THE IMPACT OF PREDATION ON A SHEEP ENTERPRISE IN THE FREE STATE PROVINCE

by

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Dissertation submitted in accordance with the academic requirements of the degree

MAGISTER SCIENTIAE AGRICULTURAE

to the

Faculty of Natural and Agricultural Sciences
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27 November 2009

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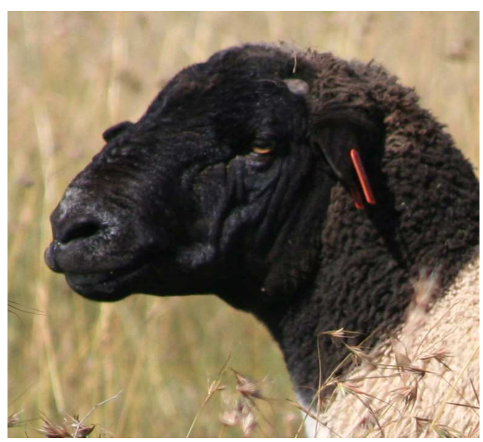

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Acknowledgements

Immense gratitude is expressed to the following persons and institutions for their contribution without which this study would not have been possible:

The black-backed jackal at Glen. Without you this study would not have been possible.

My supervisor, Prof. H.O. de Waal, for the guidance, support and belief in the study. Your enthusiasm and knowledge served as a big motivation for me.

Dr. Nico Avenant, the co-supervisor of the study, for in-depth knowledge and insight into Zoology, which provided a lot of inspiration for me.

My beloved wife, Monique, who carried me and believed in me, even when I stopped believing in myself. Thank you for your loving support.

Our daughter Meninke, you are the best.

The Department of Agriculture Free State and its Glen Agricultural Institute (AI), for providing the environment, study material and means to execute the study.

Special thanks to the following persons at the Glen AI: Mr. Jacques Olivier (Director), Mr. Siegfried van der Merwe (Deputy director: Research) and Dr. Johann Erasmus (Assistant director: Animal Science) for their support and making it possible for me to complete the study. For all the personnel at the research division (Glen AI), for their constant input and motivation. The Merino team, especially Daniel Kgomo, in assisting with the collection of the data. I appreciate your hard work and dedication.

Mr. Mike Fair, Department of Animal, Wildlife and Grassland Sciences of the University of the Free State, for the statistical analysis of the data.

Mr. Carel Fourie, Department of Agriculture Free State and Dr. Antonie Geyer, Grootfontein Agricultural Development Institute, for your input on economic aspects regarding sheep production.

Mr. Lourens Goosen and Mr. Robert Wilke, of the Free State Department of Economical Development, Tourism and Environmental Affairs, for your specific practical knowledge, enthusiasm and motivation.

The National Wool Growers' Association of South Africa for their input on the management of the Merinos at the Glen AI.

ALPRU at the University of the Free State for its financial support through the bursary provided.

Mrs. Hester Linde for preparing and printing the final copy of the dissertation.

My friends for all their support and understanding of my absence while working on the study.

My Father, Andries Strauss, for developing the love of agriculture in me since my childhood and providing me with hands-on, lifetime knowledge.

My Mother, Hettie Strauss, for always believing in me and her constant interest in the study.

My brothers, Pieter and Ian, my sister, Sulene and my sisters-in-law, Alma and Igmé for supporting me through all my years of studying.

My father and mother-in-law, Pieter and Irene Miles, and my brother-in-law, Edward and his girlfriend Marlize, for their encouragement and motivation.

Above all I thank God, my Creator, from whom this study originated and who gave me the strength to complete this study.

Abstract

The impact of predation on a sheep enterprise in the Free State region

by

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The Free State Wool Sheep Project was initiated in 1998 at the Glen Agricultural Institute (AI) and a selection of 280 of the available Merino ewes were randomly divided in the following four production system treatments, namely:

- Treatment SL-V(C) **S**pring **L**ambing season on **V**eld with a salt (NaCl) lick only (**c**ontrol)
- Treatment SL-V&S **S**pring **L**ambing season on **V**eld with **S**upplementary feeding
- Treatment SL-R&V **S**pring **L**ambing season on irrigated **R**ye-grass (*Lolium multiflorum* and *L. perenne*) and **v**eld
- Treatment AL-O&V **A**utumn **L**ambing season on **O**ats (*Avena sativa*) pasture in winter and **V**eld in summer and spring

The broad aim of the Free State Wool Sheep Project was to “develop profitable and sustainable wool farming systems on the resource combination of Glen AI”. However, it was not foreseen at the conceptualization of the Project in 1998 that the impact of predation, mostly by black-backed jackal *Canis mesomelas* on the sheep flocks at Glen AI would soon reach the high levels experienced in later years.

A Merino shearing flock (77 ewes in 2003) and a Dorper flock (219 ewes in 2003) at the Glen AI were also severely impacted by predation. These two flocks were managed in the same way as the Merino ewes in Treatment SL-V(C), therefore, it was decided to include the results of these two flocks also in this study.

The impact of predation on reproduction and production performance of sheep flocks (Merino and Dorper) are reviewed and put into perspective for the period 1999 to 2007. Four categories of sheep losses were identified namely: predation, diseases, metabolic disorders or accidents and stock theft. Direct financial losses, veterinary and shearing cost, lick, labour and planted pasture cost were calculated for each of these categories of losses. The calculations were included in the review and served as basis for determining the extent to which financial losses ascribed to predation exceeded the financial losses due to diseases, metabolic disorders or accidents and stock theft.

Ewe productivity was negatively influenced by predation. The Merino and Dorper flocks decreased in numbers from 1 130 sheep to 552 sheep over a period of nine years. From 1999 until 2007, a total of 747 lambs were lost to predation before weaning and a total of 1 422 lambs were lost post weaning. The number of reproductive Merino and Dorper ewes that were available for mating declined from 506 ewes in 2003 to 316 ewes in 2007. Some of the ewes in the four Merino production system flocks, the shearing flock, and the Dorper flock could not raise one lamb in a six-year production cycle due to predation. Therefore, it became increasingly difficult to replace older ewes and maintain flock sizes for the respective flocks. The only exception was the Treatment SL-R&V flock, because they were better protected from predation during critical phases in the reproduction cycle.

The black-backed jackal specifically, had a big impact on the sheep flocks at the Glen AI (70% of the 730 post-weaning losses from 2003 until 2007). 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%. Therefore, 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.

The negative impact of predation on the sheep flocks at the Glen AI made it impossible to evaluate the economical viability and sustainability of the Merinos in the different treatment flocks as envisaged in the protocol of the Free State Wool Sheep Project. Furthermore, a large component of the genetic base of the two sheep breeds at the Glen AI has been lost for the future, due to the effect of predation.

An urgent and concerted approach of all role-players in the sheep industry is needed to develop and implement effective predator management programmes to reduce the negative impact of predation.

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.) Animal Science 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.

Andries Jacobus Strauss
Bloemfontein
November 2009

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1. Introduction

Research and extension is important to ensure that the South African wool producers stay competitive in a rapidly changing world market. The involvement of all role-players in a multi-disciplinary approach is, however, also very important to ensure that appropriate technologies are generated cost-effectively. Such technologies will contribute to an increase in household and national food security, and thereby improve the quality of the people residing in previously disadvantaged as well as established commercial communities.

As a result of changes in livestock production activities in the Free State, it was inevitable that such changes would impact on wool sheep numbers. It was assumed that the number of wool sheep declined in the Free State, as well as the income derived thereof. Therefore, various role-players decided in the 1990's to initiate a project to try and reinvigorate and restore the wool sheep enterprise in the Free State to its former levels.

The Free State Wool Sheep Project conducted at the Glen Agricultural Institute (Glen AI) is designated the Wool Sheep Project. It is a joint venture between the Provincial Department of Agriculture (FS DoA), the National Wool Growers Association (NWGA), the Agricultural Research Council (ARC), the University of the Free State (UFS), various input providers as well as representatives of the emerging and commercial farming communities in the Free State Province. The project was initiated in 1998 and the broad aim was to "develop profitable and sustainable wool farming systems on the resource combination of Glen" (Unpublished Project, Research FS DoA Archive, Glen).

When the project was conceptualized in the middle 1990's, it was foreseen that the major environmental effect of recurring food shortages or drought would have to be planned for. At that stage it was well known that recurring drought or food shortages can have devastating effects on natural pasture or veld and hence on livestock (Fouché *et al*., 1985). Based on local experience, it was not foreseen at that stage that the impact of predation on livestock would very soon reach the high levels experienced in later years.

Large numbers of livestock are killed or maimed annually in South Africa by medium-sized predators. The black-backed jackal *Canis mesomelas* and the caracal *Caracal caracal* are implicated mostly, but vagrant dogs *Canis familiaris* also cause considerable losses among small stock (Avenant *et al*., 2006; De Waal *et al*., 2006). In relatively isolated cases compared to the damage caused by these species, the leopard *Panthera pardus*, brown hyaena *Parahyaena brunnea*, and cheetah *Acinonyx jubatus* are also predating on livestock. Reliable information is not available, but it is estimated (H.N. van Niekerk, 2008; unpublished data) that the losses ascribed to predation currently runs into several hundred million Rand (SAR) per annum for South Africa, exceeding the estimated annual loss of R 300 million ascribed to stock theft by quite a margin.

The situation at the Glen AI, the main livestock research and training facility of the FS DoA seems to be no different from private sheep farms in terms of the negative effects of predation. During the early 2000's it was realised that the Glen AI was severely impacted by the effects of livestock predation. The predators implicated for predating on the sheep flocks were the black-backed jackal, caracal and stray dogs. Therefore, it was decided to initiate a structured and systematic approach in developing a predator management strategy for the Glen AI. The goal was that this strategy would also have much wider application in the Free State Province and South Africa.

The most important components of ewe productivity are the total weight of lambs produced, body weight of sheep culled and, in the case of wool producing sheep, the amount and quality (mainly fibre diameter) of the wool (Hoon *et al*., 2000). It soon became evident that the Free State Wool Sheep Project could not reach its goal namely to develop profitable and sustainable wool farming systems on the resource combination of Glen. South African farmers are faced with increasing input costs and low product price increases, resulting in the profit margins becoming smaller. Local farmers need to run their enterprises in the most effective manner in order to survive economically. Given the increasing economic pressures on sheep farmers, it is evident that reproduction should receive the necessary attention (Hoffman *et al*., 2003). Reproduction of sheep plays a major role in the economic viability of the industry in South Africa. According to Olivier *et al*. (1998) reproduction and survival rates are the two important factors determining the efficiency of lamb production.

The impact of predation on the Merino sheep at the Glen AI resulted in very few and even no lambs being weaned in some treatment flocks in the Wool Sheep Project. A Dorper flock at Glen AI (De Waal & Combrinck, 2000) was not included in any active research project during the period of this study, but the Dorper flock also suffered big losses due to predation. Despite the big losses ascribed to predation, the sheep flocks are well managed and data on production and reproduction as well as other information are recorded diligently.

The impact of very few or no lambs being weaned is only the tip of the iceberg. Although the direct income lost to predation plays a major role in the economy of a sheep enterprise, the indirect financial losses due to input costs (veterinary care, labour and licks) are usually lacking. Therefore, production and reproduction of the sheep at Glen AI was negatively impacted by predation. Age was not a determining factor when Merino and Dorper ewes were culled at Glen AI. However, because of the few maiden ewes available annually for mating, older ewes were given a second change to mate unless its teeth were worn down. Due to predation, insufficient numbers of replacement ewes were available and therefore selection could not be implemented as advised. Older ewes that would usually have been culled had to be kept longer than five years in order to conduct the study. According to Fourie and Heydenrych (1983), differences in reproductive potential of Dohne Merino ewes between the ages 5 to 7 years was usually small, but thereafter there was a sharp decline in reproduction. Keeping ewes for longer means that selection intensity is lower for breeding material and also leads to lower fecundity, lambing and weaning percentages.

As a management tool, farmers have started to kraal livestock during the night to reduce losses due to predators. This practise is especially applied during the lambing seasons. It is however important to recognise the inherent grazing patterns of ruminants (De Waal, 1986). By kraaling ruminants during extended periods from late afternoon to early morning impact severely on their diurnal grazing patterns. When Merino sheep was kraaled at the Glen AI, a negative effect observed was the occurrence of a break in the wool. This was ascribed to the high energy requirements of the ewes that were lactating (De Waal, 1986). The normal working hours for staff at Glen AI are from 07h30 to 16h00. The officials depend on public transport, therefore, the kraaled sheep were only able to start grazing after 08h00 and had to be kraaled again at 15h00 to accommodate the public transport needs of the staff. According to De Waal (1986), livestock are the most active early in the mornings, especially during the hot summer months. Therefore, the lactating ewes at Glen AI were forced to graze at the worst time of the day, putting the sheep under severe nutritional stress. Lactating ewes are more likely to be affected by an inadequate nutrient intake, resulting in a severe loss of body condition (De Waal, 1990). It is possible to turn the sheep out earlier in the morning out on veld, but this remains a full time job and is very labour intensive.

Most farmers have an infrastructure problem which makes the kraaling of sheep difficult. No grazing system is in place, which leads to veld degradation close to these kraals. The grazing intensity by all livestock species increased following rangeland degradation from the benchmark (excellent condition) to poor condition site. This indicates that an increase in the degradation level causes an increase in grazing time due to the availability of preferred forage species (Amaha, 2006).

These problems of kraaling lead to the feeding of small livestock during the night. Higher mortality may also occur due to more diseases when livestock are kraaled. The bottom line is to make a sustainable profit and each action on the farm must be linked to an economic value to strike a balance between the financial input and the impact of predators and other mortalities.

In farm management, it is of primary importance to know that no precisely repeatable patterns exist in nature. Each farm is in itself unique and consists of a combination of abiotic factors such as soil and climate, and biotic factors such as animals and plants that are unique to that particular farm. Every farm should therefore be dealt with and studied on its own merits, and management policies be developed specifically for it (Bothma, 2002). Livestock production systems on veld should be planned according to the ability of the veld to satisfy the specific nutrient requirements for reproduction (De Waal, 1990).

The natural diet of the black-backed jackal is mainly small animals, carrion, occasionally small or young antelopes, insects, eggs, fruit and reptiles (Hodkinson *et al.,* 2007). According to Avenant *et al*. (2008) the small mammal population peaks towards the end of summer, providing a good feed resource to the predators. If the ecosystem on the farm is disturbed, the financial impact of predators can even be worse.

To a many people, the word “predator” brings to mind a fierce, cruel animal that we can well do without. Yet, in reality, predation plays an important role in the economy of nature. Fluctuations in nature, especially the rainfall, have a direct influence on vegetation growth and growth rate of any population and in this study especially predators and their natural prey.

In their efforts to reduce the effects of predation on livestock, farmers are resorting to a range of non-lethal and lethal methods that are available to manage and control predators. As a consequence many predators as well as non-target wild animals are killed annually. However, reliable data on the efficacy of the predator control measures in reducing the impact of predation on livestock are grossly lacking.

Initiatives are currently underway in South Africa to promote the sale and consumption of so-called free-range animal products. The perceptions about and classification of so-called free-range lamb or mutton vary greatly, but essentially it means that the sheep are kept and reared under natural and free ranging conditions with a minimum of human intervention. Practices or factors that will induce stress are kept to a minimum or even prohibited. It is also preferred that farmers refrain from using inhumane methods such as gin traps and poisoned baits in their efforts to control the predators.

An ecosystem consists of all the living organisms and the non-living aspects of their environment, such as soil and climate, which act interdependently, influence one another and are essential for the preservation of life in a particular area. A disturbance of change in any facet of an ecosystem has a ripple effect on the entire system and can lead to displacements and adjustments. Adjustments usually occur over two to three decades, and this timescale should be taken into account when evaluating the effect that management policies have on a farm (Bothma, 2002).

An ecological management system may reduce the impact of predation and other sheep mortalities on small livestock (Avenant & Du Plessis, 2008). Even the best "ecological" farmer with good livestock husbandry and managerial skills, still does have livestock losses due to predation, diseases, accidental mortalities and theft. The Glen AI plays a leading role in research, in this case small stock research. It also experienced great challenges to set a basis for economical viable small stock farming.

In this study the impact of predation on production and reproduction performance of sheep (Merino and Dorper) are put into perspective. Four different categories of small stock losses were identified, namely:

- Predation
- Diseases
- Metabolic disorders and accidents
- Stock theft

Direct financial losses, veterinary and shearing cost, lick, labour and pasture cost are calculated for each of the abovementioned categories. These calculations were included in the review to determine the extent of financial losses ascribed to predation, exceeded the financial losses due to diseases, metabolic disorders or accidental mortalities and stock theft.

2. Materials and Methods

2.1 Description of the experimental location

The study was conducted at the Glen Agricultural Institute (Glen AI) (26° 20`E, 28º 57`S), 30km north of Bloemfontein, in the central part of the Free State Province. This research and training facility comprises 4 614 ha of which most is natural pasture or veld, which was described by Acocks (1988) as a *Themeda-Cymbopogon* veld type. In a botanical survey made at Glen, *Themeda triandra*, *Eragrostis chloromelas* and *Cymbopogon pospischilii* (previously known as *Cymbopogon plurinodis*) comprised 56% of the basal plant cover of the native pasture (De Waal, 1986). Furthermore, the vegetation was classified by Van der Westhuizen *et al*. (1999) and Van der Westhuizen (2003) as sweet grassland, with *Themeda trianda* dominating when it is in a well-conserved condition. *Cymbopogon pospichilii* and *Digitaria eriantha* are other climax species that occur less abundantly. *Eragrostis chloromelas* is the dominant sub-climax species, with pioneers such as *Aristida bipartita* predominating on heavier soils and *Cynodon hirsutus* on trampled and overgrazed areas. No plant surveys were done in this study to describe composition and range land condition.

The Free State Department of Agriculture (Department of Agriculture, 2003) advocates a long-term grazing capacity of 6 ha per Large Stock Unit (LSU, Meissner *et al*., 1983) for the Glen AI. The long-term annual rainfall for the Glen AI is 547 mm (ISCW, 2007). Seasonal variation occurs (Fouché *et al.*, 1985), but more than 70% of the annual rainfall is received in summer from November to March. The climate is characterised by cold winters with frost and hot summers (ISCW, 2007).

2.2 Sheep production systems

2.2.1 Free State Wool Sheep Project

Data on production and reproduction are collected routinely from five Merino flocks and a Dorper flock at the Glen AI. However, the bulk of the data for this study were obtained from the four Merino flocks that formed the Free State Wool Sheep Project at the Glen AI.

At the start of the Free State Wool Sheep Project in 1998 a selection of 280 of the available Merino ewes ranging from one to six years old were randomly divided into the following four production system treatment flocks:

- Treatment SL-V(C) **S**pring **L**ambing season on **V**eld with a salt (NaCl) lick only (**c**ontrol)
- Treatment SL-V&S **S**pring **L**ambing season on **V**eld with **S**upplementary feeding[1]
- Treatment SL-R&V **S**pring **L**ambing season on irrigated **R**ye-grass (*Lolium multiflorum* and *L. perenne*) and **v**eld
- Treatment AL-O&V **A**utumn **L**ambing season on **O**ats (*Avena sativa*) pasture in winter and **V**eld in summer and spring

Two of the Merino flocks [Treatments SL-V(C) and SL-V&S] were utilising veld all year round (Table 2.1), while the other two Merino flocks [Treatments SL-R&V and AL-O&V] utilised veld only for certain periods of the year.

