P = 0.007) played a role in the level of predation on a farm. Non-lethal methods usually do not stop predation but only will reduce the level of predation on a farm.

In the questionnaire it was asked where the problem of predation originates? Nature reserves (Probit, P = 0.011) and neighbouring small livestock farms (Probit, P = 0.000) was found to be significant in the Probit model in effecting the occurrence of predation on a farm. A number of nature reserves exist in the eastern and southern FS province and farmers believe that nature reserves do not control predator populations and fences are inadequate to contain predators. In the case of neighbouring small livestock farms many farmers hold the view that neighbours do not control predators and that fence are inadequate to contain predators. The negative coefficient in the case of neighbouring small livestock farms can be that it will have an influence on the level of predation, but not necessarily on that specific farm.

4.3.3 The cost of predation in the FS province

The direct cost of predation in the FS province is shown in Table 4.14, the estimation of values used see section 4.2.3. These do not indirect cost of predation in the FS province. The indirect cost will also differ between regions and provinces, depending on the different control methods used in the region or province. These preventive measures included in the indirect cost are difficult to accurately estimate, some methods are a once-off payment and others are continuous costs. The number of small stock is an estimate provided by the National Department of Agriculture (2005); for commercial farmers only. Market value was used for one unit lost (lamb/kid 6 months old).

Table 4.14 The direct cost of predation in the FS province

		Number of small livestock	Average predation losses (%)	Losses due to predators	Unit cost per animal (R)*	Cost of predation (R)
Sheep	< 6 months	5 112 184	7.4	378 302	600	226 980 970
	> 6 months	5 112 184	0.2	10 224	1 000	10 224 368
Goats	< 6 months	214 131	7.4	15 846	600	9 507 416
	> 6 months	214 131	0.2	428	1 000	428 262
Total		5 326 315		404 800		247 141 016

4.4 Northern Cape (NC) province

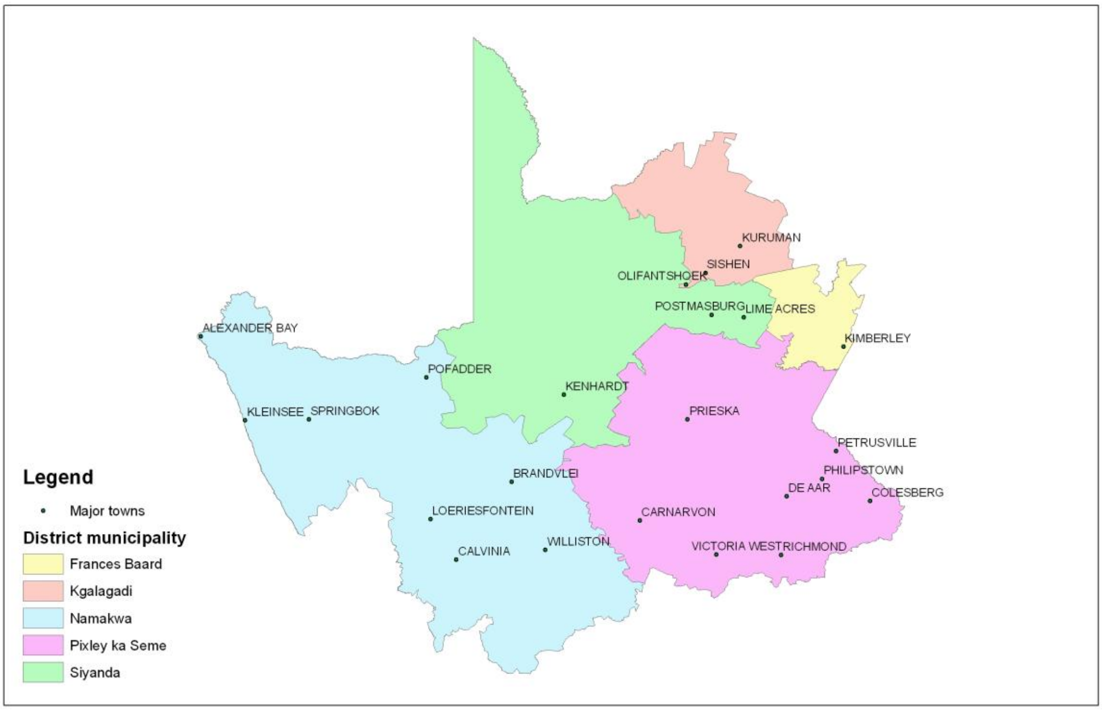

Figure 4.9 District Municipalities and towns in the NC province (MDB, 2009).

4.4.1 Descriptive analyses of the NC province

The NC province comprises five District Municipalities (see Figure 4.9). The NC province is the largest province in South Africa and this study, with 426 farmers being surveyed. In the

NC province about 80% of the total area is used for grazing (NDA, 2008), where the main agriculture practices are large and small livestock as well as field crops and a number of irrigation schemes. The average farm size in the NC province was 7 949 ha. In Table 4.15 the number of farmers surveyed, land utilization, small livestock numbers are summarised for the NC province for the commercial farming sector. In the NC province 15% of the small live stock flock was surveyed and 11.3% of the total of the NC province.

Table 4.15 Number of farmers surveyed, land utilization and small livestock numbers in the NC province

	Surveyed	NC province	Percentage
Farmers	426	6 114	6.9
Head of small livestock	1 085 714	6 898 565	15
Land (ha)	3 290 790	29 089 367	11.3

Source: NDA, 2008

The different small livestock breeds in this province are presented in Figure 4.10. The NC province is dominated by mutton sheep breeds and less wool producing breeds, mainly because of the arid and semi-arid climate and vegetation. According to farmers there is no preference by predators for any small livestock breed

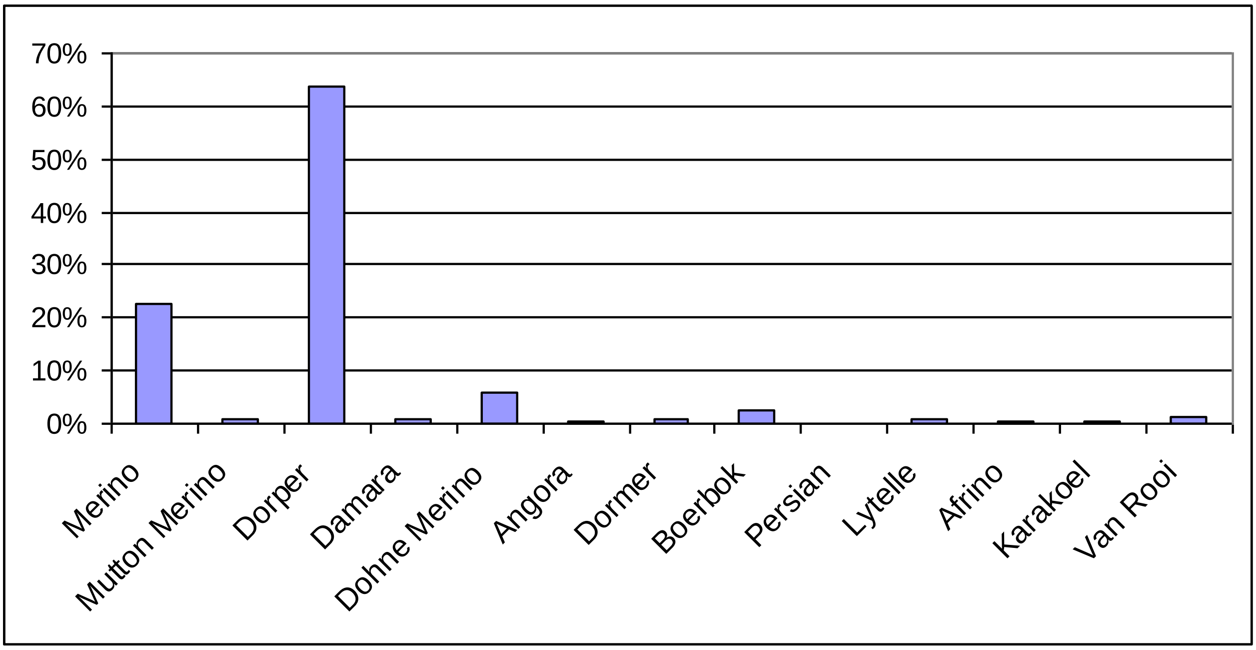

Figure 4.10 Small livestock breeds reported by the farmers surveyed in the NC province.

Time of lambing plays an important role in predation; high losses are associated with lambing in certain seasons. These lambing seasons include August-September season and March-April season, these seasons are in conflict with predators' social time and when puppies are born. In Table 4.16 a summary is shown of the different lambing seasons in NC province lambing in March-April and August-September was the most popular lambing practice. Lambing three lambing seasons in two years became more popular in the NC province in comparison with other provinces, with 26% of farmers using this management practice.

Table 4.16 Lambing seasons reported by responding farmers in the NC province

Lambing season	March-April	August-September	March-April and August-September	Year round (3 lambing seasons in 2 years)
Percentage	14	16	44	26

4.4.1.1 Small livestock losses

Predation losses for the NC province are shown in Table 4.17. Losses due to black-backed jackal are considerably higher than losses due to caracal. As previously said, the NC province is the largest province in South Africa and covers a large range of different terrain and habitats and it seems that the population density of the black-backed jackal is considerably higher than in the other provinces. Over 90% of the farmers practiced control of black-backed jackal and 76% for caracal.

Table 4.17 Classes of small livestock losses reported for two consecutive years in the NC province

	2006		2007	
Losses	Black-backed jackal	Caracal	Black-backed jackal	Caracal
Ewes/does	179	177	80	51
Lambs/kids 0-1 months	25 112	5 830	25 008	6 767
Lambs/kids 1-6 months	22 611	14 513	19 549	13 525
Total	47 902	20 520	44 637	20 343

On average, farmers in the NC province are losing 6.14% of their total small livestock and 13% of production (lambs between 0–6 months). The majority of losses were associated with lambs older than one month, but in the case of black-backed jackal more losses occurred between up to one month of age. Losses as high as 12% of total livestock (total losses) and 50% for production were reported in the NC province. In Figure 4.11 the composition of total losses in the NC province is presented, where black-backed jackal is responsible for 65% of the losses.

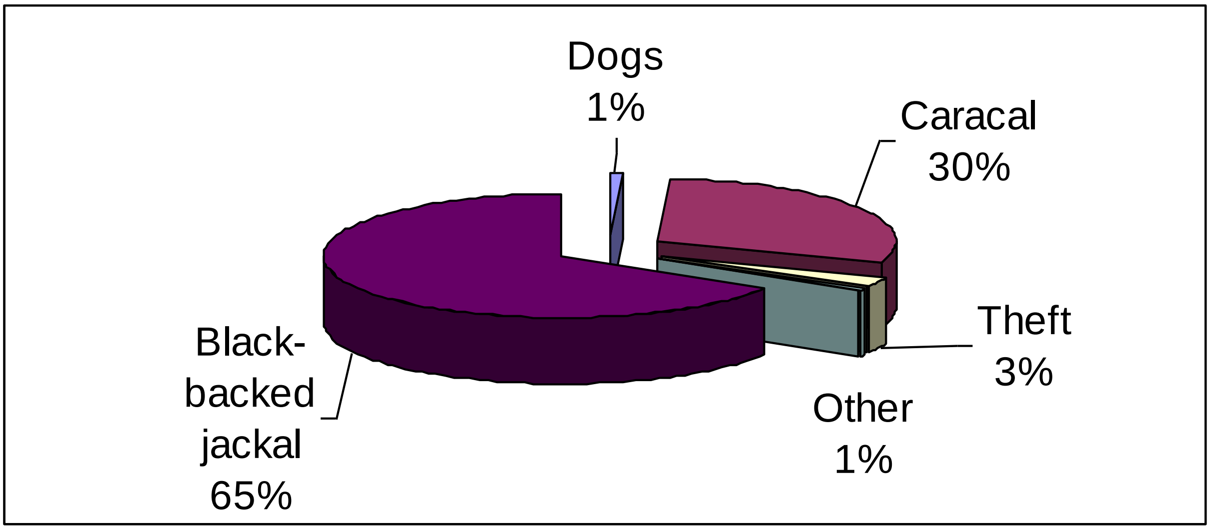

Figure 4.11 Reported causes of small livestock losses for two consecutive years (2006/07) in the NC province.

Predation losses per district are shown in Table 4.18. In the Pixley Ka Seme and Namakwa Districts some of the highest predation losses occurred, contributing to over 45% of the total losses in the NC province. This part of the NC province which includes towns such as Carnarvon, Colesberg and Victoria West, is part of the greater Karoo where the main farming practices is small livestock farming. In the NC province there is a number of large stock farming areas, for example the Frances Baard District (Kimberley, Reivilo, Griekwastad, Barkley West) which may be more suitable for cattle and where less predation problems occurred. However, in most parts of the NC province small and large livestock farming is practiced in combination to effectively benefit the vegetation. In the Siyanda District predation losses accounts for over 17% of losses in the NC province. This might be due to the fact that in this part of the Kalahari, where farm sizes are larger than in the rest of the province, which conflicts with predator control practices

Table 4.18 Predation per district (%) over two consecutive years in the NC province

	2006		2007	
District Municipality	Black-backed jackal	Caracal	Black-backed jackal	Caracal
Frances Baard	5.69	6.35	6.17	6.40
Kgalagadi	3.14	3.12	3.82	3.38
Namakwa	16.60	19.82	15.47	19.05
Pixley Ka Seme	57.56	49.49	56.15	49.14
Slyanda	17.00	21.22	18.39	22.04
Total	100.00	100.00	100.00	100.00

4.4.1.2 Control of predators in the NC province

Over 90% of the 426 farmers interviewed actively controls predators in the NC province. Hunting and Soft Catch traps are the methods most used. Cage traps proof to be very effective in controlling caracal and less effective with black-backed jackal. These three methods are probably the most common methods used for controlling predation and according to respondents, also being the most cost effective. According to farmers it is nearly impossible to catch black-backed jackal in cage traps, due to the adaptability and intelligence of these animals. Poison is a very effective way to control predators, but are a non-selective killer and legislation prohibits farmers to use most poison as illustrated in Table 4.19.

In the NC province 87% of farmers adopt non-lethal methods to reduce predation. Jackal-proof fencing and bells are the methods most favoured, with fewer farmers using King Collars and kraaling. The reason for the large number of farmers using jackal-proof fencing is, before the early 1990s, the Government subsidized fences to a certain extent. Farmers in the NC province have large numbers of small livestock and it is not always possible to implement a combination of different non-lethal methods. As seen in Figure 4.12 about 10% of the farmers used electrical fences. However, in some cases only small parts of the farm were protected, usually only small lambing areas.

Table 4.19 Methods used and predators killed in the NC province

	2006		2007	
Predators killed	Black-backed jackal	Caracal	Black-backed jackal	Caracal
Soft Catch traps	1 560	601	1 466	438
Dogs	539	192	641	178
Cage traps	200	994	150	724
Hunting	2 384	901	2 280	653
Poisons	217	42	310	51
Total	5 250	2 730	5 351	2 044

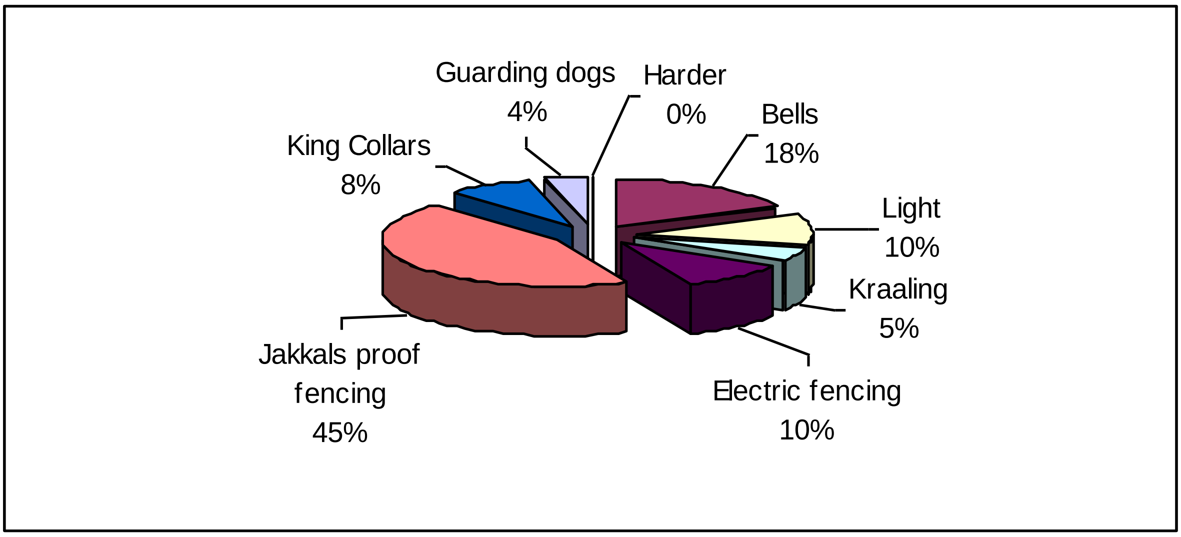

Figure 4.12 Non-lethal methods used to reduce predation in the NC province.

4.4.3 Factors associated with predation in the NC province

The results of the analyses are shown in Table 4.20. Variables differ between provinces, according to the different agricultural practises used in that specific province. There is a smaller number of farming activities in the NC province in comparison with the other provinces and livestock farming dominates as one of the main agricultural practices. As previously mentioned, the NC province is the largest of the five provinces surveyed and the variables selected represent the whole of the NC province. Variables are selected at a statistically significant level of 0.15 (see section 4.2.3).

The Cragg's model is used to test the hypothesis of variables affecting the occurrence of predation and variables affecting the level of predation are not the same. The Cragg's model had a significant P value (P = 0.000; CHIQS = 190.215); the factors affecting occurrence of predation were significantly different from the factors affecting the level of predation.

Table 4.20 Regression results for the Probit and Truncated models for the NC province

	Probit		Truncated	
Variables	Coefficient	P value	Coefficient	P value
Constant	0.454	0.028	-0.563	0.052
Lambing in protected areas	-0.710	0.007	-0.002	0.980
Counting of small stock	-0.001	0.237	-0.000	0.005
Tagging of small stock	0.350	0.081	0.083	0.086
Hunting (using professional hunter)	0.511	0.025	0.075	0.173
Active hunting of predators	0.961	0.000	0.208	0.034
Jackal proof fencing	0.324	0.115	-0.096	0.178
Electric fences	-0.558	0.031	0.061	0.416
Combination of non-lethal methods	0.350	0.112	0.078	0.238
Neighbouring large stock farms	0.262	0.259	0.108	0.134

A number of variables were found to be significant in factors affecting the occurrence of predation (Probit) on a farm. It was expected that management aspects would be significant in the Probit model and negatively correlated. A higher level of management is associated with a larger number of small livestock on a farm. As previously said, the NC province is largely dominated by large and small livestock farmers, meaning a large number of livestock is present on farms in the NC province. Most of the management aspects like number of ewes and lambing interval were eliminated by the backward linear regression and were not included in the regression models. It was assumed that some of these aspects already existed on farms and would not be significant in the regression models.