Table 2.1 The Merino flocks in the four different treatments of the Free State Wool Sheep Project at the Glen AI, showing the months during which the sheep were utilising veld

	Months											
Treatment	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
SL-V(C)	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
SL-V&S	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
SL-R&V	**x**	**x**										**x**
AL-O&V	**x**	**x**	**x**							**x**	**x**	**x**

Due to limited numbers and differences in sizes of camps allocated to the Merino and Dorper flocks at the Glen AI, the camps available for the Free State Wool Sheep Project were divided in groups of three. One third of the camps received a full season's rest, the second

[1] A mixture of 40% Voermol Maxiwol, 49% maize meal, 10% salt (NaCl) and 1% feed lime. Maxiwol contains (g/kg) 350 g crude protein, 100 g fibre, 160 g moisture, 12.2 g calcium, 3.6 g phosphorus, 6.7 g sulphur, 200 mg manganese, 30 mg copper, 1 mg cobalt, 150 mg iron, 6 mg iodine, 240 mg zinc and 1 mg selenium.

third group of camps was actively grazed during the growing season and the last third was utilised during winter and early spring.

As shown previously, the pregnant Merino ewes in Treatment SL-V&S were provided with a production lick on veld consisting of a mixture of Voermol Maxiwol, maize meal, salt and feed lime at a level of 250 g/sheep/day. This production lick was provided from about six weeks before the ewes started lambing (beginning of August) until about six weeks after all the ewes have lambed. The objective was to enable the Merino ewes to lamb and raise their young on veld.

Except for the Merino flock in Treatment SL-V&S described previously, the sheep in all the other Merino and Dorper flocks were provided only with a salt lick, all year round (De Waal *et al.*, 1989a,b).

The Merino ewes in Treatment SL-R&V lambed in spring and grazed irrigated rye-grass from March to middle December. Ewes were mated in the autumn (beginning of March) on the rye-grass where they stayed and lambed (beginning of August) until the lambs were weaned in December. The rye-grass was grazed as soon as it reached a height of about 20 cm and then grazed to a height of about 10 cm.

The rye-grass was planted early in February. With an early planting date, weed infestation is low (Goodenough *et al.,* 1984). Irrigation, fertilization and grazing were done according to Theron (1994).

2.2.2 Merino shearing flock and the Dorper flock

As described previously, a Merino shearing flock is maintained at the Glen AI to produce sufficient numbers of fleeces for practical training of students at the Agricultural College. In addition, there is also a mutton producing Dorper flock (De Waal & Combrinck, 2000). The ewes and lambs in these two flocks were also heavily predated, thus impacting negatively on the recruitment of replacements and the number of ewes that were annually available for mating.

Therefore, it was decided to also include the results of the following two flocks also from 2003 in this study:

- Merino shearing flock: **S**pring **l**ambing season on **v**eld with a salt (NaCl) lick only (started with 77 ewes in 2003).
- Dorper flock: **S**pring **l**ambing season on **v**eld with a salt (NaCl) lick only (started with 219 ewes in 2003).

2.3 Reproduction

2.3.1 Lambing seasons

The lambing seasons were planned to utilize the available resources to the best advantage of both the animals and the resource (Engels, 1972; De Waal, 1989; De Waal *et al*., 1989a,b; De Waal & Biel, 1989a,b,c).

The autumn lambing season included only one of the Merino flocks (Treatment AL-O&V). The ewes were mated from the middle of November for the ewes to lamb in April of the next year. Several studies at the Glen AI have shown that there is a sharp decline in the nutritive value of veld during winter (De Waal *et al*., 1989a,b; De Waal & Biel, 1989a,b,c). Oats pastures play an important role in the nutrition of especially gestating ewes or ewes nursing lambs (De Waal, 1989). Oats is a winter cereal and is produced at the Glen AI with a view to supply a high quality pasture during winter or early spring when the veld is unable to provide readily in the nutrient requirements of grazing animals (Engels, 1972; De Waal, 1989; De Waal *et al*., 1989a,b; De Waal & Biel, 1989a,b,c).

A spring lambing season was practiced for the rest of the Merino ewes in Treatments SL-V(C), SL-V&S, SL-R&V, as well as the Merino shearing flock and the Dorper flock. The ewes were mated from April for the ewes to lamb in September. This meant that the lambing season coincided approximately with the onset of new spring growth on the veld (Engels, 1972; De Waal, 1986; De Waal & Combrinck, 2000). The Merino ewes in Treatment SL-R&V were mated slightly earlier in March to ensure that the lambs could be weaned when the rye-grass was still in production (Goodenough *et al*., 1984).

2.3.2 Mating procedures

The Merino ewes in Treatments SL-V(C), SL-V&S, SL-R&V, AL-O&V, as well as the ewes in the Merino shearing flock and the Dorper flock, were subjected to individual mating for the first 18 days. Thereafter the mating groups (ewes and rams) were placed together for the rest of the mating period. This ensured that if a ram became infertile during mating, the particular group of ewes would still be able to conceive from another ram without penalising reproduction of the flock. Maiden ewes were mated for the first time at 2-tooth age (about 14-18 months). Old ewes were culled at an average age of about six years.

The recommended ratio of 3% rams to ewes (Van Niekerk & Schoeman, 1993) was used in this study. Rams were tested before the mating season for fertility and serving capacity. For the flocks mated in autumn [Treatments SL-V(C), SL-V&S, SL-R&V, the Merino shearing flock and the Dorper flock] one ram was used to serve 35 ewes over a period of 36 days. A mating period longer than this for flocks mated in autumn held no advantage (De Wet & Bath, 1994). For the Merino flock mated in spring (Treatment AL-O&V), one ram was used to serve 35 ewes over a period of 42 days.

2.3.3 Procedures during the lambing season

Lambing commenced in September for the spring lambing systems on veld [Treatments SL-V(C), SL-V&S, SL-R&V] and in April for the Merino ewes in Treatment AL-O&V. The ewes and their newborn lambs were weighed within 24 hours after lambing and the lambs identified with an ear tag. The tails were docked not later than five days after birth.

Ewes that have lambed were removed from the group with her lamb or lambs and put into an adjacent camp. This was a deviation from the standard practice where ewes that have lambed stay in the camp and the others are removed.

2.3.4 Weaning

Lambs in all the Merino flocks and the Dorper flock were weaned at an age of approximately 110 days. The mean weaning date was calculated as 110 days from the middle date of the specific lambing season. Since the majority of the lambs were born during the earlier part of the lambing seasons, it meant that the weaning age of most lambs were effectively more than 110 days.

Weaning shock was limited by exchanging the ewes and the ewe lambs of two adjacent weaning groups. The ram lambs were removed and placed directly with older young rams. In this study the two Merino flocks on veld [Treatments SL-V(C) and SL-V&S] were handled in this way. The ewes remained in the camp and the lambs were moved to the other group (Hoon *et al*., 2008). The Merino lambs from the two flocks on planted pastures, namely Treatments SL-R&V and AL-O&V, were simply removed from the dams and placed with older young sheep on similar pasture. Weaned Dorper lambs were removed from the dams and joined with older young Dorpers on veld.

2.3.5 Records

Data were meticulously recorded from 1999 until 2007, focussing on records of 2003 - 2007. The following records were kept during different phases of the production cycles of the Merino and Dorper flocks at the Glen AI:

Mating

- Number of ewes put to the ram.
- Identification of the ewes put to a certain ram.
- Date when the rams were put to the ewes.
- Body weight of the ewes when put to the ram.
- Date when the rams were removed.
- Body weight of the ewes after the ram was removed.

Lambing

- Number of ewes lambed.
- Number of lambs born.
- Birth weight of the lambs (weighed within 24 hours of birth).
- Body weight of the ewes at lambing.

Weaning

- Weaning body weight of the lambs.
- Body weight of the ewes at weaning.
- Number of lambs weaned.

Losses and mortalities

- Mortalities due to diseases (e.g. pulpy kidney, blue tongue, etc.)
- Mortalities due to accidents, e.g. acidosis, bloat.
- Detail on losses due to theft.
- Detail on losses due to different predators.
- Camp numbers and localities where losses and mortalities occur.
- Exact dates when losses and mortalities occur.
- Age and tag number of sheep that died.
- See Table 2.2 for a typical example of how each loss or mortality was recorded at the Glen AI.

2.3.6 Statistical analysis

The data were analysed with a General Linear Model (SAS, 2004) for years separately in a factorial experimental design (four treatments x age of dam).

Table 2.2 A typical example of a Mortality Certificate: Farm Animals

MORTALITY CERTIFICATE: FARM ANIMALS

DATE:	18/09/2008
ANIMAL NUMBER:	No tag
ANIMAL AGE:	Mature Merino ewe (Shearing flock)
CAMP NUMBER:	S1B
LOCATION IN CAMP:	GPS co-ordinates: S28^{o} 56.121$^{/}$ E^{o} 26 20.881$^{/}$
(Provide sketch)	
REASON FOR DEATH:	Caught by black-backed jackals (*Canis mesomelas*)

OFFICIAL RESPONSIBLE:	
NAME:	Daniel Kgomo
(Animal Science official reporting the death)	
SIGNATURE:	________________
RANK:	Senior Foreman
APPROVAL TO DISPOSE OF:	
NAME:	Shane van Rooi
(Animal Scientist/Technician)	
SIGNATURE:	________________
RANK :	A.D.T.
DATE :	2008/09/18
OFFICIAL VERIFIED: (Provisioning):	________________
RANK:	________________
DATE:	________________

Sketch

3. The reproduction of the Merino and Dorper flocks at the Glen Agricultural Institute

As previously discussed (see section 2.2), four Merino flocks collectively formed the Free State Wool Sheep Project at the Glen AI. The four Merino flocks were subjected to the following production system treatments:

- Treatment SL-V(C) **S**pring **L**ambing season on **V**eld with a salt (NaCl) lick only (**C**ontrol)
- Treatment SL-V&S **S**pring **L**ambing season on **V**eld with **S**upplementary feeding[1]
- Treatment SL-R&V **S**pring **L**ambing season on irrigated **R**ye-grass (*Lolium multiflorum* and *L. perenne*) and **V**eld
- Treatment AL-O&V **A**utumn **L**ambing season on **O**ats (*Avena sativa*) pasture in winter and **V**eld in summer and spring

Data on reproduction and body weight of the sheep enterprise at the Glen AI have been recorded from 1999 to 2007.

The reader is reminded again that in the context of this study (see section 2.2.1), the sheep enterprise at the Glen AI refers to the four Merino flocks comprising the Free State Wool Sheep Project, a Merino flock maintained specifically to provide fleeces (Merino shearing flock) and a mutton producing Dorper flock.

The Merino shearing flock and the Dorper flock also experienced huge losses as a result of predation, thus impacting negatively on the number of replacements and the ewes that were annually available for mating. Therefore, because the information on these two flocks complemented the results of the Free State Wool Sheep Project, it was decided to include the results also in this study.

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[1] A mixture of 40% Voermol Maxiwol, 49% maize meal, 10% salt (NaCl) and 1% feed lime. Maxiwol contains (g/kg) 350 g crude protein, 100 g fibre, 160 g moisture, 12.2 g calcium, 3.6 g phosphorus, 6.7 g sulphur, 200 mg manganese, 30 mg copper, 1 mg cobalt, 150 mg iron, 6 mg iodine, 240 mg zinc and 1 mg selenium.

3.1 Rainfall

The long-term monthly and annual rainfall (1922 to 2007) for the Glen AI (ISCW, 2007), as well as detail on the corresponding rainfall during the period covered by this study, namely 1999 to 2007, is presented in Table 3.1.

Table 3.1 The long-term monthly and annual rainfall (1922 to 2007) for the Glen AI, as well as detail on the corresponding rainfall during the period covered by this study (1999 to 2007)

Year	Months												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
	Rainfall (mm)												
1999	73	31	27	33	65	5	2	2	0	77	57	142	514
2000	112	29	142	41	38	4	4	1	59	37	68	83	618
2001	35	66	101	172	20	24	0	22	34	92	183	158	907
2002	142	36	28	22	77	0	1	47	11	36	29	110	539
2003	69	90	96	6	16	0	0	4	19	17	71	73	461
2004	58	104	77	44	0	10	0	8	34	18	25	78	456
2005	100	56	64	85	22	13	0	1	6	79	66	17	509
2006	111	181	157	55	22	0	0	48	0	64	132	78	848
2007	31	9	31	67	3	31	0	2	47	82	79	91	473
Long-term average '22-'07	83	79	84	51	20	9	8	12	19	49	69	68	547

The effects of climate, especially the effects of rainfall on veld production have been well documented for the Glen AI (Fouché *et al.*, 1985; De Waal, 1986; 1990; De Waal & Combrinck, 2000). These effects are manifested in both the quantity and quality of veld produced during the growing season (De Waal, 1990). Furthermore, studies by De Waal and Biel (1989a,b,c) clearly demonstrated the inability of veld during autumn and winter to support lactating Merino and Dorper ewes and their lambs in a meaningful way. These studies also showed that it was not readily possible to increase lamb weaning weights or reduce body weight losses of the lactating ewes with supplementary energy and crude protein provided to the ewes on veld during autumn and winter.

In pursuance of the quest to find ways of supporting the production by lactating ewes on veld, Engels (1972) and De Waal (1989) elaborated on the need to include planted pastures, for example dry land oats, in fodder flow planning for sheep in the central Free State Province. Incorporating the principles suggested by De Waal (1989), one of the treatments (Treatment AL-O&V) implemented in this study was based on this concept.

3.2 Ewes mated and ewes that lambed

The number of ewes annually available for mating in the different flocks is presented in Table 3.2. The study started with 70 Merino ewes being allocated to each flock in the Free State Wool Sheep Project. However, since the study commenced, only the Merino flock on rye-grass pasture (Treatment SL-R&V) could provide sufficient replacement maiden ewes to maintain this number of 70 breeding ewes per treatment flock.

Table 3.2 The number of Merino and Dorper ewes annually available for mating in the sheep enterprise at the Glen AI from 1999 to 2007

	Merino flocks					
Years	SL-V(C)	SL-V&S	SL-R&V	AL-O&V	Shearing flock	Dorper flock
1999	63	68	74	76	*	*
2000	67	76	80	73	*	*
2001	63	73	72	63	*	*
2002	63	71	70	60	*	*
2003	38	51	70	51	77	219
2004	34	30	68	50	73	166
2005	26	24	70	50	81	145
2006	20	20	68	45	42	135
2007	25	25	68	36	36	126
Average	44	49	71	56	62	158

* Complete data sets not available for these years

The results for the Merino shearing flock and the Dorper flock are shown separately from the other four Merino flocks. The reason for this is that non-reproducing Merino ewes from Treatments SL-V(C), SL-V&S, SL-R&V and AL-O&V were culled and transferred to the Merino shearing flock. Accurate records of reproduction and production in the Merino shearing flock were also kept, therefore, some ewes or maiden ewes could be transferred back as replacements for either Treatments SL-V(C) or SL-V&S, because these flocks received the same treatment on veld. This procedure was often the case when too few replacement ewes were available at mating for the Merino flocks in Treatments SL-V(C) and SL-V&S. Therefore, because animals were transferred to and from the Merino shearing flock, the results on reproduction of the flock may be skewed.

Since the founding of the Dorper flock in 1981 at the Glen AI (De Waal & Combrinck, 2000), selection was based on reproduction and production. For unknown reasons and unlike the Merino flocks, this practice was somehow discontinued for the Dorpers by successive managers. As a result, only Dorper ewes older than six years or ewes with badly worn teeth were culled. The Dorper ewes annually available for mating declined each year and, therefore, less productive and older ewes were given several opportunities to produce an extra lamb. Thus, the reproduction of the Dorper flock may also, as is the case of the Merino shearing flock, be skewed to some extent.

The Merino ewes that lambed in autumn on oats pasture (Treatment AL-O&V) also suffered severe losses due to predation, thus not being able to sustain the required number of ewes in the flock as provided for by the project protocol. In 2002, 17 ewes in Treatments SL-V(C) and SL-V&S were seven years or older. These ewes had to be culled in 2003, thus ending with three ewes in treatment SL-V(C) and 10 ewes in Treatment SL-V&S in this age category. Ewes were also culled based on other criteria of poor performance, thus accounting for the drop in number of ewes in 2003 (Table 3.2). The number of ewes in the Merino shearing flock also declined after 2005 when Merino ewes from this flock were used to maintain flock numbers in the four Merino treatment flocks. The numbers in the Dorper flock declined rapidly from 2003 to 2007, primarily because of predation. This impacted negatively on the recruitment of Dorper ewes into the flock.

3.3 Reproduction of the Merino and Dorper flocks

Partly as a result of fewer ewes annually available for mating (Table 3.2) the ewes that lambed also decreased annually (Table 3.3), especially in Treatments SL-V(C) and SL-V&S, the Merino shearing flock and the Dorper flock.

Only the Merino ewes in Treatment SL-R&V lambed more consistently over the study period (Figure 3.1) and consistently maintained the highest lambing percentage (mean = 94.6% with a range from 89.7 to 97.1%). In this study lambing percentage is expressed as the number of ewes that lambed per number of ewes that were mated.

Rye-grass pasture start producing in March, therefore, its utilization could be improved by moving the mating season forward. Therefore, in 2001 the mating season for the Merino ewes in Treatment SL-R&V was changed to the beginning of March compared to the middle of April for Treatments SL-V(C) and SL-V&S (see 2.3.1).

Table 3.3 The number of Merino and Dorper ewes that lambed annually in the sheep enterprise at the Glen AI from 1999 to 2007

	Merino flocks					Dorper flock
Years	SL-V(C)	SL-V&S	SL-R&V	AL-O&V	Shearing flock	
1999	53	61	70	51	*	*
2000	60	68	77	55	*	*
2001	51	56	69	53	*	*
2002	35	53	68	39	*	*
2003	31	45	66	39	53	185
2004	22	18	63	43	19	141
2005	21	15	66	43	60	132
2006	13	15	61	30	16	92
2007	15	16	66	30	20	70
Average	33	39	67	43	34	124

* Complete data sets not available for these years

It would appear that the Merino ewes in Treatments SL-V(C), SL-V&S and AL-O&V showed considerable variation in lambing percentage throughout the study period (Figure 3.1). However, these values should be viewed against the specific breakdown of the age structures of the flocks.

In 2002, the ewes in Treatments SL-V(C) and SL-V&S were kraaled during the night. This resulted in the sheep being forced to graze during times of the day that are not in line with their inherent grazing behaviour. Previous studies at the Glen AI have shown that grazing sheep actively started grazing on veld at sunrise (05h30) in summer and in winter grazing started later after sunrise (07h00) (De Waal *et al.*, 1980; De Waal *et al.*, 1989b). In this study, the sheep were released from being kraaled overnight much later in the morning and they could only start grazing after 08h00. The sheep had to be kraaled again at 15h00 to accommodate commuting arrangements of staff to their dwellings in town, further impeding on grazing time. The variation in lambing percentage observed in Treatments SL-V(C) and SL-V&S, as well as Treatment AL-O&V, precluded any meaningful conclusions being drawn as to whether this management practice (kraaling at night) impacted negatively on the lambing percentage.