Although control methods reduce the level of predation (Truncated), some of these methods will also play a role in the occurrence of predation on a farm (Probit). This can be attributed to the fact that a specific method or farming action can be highly effective in the specific region at a certain point in time.

Lambing in protected areas (Probit, P = 0.007) and the tagging of small livestock (Probit, P = 0.081) was found to play a role in the occurrence of predation on a farm. A negative coefficient was expected in all management activities; however, a positive coefficient was encountered with the tagging of small livestock. Tagging of small livestock can be seen as an intensive management technique that is mostly used by stud farmers and not as a way to physically control damage-causing animals on a farm.

Both the use of a professional hunter (Probit, P = 0.025) and active hunting (Probit, P = 0.000) as a control method were found to play a significant role in the occurrence of predation. The positive coefficient indicates that, the more hunting occurs, the more there will be an increase in predation losses. Non-lethal methods only reduce the level of predation, but if a certain method or action works successfully it will have an impact on the occurrence of predation. These methods or actions, according to responding farmers, only work for a short while, due to the adaptability of predators, specifically the black-backed jackal.

The use of jackal-proof fencing (Probit, P = 0.115), electrical fences (Probit, P = 0.031) and a combination of non-lethal methods (Probit, P = 0.112) can be seen as actions resulting in a great deal of success to reduce predation. Electrical fences are gaining popularity. Although this method is very expensive, a high level of success is associated with it. When electrical fences are used, problems can be detected quickly in contrast with jackal-proof fencing, thus explaining the negative coefficient.

Regular counting of small livestock, tagging of small livestock, hunting by a professional hunter and active hunting are significantly contributing to the level of predation (Truncated). There is no justification for the positive coefficient for tagging of small stock. It can be assumed that tagging is a once-off farming activity and mostly used for record keeping. Neighbouring cattle farms (Truncated, P = 0.134) also play a role in the level of predation. Cattle farmers have in general little need to control problem-causing animals on their farms.

However, in some cases problem-causing animals have been known to maul cattle while calving and predating on small calves.

4.4.4 The cost of predation in the NC province

The direct cost of predation for the NC province is shown in Table 4.21 (estimation of value per unit see 4.2.3). Indirect cost of predation was expected to be higher is this province than the rest. The majority of the NC province adopted non-lethal control to reduce predation. These non-lethal methods include jackal proof fencing and electric fencing and, while hunting is use to reduce damage-causing animals. This leads to an increase in indirect cost. Small livestock numbers used was estimated in 2005 (NDA, 2005) was only for commercial farmers.

Table 4.21 The direct cost of predation in the NC province

		Number of small stock	Average predation losses (%)	losses due to predators	Unit cost per animal (R)	Cost of predation
Sheep	< 6 months	6 341 801	12.9	818 092	600	490 855 397
	> 6 months	6 341 801	0.1	6 342	1 000	6 341 801
Goats	< 6 months	556 764	12.9	71 823	600	43 093 534
	> 6 months	556 764	0.1	557	1 000	556 764
Total		6 898 565		896 813		540 847 496

4.5 Mpumalanga (MP) province

4.5.1 Descriptive analysis of the MP province

The MP province comprises three District Municipalities (Figure 4.13) and being the smallest province in this study with 113 farmers surveyed. In the MP province about 88% of farmers reported small livestock predation losses. Table 4.22 provide a summary of farmers surveyed, land utilization and small livestock numbers showing that 60% of the land is used for farming practices of which 39% is specifically used for grazing purposes

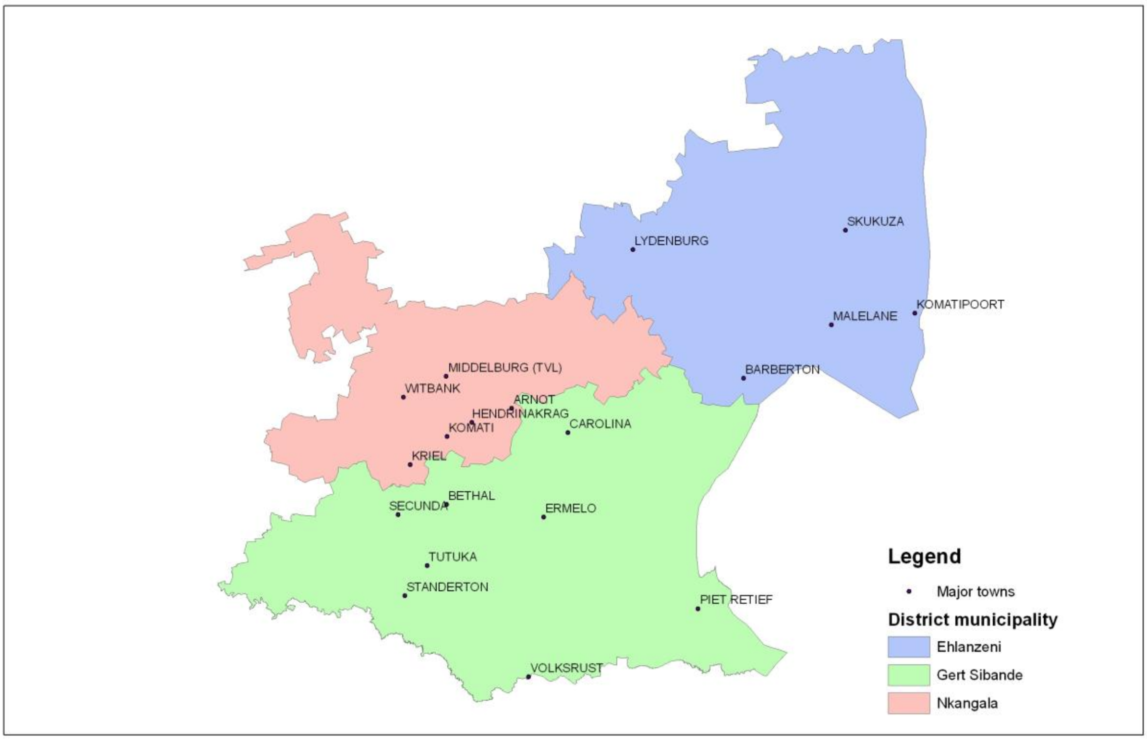

Figure 4.13 District Municipalities and towns in the MP province (MDB, 2009).

In the MP province small livestock farming is not a major agricultural practice. The Merino (47%), Dohne Merino (23%) and Mutton Merino (26%) are the most common breeds. Field crop production in this province is a main agricultural activity and these breeds adapt well to utilize crop residues after harvesting.

Table 4.22 Number of farmers surveyed, land utilization and small livestock numbers in the MP province

	Surveyed	MP province	Percentage
Farmers	113	5 104	2.2
Head of small livestock	247 464	1 764 030	14
Land (ha)	318 497	3 243 931	9.8

Source: NDA, 2008

Time of lambing plays an important role in predation, with high losses associated in certain seasons. These lambing seasons include August-September seasons and March-April seasons. Table 4.23 shows the different lambing seasons used in the MP province, with one lambing season per year being the most popular (March-April and August-September).

Table 4.23 Lambing seasons reported by responding farmers in the MP province

Lambing season	March-April	August-September	March-April and August-September	Year round (3 lambing seasons in 2 years)
Percentage	30	8	45	17

On average 83% of the responding farmers in the MP province are lambing their small livestock once every year and the remaining 17% lamb their small livestock three times every two years. If farmers use three lambing seasons in two years, the lambing months differ and the losses by predators can be minimized in some cases.

4.5.1.1 Small livestock losses in the MP province

Losses associated with predation in the MP province are shown in Table 4.25. According to farmers surveyed, the black-backed jackal is responsible for the majority of the losses and the caracal is relatively low in comparison with black-backed jackal.

Table 4.24 Classes of small livestock losses attributed for two consecutive years in the MP province

	2006		2007	
Losses	Black-backed jackal	Caracal	Black-backed jackal	Caracal
Ewes/does	0	0	0	2
Lambs/kids 0-1 months	5 074	448	4 881	430
Lambs/kids 1-6 months	3 797	837	3 574	933
Total	8 871	1 285	8 455	1 356

The majority of losses occurred with lambs younger than one month in the case of black-backed jackal. Losses in the MP province were reported as high as 33% of production (lambs 0–6 months) and 14% of total livestock (total losses). Predation losses in the different District Municipalities of the MP province are shown in Figure 4.14, where losses due to black-backed jackal were the primary reason of predation loss. Stock theft in the MP province is very high in contrast with the other provinces, considering the small size of the sample in this province.

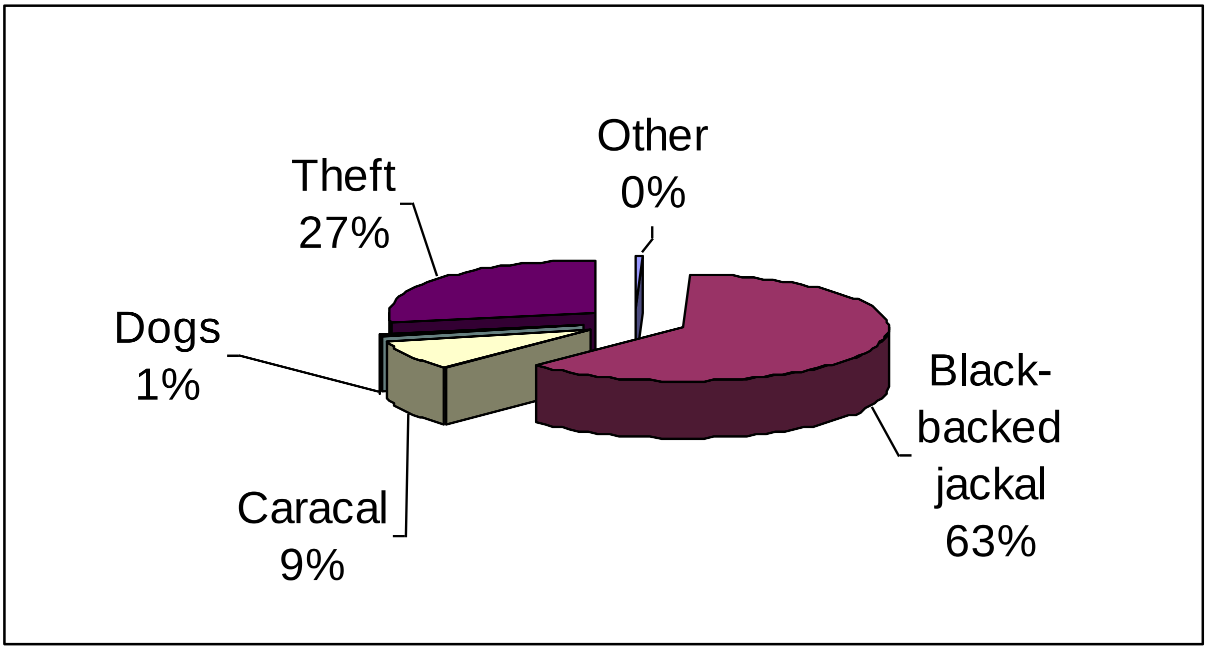

Figure 4.14 Reported causes of small livestock losses for two consecutive years (2006/09) in the MP province.

The MP province comprises three District Municipalities (see Figure 4.13), namely the Gert Sibande, Nkangala and Ehlanzeni District Municipality. The main agricultural practice in the MP province is field crop production, game farming (Ehalanzeni District) and large livestock farming (on crop residue after harvesting) and to a lesser extent, small livestock farming. Over 95% of the losses occurred in the Gert Sibande (Carolina, Piet Retief, Ermelo and Amersfoort) district and black-backed jackal was responsible for over 70% of the losses in this district. According to the farmers the problem of predation originates on cattle farms and this is followed by other small stock farmers who are not controlling predators. It is understandable that large stock farmers have no need to control predators, but in certain areas black-backed jackal have been known to maul cows while calving and predating on newly born calves.

4.5.1.2 Control of predators in the MP province

Of the 113 farmers surveyed in the MP province, over 60% of the farmers actively control predators. The methods mainly used include hunting with rifles, hunting dogs, soft catch traps and poison (Table 4.25). Dogs, hunting and poisons are the methods mostly used to control black-backed jackal. In comparison with the other provinces, the use of poisons in the MP province was the highest.

Table 4.25 Methods used and predators killed in the MP province

	2006		2007	
Predators killed	Black-backed jackal	Caracal	Black-backed jackal	Caracal
Soft Catch traps	35	23	55	26
Dogs	203	33	235	14
Cage traps	1	37	3	27
Hunting	819	13	892	55
Poisons	385	29	381	26
Total	1 443	143	1 564	138

About 80% of farmers in the MP province have adopted non-lethal methods to reduce predation. Kraaling at night and jackal-proof fencing are the methods mainly used. The reason for kraaling at night is that stock theft in this province is very high and because small livestock usually graze in concentrated areas (it is easy to kraal them at night). Kraaling at night is one of the best non-lethal methods used to protect small livestock predators as illustrated in Figure 4.15. However, this is not always possible in certain areas, due to management aspects (labour and size of farming land).

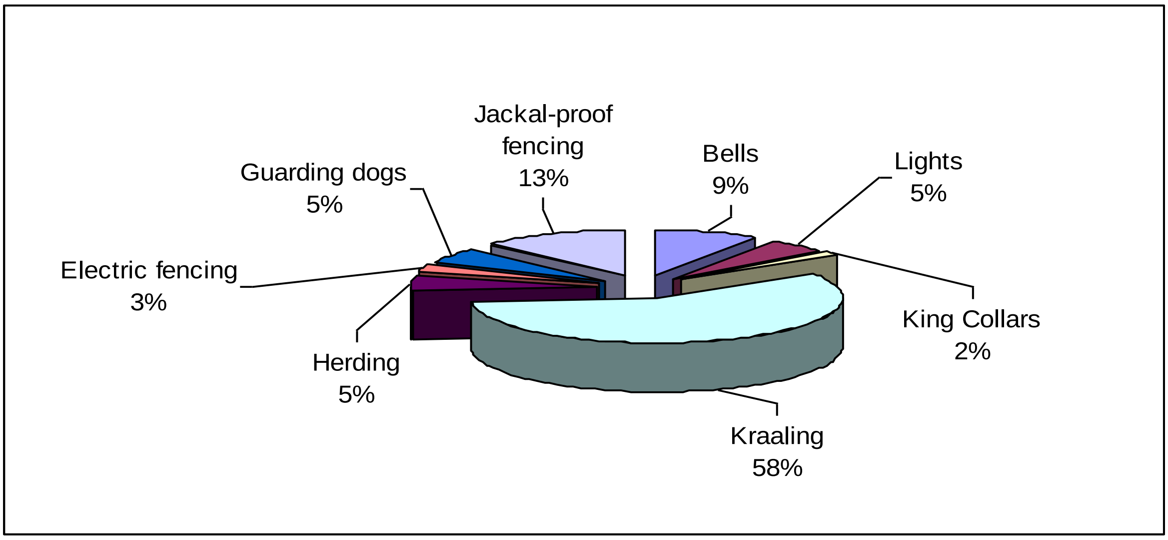

Figure 4.15 Non-lethal methods used to reduce predation in the MP province.

4.5.2 Factors associated with predation losses in the MP province

The results of the analyses showed a small number of variables being significant in the MP province. This is the smallest of the five provinces with only 113 observations and contributing only 7% to the total sheep population of South Africa. The hypothesis of variables affecting the occurrence of predation and variables affecting the level of predation being the same, was rejected by the Cragg's model (P = 0.323; CHISQ = 9.230). Meaning that the variables that affecting the occurrence of predation and variables that affecting the level of predation, was found to be the same. The Cragg's model indicated that the Tobit regression model should be efficient to analyse data on predation in the MP province. In Table 4.27 is an indication of variables in the Tobit regression model.

These variables are equally important in affecting the occurrence of predation and the level of predation. It must be considered that there are only a small number of small livestock farmers in the MP province, suggesting that small livestock farming is not the major agricultural activity. As expected, these variables will contain more control methods and measures than management aspects, because there are a small number of small livestock farmers to control the damage-causing animals.

As previously mentioned, the MP province is known for field crop production. It is difficult for small livestock farmers in the MP province to farm effectively with the existing predation losses. Field crop farmers and also to a certain extent large livestock farmers, have no need to control damage-causing animals, thus increasing the challenge of predation for small livestock farmers in the MP province.

Table 4.26 Regression results for the Probit and Truncated models for the MP province

	Tobit	
Variables	Coefficient	P value
Constant	-0.023	0.097
Number of ewes	-0.834	0.086
Lambing in protected areas	-0.024	0.073
Active hunting of predators	0.060	0.000
Hunting (using a professional hunter)	0.047	0.005
Bells	0.050	0.013
Lethal control method (using hunting dogs)	0.058	0.000
Lethal control method (hunting with rifles)	0.017	0.170

The dependent variable in the Tobit model is a continuous variable that measured the percentage loss of small stock on a farm. The number of ewes (Tobit, P = 0.086) and lambing in protected areas (Tobit, P = 0.073) are the only management aspects that were found to be significant. As expected, these variables were negatively correlated with predation losses. A higher level of management is associated with a reduction in predation losses; however, in some parts of South Africa where small livestock is farmed at a lower intensity, management is not that effective and physical control methods will dominate in reducing predation on a farm. This is the reason for physical lethal control methods, dominates in the Tobit model.

Active hunting (Tobit, P = 0.000), hunting by a professional predator hunter (Tobit, P = 0.005), bells (Tobit, P = 0.013) and hunting using hunting dogs (Tobit, P = .0000) played a significant role in reducing predation losses and are positively correlated; it was expected that all lethal control methods would be positively correlated.

4.5.3 The cost of predation in the MP province

The direct cost of predation for the MP province is illustrated in Table 4.22. Management and farming activities differ between farms and regions, which makes it difficult to calculate the indirect cost of predation. The 1 764 303 head of small livestock is an estimated number provided by the National Department of Agriculture (2005) for only for commercial farmers, with sheep contributing 96% of the total small stock numbers. The value per unit was estimated at R600 per unit for small stock younger than six months and R1 000 per unit for small stock older than six months (see 4.2.3)

Table 4.27 The direct cost of predation in the MP province

		Number of small livestock	Average predation losses (%)	Losses due to predators	Unit cost per animal (R)	Cost of predation (R)
Sheep	< 6 months	1 700 191	8	136 015	600	81 609 168
	> 6 months	1 700 191	0	0	1 000	0
Goats	< 6 months	63 839	8	5 107	600	3 064 272
	> 6 months	63 839	0	0	1 000	0
Total		1 764 030		141 122		84 673 440

4.6 Western Cape (WC) province

4.6.1 Descriptive analysis of the WC province

The WC province comprises six district Municipalities (Figure 4.16). In the WC province 192 farmers were surveyed and over 90% of the farmers reported predation losses due to black-backed jackal and caracal. In Table 4.28 provides a summary of farmers surveyed, land utilisation and small livestock numbers. Sheep and goat numbers are estimated at 2 792 047 head of small stock (NDA, 2005/06); for the commercial farmers and in the WC province. About 89% of the total area is used for farming purposes, of which 70% is utilized for grazing (NDA, 2008).