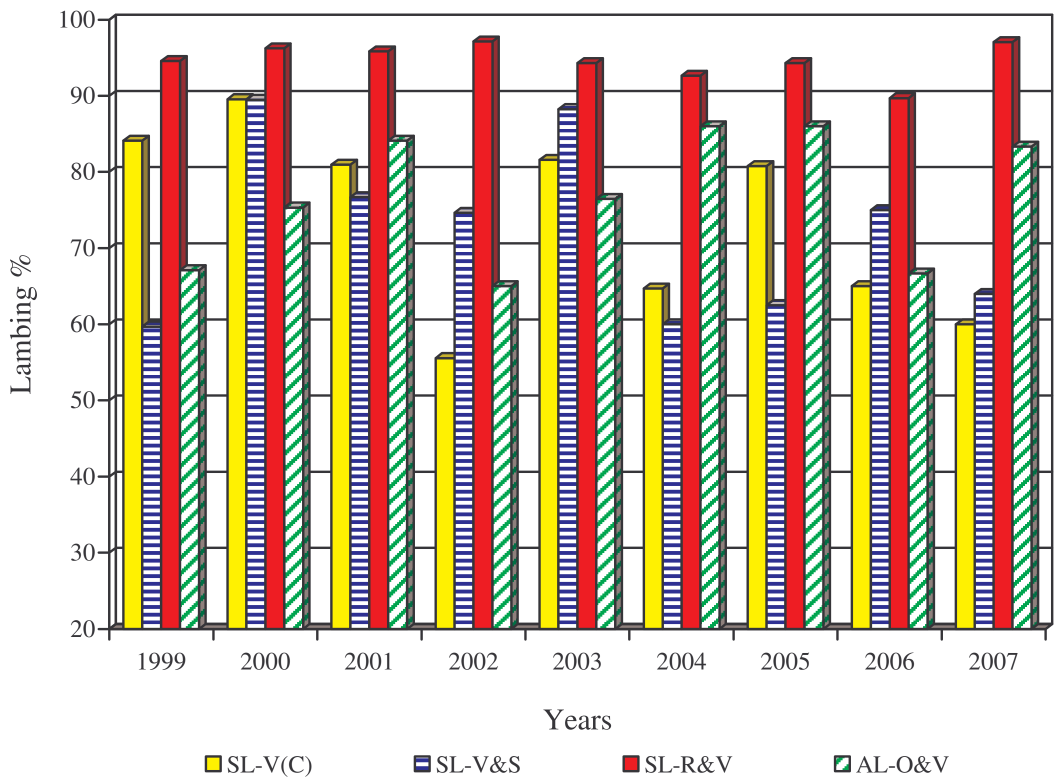

Figure 3.1 Annual lambing percentages of the Merino ewes in the four treatment flocks at the Glen AI.

The mean lambing percentage of the Merino ewes in Treatment SL-V&S decreased gradually since 2000, except for the noticeable increase in 2003 (Figure 3.1). At the beginning of 2003 and 2005, the Merino ewes that did not reproduce were culled in all treatments, thus leading to the noticeable improvement of conception in Treatments SL-V(C), SL-V&S and AL-O&V. Although differences in lambing success of up to 25% have been observed in some years between Treatments SL-V&S and SL-V(C), the averages over the nine year period were similar at 74.4% and 73.6%, respectively.

The lambing percentages of the Merino ewes in Treatment AL-O&V gradually increased until 2001 (Figure 3.1). Except for sharp declines in lambing percentages during 2002 and 2006, the lambing percentage of the flock was fairly stable at an average of 76.7%. These ewes were mated during spring, which is not the optimum for reproductive activity (De Waal, 1986), thus photoperiodicity may have affected conception. However, the older ages of the ewes during some years may also have played a role. In 2002, seven of 18 ewes which were seven years or older did not lamb. Furthermore, there was a drop of almost 5 kg in the body weight of the three year old ewes from the beginning of mating until the end of mating. Only four of the 14 ewes mated in this age category, lambed. In 2006, the higher ages of the ewes could have caused the drop in lambing percentage of the ewes, when nine of the 25 ewes that were five years or older did not lamb.

The Merino ewes culled from Treatments SL-V(C), SL-V&S, SL-R&V and AL-O&V were transferred to the Merino shearing flock before mating commenced in 2003 and 2005. The older Merino ewes from Treatment SL-R&V were still fertile, and contributed to the two sharp increases in lambing percentage of the Merino shearing flock during those years (Figure 3.2). The data presented in Figure 3.2 only cover the years from 2003, but the timescale is retained similar to previous graphs, thus enabling easier comparisons.

It should be noted that the teeth of Merinos on the rye-grass were usually less worn down than similar age ewes on veld. Therefore, it was possible to keep older ewes longer in production on the rye-grass. As a result of the older culled Merino ewes being transferred from Treatment SL-R&V, the production of the Merino shearing flock dropped drastically in 2004 and 2006 (Figure 3.2).

The reproduction of the Dorper flock was relatively constant during the first three years, at ca. 85% (Figure 3.2). The relatively sharp decrease after 2005 can be attributed to relatively less productive ewes that were not culled, but given another chance for mating in the flock.

3.4 Fecundity

In this study fecundity is expressed as the number of lambs born per number of ewes that lambed.

Similar to the lambing percentage (Figure 3.1), the fecundity of the Merino ewes on rye-grass (Treatment SL-R&V) was markedly higher than for the other treatment flocks (Figure 3.3). In all years the body weight of the Merino ewes in Treatment SL-R&V dropped over the period from August (when the ewes started to lamb) to December. At weaning (in the middle of December) the rye-grass pasture died down and the ewes and lambs were moved from the rye-grass to veld.

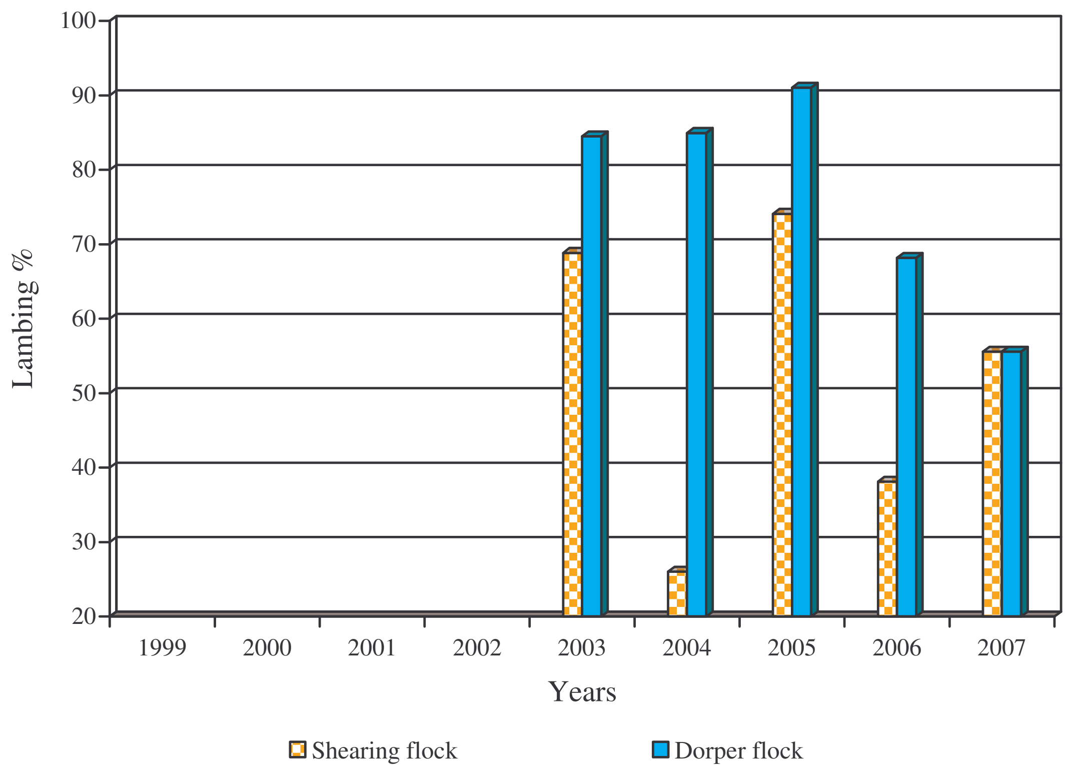

Figure 3.2 Annual lambing percentages of the Merino shearing flock and the Dorper flock at the Glen AI.

Several factors could have influenced fecundity of ewes. In an early growing phase of rye-grass during March, its crude protein (CP) content is about 26% and declines with 2%-units per month to a level of 8% CP in December (Kynoch, 1990). According to Theron (1994), higher CP values may be achieved at any time of the year, depending on the amount of nitrogen fertiliser applied and the frequency of grazing. This higher CP content was ideal for the Merino ewes in Treatment SL-R&V when mating commenced in early March. The body weight of the Merino ewes in Treatment SL-R&V was not markedly higher than the body weight of the ewes in the other three treatments when the mating season commenced in autumn (see 3.7). However, the body weight of the ewes in Treatment SL-R&V increased markedly when they were mated on the rye-grass early in March. This increase in body weight during mating is ideal for follicle development (Van Niekerk & Schoeman, 1993), resulting in higher fecundity for the Merino ewes in Treatment SL-R&V. During 2005 and 2007 the rye-grass was planted late and therefore the ewes had to be mated on the veld before the rye-grass could be grazed.

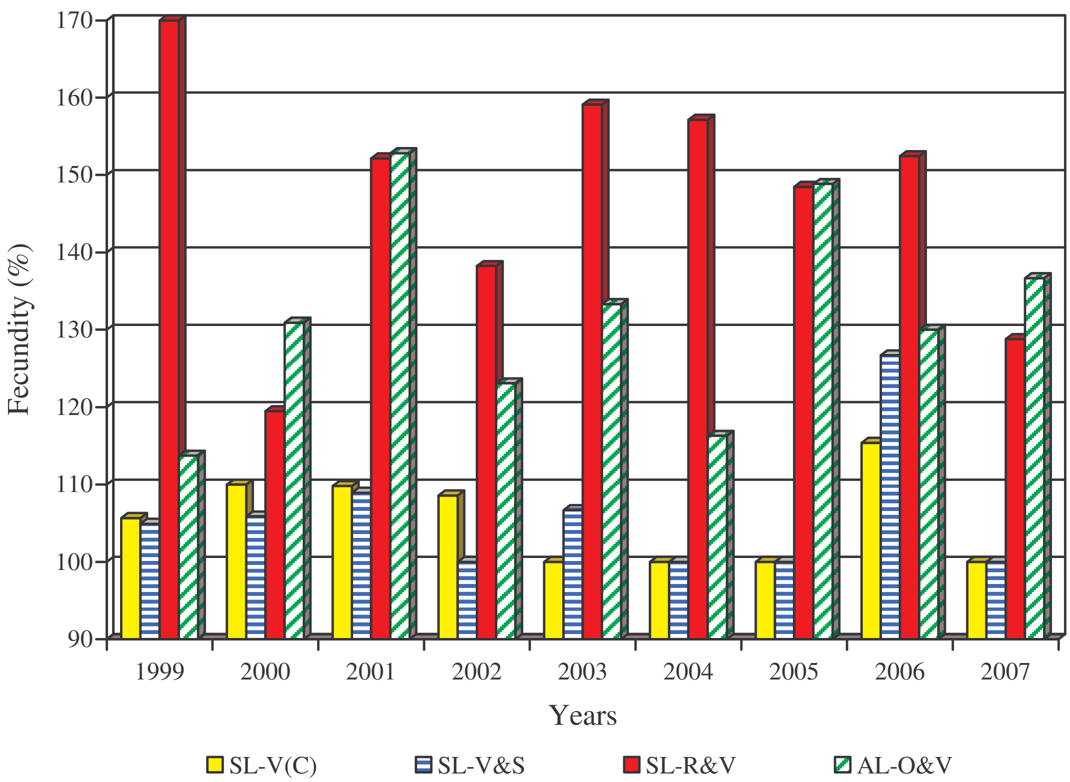

Figure 3.3 Annual fecundity of the four Merino flocks in the different treatments at the Glen AI.

The drop in fecundity in 2007 of the Merino ewes in Treatment SL-R&V could be ascribed to the fact that the replacement ewes constituted 31% (21 ewes of 68) of the flock at mating. When dividing the Merino ewes in Treatment SL-R&V into three age groups, namely ewes older than four years (normal more productive age category), ewes between 3 to 4 years, and young replacement ewes (2-tooth), it is evident that this influenced fecundity. Seven of the ewes older than four years had twins, while one of the nine ewes did not lamb. In the 3 to 4 year age group 100% of the 38 ewes lambed and 10 of these ewes had twins. Only one of 21 2-tooth ewes had twins and one ewe did not lamb.

More maiden Merino ewes were mated in 2007 in Treatment SL-R&V compared to other years. Maiden ewes are on heat for a shorter period of only 30 minutes to 24 hours compared to mature ewes (12 to 36 hours) (Coetzee, undated). Coetzee (undated) recommended that a larger number of rams (up to 4%) be used with maiden ewes. The reason is that there is a greater chance that a ram will miss signs of heat in a maiden ewe. When the Merino ewes in Treatment SL-R&V were mated on the veld during 2005 and 2007, they were grazing a larger camp (26 ha) compared to the smaller 1 ha camps used on the rye-grass for mating. Therefore, camp size could have influenced both lambing percentage and fecundity. Coetzee (undated) stated that if a ewe has more servings, the chance of conceiving is greater and also with an increased possibility of multiple births.

In 2007, a markedly lower rainfall was recorded from January to March (Table 3.1). In February 2007, 9 mm rain was received which is the 3rd lowest rainfall since 1922 for the Glen AI during March. This would have had an influence on the dry matter yield of the veld (De Waal, 1990). The Merino ewes in Treatment SL-R&V had to be mated on the veld and the ewes did not show the expected body weight gain during the mating season (see Tables 4.1 and 4.2). This could account for the drop in fecundity during 2007. The Merino ewes in Treatments SL-V(C) and SL-V&S may also have been negatively influenced by the effects of the poor rainfall on veld during the preceding January and February 2007 (Table 3.1).

The Merino ewes in Treatment AL-O&V were removed from the oats pastures after the lambs were weaned at the end of September. Due to the high nutritive value of the oats pasture, these ewes were usually in a very good condition. The Merino ewes were also able to maintain this good body condition on veld during the mating season in late spring. This good body condition was expressed in higher body weight (see 3.7) and may have contributed to the higher fecundity of the Merino ewes in Treatment AL-O&V compared with those in Treatments SL-V(C) and SL-V&S (Figure 3.3).

As a result of the high rainfall received during January to March 2006 (Table 3.1), the veld was overgrown. Therefore, it was decided to remove the excess material by grazing it with dry dairy cows, thus enabling the Merino ewes in Treatments SL-V(C) and SL-V&S to graze the shorter grass. Overall, the Merino ewes in Treatments SL-V(C) and SL-V&S were in a better condition during 2006, especially the mature ewes. In 2006 the Merino ewes in Treatments SL-V(C) and SL-V&S were fecund (Figure 3.3). The good grazing condition favoured ewes, especially the older ewes that were usually only in a moderate condition. According to Cumming (1977) weight gain in the mating season, especially for ewes in a poor condition, will have a positive effect on fecundity.

The highest fecundity for the Dorper flock during the five-year period from 2003 to 2007 was 120% in 2005 (Figure 3.4). This was noticeably lower than the 16-year mean of 128% reported earlier for the same Dorper flock (De Waal & Combrinck, 2000). The fecundity of the Merino shearing flock (Figure 3.4) during the same five-year period from 2003 to 2007 compared well with the Merino ewes in Treatments SL-V(C) and SL-V&S (Figure 3.3).

Meaningful selection for reproduction and production in the Dorper flock was not possible in recent years because of too few replacement ewes as a direct result of predation.

3.5 Weaning percentage

In this study weaning percentage is expressed as the number of lambs weaned per number of ewes that were mated.

The weaning percentage of the Merino ewes in Treatment SL-R&V (Figure 3.5) was markedly higher than the rest of the Treatments with an average of 113.5%. Weaning percentage of Treatment AL-O&V (annual mean = 73%) was second highest, also markedly higher that for Treatments SL-V(C) and SL-V&S. The weaning percentages of the latter two treatments were very low with an annual mean of less than 40%.

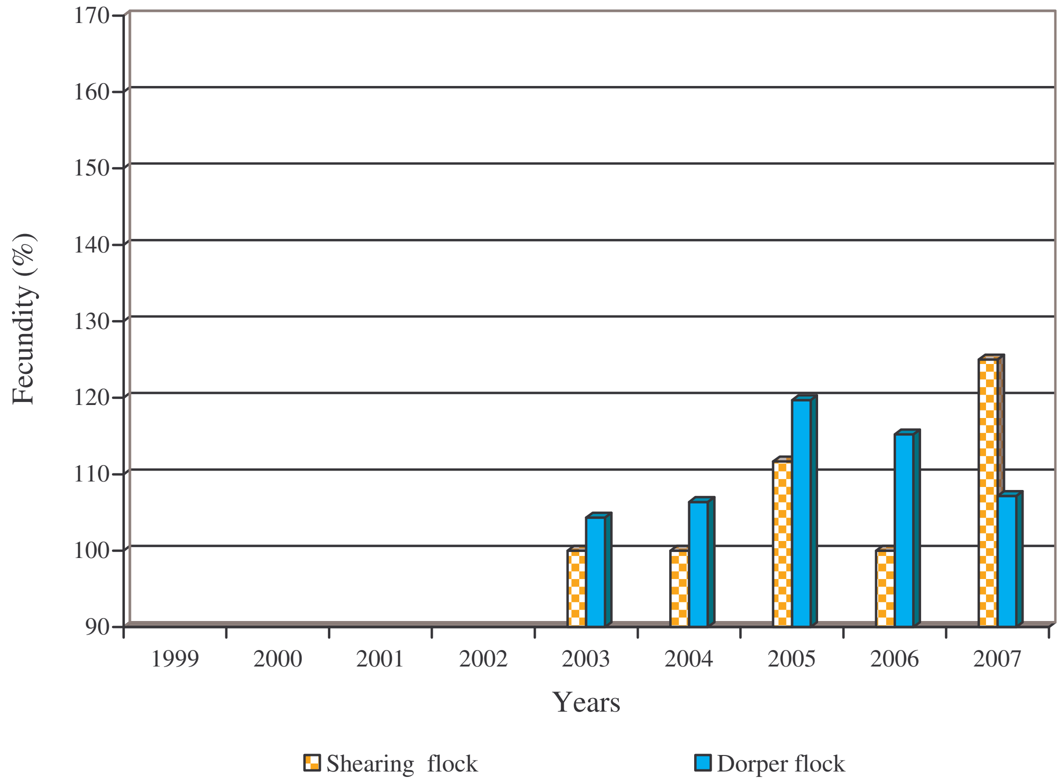

Figure 3.4 Annual fecundity of the Merino shearing flock and the Dorper flock at the Glen AI.