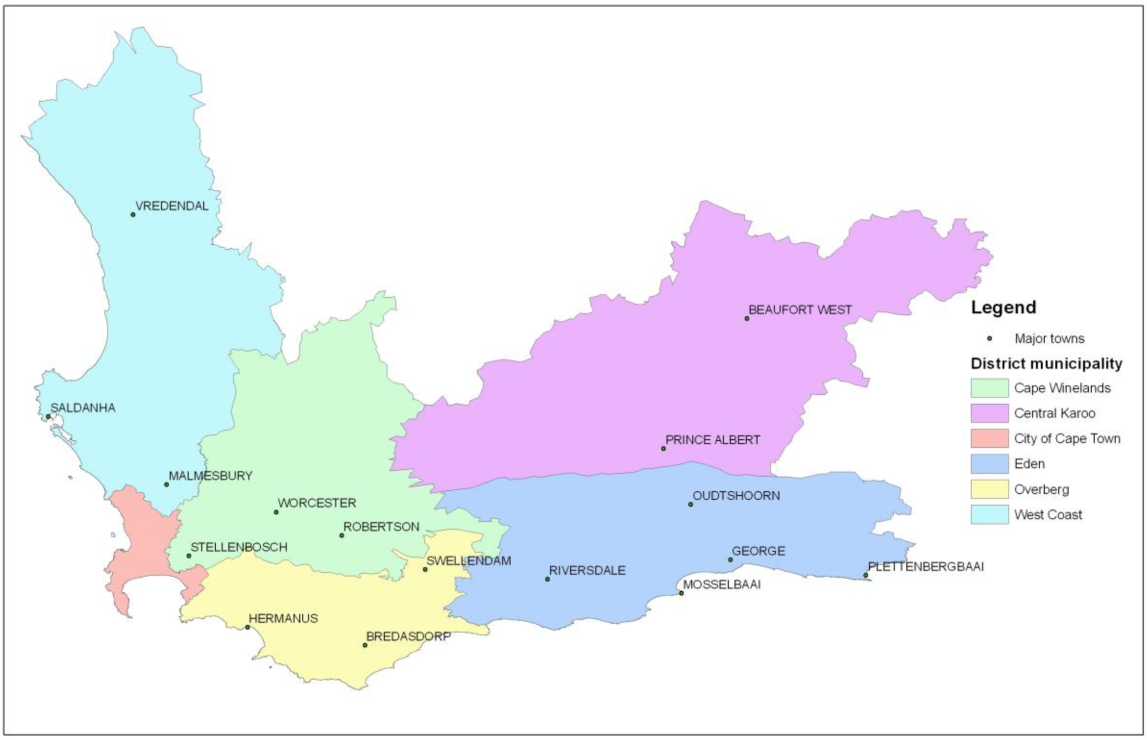

Figure 4.16 District Municipalities and towns in the WC province (MDB, 2009).

Table 4.28 Number of farms surveyed, land utilization and small livestock numbers in the WC province

	Surveyed	WC province	Percentage
Farmers	192	7 185	2.6
Head of small livestock	468 453	2 792 047	16
Land (ha)	658 872	9 105 821	7.2

Source: NDA, 2008

In the WC province agriculture is to a great extent diversified. The WC province is known for its small livestock producing areas in the Karoo, the wine producing areas in the south-western parts and field crop production in the western and southern parts of the province. In the areas where field crops are produced, there are a number of small livestock farmers using stubble after harvesting as grazing for small livestock production. In Figure 4.17 the different small livestock breeds in the WC province are provided.

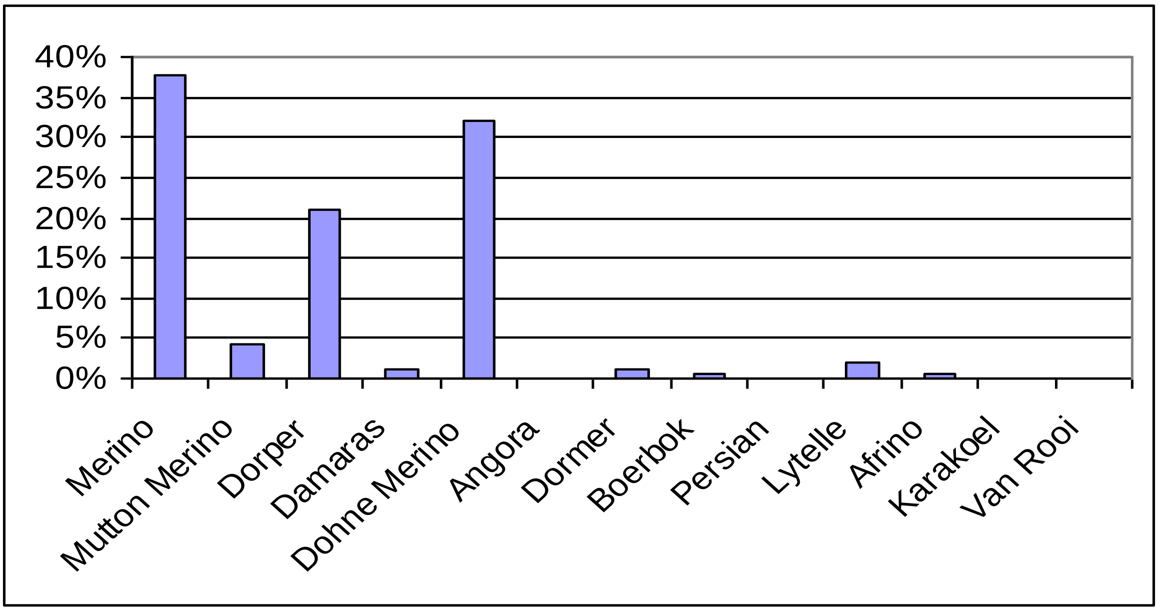

Figure 4.17 Small livestock breeds reported by the farmers surveyed in the WC province.

Time of lambing plays an important role in predation; high losses are associated with lambing in certain seasons. These lambing seasons include August-September and March-April seasons. In Table 4.29 the different lambing seasons are shown, with 19% of respondents in the WC province lambing their small livestock three times in two years and the remaining 81% lambing once every year. If farmers use three lambing seasons in two years, the lambing months differ and in most cases losses can be minimized.

Table 4.29 Lambing seasons reported by responding farmers in the WC province

Lambing season	March-April	August-September	March-April and August-September	Year round (3 lambing seasons in 2 years)
Percentage	32	12	37	19

4.6.1.1 Small livestock losses in the WC province

Losses associated with predation are shown in Table 4.30. In the WC province losses due to caracal are lower than that of black-backed jackal. The majority of losses is due to caracal and associated with lambs older than one month.

Table 4.30 Classes of small stock losses attributed for two consecutive years in the WC province

	2006		2007	
Losses	Black-backed jackal	Caracal	Black-backed jackal	Caracal
Ewes/does	123	135	85	124
Lambs/kids 0-1 months	5 313	823	5 707	965
Lambs/kids 1-6 months	2 780	4 349	2 483	4 911
Total	8 216	5 307	8 275	6 000

Losses differ between farms and regions. The WC province is a good example of fluctuating predation differences in a province: a farmer may experience high predation losses on a farm, but on another farm not far away there will be virtually any losses. Losses as high as 35% of total small livestock and 60% of production lost (0–6 months) were reported. The breakdown of losses in the WC province is shown in Figure 4.18. It is important to note that in the WC province a high number of losses occurred due to crows and seagulls, by pecking out the eyes of new-born lambs.

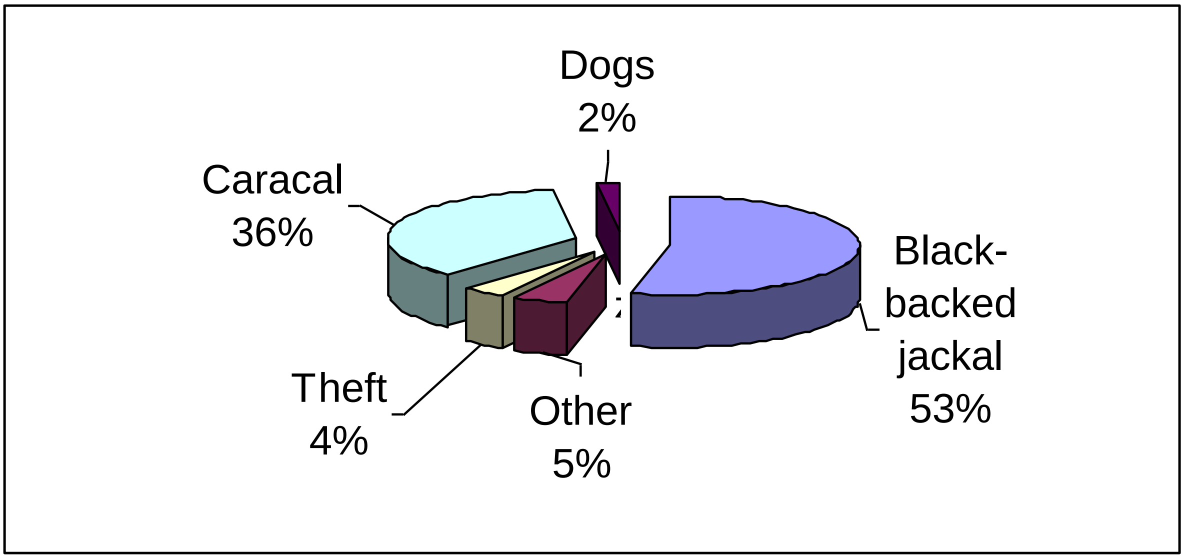

Figure 4.18 Reported causes of small livestock losses for two consecutive years (2006/07) in the WC province.

In the WC province farmers lose on average 2.79% of total small livestock and 6% of production animals. However, this is still relatively low in comparison with the other provinces. However, in some parts of the WC province, specifically the small livestock producing areas such as the Karoo, major losses are not adequately reflected by calculating the average losses. The predation per district is summarised in Table 4.31.

Table 4.31 Predation reported per district (%) over two consecutive years in the WC province

	2006		2007	
District Municipality	Black-backed jackal	Caracal	Black-backed jackal	Caracal
City of Cape Town	0	0	0	0
West Coast	13	11	13	12
Cape Winelands	4	5	4	4
Overberg	4	34	4	33
Eden	11	12	9	11
Central Karoo	68	38	70	40
Total	100	100	100	100

The highest predation losses occurred in the Central Karoo district, where black-backed jackal and caracal occur naturally. This district includes areas such as Beaufort West, Laingsburg and Murraysburg. These areas are well-known for small livestock farming and because of the nature of the vegetation, make it mostly only suitable for small livestock and game farming. The Overberg district has the second highest number of predation losses, which include areas such as Bredasdorp, Caledon and Swellendam. This area is also known for field crop production, where small livestock is fed on a combination of veld (mainly grass) and crop residues or stubble after harvesting the small grain crops. This makes certain management aspects easier because small livestock is usually concentrated on a specific part of a farm and this makes kraaling at night easier when predation losses do occur. The West Coast district consists of areas such as Clanwilliam, Malmesbury, Vredenburg and Vanrhynsdorp, where the majority of predation losses occurred in the Vanrhynsdorp area.

4.6.1.2 Control of predators in the WC province

More than 80% of the 192 farmers interviewed in the WC province actively controls predators. The methods that were mainly used include hunting with rifles, soft catch traps and cage traps (Table 4.32). Fewer farmers are using poisons in the EC province.

Table 4.32 Methods used and predators killed in the WC province

	2006		2007	
Predators killed	Black-backed jackal	Caracal	Black-backed jackal	Caracal
Soft Catch traps	219	100	230	81
Dogs	77	60	78	11
Cage traps	25	394	26	317
Hunting	526	200	425	153
Poison	14	4	11	8
Total	861	758	770	570

In the WC province only 44% of the farmers interviewed used non-lethal methods such as jackal-proof fencing, bells, King Collars, and kraaling at night to reduce predation. These methods are very expensive and there is no guarantee that it will reduce losses. Where non-lethal methods are used in combination or in rotation with one another, predation losses are kept to a minimum.

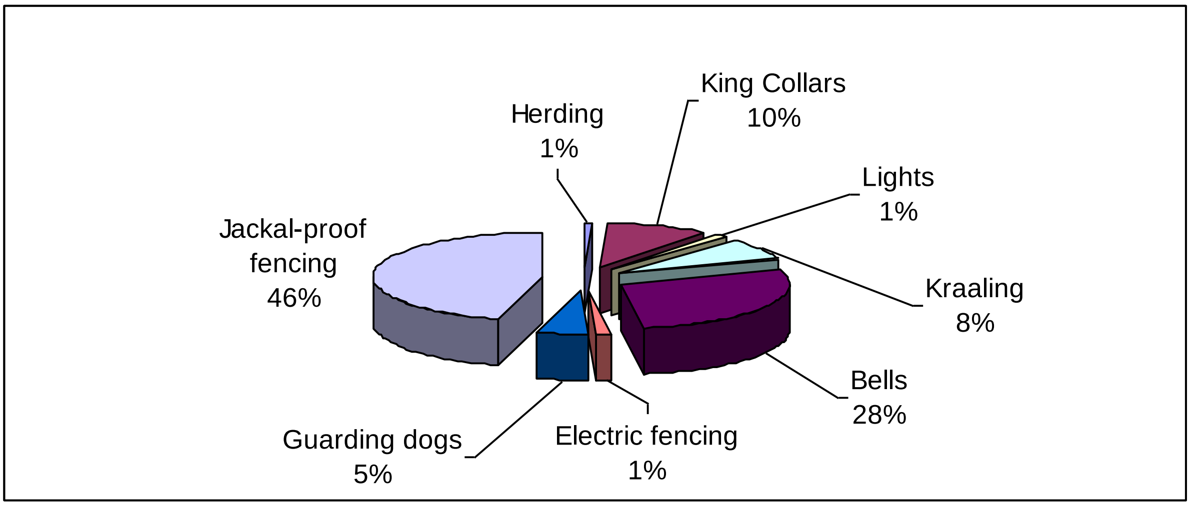

Figure 4.19 Non-lethal methods used to reduce predation in the WC province.

4.6.2 Factors associated with predation losses in the WC province

Different variables that were included into the regression models are shown in Table 4.34. Variables are kept the same between the two model specifications to test the Cragg's model specifications. The variables are selected at a statistically significant level of 15%. The Cragg's model shows a significant P value (P = 0.000; CHISQ = 43.312); according to the Cragg's model it was necessary to use the Probit and Truncated models to analyse data on predation in the WC province.

Table 4.33 Regression results for the Probit and Truncated models for the WC province

	Probit		Truncated	
Variables	Coefficient	P value	Coefficient	P value
Constant	0.458	0.015	-0.127	0.050
Number of ewes	-0.000	0.005	-0.296	0.807
Counting of small stock	-0.013	0.630	-0.002	0.592
Hunting (by professional hunter)	-0.022	0.957	0.083	0.047
Combination of non-lethal methods	-1.100	0.050	-0.057	0.264
Bells	1.125	0.013	0.06	0.279
Jackal-proof fencing	1.386	0.000	0.052	0.448
Kraaling small stock at night	0.026	0.966	0.117	0.081
Gin traps	0.594	0.069	0.100	0.011

In the Probit model a number of variables is significant. It is anticipated that management should be significant in the Probit model and should reduce predation, i.e. a negative correlation. A higher level of management is associated with larger small livestock numbers on a farm. The number of ewes (Probit, P = 0.005) is found to play a significant role in the occurrence of predation, mostly applicable to farmers in the larger small livestock producing areas in the WC province. However, where small livestock is farmed at a lower intensity management, it is not that effective as physical control methods (lethal and non-lethal methods). In the WC province agriculture practices are diversified, making it difficult for farmers to manage predation. A great deal of success is associated with the specific control method used, which makes these variables significant in the Probit model in affecting the occurrence of predation; the same occurrence exists in the MP province (see 4.5.3). A combination of non-lethal methods such as bells, jackal-proof fences, and gin traps proofed very effective in reducing predation in the WC province.

Hunting by a professional predator hunter in the WC province had an influence on the level of predation, due to the fact that damage-causing animal control is only practised in small parts of the WP province which makes it very difficult to control predation. By kraaling small stock (Truncated, P = 0.081) at night a farmer can reduce the level of predation on a farm. The reason that kraaling at night is not significant in the occurrence of predation is that damage-causing animals adapt themselves to infiltrate in closed areas and cause major losses, where fences are not up to standard.

4.6.3 The cost of predation in the WC province

Predation in the WC province is expected to be higher in comparison to the other provinces. These costs only include the direct cost of predation (refer to section 4.2.3 for more detail). Although predation losses are relatively low for the province as a whole there are some areas within the province that experience very high losses due to predation. These areas mostly include the Central Karoo where small stock farming is the main agricultural activity. Farmers in these areas have high indirect costs in preventing predation on their farms, costs which including professional predator hunters, electrical fences and management practices.

Table 4.34 The cost of predation in the WC province

		Number of small livestock	Average predation losses (%)	Losses due to predators	Cost per unit (R)	Cost of predation (R)
Sheep	< 6 months	2 564 250	6.1	156 419	600	93 851 550
	> 6 months	2 564 250	0.1	2 564	1 000	2 564 250
Goats	< 6 months	227 797	6.1	13 896	600	8 337 370
	> 6 months	227 797	0.1	228	1 000	227 797
Total		2 792 047		173 107		104 980 967

4.7 Summary

Predation losses due to the black-backed jackal and caracal differ immensely between provinces as well as region within provinces. The NC province being the largest of the five provinces surveyed shows the majority of the losses. High predation losses are associated with large small livestock producing provinces and areas within provinces. A summary of predation per province is illustrated in Figure 4.20.

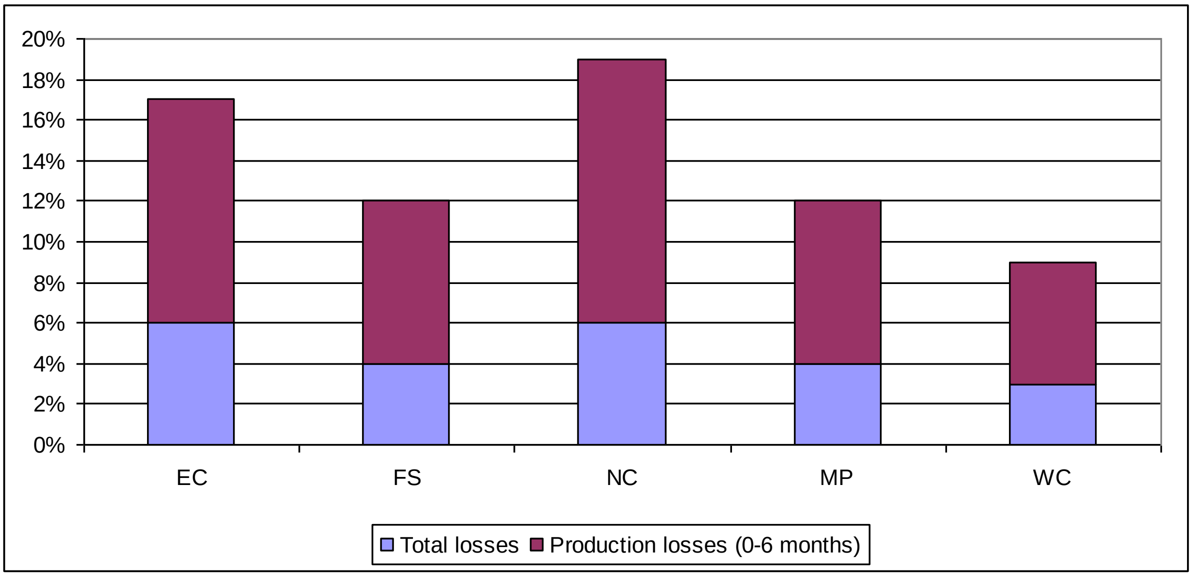

Figure 4.20 Average predation losses (2006/07) per province.