In Figure 3.5 the poor weaning percentages for Treatment SL-R&V in 2000 and 2002 can be attributed to the fact that many lambs were stillborn (see also section 5.1). This was usually the case with ewes older than five years. The other pre-weaning mortalities among lambs on the rye-grass pastures were caused as a result of ewes with blue udder or ewes that did not produce enough milk.

The main pipeline supplying water to irrigate the rye-grass pasture burst at the end of September 2004 and was only repaired a month later in October. Irrigation was also completely interrupted during this interruption of irrigation and with a below average rainfall in October 2004 (Table 3.1), the production of the rye-grass was negatively affected. The water stress caused the rye-grass to rapidly advance to a reproductive stage and the seeds irritated the eyes of especially the lambs, while the courser plant material was less acceptable for grazing.

The cause of death of a number of the lambs before weaning in December 2004 could not be established, especially when the deaths occurred over weekends. A post mortem was not possible anymore on the Monday, due to warm conditions that contributed to rapid deterioration of the carcass. These deaths led to a lower weaning percentage in 2004 for the Merino flock in Treatment SL-R&V. The CP content of rye-grass is low at the end of its reproduction cycle. This may have contributed to the low weaning weight of 28.1 kg for the Merino lambs during 2004 in Treatment SL-R&V (see Table 4.6), which was the lowest weaning weight recorded for this flock between 1999 and 2007.

Some Merino lambs in Treatment SL-R&V died at the beginning of the lambing season in August 2006 because of wet (Table 3.1), cold and windy conditions. Although the weaning percentage was not particularly low in 2006, it could have been higher if sufficient shelter was available for the ewes and their lambs. The mortality percentage of the Merino lambs in Treatment SL-R&V was the lowest in 2007 (see Figure 3.7). However, a lower weaning percentage was observed in 2007 (Figure 3.5), mainly due to a low fecundity (Figure 3.3).

The weaning percentage in Treatment AL-O&V was relatively constant with an annual mean of 81.2% over the nine years (Figure 3.5). As a result of differences in rainfall, the dry matter production varied. Therefore, it was decided in 2007 to produce oats pasture under irrigation, thus sufficient dry material was available early in winter when the ewes lambed and more material was available later in the season. This change improved the weaning percentage of Treatment AL-O&V in 2007 (Figure 3.5).

From January to May 2006 the markedly above average rainfall (see Table 3.1) resulted in many sheep being infected with foot rot, especially the Merino ewes in Treatment AL-O&V. This severe foot rot infection influenced the weaning percentage negatively (Figure 3.5). Although a good rainy season resulted in good oats pasture, the weaning weight of the lambs in 2006 was below the annual mean weaning weight of 34.8 kg during the nine year period from 1999 to 2007 (see section 4.6).

After 2002 the Merino flocks in Treatments SL-V(C) and SL-V&S on veld had very low weaning percentages of 45.3% and 35.4%, respectively (Figure 3.5). As discussed later (see section 3.6), these losses can be ascribed to severe predation that afflicted these flocks on veld.

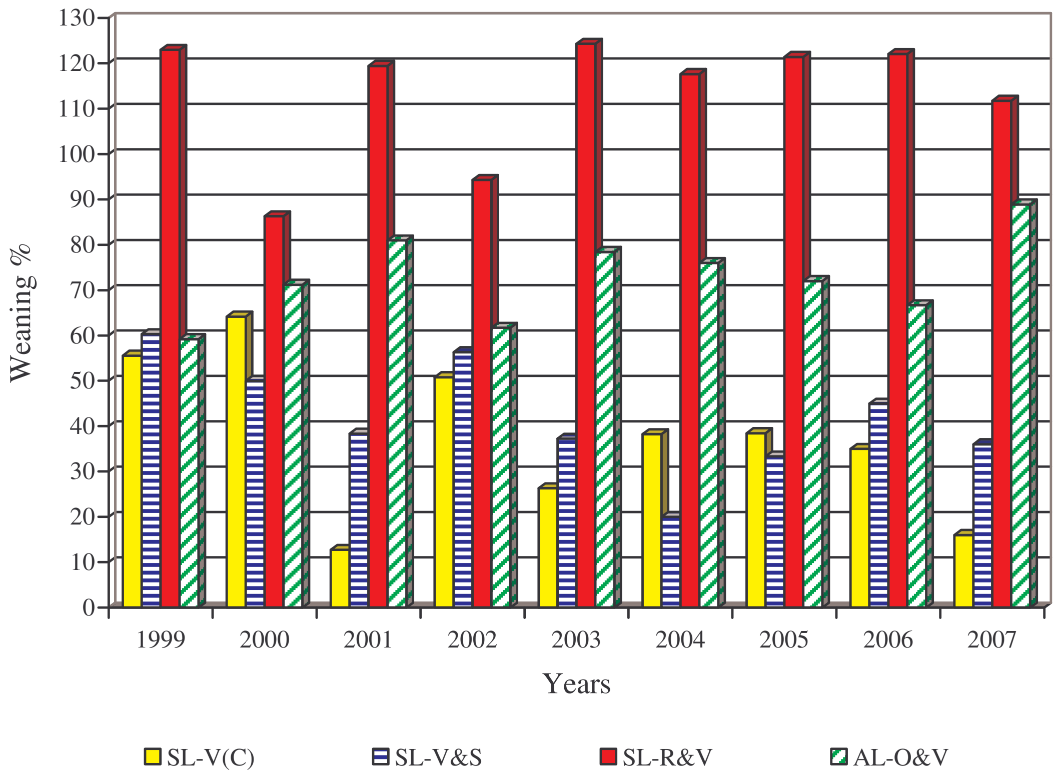

Figure 3.5 Annual weaning percentage of the four Merino flocks in the different treatments at the Glen AI.

The low and varying weaning percentages of the Merino shearing flock until 2006 (Figure 3.6) were mainly caused by predation. In 2007 all the Merino ewes in the shearing flock were protected from predators by grazing an area enclosed behind an electric fence, with a marked increase in weaning percentage.

Similar to the Merino shearing flock, the Dorper flock suffered big losses due to predation, which increased steadily from 2003 to 2005 (see section 3.6). In 2006 predation was extremely severe with only six of the 106 Dorper lambs born that survived until weaning. In 2007 the Dorper flock was, similar to the Merino shearing flock, also protected from predators for a period when they grazed veld enclosed behind an electric fence. Thus the impact of predation was drastically reduced (Figure 3.6). However, when the Dorper flock was removed from the relative protection behind the electric fence due to a lack of grazing material on the veld, they again suffered severe losses due to predation.

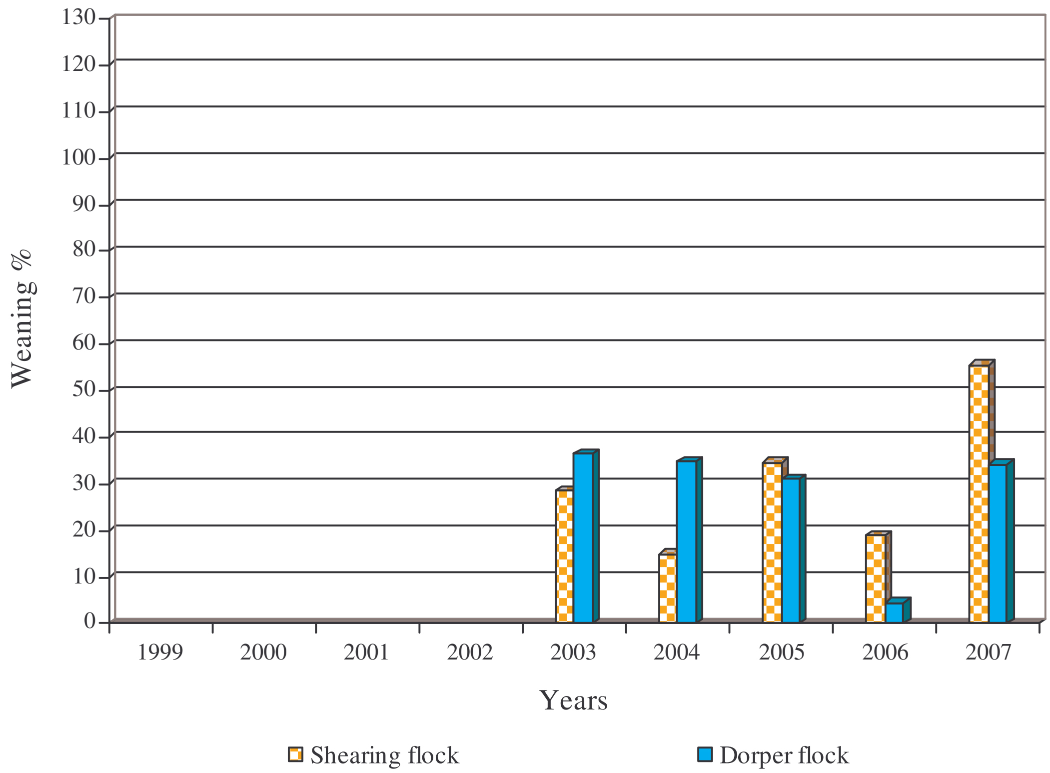

Figure 3.6 Annual weaning percentages of the Merino shearing flock and Dorper flock at the Glen AI.

3.6 Mortality

In this study mortality is expressed as the number of lambs that died per number of lambs born.

The mortality of lambs in the four Merino flocks in the different treatments (Figure 3.7) and the Merino shearing flock and the Dorper flock (Figure 3.8) show considerable variation.

In general, the mortality of lambs in the Merino flock in Treatment SL-R&V was the lowest (Figure 3.7), but it was still high with an annual mean of 18.6%. In 2000 and 2002 the mortalities of the Merino flock in Treatment SL-R&V were high due to the same reasons given for the low weaning percentages for this treatment. After 2004 the survival rate improved for Treatment SL-R&V, partly because ewes were also selected for mothering ability. Furthermore, from 2003 ewes were inoculated against blue udder before lambing occurred, which also helped to improve their survival. In this study the Merino sheep on planted pastures (Treatments SL-R&V and AL-O&V) were not exposed to any predators before weaning. This is one of the major reasons why the Merino flocks in Treatments SL-R&V and AL-O&V have a markedly higher survival rate of their offspring up to weaning than the flocks on the veld.

The mortality percentages of the Merino flock in Treatment AL-O&V were consistently low except for 2001 and 2005 when the mortalities were much higher (Figure 3.7). The variation in rainfall in 2005 (Table 3.1) lead to poor oats pastures. The sheep had to be returned to the veld for almost a month until the oats pasture was ready to be grazed and during this short period a number of lambs were lost to predators (mostly dogs). Even without this incident, the mortality of Merino lambs in Treatment AL-O&V was high, with an annual mean of 26.9% in 2005.

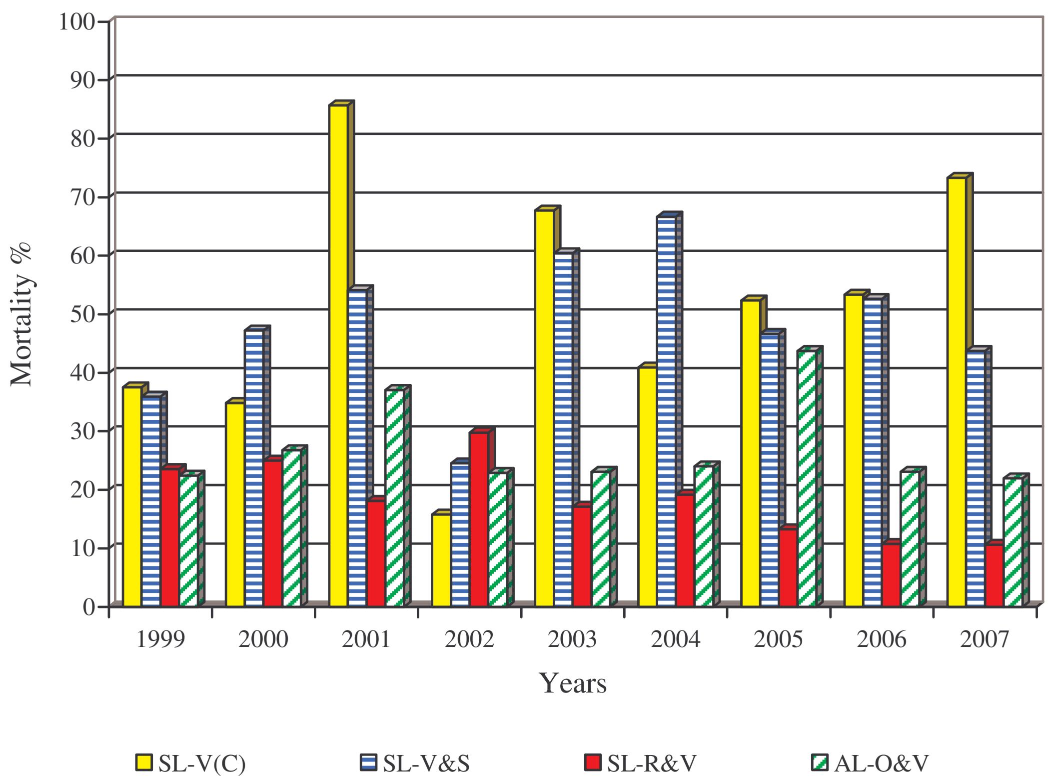

Figure 3.7 Annual mortality percentages of lambs in the four Merino flocks in the different treatments at the Glen AI.

Weaning percentages were affected by mortalities. Lamb mortality in the Merino flocks in Treatments SL-V(C) and SL-V&S varied (Figure 3.7) but was high with averages of 50.2% and 51.3%, respectively. The exception was during 2002, the first year of kraaling these flocks at night when lamb mortality was low. The decision to kraal the sheep was made after predators killed almost all the Merino lambs in Treatment SL-V(C) and a large percentage (more than 50%) of lambs in Treatment SL-V&S during 2001.

The reader is reminded that although the mortalities of Treatments SL-V(C) and SL-V&S were very high and the survival rate decreased since 2003, the loss of only one lamb can make a difference of up to 6% in the calculations, because the total number of sheep became smaller.

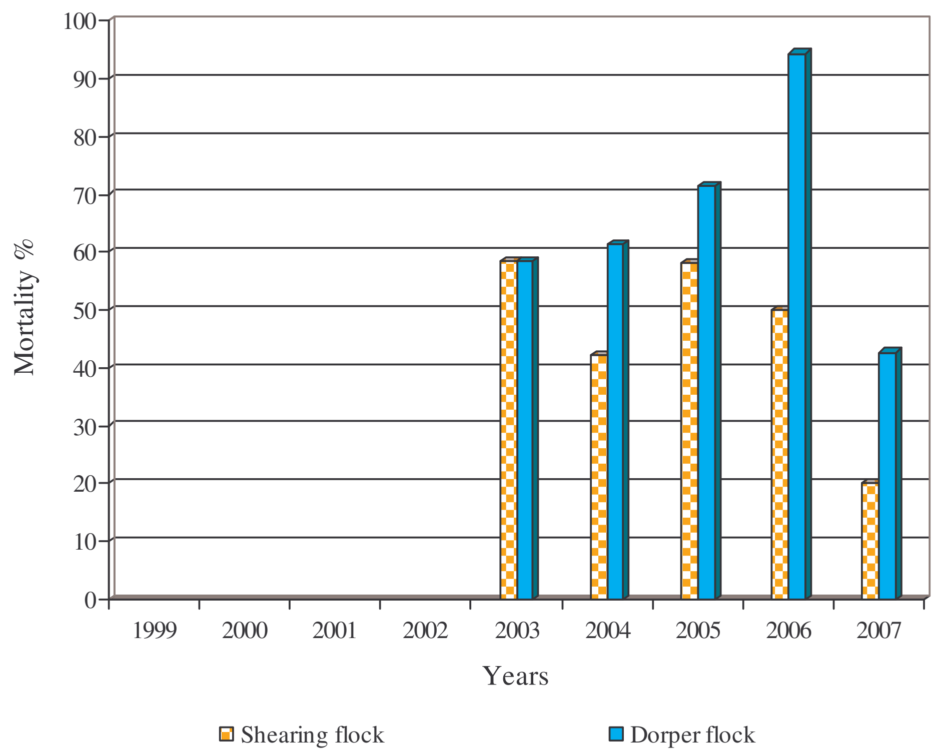

Figure 3.8 Annual mortality percentages of lambs in the Merino shearing flock and Dorper flock at the Glen AI.

The reasons for the mortalities of the lambs in the Merino shearing flock and Dorper flock (Figure 3.8) are the same as those given for their low weaning percentages (see section 3.5).

4. The production of the Merino flocks at the Glen Agricultural Institute

As previously discussed (see section 2.2), four Merino flocks collectively formed the Free State Wool Sheep Project at the Glen AI. The four Merino flocks were subjected to the following production system treatments:

- Treatment SL-V(C) **S**pring **L**ambing season on **V**eld with a salt (NaCl) lick only (**C**ontrol)
- Treatment SL-V&S **S**pring **L**ambing season on **V**eld with **S**upplementary feeding[1]
- Treatment SL-R&V **S**pring **L**ambing season on irrigated **R**ye-grass (*Lolium multiflorum* and *L. perenne*) and **V**eld
- Treatment AL-O&V **A**utumn **L**ambing season on **O**ats (*Avena sativa*) pasture in winter and **V**eld in summer and spring

4.1 Body weight of the Merino ewes at the beginning of mating

The average body weight of the Merino ewes in the four treatment flocks at the beginning of the annual mating periods over a period of nine years is presented in Table 4.1.

The body weight of the Dorper flock is not presented due to the incomplete data in some years.

The average body weight of the Merino ewes in the two treatment flocks on veld [Treatments SL-V(C) and SL-V&S] were lower (Table 4.1) than the two Merino flocks maintained for more than six months every year on planted rye-grass or oats pastures [Treatments SL-R&V and AL-O&V]. However, as a direct consequence of predation, older Merino ewes were kept past their prime for production because of insufficient numbers of maiden ewes annually

[1] A mixture of 40% Voermol Maxiwol, 49% maize meal, 10% salt (NaCl) and 1% feed lime. Maxiwol contains (g/kg) 350 g crude protein, 100 g fibre, 160 g moisture, 12.2 g calcium, 3.6 g phosphorus, 6.7 g sulphur, 200 mg manganese, 30 mg copper, 1 mg cobalt, 150 mg iron, 6 mg iodine, 240 mg zinc and 1 mg selenium.

available for mating. Therefore, the body weight of the Merino flocks was biased because of unequal age distribution and lower body weight of older Merino ewes.

Table 4.1 ANOVA for annual body weight (average ± s.d.) of the Merino ewes at the beginning of mating in the four treatment flocks from 1999 to 2007 at the Glen AI

	Ewe weight at the beginning of mating			
	SL-V(C)	SL-V&S	SL-R&V	AL-O&V
Years	kg			
1999	54.3 ± 7.56^{a}	49.0 ± 5.95^{b}	51.7 ± 7.33^{c}	51.4 ± 4.97^{c}
2000	54.6 ± 7.66^{a}	57.4 ± 5.86^{b}	58.9 ± 6.30^{b}	49.9 ± 6.69^{c}
2001	51.4 ± 6.91^{a}	54.5 ± 5.81^{b}	61.9 ± 9.21^{c}	57.0 ± 6.04^{b}
2002	52.8 ± 5.63^{a}	56.2 ± 5.04^{b}	58.9 ± 7.93^{c}	58.7 ± 5.86^{bc}
2003	51.0 ± 4.11^{a}	55.1 ± 5.10^{b}	65.4 ± 5.90^{c}	62.5 ± 7.01^{d}
2004	52.9 ± 4.36^{a}	55.5 ± 4.47^{a}	61.1 ± 7.69^{b}	60.6 ± 6.49^{b}
2005	53.0 ± 6.27^{a}	52.9 ± 3.83^{a}	62.5 ± 7.51^{b}	60.0 ± 8.30^{b}
2006	53.4 ± 6.84^{a}	53.6 ± 7.33^{a}	57.4 ± 7.49^{b}	61.9 ± 7.00^{c}
2007	47.6 ± 5.21^{a}	51.0 ± 4.46^{ab}	53.9 ± 9.17^{b}	57.1 ± 4.23^{c}

^{a,b,c,d}Values in a row with the same superscript did not differ significantly (P>0.05)

The body weight of the ewes in Treatment SL-V(C) at the beginning of mating ranged from 47.6 kg to 54.6 kg (average = 52.3 kg), in Treatment SL-V&S from 49.0 kg to 57.4 kg (average = 53.9 kg), in Treatment SL-R&V from 51.7 to 65.4 kg (average = 59.1 kg) and in Treatment AL-O&V from 49.9 kg to 62.5 kg (average = 57.7 kg) (Table 4.1).

4.2 Body weight of the Merino ewes at the end of mating

The body weight of the ewes in Treatment SL-V(C) at the end of mating ranged from 48.2 kg to 54.2 kg (average = 52.5 kg), in Treatment SL-V&S from 49.6 kg to 58.7 kg (average = 54.2 kg), in Treatment SL-R&V from 53.5 to 68.7 kg (average = 61.0 kg) and in Treatment AL-O&V from 54.8 kg to 65.0 kg (average = 60.6 kg) (Table 4.2).

Table 4.2 ANOVA for annual body weight (average ± s.d.) of the Merino ewes at the end of mating in the four treatment flocks from 1999 to 2007 at the Glen AI

	Ewe weight at the end of mating			
	SL-V(C)	SL-V&S	SL-R&V	AL-O&V
Years	kg			
1999	53.4 ± 6.85[a]	49.6 ± 6.06[b]	53.5 ± 7.89[a]	54.8 ± 5.51[a]
2000	53.5 ± 7.47[a]	58.7 ± 5.80[b]	57.4 ± 6.45[b]	56.6 ± 6.08[b]
2001	52.4 ± 6.94[a]	54.5 ± 5.81[a]	62.2 ± 7.55[b]	62.7 ± 5.63[b]
2002	51.4 ± 4.82[a]	52.4 ± 4.48[a]	59.6 ± 7.91[b]	57.9 ± 5.79[b]
2003	52.8 ± 4.74[a]	57.1 ± 4.95[b]	68.7 ± 8.30[c]	62.1 ± 5.22[d]
2004	54.2 ± 4.08[a]	55.5 ± 4.45[a]	66.6 ± 7.50[b]	64.1 ± 6.00[c]
2005	52.2 ± 5.05[a]	54.6 ± 4.82[a]	64.1 ± 7.03[b]	63.2 ± 8.00[b]
2006	54.0 ± 6.14[a]	55.6 ± 7.08[a]	61.3 ± 6.38[b]	65.0 ± 6.45[c]
2007	48.2 ± 4.32[a]	50.0 ± 4.28[a]	55.5 ± 9.03[b]	58.9 ± 5.56[c]

[a,b,c,d]Values in a row with the same superscript did not differ significantly (P>0.05)

4.3 Body weight of the Merino ewes at lambing

The body weight of the Merino ewes at lambing (Table 4.3) in the two treatment flocks on veld [Treatments SL-V(C) and SL-V&S] was slightly lower than at mating (Table 4.1). As a direct result of a higher level of nutrition for the rye-grass and oats pastures, the Merino ewes in Treatment SL-R&V and Treatment AL-O&V increased in body weight until lambing, especially the Merino ewes on the rye-grass pasture (Table 4.3).

The body weight of the ewes in Treatment SL-V(C) at lambing ranged from 46.7 kg to 56.7 kg (average = 49.7 kg), in Treatment SL-V&S from 48.1 kg to 58.7 kg (average = 52.6 kg), in Treatment SL-R&V from 68.7 to 77.0 kg (average = 72.5 kg) and in Treatment AL-O&V from 56.9 kg to 71.7 kg (average = 64.6 kg) (Table 4.3).

Table 4.3 ANOVA for annual body weight (average ± s.d.) of the Merino ewes at lambing in the four treatment flocks from 1999 to 2007 at the Glen AI

	Ewe weight at lambing			
	SL-V(C)	SL-V&S	SL-R&V	AL-O&V
Years	kg			
1999	52.4 ± 5.37^{a}	51.9 ± 5.61^{a}	68.7 ± 8.53^{b}	56.9 ± 6.77^{c}
2000	47.2 ± 6.50^{a}	51.6 ± 5.23^{b}	72.0 ± 8.09^{c}	61.0 ± 6.25^{d}
2001	49.0 ± 4.84^{a}	52.9 ± 5.36^{b}	71.1 ± 7.26^{c}	66.7 ± 6.01^{d}
2002	56.7 ± 4.57^{a}	56.2 ± 5.29^{a}	73.3 ± 8.05^{b}	57.8 ± 5.54^{a}
2003	46.7 ± 3.52^{a}	53.7 ± 4.78^{b}	77.0 ± 8.40^{c}	66.3 ± 6.77^{d}
2004	46.7 ± 3.21^{a}	51.4 ± 4.90^{a}	73.8 ± 9.24^{b}	71.7 ± 8.82^{b}
2005	49.6 ± 5.16^{a}	48.7 ± 4.23^{a}	74.5 ± 7.94^{b}	70.3 ± 7.83^{c}
2006	52.4 ± 4.92^{a}	58.7 ± 6.46^{ab}	72.0 ± 7.59^{c}	64.1 ± 7.08^{b}
2007	46.7 ± 4.95^{a}	48.1 ± 5.97^{a}	70.5 ± 7.89^{b}	66.5 ± 6.51^{c}

^{a,b,c,d}Values in a row with the same superscript did not differ significantly (P>0.05)

A combination of energy and crude protein (similar to that used in this study) provided during spring lambing seasons to Merino and Dorper ewes at the Glen AI, reduced their body weight loss by 50% and lamb growth rate was improved markedly (De Waal, 1989). However, the body weight of the Merino ewes in Treatments SL-V(C) and SL-V&S show a significant difference in only three of the nine years (Table 4.3).

The body weight of the Merino ewes in Treatments SL-R&V and AL-O&V at lambing differs significantly in all years from each other, except 2004. The body weight of the Merino ewes in Treatment SL-R&V was significantly higher than all other treatments at lambing (Table 4.3).

4.4 Body weight of the Merino ewes at weaning

The body weight of the ewes in Treatment SL-V(C) at weaning ranged from 47.3 kg to 58.1 kg (average = 53.6 kg), in Treatment SL-V&S from 51.6 kg to 59.8 kg (average = 55.2 kg), in Treatment SL-R&V from 61.7 to 73.3 kg (average = 66.3 kg) and in Treatment AL-O&V from 57.5 kg to 74.4 kg (average = 64.3 kg) (Table 4.4).

Table 4.4 ANOVA for annual body weight (average ± s.d.) of the Merino ewes at weaning in the four treatment flocks from 1999 to 2007 at the Glen AI

	Ewe weight at weaning			
	SL-V(C)	SL-V&S	SL-R&V	AL-O&V
Years	kg			
1999	55.0 ± 5.04^{a}	55.0 ± 6.08^{a}	65.1 ± 7.97^{b}	58.7 ± 5.51^{c}
2000	53.0 ± 5.63^{a}	54.8 ± 5.63^{a}	68.6 ± 7.33^{b}	57.5 ± 5.82^{c}
2001	47.3 ± 5.66^{a}	51.6 ± 6.21^{b}	65.3 ± 6.86^{c}	62.6 ± 4.93^{d}
2002	54.5 ± 4.55^{a}	55.5 ± 4.91^{a}	73.3 ± 8.05^{b}	57.8 ± 5.54^{c}
2003	53.9 ± 3.59^{a}	51.7 ± 5.51^{a}	67.1 ± 6.38^{b}	61.9 ± 7.44^{c}
2004	53.0 ± 3.90^{a}	56.8 ± 4.16^{a}	64.4 ± 8.90^{b}	68.8 ± 9.15^{c}
2005	55.3 ± 8.81^{a}	56.5 ± 5.50^{a}	68.2 ± 7.32^{b}	64.8 ± 7.63^{b}
2006	52.3 ± 5.95^{a}	55.5 ± 5.92^{a}	62.6 ± 7.17^{b}	72.1 ± 7.28^{c}
2007	58.1 ± 5.42^{a}	59.8 ± 5.80^{a}	61.7 ± 7.56^{a}	74.4 ± 7.34^{b}

[a,b,c,d]Values in a row with the same superscript did not differ significantly (P>0.05)

Some of the relatively large increases in body weight of Merino ewes from lambing until weaning (Tables 4.3 and 4.4), can be ascribed to the loss of lambs due to predation and the resulting positive response by the non-lactating ewes to better nutrition.

As indicated in section 2.2.1 a production lick was provided from about six weeks before the ewes started lambing (beginning of August) until about six weeks after all the ewes have lambed. Providing supplementary feeding did not improve the weight of the Merino ewes weight significantly in Treatment SL-V&S compared to Treatment SL-V(C), 110 days after lambing. Although the body weight of these Treatments on veld differed significantly in 2001, it was mainly due to an increase of 21% in younger ewes (two to three years old) with a lower body weight in Treatment SL-V(C) compared to Treatment SL-V&S. The body weight of the Merino ewes in Treatment SL-R&V was significantly higher than all other Treatments at weaning (Table 4.4) except for 2004, 2006 and 2007.

4.5 Birth weight of the Merino lambs

The average birth weight of the Merino lambs in the four treatment flocks are presented in Table 4.5. On a flock basis the birth weight of the Merino lambs in the four treatments was very similar.

Fewer twin lambs were born since 2003 in Treatments SL-V(C) and SL-V&S, with no twins born in either of these Treatments during 2004, 2005 and 2007. Single born lambs normally weigh heavier than twins, therefore, the average weight of the lambs did not differ significantly in years 2005 to 2007. Only in 2003 the average birth weight of Treatment SL-V&S differed significantly from Treatment SL-R&V. Treatments SL-V(C) and SL-V&S differ significantly in 1999, 2000 and 2002 (Table 4.5). In 1999 and 2002 below average rainfall was recorded (Table 3.1). Treatment SL-V&S could therefore have benefited from the supplementary feeding provided in these years.

According to Van der Westhuizen (2006) enough material for animal production had to be produced in autumn on veld to ensure enough carry-over material for the period from May until October. Below average rainfall was recorded during 2003 until 2005, but sufficient rainfall was recorded from January to April in these years to ensure enough material in spring when Treatments SL-V(C) and SL-V&S started lambing (Table 3.1). The average birth weight of Treatments SL-V(C) and SL-V&S did not differ significantly during 2003 until 2005. In 2006 above average rainfall was recorded and the supplementary feeding had no effect on birth weight in Treatment SL-V&S and, therefore, the average birth weight in Treatments SL-V(C) and SL-V&S did not differ significantly.

Protein supplementary feeding was given at 16 different localities (13 sheep, 3 Angora goat) for a four-year period, representative of the different small stock grazing areas of South Africa, to include as much as possible of South Africa's diverse vegetation. During years with lower rainfall and poorer grazing conditions, the provision of supplementary feeding to small stock during late pregnancy and lactation, improved production substantially, compared to ewes not supplemented. In regions with a sour grass veld type such as Noupoort, Cedarville and Ermelo, supplementation was economically viable compared to animals under mixed grass/shrub veld conditions (Hoon & Herselman, 2007).

In 2002 (see section 4.2) the Merino ewes in Treatments SL-V(C) and SL-V&S were kraaled and the supplementary feeding in Treatment SL-V&S had a significant effect on birth weight (Table 4.5).

Table 4.5 ANOVA for annual birth weight (average ± s.d.) of the Merino lambs in the four treatment flocks from 1999 to 2007 at the Glen AI (1 - single lambs; 2 - twins)

			Birth weight			
			SL-V(C)	SL-V&S	SL-R&V	AL-O&V
Year			kg			
1999	1	Ewe	4.4 ± 1.02	4.9 ± 1.07	5.1 ± 1.00	4.9 ± 0.67
		Ram	4.7 ± 1.01	4.9 ± 1.11	5.1 ± 1.20	4.7 ± 0.92
	2	Ewe	3.5 ± 0.75	4.5 ± 0.50	4.9 ± 0.70	3.2 ± 0.68
		Ram	3.7 ± 0.45	4.7 ± 0.89	5.2 ± 0.68	3.7 ± 1.22
	Average		4.4 ± 1.00[a]	4.9 ± 1.04[b]	5.0 ± 0.07[b]	4.4 ± 1.02[a]
2000	1	Ewe	4.6 ± 0.84	5.1 ± 0.82	5.2 ± 0.92	5.3 ± 1.23
		Ram	5.1 ± 0.98	5.6 ± 0.74	5.4 ± 1.18	5.4 ± 1.09
	2	Ewe	3.8 ± 0.42	3.9 ± 0.12	4.7 ± 0.81	3.8 ± 0.38
		Ram	3.8 ± 0.54	4.0 ± 0.58	4.8 ± 0.74	4.6 ± 0.70
	Average		4.6 ± 0.95[a]	5.2 ± 0.89[b]	5.1 ± 1.00[b]	4.9 ± 1.12[ab]
2001	1	Ewe	5.6 ± 1.07	5.6 ± 0.77	5.8 ± 1.17	5.2 ± 1.06
		Ram	5.7 ± 0.92	5.8 ± 0.95	5.6 ± 0.79	5.6 ± 1.09
	2	Ewe	4.6 ± 0.53	4.4 ± 0.25	5.0 ± 0.78	4.5 ± 0.76
		Ram	5.5 ± 0.58	4.9 ± 0.54	5.5 ± 0.93	5.0 ± 0.75
	Average		5.6 ± 0.96[a]	5.5 ± 0.88[a]	5.4 ± 0.97[a]	4.9 ± 0.94[b]
2002	1	Ewe	4.6 ± 0.59	5.3 ± 0.80	5.6 ± 1.10	4.7 ± 1.28
		Ram	5.1 ± 0.94	5.7 ± 1.15	5.7 ± 1.29	5.0 ± 1.28
	2	Ewe	3.6 ± 0.28	4.7 ± 0.00	4.8 ± 0.77	2.8 ± 0.72
		Ram	4.4 ± 0.71	4.7 ± 0.59	5.1 ± 0.91	3.7 ± 1.04
	Average		4.7 ± 0.85[a]	5.4 ± 1.00[b]	5.3 ± 1.10[b]	4.3 ± 1.40[a]
2003	1	Ewe	4.1 ± 0.72	3.9 ± 0.69	5.7 ± 1.36	6.4 ± 0.82
		Ram	4.4 ± 0.69	4.4 ± 0.83	5.8 ± 1.16	6.2 ± 1.33
	2	Ewe	0.0 ± 0.00	3.2 ± 0.47	4.9 ± 0.97	5.8 ± 0.87
		Ram	0.0 ± 0.00	2.9 ± 0.85	5.1 ± 1.05	6.0 ± 0.83
	Average		4.3 ± 0.71[a]	4.0 ± 0.83[a]	5.2 ± 1.12[b]	6.1 ± 0.99[c]
2004	1	Ewe	5.2 ± 0.98	4.9 ± 0.46	4.6 ± 1.14	5.5 ± 1.05
		Ram	4.7 ± 0.70	4.2 ± 0.68	5.2 ± 0.77	5.6 ± 0.74
	2	Ewe	0.0 ± 0.00	0.0 ± 0.00	4.5 ± 0.96	4.2 ± 0.76
		Ram	0.0 ± 0.00	0.0 ± 0.00	4.8 ± 0.89	4.2 ± 0.78
	Average		4.9 ± 0.83[ab]	4.6 ± 0.65[ab]	4.7 ± 0.95[ab]	5.2 ± 1.03[a]
2005	1	Ewe	4.9 ± 0.97	5.0 ± 1.42	5.2 ± 0.63	5.6 ± 1.09
		Ram	4.9 ± 0.78	5.4 ± 1.56	5.5 ± 0.66	5.4 ± 0.96
	2	Ewe	0.0 ± 0.00	0.0 ± 0.00	4.2 ± 1.06	4.6 ± 1.03
		Ram	0.0 ± 0.00	0.0 ± 0.00	4.8 ± 0.65	4.8 ± 0.74
	Average		4.9 ± 0.87[a]	5.1 ± 1.43[a]	4.8 ± 0.93[a]	4.9 ± 1.02[a]
2006	1	Ewe	5.2 ± 0.58	5.1 ± 1.49	5.5 ± 0.83	5.3 ± 1.44
		Ram	4.9 ± 1.12	6.1 ± 0.83	6.0 ± 0.59	6.0 ± 1.15
	2	Ewe	3.3 ± 0.00	4.1 ± 0.93	4.8 ± 0.67	4.0 ± 1.45
		Ram	3.8 ± 0.82	4.0 ± 0.89	5.3 ± 0.83	4.7 ± 0.84
	Average		4.7 ± 1.08[a]	5.1 ± 1.30[a]	5.3 ± 0.84[a]	5.1 ± 1.44[a]
2007	1	Ewe	5.4 ± 1.08	0.0 ± 0.00	5.7 ± 0.96	5.7 ± 0.81
		Ram	5.7 ± 0.50	4.0 ± 0.00	5.8 ± 0.99	6.1 ± 0.86
	2	Ewe	0.0 ± 0.00	0.0 ± 0.00	5.5 ± 1.02	4.9 ± 0.71
		Ram	0.0 ± 0.00	0.0 ± 0.00	5.6 ± 0.92	4.7 ± 0.61
	Average		5.5 ± 0.96[a]	4.0 ± 0.00[a]	5.7 ± 0.97[a]	5.3 ± 0.91[a]

[a,b] Values in a row with the same superscript did not differ significantly (P>0.05)

4.6 Weaning weight of the Merino lambs

The Merino lambs were weaned at an age of about 110 days (see 2.3.4). It is obvious that the lambs performed quite differently in the four Merino flocks (Table 4.6), ranging from an average weight of 23.2 kg for Treatment SL-V(C) to 34.8 kg for Treatment AL-O&V. Furthermore, the average weaning weight shows considerable variations between years. However, the sheep flocks at the Glen AI were severely impacted by predation. Therefore, the weaning weight of the lambs reflects the situation after the numbers of the lambs in the different flocks have been reduced to various degrees mainly by predators.