Topographical differences play an important roll in predation in a province or areas within a province. Topographical differences cause predator and farm management practices differ, which makes it difficult to compare provinces and areas within a province directly with each other. These management practices include breed of small livestock, number of small livestock on a farm, frequency of counting small livestock, identification or tagging of small livestock and a number of non-lethal and lethal predator control methods.

The majority of losses in these five provinces are small livestock younger than one month, where black-backed jackal was responsible for the majority of the damages in these five provinces. Losses due to caracal are not as high as in comparison with black-backed jackal. This is mainly due to generally lower caracal populations and the occurrence and uneven distribution of caracal within the provinces. Losses due to caracals are associated with lambs/kids older than one month and causing damages to larger animals.

In these five provinces more than 60% of farmers actively control damage causing animals. Lethal control methods are the method most used and are most effective in controlling damage causing animals. The methods most used is hunting with calling equipment at night and hunting using hunting dogs. The use of poisons is one of the effective ways in controlling damage causing animals, but is losing popularity in some provinces and regions within a province, due to legislation and the fact that poisons is not a very humane method of controlling damage causing animals.

Non-lethal control methods are gaining popularity in South Africa with more farmers using these methods. The methods most used are jackal proof fencing, electrical fencing, King Collars and bells. However, these methods are very expensive and intensify management practices. Furthermore, due to the adaptability of these predators non-lethal methods must be used in rotation with one another to reduce familiarization of the methods used

The factors which affect predation on a farm differentiated between provinces. A hypothesis was made that variables affecting the occurrence of predation an variables affecting the level of predation was not the same (see Table 3.5 for list of variables). In the models used (Tobit and Truncated) it was founded that factors influencing the occurrence of predation are mostly associated with management aspects, meaning the higher level of management, the less the occurrence of predation. When a variable is affecting the level of predation it means it contributes either to a reduction or an increase in the level of predation. These factors usually include non-lethal and lethal control methods to a large extent. However in some cases where a great deal of success is associated with a specific non-lethal or lethal control method it will have a significant influence in affecting the occurrence of predation on a farm.

The direct cost of predation very immensely between provinces, with the highest being the NC province with R 540 847 496 in direct losses in small livestock. The smallest number of losses incurred in the MP province with R 84 673 440 in direct losses to predation. This however does not include the indirect cost of preventing predation on a farm. The cost of prevention includes among other cost the cost of a professional hunter, fencing (jackal proof and electrical) and management input. Although some of these methods is a once-off expense, the methods are very expensive and therefore not a viable option to all farmers. Other methods like poison and the use of professional hunters or the farmer hunting himself represent a continuous cost to farmers. It is difficult toe estimate the indirect cost of predation. Management and farming activities differ between farmers and regions, but these costs have to be taken into account.

5. Conclusions and Recommendations

5.1 Introduction

The impact of predation on all classes of livestock, especially small livestock, by black-backed jackal and caracal is a huge problem in South Africa. Limited information is available on these so-called predators and the magnitude or impact of predation in South Africa. The primary objectives of the study is to quantify the economic loss due to predation on small livestock in the five major small livestock producing areas in South Africa and secondary also to determine the factors affecting predation on farms.

5.2 Meeting the objectives of this study

As discussed previously, the primary objective of this study was to estimate the cost of predation in South Africa. A secondary objective was to determine the factors affecting predation on farms. These aspects include different methods to control damage-causing animals (non-lethal and lethal control methods), topography and management aspects. The latter aspects studies included among others time of lambing, lambing months and controlling damage-causing animals.

5.2.1 Predation in the five major small livestock producing areas in South Africa

Predation losses in South Africa differ between provinces. Provinces vary primarily in their agricultural practices, which include intensive or extensive small livestock farming and ostensibly the population of predators. Provinces surveyed included the EC, FS, NC, MP and WC provinces accounting for more than 85% of national the sheep and goat flock. Differences in predation losses are shown in Figure 5.1, where the highest levels of predation losses occurred in the NC province, with a total loss of 6% and 13% of production. From the five provinces surveyed, the WC province is the least affected by predation. The majority of predation losses occurred with lambs/kids between lambing and weaning. In particular the majority of lambs/kids lost were associated with black-backed jackal and to a lesser extent caracal. The data obtained during the telephonic survey showed that the majority of predation losses due to black-backed jackal were associated with lambs/kids between lambing/kidding and the age of one month. Predation on older lambs/kids (older than one month) was more associated with caracal.

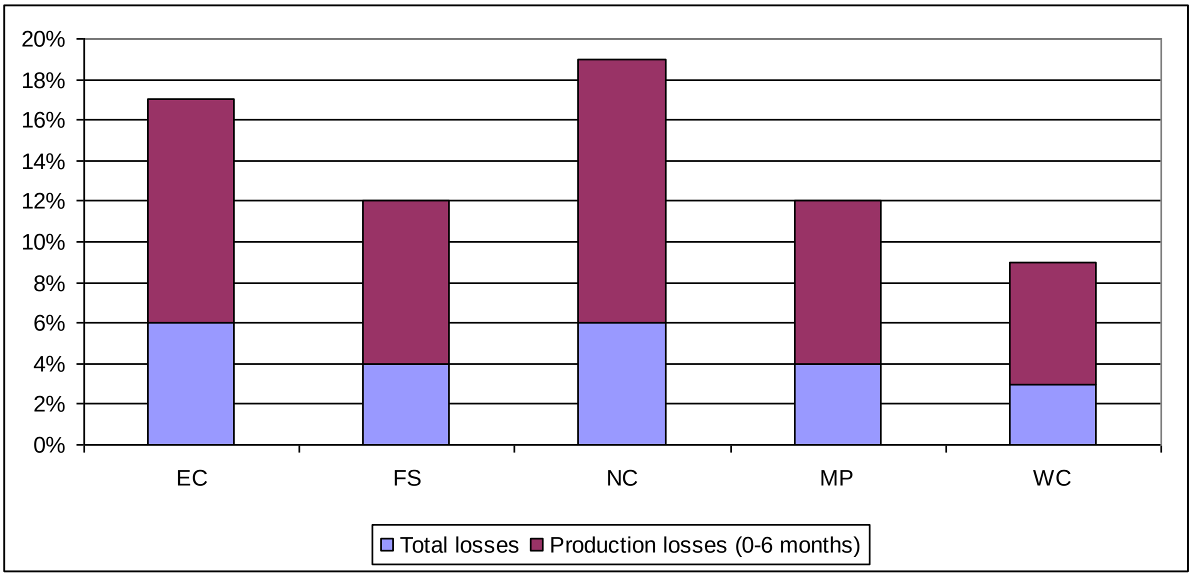

Figure 5.1 Average percentage losses due to predators per province (2006/07).

Predation losses not only differ between provinces but also between regions within provinces. It should be noted that the percentage of predation losses represents the entire province. For example in the WC province there are regions experiencing relative high levels of losses (central Karoo) and in some regions not far away there is virtually any predation. The FS province is another example: in the southern and eastern parts of the province where small livestock farming is an important agricultural activity, predation losses are high, but to the north in the province predation losses are much less. There are a number of factors that may influence predation within a region or province, namely:

- Location of the farm
- The main agricultural practice of the region
- The human footprint of the region
- Topography

The location of a farm plays an important role in determining the level of predation in a region. In some parts within a province there could be an absence of predators or the farm could be located near a wildlife ranch or nature reserve, which can lead to predation. From the information provided by the respondents, farmers were adamant that being in close proximity to a wildlife ranch or nature reserve can lead to increased levels of predation losses.

The main agricultural activity of the region or province can have a negative or positive influence on predation. In some of the provinces the main agricultural activity is small and large livestock production, which can be used to the advantage of farmers. The survey results shows that the more small livestock farmers in an area, the easier the control of damage-causing animals. In the NC province there are equal numbers of large and small livestock farmers, with large livestock farmers not having a real need to control predators. However, in some cases predators such as black-backed jackal are known to attack large livestock, mostly cows while in the process of giving birth to a calf.

Small livestock farmers who lamb their livestock on crop residues after harvesting, usually have higher levels of management which lead to a reduction in predation on a farm. In general, these farmers use different management procedures, which include lambing/kidding in protected areas or kraaling at night. Kraaling at night is mostly used in the FS and MP provinces where small livestock is fed on a combination of natural grazing and crop residues after harvesting which reduces losses, but this is also due to a high theft rate in these two provinces.

In some provinces the human footprint is relatively low. The human footprint means the number of people in a specific area or region. The EC and NC provinces and some parts of the FS province are good examples. Rapid urbanization is a major contributing factor responsible for the low human footprint. Farmers are adapting by becoming more efficient with a smaller workforce on farms. In these provinces a number of “part time farmers” and livestock posts exist which contributes to the reduction in effective human footprint. Taking these factors into account it complicates efforts to apply effective predator control for that area or region.