Table 4.6 Average weaning weight of the Merino lambs in the four treatment flocks from 1999 to 2007 at the Glen AI

	Weaning weight			
	SL-V(C)	SL-V&S	SL-R&V	AL-O&V
Years	kg			
1999	25.8	26.8	28.3	36.4
2000	24.5	26.1	28.5	37.4
2001	23.6	26.2	29.0	36.9
2002	25.2	25.1	32.7	35.1
2003	22.2	25.5	32.3	29.7
2004	19.9	20.2	28.1	31.7
2005	20.3	28.9	29.4	36.6
2006	25.0	27.5	29.1	34.3
2007	22.0	26.5	30.0	35.0
Average	23.2	25.9	29.7	34.8

The data in Table 4.6 were not statistically analysed. Therefore, the data do not reveal the inherent bias introduced because of differences in the distribution of the sexes (ram versus ewe lambs) and birth status (single versus twins).

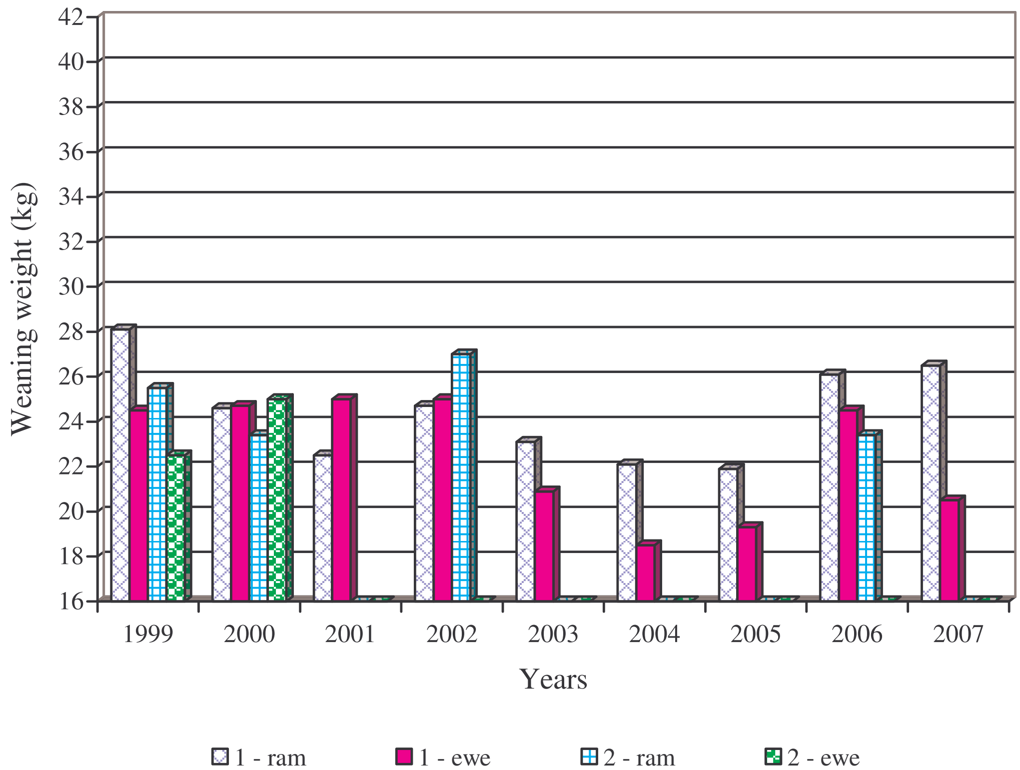

Figure 4.1 Annual weaning weight of Merino ram and ewe lambs with different birth status in Treatment SL-V(C) at the Glen AI (1 - single lambs; 2 – twins).

Only in 2002 a higher weaning weight for Treatment SL-V(C) was recorded compared to Treatment SL-V&S (Table 4.6). In this year, five twin ram lambs with a higher weaning weight than the single lambs contributed to the higher weaning weight (Figure 4.1). Twin lambs usually weigh less than single lambs and have an effect on the average weaning weight of lambs (De Waal & Combrinck, 2000). Although twin lambs were weaned in three other years (Figure 4.2), the weaned weight of these twin born lambs, had no marked influence on the weaned weight in that year.

In 2005 the average weaning weight for the lambs in Treatment SL-V(C) was 8.6 kg less than the average weaning weight for the lambs in Treatment SL-V&S (Table 4.6). More single ewe lambs were weaned in Treatment SL-V(C) (Figure 4.2) with a low average weaning weight of 19.3 kg (Figure 4.1). This contributed to the 8.6 kg difference in weaning weight in 2005 for Treatments SL-V(C) and SL-V&S.

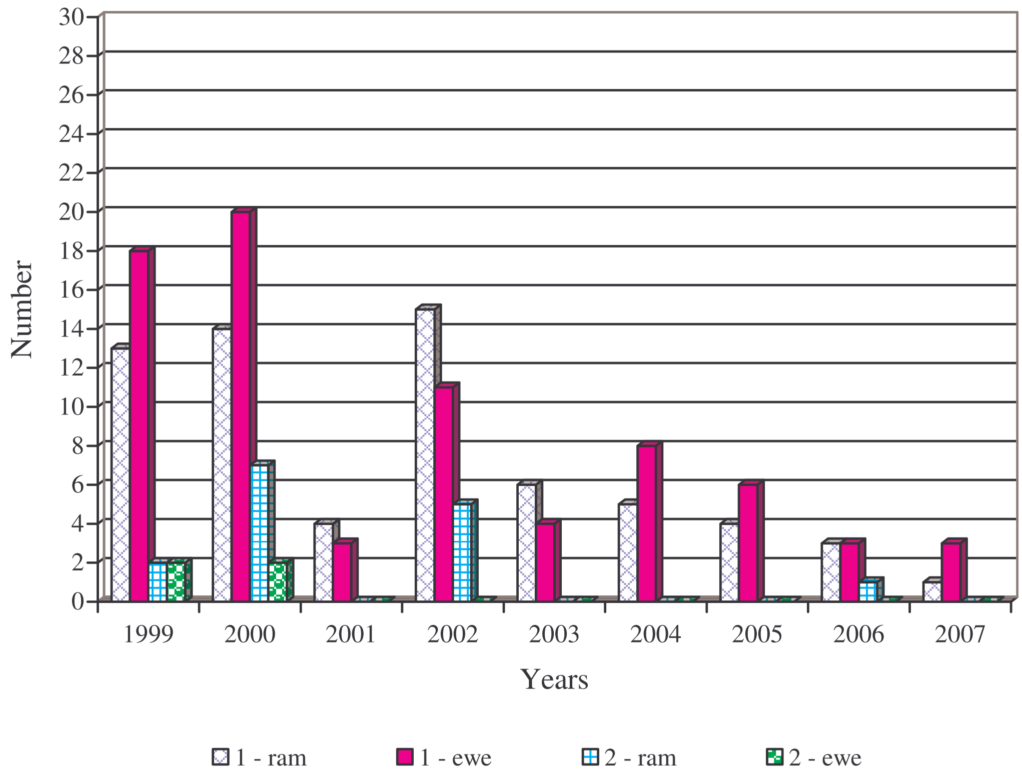

Figure 4.2 The number of Merino ram and ewe lambs with different birth status in Treatment SL-V(C) over a period of nine years at the Glen AI (1 - single lambs; 2 - twins).

In 1999, 2000 and 2002 the average weaning weight for Merino lambs in Treatments SL-V(C) and SL-V&S did not differ more than 1.6 kg (Table 4.6). In these years a total number of 109 lambs were weaned in Treatment SL-V(C), compared to a total of only 51 lambs weaned in this Treatment in all other years (Figure 4.2). In 1999, 2000 and 2002 a total number of 135 lambs were weaned in Treatment SL-V&S compared to only 71 lambs weaned in this Treatment in all other years (Figure 4.3). The larger target population in 1999, 2000 and 2002 minimized the effect of the differences in the distribution of number of lambs weaned and weaned weight between the sexes (ram versus ewe lambs) and birth status (single versus twins).

Below average weaning weight were recorded in 2003, 2004, 2005 and 2007 in Treatment SL-V(C) (Table 4.6). Below average rainfall were also recorded for the respective years (Table 3.1). Furthermore, "secured" lamb camps against predators were utilized each year during the active growing season of the veld. These two factors namely rainfall and availability of soft good quality herbage for the lambs also influenced the weaning weight of the lambs in Treatment SL-V(C) during 2003, 2004, 2005 and 2007.

In Figure 4.4 it is evident that the highest weaning weight was recorded for single lambs and twins in all years, except for the single ewe lambs in 2007.

Although the Merino ewes with their lambs in Treatments SL-V(C) and SL-V&S were kraaled in 2007, there was no increase in the number of lambs weaned, due to fewer ewes being available for mating (Figure 3.12).

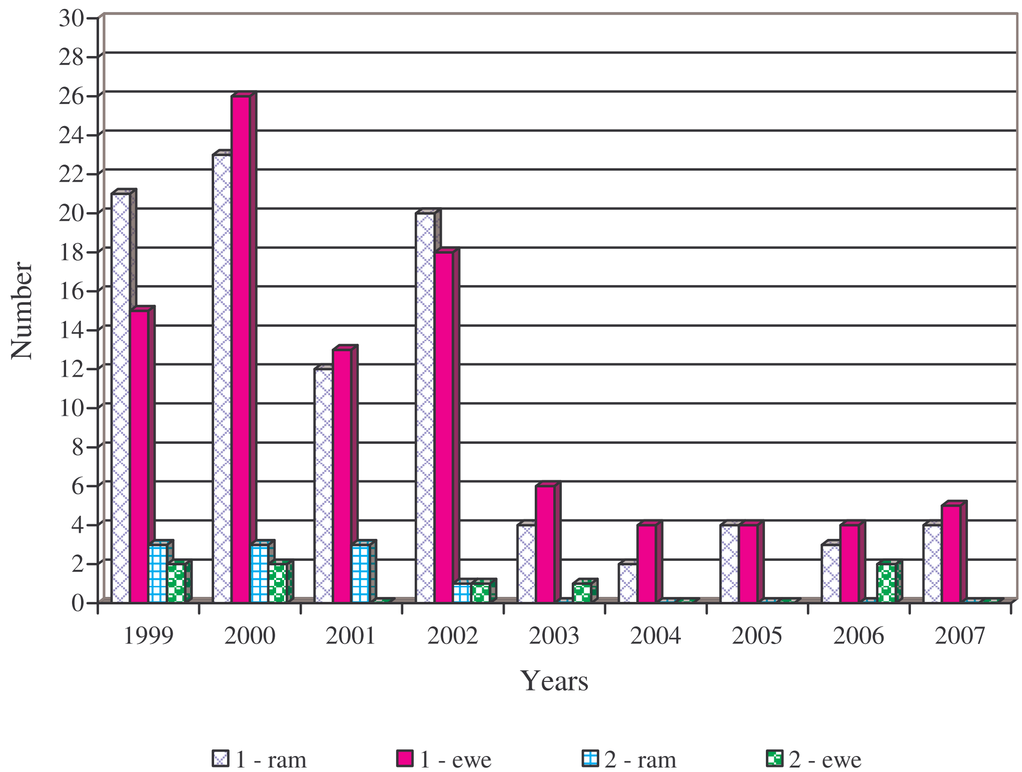

Figure 4.3 The number of Merino ram and ewe lambs with different birth status in Treatment SL-V&S over a period of nine years at the Glen AI (1 - single lambs; 2 - twins).

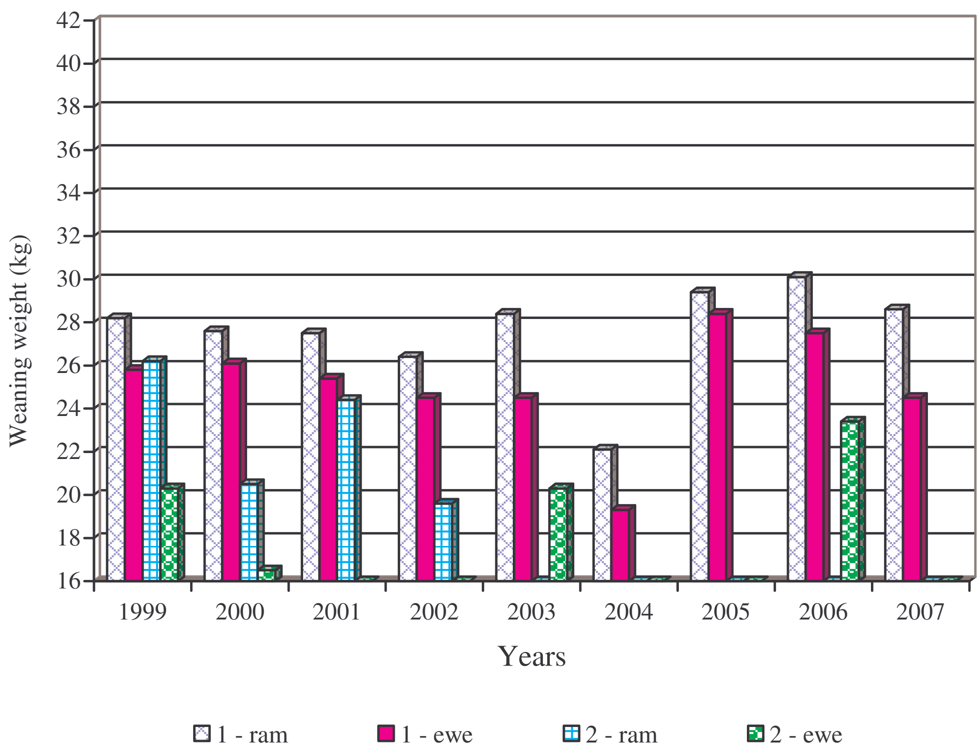

Figure 4.4 Annual weaning weight of Merino ram and ewe lambs with different birth status in Treatment SL-V&S at the Glen AI (1 - single lambs; 2 - twins).

As a result of a smaller target population in 2001, 2003, 2004, 2005, 2006 and 2007, no significant deductions can be made from the weaning weight for Treatments SL-V(C) and SL-V&S, displayed in Table 4.6.

The effect of predation can clearly be seen in both Treatments SL-V(C) and SL-V&S, especially from 2003 to 2007 (Figures 4.2 & 4.3). This resulted in the decrease in the number of replacement ewes. Since 2003 a non-lethal strategy was followed to reduce the impact of predation on the veld groups, with minimum lethal methods.

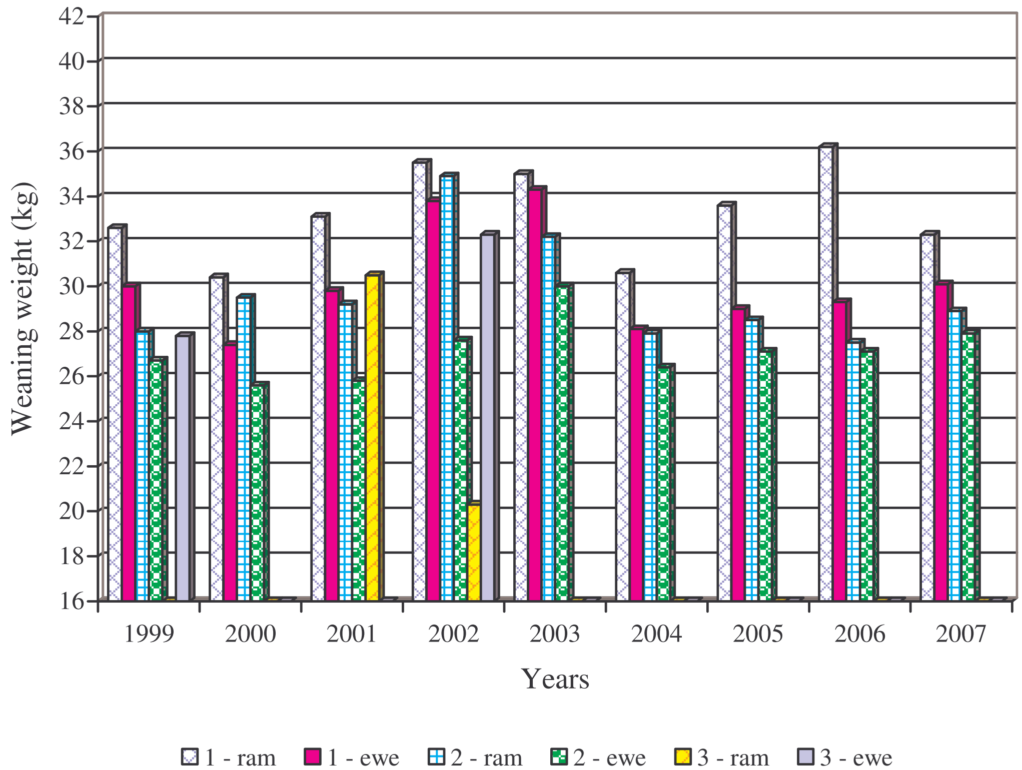

Figure 4.5 Annual weaning weight of Merino ram and ewe lambs with different birth status in Treatment SL-R&V at the Glen AI (1 - single lambs; 2 - twins; 3 - triplets).

There is a small difference between the weaning weight of the single lambs versus the twin lambs in Treatment SL-R&V (Figure 4.5), however, the average weaning weight was influenced due to the fact that many twins were weaned in each year (Figure 4.6).

Only during 1999, 2001 and 2002 triplets were weaned (Figure 4.6). Due to the fact that a small number of triplets were weaned, it had no marked effect on the average weaning weight (Figure 4.5).

The management of the rye-grass (grazing frequency, fertilization and irrigation) had a great impact on the production of the rye-grass and therefore the weaning weight of the lambs in Treatment SL-R&V (Theron, 1994). More plant material was available, especially during October, which could not be utilized by the 70 ewes and their lambs. If irrigation scheduling was interrupted as in 2004 (see section 3.5) the production cycle of the rye-grass is shorter and palatability decreased. At the time when the lambs in Treatment SL-R&V are more dependent on grazing material than on the ewes' milk in November, the rye-grass is less palatable, ending with lower weaning weight in December.

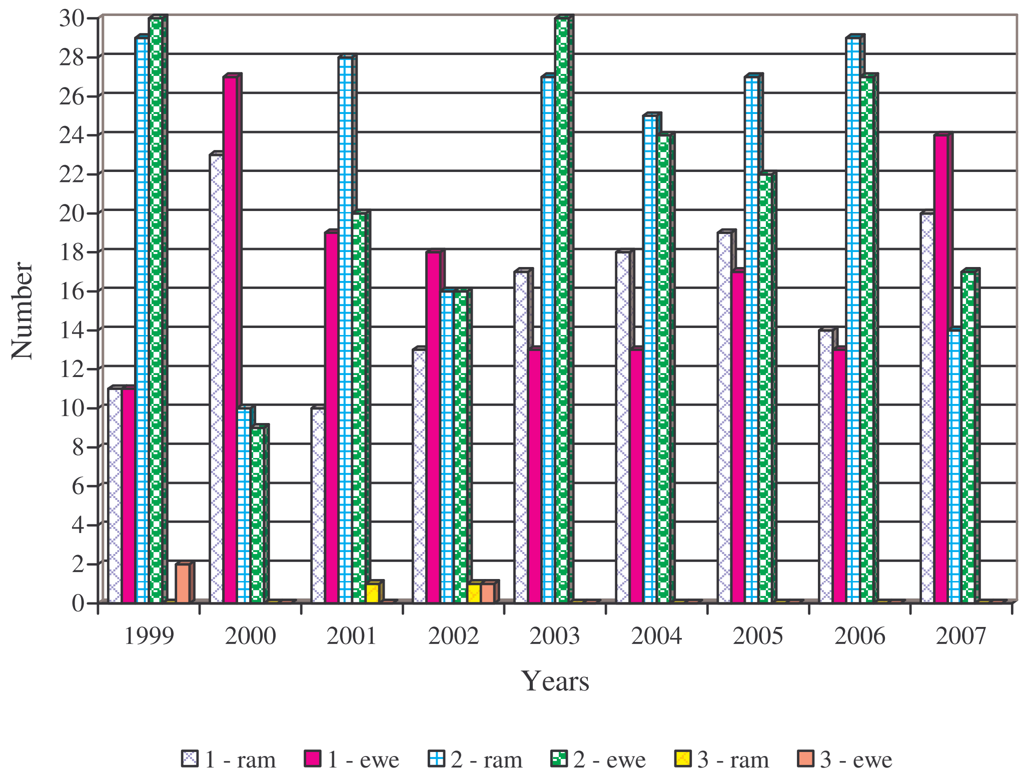

Figure 4.6 The number of Merino ram and ewe lambs with different birth status in Treatment SL-R&V over a period of nine years at the Glen AI (1 - single lambs; 2 - twins; 3 - triplets).

If more ewe twin lambs were weaned (1999 & 2003) (Figure 4.6) there was a greater chance that more of these ewes would survive especially predator attacks until they were mated 18 months later. These ewe twin lambs contributed to a higher fecundity in their reproduction cycle.

Only during 2000 and 2007 more single ram and ewe lambs were weaned compared to twin ram and ewe lambs.

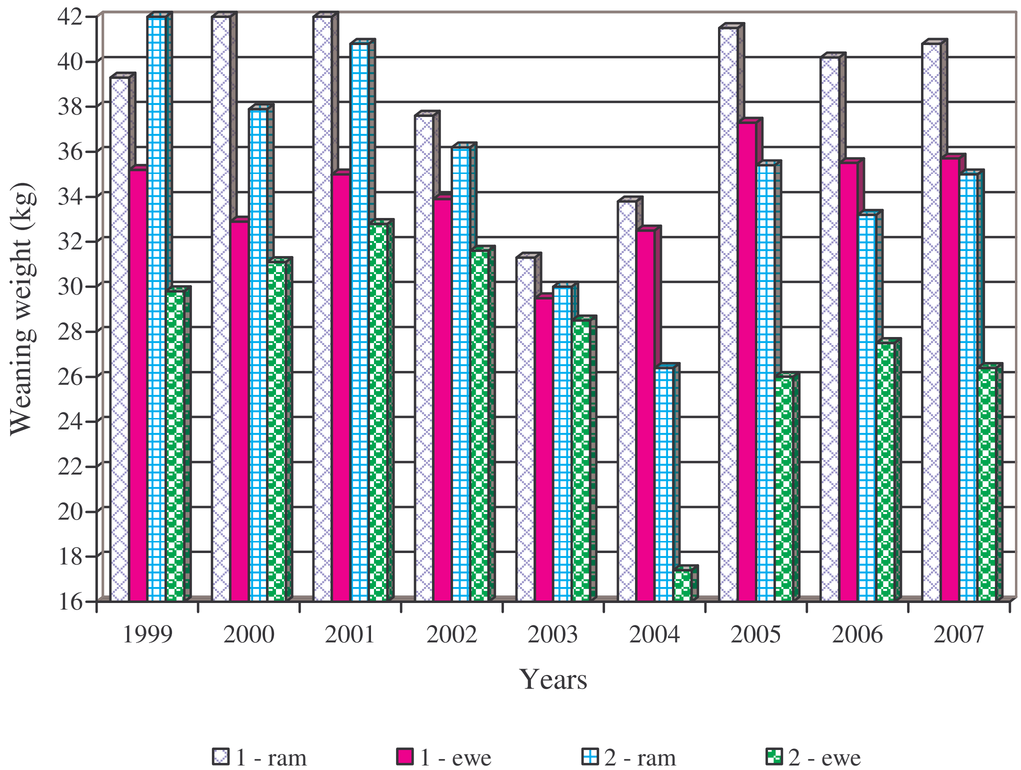

Figure 4.7 Annual weaning weight of Merino ram and ewe lambs with different birth status in Treatment AL-O&V at the Glen AI (1 - single lambs; 2 - twins).

In 2003, the lowest average weaning weight (29.7 kg) was recorded for Merino lambs in Treatment AL-O&V (Table 4.6; Figure 4.7). More ewe twin lambs, compared to twin ram lambs or single ewe and ram lambs were weaned during this year (Figure 4.8). This was also the second highest number of ewe twin lambs weaned than in any other year (Figure 4.8). Therefore, the average weaned weight decreased in 2003 because of the large number of ewe twin lambs with a lower weaning weight. Poor oats pastures, due to only 45 mm of rainfall (Table 3.1) from April until September 2003, also influenced the weaning weight negatively in this year (Table 4.6). More twin ewe lambs were weaned in 2001 (Figure 4.8), but better oats pastures due to above average rainfall in March, April, August and September (Table 3.1), resulted in the highest weaning weight of twin ewe lambs in all years (Figure 4.7).

During 2000 the highest average weaning weight (37.4 kg) was recorded for the Merino lambs in Treatment AL-O&V (Table 4.6). The highest number of single ram lambs was weaned with a high weaning weight which contributed highly to this high weaning weight.

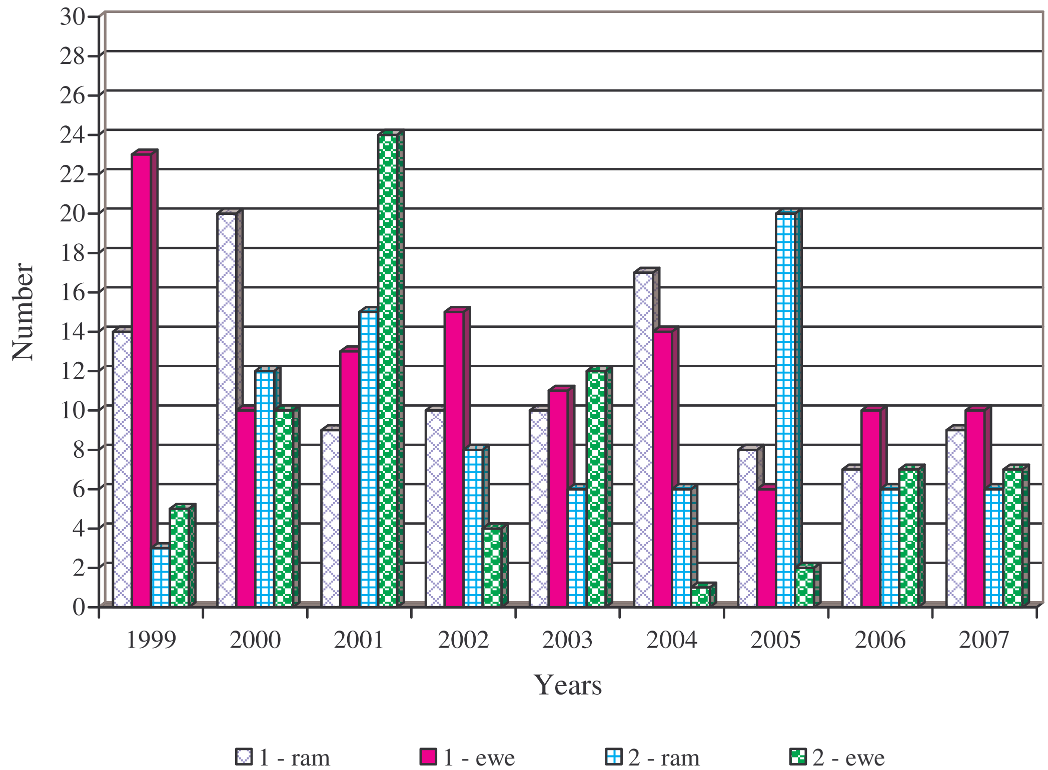

Figure 4.8 The number of Merino ram and ewe lambs with different birth status in Treatment AL-O&V over a period of nine years at the Glen AI (1 - single lambs; 2 - twins).

Due to the fact that the Merino lambs in Treatments SL-R&V and AL-O&V were not exposed to predation, more lambs were weaned (Figures 4.6 and 4.8). In 2005 losses occurred due to predation when the Merino ewe and their lambs in Treatment AL-O&V were on veld, due to poor oats pastures (see section 3.5)(Figure 4.8). However, the weaning weight was not influenced due to this (Figure 4.7). The ewes were mostly effected due to the time spend grazing veld before their lambs were weaned. During 2005 the biggest weight loss (5.5 kg) in all years was recorded from lambing (Table 4.3) until weaning (Table 4.4) for the ewes in Treatment AL-O&V.

The Glen Dorper flock was founded in 1982 and during the first 16 years the Dorpers grazed veld with all year access only to a salt (NaCl) lick (De Waal & Combrinck, 2000). After being exposed to teaser rams for 14 days, the Dorper ewes were mated for a period of 34 days during April/May (autumn) to lamb during October/November (spring/early summer).

During the 16-year period fecundity of the ewes differed between years, varying between 112% and 145% with a mean of 128%.

According to De Waal and Combrinck (2000), the body weight of Dorper lambs at weaning reflects their own ability to ingest sufficient nutrients from veld to a greater extent than the presence of the milk yield of their dams at that time. Furthermore the effect of variation in rainfall on availability and quality of herbage on offer plays a huge role in terms of lamb growth (De Waal & Combrinck, 2000).

5. The impact of predation on the Merino and Dorper flocks at the Glen Agricultural Institute

As previously discussed (see section 2.2), four Merino flocks collectively formed the Free State Wool Sheep Project at the Glen AI. The four Merino flocks were subjected to the following production system treatments:

- Treatment SL-V(C) **S**pring **L**ambing season on **V**eld with a salt (NaCl) lick only (**C**ontrol)
- Treatment SL-V&S **S**pring **L**ambing season on **V**eld with **S**upplementary feeding[1]
- Treatment SL-R&V **S**pring **L**ambing season on irrigated **R**ye-grass (*Lolium multiflorum* and *L. perenne*) and **V**eld
- Treatment AL-O&V **A**utumn **L**ambing season on **O**ats (*Avena sativa*) pasture in winter and **V**eld in summer and spring

In the context of this study the sheep enterprise at the Glen AI refers to the four Merino flocks (comprising the Free State Wool Sheep Project) as well as a Merino flock maintained specifically for shearing purposes (Merino shearing flock) and a Dorper flock. The latter two flocks were, similar to Treatments SL-V(C) and SL-V&S above, maintained on veld.

5.1 Lambs born and lambs lost before weaning

Accurate records are kept of all lambs born and sheep losses at the Glen AI. In addition to the common sheep mortalities ascribed to diseases, the sheep flocks at the Glen AI are impacted by predation.

The number of lambs born and the number of lambs lost before weaning to predators and other causes for the Merino flocks in Treatments SL-V(C) and SL-V&S over a period of nine years are shown in Tables 5.1 and 5.2. The veld camps allocated to these two Merino flocks

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[1] A mixture of 40% Voermol Maxiwol, 49% maize meal, 10% salt (NaCl) and 1% feed lime. Maxiwol contains (g/kg) 350 g crude protein, 100 g fibre, 160 g moisture, 12.2 g calcium, 3.6 g phosphorus, 6.7 g sulphur, 200 mg manganese, 30 mg copper, 1 mg cobalt, 150 mg iron, 6 mg iodine, 240 mg zinc and 1 mg selenium.

were not far apart from each other and, except for the supplementary feeding, similar conditions applied to both Merino flocks.

In these two flocks [Treatments SL-V(C) and SL-V&S] the largest number of annual lamb losses (mean > 66%) is attributed to predation (Tables 5.1 and 5.2). This accounts for the relative percentage of lambs taken by predators in both flocks being 39.1% of the total number born. The predators implicated for causing these losses are black-backed jackal, caracal and vagrant dogs (see section 5.3).

Table 5.1 The number of lambs born and the number of lambs lost before weaning to predation and other causes for the Merino flock in Treatment SL-V(C) over a period of nine years at the Glen AI

	Merino flock in Treatment SL-V(C)[1]					
	Lambs born	Total losses	Lost to predators		Lost to other causes	
Year			n	%	n	%
1999	56	21	13	61.9	8	38.1
2000	66	23	18	78.3	5	21.7
2001	56	48	42	87.5	6	12.5
2002	38	6	3	50.0	3	50.0
2003	31	21	13	61.9	8	38.1
2004	22	9	9	100	0	0.0
2005	21	11	10	90.9	1	9.1
2006	15	8	7	87.5	1	12.5
2007	15	11	10	90.9	1	9.1
Total	320	158	125	79.1	33	20.9

[1] **S**pring **L**ambing season on **V**eld with a salt (NaCl) lick only (**C**ontrol)

It should be noted that some lambs may have been scavenged after death and not predated. Usually only parts of these small carcasses were found, making it difficult to ascertain whether it was in fact predated. This applies to all relevant tables in this section.

The practice of kraaling the two Merino flocks in Treatments SL-V&S and SL-V(C) at night in 2002 seems to have resulted in an immediate decrease in the number of losses due to predation, but no lasting effect was evident (see later, Figures 5.1 and 5.2).

None of the lambs born to ewes in Treatment SL-R&V were lost to predation (Table 5.3). The rye-grass lands grazed by this flock are situated on the Glen campus which provided some measure of security for these sheep because of its close proximity to staff houses and the surrounding crop and pasture trials. Although not shown in Table 5.3, the mortalities in 2000 and 2002 were mainly due to still born lambs. The ewes in Treatment SL-R&V grazed rye-grass pasture for the duration of pregnancy. The good quality of the rye-grass promoted rapid *in utero* development of fetuses. The average weight at birth for lambs in Treatment SL-R&V was 5.1 kg. Lamb weights at birth as high as 7 kg was recorded. This makes the lambing process very difficult, especially for younger ewes, often resulting in the loss of lambs. Other mortalities were caused as a result of ewes with blue udder or ewes that did not produce enough milk.

Table 5.2 The number of lambs born and the number of lambs lost before weaning to predation and other causes for the Merino flock in Treatment SL-V&S over a period of nine years at the Glen AI

	Merino flock in Treatment SL-V&S[1]					
	Lambs born	Total losses	Lost to predators		Lost to other causes	
Year			n	%	n	%
1999	64	23	8	34.8	15	65.2
2000	72	34	19	55.9	15	47.1
2001	61	33	27	81.8	6	18.2
2002	53	13	11	84.6	2	15.4
2003	48	29	13	44.8	16	55.2
2004	18	12	12	100.0	0	0.0
2005	15	7	6	85.7	1	14.3
2006	19	10	9	90.0	1	10.0
2007	16	7	6	85.7	1	14.3
Total	366	168	111	66.1	57	33.9

[1] **S**pring **L**ambing season on **V**eld with **S**upplementary feeding

The oats pastures grazed by the ewes in Treatment AL-O&V (Table 5.4) are secured with electric fencing and thus not exposed to predators. Nevertheless, in 2003 and 2005 several lambs born to Merino ewes in Treatment AL-O&V were killed by predators. In both years, a few ewes and their lambs were removed temporarily to the veld where lambs were caught by black-backed jackal before they could be returned to the flock on the oats pasture.

Table 5.3 The number of lambs born and the number of lambs lost before weaning to predation and other causes for the Merino flock in Treatment SL-R&V over a period of nine years at the Glen AI

	Merino flock in Treatment SL-R&V[1]					
	Lambs born	Total losses	Lost to predators		Lost to other causes	
Year			n	%	n	%
1999	119	28			28	100
2000	92	23			23	100
2001	105	19			19	100
2002	94	28			28	100
2003	105	18	0	0	18	100
2004	99	19			19	100
2005	98	13			13	100
2006	93	10			10	100
2007	85	9			9	100
Total	890	167	0	0	167	100

[1] **S**pring **L**ambing season on irrigated **R**ye-grass (*Lolium multiflorum* and *L. perenne*) and **V**eld

Table 5.4 The number of lambs born and the number of lambs lost before weaning to predation and other causes for the Merino flock in Treatment AL-O&V over a period of nine years at the Glen AI

	Merino flock in Treatment AL-O&V[1]					
	Lambs born	Total losses	Lost to predators		Lost to other causes	
Year			n	%	n	%
1999	58	13	0	0.0	13	100
2000	72	17	0	0.0	17	100
2001	81	30	0	0.0	30	100
2002	48	11	0	0.0	11	100
2003	52	13	2	15.4	11	84.6
2004	50	12	0	0.0	12	100
2005	64	28	13	46.4	15	53.6
2006	39	9	0	0.0	9	100
2007	41	9	0	0.0	9	100
Total	505	142	15	10.6	127	100

[1] **A**utumn **L**ambing season on **O**ats (*Avena sativa*) pasture in winter and **V**eld in summer and spring

Losses due to predators were high among the lambs in the Merino shearing flock (Table 5.5) that were also kept on veld. In 2007 the Merino shearing flock was moved to an area secured with electrical fencing, thus protected from predators, and no further losses to predators occurred.

Table 5.5 The number of lambs born and the number of lambs lost before weaning to predation and other causes for the Merino shearing flock over a period of five years at the Glen AI

	Merino shearing flock[1]					
	Lambs born	Total losses	Lost to predators		Lost to other causes	
Year			n	%	n	%
2003	53	31	31	100	0	0.0
2004	19	8	5	62.5	3	37.5
2005	67	39	39	100	0	0.0
2006	16	8	8	100	0	0.0
2007	25	5	0	0.0	5	100
Total	180	91	83	91.2	8	8.8

[1] This flock was only supplemented when the need arose; effectively rendering treatment similar to the ewes in Treatment **S**pring **L**ambing season on **V**eld with **S**upplementary feeding.

The Dorper flock (Table 5.6) suffered the heaviest lamb losses due to predators (mean annual relative percentage loss was about 58.8%). The Dorper ewes were often separated from their lambs when they habitually crawled through fences, thus increasing the chances for predation, especially over weekends. During the week the straying Dorper ewes were noticed quickly and regularly brought back to the camp.

In 2007 the Dorper flock was grazing an area of veld secured by electric fencing resulting in a marked decrease in losses due to predation. By the time that the suckling lambs started grazing, feed shortages occurred on the veld. Supplementary feeding was fed to the Dorpers in the form of sun-dried lucerne (provided by the lucerne trials at Glen AI).

The lucerne was cut on a monthly basis in a trial and had to be removed immediately after it was cut, because of irrigation scheduling. The lucerne was transported to a camp close to where the Dorpers grazed, where it was sun-dried and then fed to the Dorpers. However, some of the Dorper lambs crawled through the fences and ate some lucerne not yet properly dried, resulting in the animals getting bloated and died. Very soon the small camps in the electric fenced area were overgrazed. Lucerne became also less frequently available.

Therefore, as a result of these contributing factors the Dorper flock had to be moved to the veld again in 2007. These veld camps were outside the area secured by electric fencing and this procedure resulted in 18 Dorper lambs being caught by predators (Table 5.6).