Topography is an important factor that determines the level of predation. Usually black-backed jackal and caracal have a certain habitat preference, however, these predators have adapted over a number of years to different habitats. In most provinces there are more losses due to black-backed jackal. For example in the FS province most parts of the province have a suitable habitat for black-backed jackal, but less suitable for caracal. The EC province is suitable for both black-backed jackal and caracal, which has reported almost equal losses to both predator species in comparison with the other provinces. Topography does not only influence the habitat of predators, but also plays a role in which damage-causing animals can be controlled. Controlling predators becomes difficult where the terrain is mountainous, as this also influences management aspects. In mountainous areas it is not always possible to manage small livestock effectively because it is not always easy to access the livestock. It is also difficult for specialist predator hunters and farmers to implement control methods in these mostly inaccessible areas. The presence of bush and shrub is another factor that influences effective predator control methods because certain areas of a farm or region may be inaccessible for the use of predator control methods.

5.2.2 The cost of predation by medium-sized predators in the five major small livestock producing areas in South Africa

A few studies have attempted to estimate the magnitude of the cost of predation in South Africa. Therefore, very little information is available on predation losses and also information regarding where the predation losses occur in general. Several methods exist to estimate the losses due to predators. It is customary to calculate these losses in terms of output loss to farmers, or the market price of the animal multiplied by the number of losses on a per farm or per region (Moberly, 2002). The value of lamb/kid losses are calculated as the minimum market value for finished lambs/kids at a point of sale (age of six months) multiplied by the number of lambs/kids lost. It is assumes that all lambs/kids would be sold as market ready and do not include the cost of control (non-lethal and lethal) or potential value of the animal lost.

The indirect cost of predation is difficult to calculate because provinces differ in the use of control methods. A number of methods used incur a once-off payment and usually very expensive and therefore not an option to all farmers. These typical capital investments include; electrical fences or jackal-proof fences. Other methods like poisons and the use of a professional predator hunter or control by the farmer are considered as a routine or continuous cost to farmers. Another cost that is easily overlooked, is the opportunity cost of controlling predation, the time a farmer or a farm worker spends to implement control methods. The opportunity cost of predator control can be calculated as the number of hours spent controlling predators multiplied by an average wage rate (Moberly, 2002).

The direct cost of predation losses by black-backed jackal and caracal (see Table 5.1) was the highest in the NC province (13% of production losses) followed by the EC province (11% of production losses). It must be considered that the direct cost of predation is a representation of the province as a whole. There will be regions within a province that will experience higher than normal predation losses. The direct cost that is shown in Table 5.1 is only an estimation of the cost of predation in South Africa. This is an under-estimate of the cost of predation because minimum values of small livestock (R 600 for animals younger than 6 months or R 1 000 for animals older than 6 months) were used and small livestock numbers was based only an estimate for 2005 (see section 4.2.3).

A number of regions within provinces exist where predation cost is higher than normal and not represented by the province as a whole. The WC and FS provinces are examples of provinces with relatively low predation costs, but there are regions within these provinces that encounter higher than normal losses. The central Karoo in the WC province has a higher than normal predation loss of 35% compared to the province as a whole with an average loss of 3% of total losses. The southern parts of the FS province are expressing the same problems with higher than normal predation losses.

5.2.3 Factors affecting predation in major small livestock producing provinces in South Africa

There are a number of variables affecting predation in small livestock producing areas. These variables differ from province to province according to the main agricultural practices in the area and the management practices used. The results of the study showed that the hypothesis of variables affecting the occurrence of predation and the variables affecting the level of predation was not the same. It is assumed that factors affecting the occurrence of predation is usually associated with management aspects and normally will be negatively correlated with predation losses. Variables affecting the level of predation can be seen as factors reducing the level of predation and these factors will usually include non-lethal and lethal control methods. Non-lethal control methods usually do not stop predation, but will reduce the level of predation on a farm. However, when success is associated with a certain control method, this variable will be significant in effecting the occurrence of predation on a farm and at a specific point in time.

Table 5.1 The cost of predation in the five major small livestock producing areas in South Africa

		Number of small livestock	Average predation losses (%)	Losses due to predators	Unit cost per animal (R)	Cost of predation (R)
EC province						
Sheep	< 6 months	5 062 299	11.3	572 040	600	343 223 872
	> 6 months	5 062 299	0.5	25 311	1 000	25 311 495
Goats	< 6 months	608 170	11.3	68 723	600	41 233 926
	> 6 months	608 170	0.5	3 041	1 000	3 040 850
Total		5 670 469		669 115		412 810 143
FS province						
Sheep	< 6 months	5 112 184	7.4	378 302	600	226 980 970
	> 6 months	5 112 184	0.2	10 224	1 000	10 224 368
Goats	< 6 months	214 131	7.4	15 846	600	9 507 416
	> 6 months	214 131	0.2	428	1 000	428 262
Total		5 326 315		404 800		247 141 016
NC province						
Sheep	< 6 months	6 341 801	12.9	818 092	600	490 855 397
	> 6 months	6 341 801	0.1	6 342	1 000	6 341 801
Goats	< 6 months	556 764	12.9	71 823	600	43 093 534
	> 6 months	556 764	0.1	557	1 000	556 764
Total		6 898 565		896 813		540 847 496
MP province						
Sheep	< 6 months	1 700 191	8	136 015	600	81 609 168
	> 6 months	1 700 191	0	0	1 000	0
Goats	< 6 months	63 839	8	5 107	600	3 064 272
	> 6 months	63 839	0	0	1 000	0
Total		1 764 030		141 122		84 673 440
WC province						
Sheep	< 6 months	2 564 250	6.1	156 419	600	93 851 550
	> 6 months	2 564 250	0.1	2 564	1 000	2 564 250
Goats	< 6 months	227 797	6.1	13 896	600	8 337 370
	> 6 months	227 797	0.1	228	1 000	227 797
Total		2 792 047		173 107		104 980 967
Total cost of predation in the five major small livestock producing areas						1 390 453 062

When most of these management aspects already existed within a province they were found to be insignificant in regression models. The EC province can be seen as an exception because almost all of the management factors were found to be significant and negatively correlated. The EC province is encountering high predation losses due to a high population of predators and terrain making it difficult to effectively implementing predator control methods. That is why it is necessary for farmers in these areas to have a high level of management to reduce the occurrence of predation on a farm. The same principle can be applied for the smaller small livestock producing regions within the MP and WC provinces, where the concentration of small livestock farmers is not that high. The MP province was the smallest of the five provinces, with the lowest predation losses, that was surveyed and the factors that affected the occurrence of predation and the factors affecting the level of predation proof to be the same. This suggests that predation has a big influence on all factors affecting predation in the MP province and therefore a higher level of management and control is needed.

The use of non-lethal methods is increasing in South Africa with most of the provinces making use of these methods and having a great deal of success with it. As previously discussed, these methods will mostly only affect the level of predation and will not stop predation completely. The use of these methods differs between provinces as well as regions within a province, because the effectiveness varies. The adaptability of predators furthermore complicates the use of non-lethal and lethal control methods, resulting in animals not being affected by the methods used. The use of a combination of non-lethal methods was significant in the majority of the provinces, which helps in preventing predators from adapting quickly to a specific method. In most of the cases a combination of non-lethal methods will affecting the level of predation, but when a higher level of success is achieved, it will also reduce the occurrence of predation.

Active hunting and the use of a professional predator hunter is the most popular and wide-spread method used in controlling damage-causing animals. Hunting occurs mostly at night, which makes it a very effective method in controlling damage-causing animals. Hunting by the farmer or a professional predator hunter is the only control method that is very selective, which makes it easier to eliminate only potentially damage-causing animals. Hunting as a control method was found to be significant method in almost all provinces surveyed to influence the occurrence of predation on a farm and mostly in provinces where predator populations are higher than normal. The EC province and NC province are examples where high densities of predators exist and a higher level of control is needed to reduce the impact of predation. The use of a specialist predator hunter is a very effective method of control because these hunters are usually well-trained and skilled in the art of shooting at night and with a good knowledge of the behaviour of predators. In the FS province and regions within the WC and MP provinces specialist predator hunter are very effective in controlling damage-causing animals when, according to farmers surveyed, predators are well-adapted or where only a few small livestock farmers are affected by predators.

5.3 Recommendations

There is no doubt that predation is a serious problem for the South African small livestock sector and there is also no indication that the level of predation is subsiding. This study provides valuable information in understanding the magnitude or extent of predation and some of the factors affecting predation on farms. The information collected can be used to select and evaluate smaller areas intensively in their effort to manage predation and develop strategies accordingly.

The fact that these two predator species are so abundant and widely found in South Africa makes effective predation management fairly difficult. The results of this study indicated that a higher level of animal husbandry management will lead to a reduction in predation. However, a higher level of management is not always financially or physically possible on every farm. These management aspects compete with the same resources on a farm and complicate the implementation. Due to the adaptability of these predators, mostly black-backed jackals, management aspects must be diversified to have an efficient impact through predator management programs. A farmer must decide for himself what level of predation is acceptable and what level of control would be sufficient, so that the cost does not exceed the benefit of predator control. As discussed previously, not all farmers have the ability to effectively control problem-causing animals, mainly due to a lack of resources. On the other hand, this is a major problem for farmers within areas experiencing high losses due to predation. That is why it is necessary to establish a coordinated strategy to manage predation.

Government can assist greatly in close partnership with livestock producers and wildlife ranchers by implementing a coordinated national strategy to manage predation. The producers will still have the primary responsibility for managing the impact of predation at farm level, but government can assist by rendering official support and making resources available to farmers to manage predation.

It will be very useful if this study can be followed up by detailed studies on predation in a few selected areas within at least one province.

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