Table 5.6 The number of lambs born and the number of lambs lost before weaning to predation and other causes for the Dorper flock over a period of five years at the Glen AI

	Dorper flock[1]					
	Lambs born	Total losses	Lost to predators		Lost to other causes	
Year			n	%	n	%
2003	193	113	111	98.2	2	1.8
2004	150	92	89	96.7	3	3.3
2005	158	113	101	89.4	12	10.6
2006	106	100	94	94.0	6	6.0
2007	75	32	18	56.2	14	43.8
Total	682	450	413	91.8	37	8.2

[1] The Dorper flock was managed similar to the Merino flock designated as Treatment **S**pring **L**ambing season on **V**eld with a salt (NaCl) lick only.

The total number of lambs born and lambs lost to predation and other causes in the six flocks (Merino and Dorper) over a period of five years at the Glen AI are presented in Figure 5.1.

The number of lambs that were born declined over time because fewer ewes were available annually for mating. The number of lambs caught by predators (as a percentage of the total number of lamb losses and mortalities) increased from 76% in 2003 to 81% in 2006. Predation expressed as a percentage of the total number of lambs born confirmed that the impact of predators increased from 2003 (relative percentage *ca*. 36%) to 2006 (relative percentage *ca*. 43%). The decreased losses due to predators in 2007 is a direct result of the practice of kraaling the Dorper flock at night and a partial but still incomplete protection of the Merino shearing flock behind electric fences.

It was difficult to determine which predator species was responsible for most of the killings before weaning because the lamb carcasses were mostly totally destroyed and only parts of the carcasses could be retrieved.

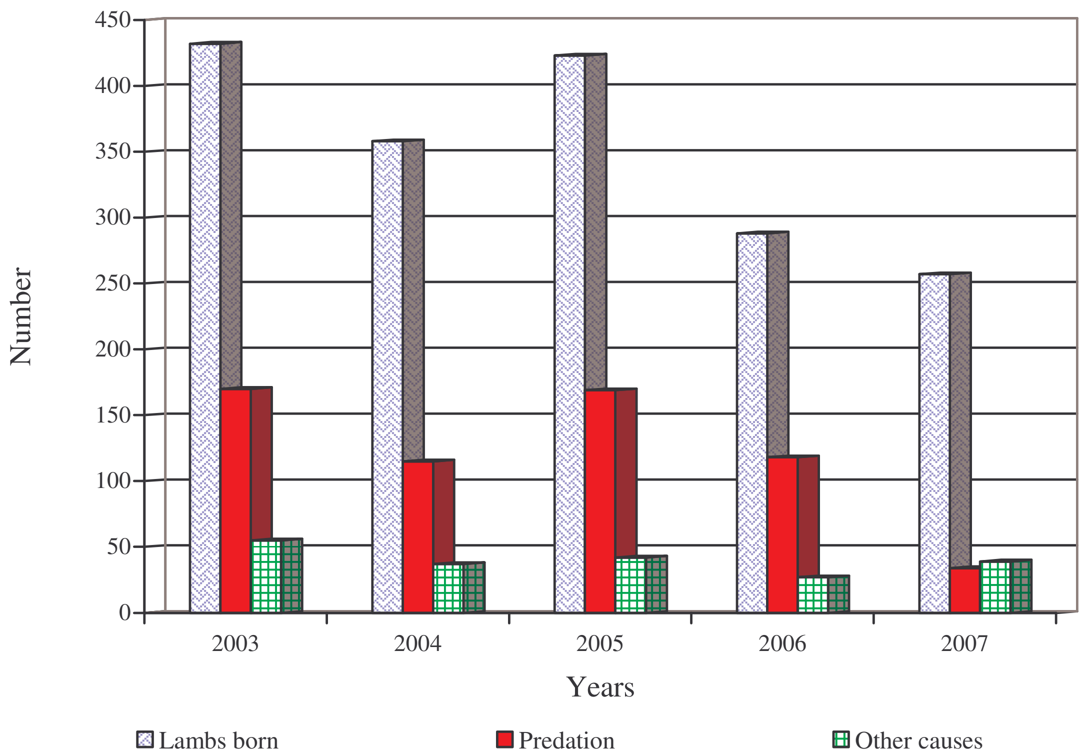

Figure 5.1 Number of lambs born and number of lambs lost to predation or other causes before weaning for all sheep flocks over a period of five years at the Glen AI.

5.2 Post-weaning losses and mortalities

Most of the annual sheep losses (expressed as losses after weaning, namely from lambs older than four months of age) was attributed to predation (Tables 5.7 and 5.8).

From 1999 to 2007, predators were responsible for 78% of all post-weaning Merino losses. The number of losses increased sharply from 1999 to 2002. In 2002 the number of lambs lost to predators in the Merino flocks in Treatments SL-V(C) and SL-V&S (Tables 5.1 and 5.2) were less due to the kraaling of the sheep at night. Consequently the mature Merino sheep that were not kraaled during this period suffered the most due to predation (Table 5.7).

Sheep mortalities due to accidents and diseases can be reduced by regular fence maintenance. Sheep often crawl under and through poorly maintained fences, resulting in sheep gaining access to maize lands causing mortalities by acidosis (a metabolic disorder, namely a sharp drop in the pH of the reticulo-rumen) or pulpy kidney (disease).

Less than 4.5% of all losses were ascribed to diseases. Most of these losses were ascribed to pulpy kidney (*Clostridium perfringens type D*). Losses were also ascribed to blue udder (*Gangreneuse mastitis*), Pasteurella (*Pasteurella haemolytica* and *P. multocida*), black quarter (*Clostridium chauvoei, C. septicum* and *C. novyi*) and blue tongue (spread by a *Culcicoides*-midge).

The mortalities as a result of accidents (less than 13% of all losses; Tables 5.7 and 5.8) were due to old ewes that experienced difficulties during lambing or died because of weakness. In this study, bloat was also classified as an accidental cause of death. If a sheep died over weekends a state veterinarian was not available to do a post mortem. On the Monday decomposition was already advanced, especially during warm summer months. By this time it was impractical to do a post mortem and establish the cause of death. These mortalities were recorded in the column designated as "Accident" in Tables 5.7 and 5.8.

To highlight the impact of predation, the data from Tables 5.7 and 5.8 have been combined and are presented in Figure 5.2. A steady increase in actual losses due to predators was observed from 1999 to 2002. Even as the number of these losses decreased after 2002, it was still very high with between 93 and 174 sheep killed by predators annually.

Table 5.7 Annual post-weaning losses and mortalities for the five Merino flocks over a period of nine years at the Glen AI

	Five Merino flocks								
	Predation		Disease[1]		Metabolic disorder[2] & Accident		Theft		Total
Year	n	%	n	%	n	%	n	%	n
1999	53	50.5	26	24.8	10	9.5	16	15.2	105
2000	91	68.4	3	2.3	29	21.8	10	7.5	133
2001	106	94.6	0	0.0	2	1.8	4	3.6	112
2002	169	99.4	1	0.6	0	0.0	0	0.0	170
2003	134	81.7	1	0.6	25	15.2	4	2.4	164
2004	106	69.7	12	7.9	28	18.4	6	39.5	152
2005	114	77.6	3	2.0	19	12.9	11	7.5	147
2006	51	63.8	3	3.8	23	28.8	3	3.8	80
2007	110	85.9	3	2.3	13	10.2	2	1.6	128
Total	934	78.4	52	4.4	149	12.5	56	4.7	1191

[1] Pulpy kidney, Pasteurella, blue tongue, blue udder and black quarter
[2] Acidosis and bloat

Table 5.8 Annual post-weaning losses and mortalities for the Dorper flock over a period of nine years at the Glen AI

	Dorper flock								
	Predation		Disease[1]		Metabolic disorder[2] & Accident		Theft		Total
Year	n	%	n	%	n	%	n	%	
1999	23	67.7	5	15.2	1	3.0	4	12.1	33
2000	63	88.7	3	4.2	2	2.8	3	4.2	71
2001	102	91.9	1	1.0	7	6.3	1	1.0	111
2002	85	81.7	0	0.0	11	10.8	8	7.7	104
2003	40	70.2	2	3.5	14	24.6	1	1.8	57
2004	60	58.3	9	8.7	20	19.4	14	13.6	103
2005	41	63.1	3	4.6	10	15.4	11	16.9	65
2006	42	91.3	2	4.3	2	4.3	1	2.2	47
2007	32	84.2	0	0.0	4	10.5	2	5.3	38
Total	488	77.7	25	4.0	71	11.3	45	7.2	629

[1] Pulpy kidney, Pasteurella, blue tongue, blue udder and black quarter
[2] Acidosis and bloat

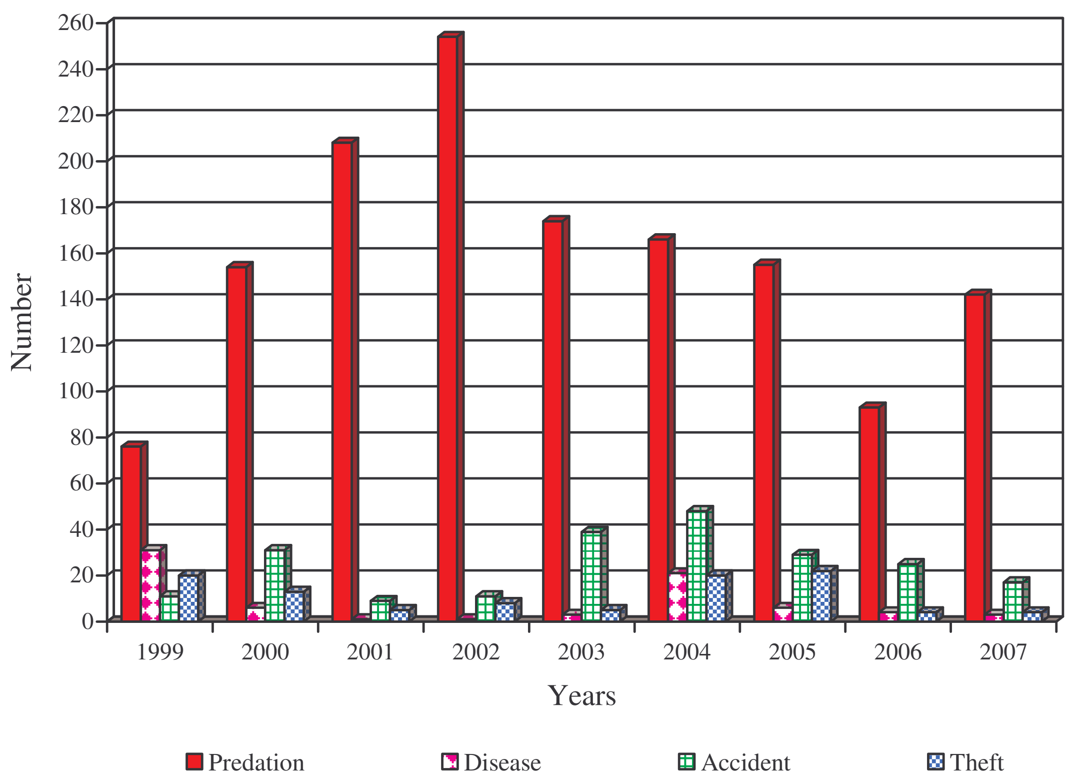

Figure 5.2 Total annual sheep losses and mortalities in the five Merino flocks and the Dorper flock at the Glen AI.

Stock theft occurred each year with the highest losses recorded during 2004 and 2005, but these stock theft losses were small compared to predation (Figure 5.2).

The data in Table 5.9 puts Figure 5.2 into perspective, due to the fact that it can easily be misinterpreted. The lowest percentage loss was recorded in 1999. Since then the losses due to predation doubled in 2000, and doubled again from 2000 to 2002. In 2003, the percentage losses due to predation accounted for a staggering 20.4% of all sheep losses at the Glen AI. This percentage loss due to predation remained high and increased in 2007 to 25.8% of the total number of sheep, while in 2006 the actual loss was markedly lower than in 2000 (Figure 5.2). The selective percentage loss due to predation was actually 2.7% higher (Table 5.9).

Table 5.9 Annual post-weaning losses as a percentage of all sheep (Merino and Dorper) flocks over a period of nine years at the Glen AI

	Five Merino flocks and the Dorper flock					
		Losses				
	Flock size	Predation	Disease[1]	Metabolic disorder[2] & Accident	Theft	Total
Year	n	%	%	%	%	%
1999	1130	6.7	2.7	1.0	1.8	12.2
2000	1165	13.2	0.5	2.7	1.1	17.5
2001	1062	19.6	0.1	0.9	0.5	21.1
2002	963	26.3	0.1	1.1	0.8	28.3
2003	854	20.4	0.4	4.6	0.6	26.0
2004	823	20.2	2.6	5.8	2.4	31.0
2005	789	19.7	0.8	3.7	2.8	26.9
2006	586	15.9	0.7	4.3	0.7	21.5
2007	552	25.8	0.5	3.1	0.7	30.1
Average		18.6	0.9	3.0	1.3	23.8

[1] Pulpy kidney, Pasteurella, blue tongue, blue udder and black quarter
[2] Acidosis and bloat

In comparison, percentage losses due to diseases and stock theft were markedly low. Percentage loss due to metabolic disorders or accidents was slightly higher after 2002 (Table 5.9). By comparing the percentage losses in each category, it is evident that predation was the highest with an average of 18.6% over nine years. Losses due to predation was 20.7 times more than losses due to diseases (x = 0.9%), 6.2 times more than metabolic disorders or accidents (x = 3.0%) and 14.3 times more than stock theft (x = 1.3%) (Table 5.9).

The number of post-weaned sheep lost to predators at different ages and sexes are presented in Tables 5.10 and 5.11. Most sheep lost was from the 4-12 months and the mature sheep classes, with both classes loosing more than 300 individuals (ewes and rams combined) over the five years. In the age categories 4-12 months and two-tooth (Table 5.10), the number of sheep lost to predators did not differ markedly between sexes. In the mature age category (older than two-tooth), however, markedly more ewes than rams were lost. Ewes older than five years were relatively easy targets for predators, especially when these ewes were pregnant.

Table 5.10 The number of post-weaned sheep lost to predators at different ages and sexes in the five Merino flocks and the Dorper flock over a period of five years at the Glen AI

	4-12 months				2-tooth				Mature				
	Ewe		Ram		Ewe		Ram		Ewe		Ram		Total
Year	n	%	n	%	n	%	n	%	n	%	n	%	n
2003	77	44.3	19	10.9	5	2.9	0	0.0	70	40.2	3	1.7	174
2004	38	22.9	46	27.7	4	2.4	5	3.0	70	42.2	3	1.8	166
2005	47	30.3	33	21.3	6	3.9	4	2.9	51	32.9	14	9.0	155
2006	37	39.8	20	21.5	1	1.0	2	2.2	31	33.3	2	2.2	93
2007	13	9.2	38	26.8	5	3.5	6	4.2	59	41.6	21	14.8	142
Total	212	29.0	156	21.0	21	3.0	17	2.0	281	38.0	43	6.0	730

Table 5.11 The total number of ewes and rams lost to predators for the five Merino flocks and the Dorper flock over a period of five years at the Glen AI

	Ewes		Rams		Total
Year	n	%	n	%	n
2003	152	87.4	22	12.6	174
2004	112	67.5	54	32.5	166
2005	104	67.1	51	32.9	155
2006	69	74.2	24	25.8	93
2007	77	54.2	65	45.8	142
Total	514	70.4	216	29.6	730

In total the number of ewes lost to predators was substantially higher (< 70%) than the number of rams (< 30%) (Table 5.11).

5.3 Specific predators responsible for sheep losses

In a breakdown of the specific predators implicated in predation over a period of five years at the Glen AI (Table 5.12), it is evident that the largest number (70.4% with an actual range varying between 59.1% and 81.0%) of sheep losses (all classes) was attributed to predation by the black-backed jackal. The second largest number of losses (19.5% with an actual range varying between 12.9% and 25.8%) were attributed to marauding vagrant or stray dogs. Caracal was responsible for 10.1% (with an actual range varying between 5.6 and 15.1%) of sheep lost to predation at the Glen AI.

Table 5.12 The sheep killed by specific predators in the five Merino flocks and the Dorper flock over a period of five years at the Glen AI

	Black-backed jackal		Vagrant dogs		Caracal		Total
Year	n	%	n	%	n	%	
2003	108	62.1	42	24.1	24	13.8	174
2004	114	68.7	37	22.3	15	9.0	166
2005	122	78.7	20	12.9	13	8.4	155
2006	55	59.1	24	25.8	14	15.1	93
2007	115	81.0	19	13.4	8	5.6	142
Total	514	70.4	142	19.5	74	10.1	730

According to the original data set of this study, most losses due to black-backed jackal occurred during the period September to November and again in March and April. The lowest losses were observed in January and May. This data is not shown in this dissertation and the seasonal effect of predation is not discussed.

6. The financial impact of predation on the Merino and Dorper flocks at the Glen Agricultural Institute

As previously discussed (see section 2.2), four Merino flocks collectively formed the Free State Wool Sheep Project at the Glen AI. The four Merino flocks were subjected to the following production system treatments:

- Treatment SL-V(C) **S**pring **L**ambing season on **V**eld with a salt (NaCl) lick only (**C**ontrol)
- Treatment SL-V&S **S**pring **L**ambing season on **V**eld with **S**upplementary feeding[1]
- Treatment SL-R&V **S**pring **L**ambing season on irrigated **R**ye-grass (*Lolium multiflorum* and *L. perenne*) and **V**eld
- Treatment AL-O&V **A**utumn **L**ambing season on **O**ats (*Avena sativa*) pasture in winter and **V**eld in summer and spring

It is common knowledge that state or public assets such as livestock are notoriously valued differently from open market prices. Therefore, the direct financial losses at the Glen AI were based on the respective monetary values for sheep obtained from eight Study Groups (Table 6.1) in specific areas, namely Barkly-East (Clifford), Rietbron, Sterkstroom, Hanover/Richmond, Klipplaat, Noupoort, Tarkastad and the southern Free State (Trompsburg, Smithfield and Springfontein).

These values ascribed to livestock are the average values for all eight the study groups (Dr. A.C. Geyer, 2008, personal communication). They were also verified with livestock traders in the specific years.

[1] A mixture of 40% Voermol Maxiwol, 49% maize meal, 10% salt (NaCl) and 1% feed lime. Maxiwol contains (g/kg) 350 g crude protein, 100 g fibre, 160 g moisture, 12.2 g calcium, 3.6 g phosphorus, 6.7 g sulphur, 200 mg manganese, 30 mg copper, 1 mg cobalt, 150 mg iron, 6 mg iodine, 240 mg zinc and 1 mg selenium.

Table 6.1 Economic values designated by eight study groups* for different classes of Merino and Dorper sheep

Year		Before weaning	4-12 months	2-tooth	Breeding ewes	Breeding rams
				Rand		
2003	Merino	100	150	300	400	1 000
	Dorper	200	300	400	600	1 000
2004	Merino	200	300	400	500	1 500
	Dorper	300	400	500	700	1 500
2005	Merino	300	400	500	700	2 000
	Dorper	400	500	600	800	2 000
2006	Merino	300	400	600	700	2 000
	Dorper	400	500	600	800	2 000
2007	Merino	350	450	550	800	2 500
	Dorper	450	600	700	900	2 500

* See text for detail

The relatively large number of mature Merino rams lost to predators in 2005 and 2007 (14 and 21, respectively; Table 5.10) added markedly to the total direct financial losses in these years (Table 6.2). In 2004, black quarter was responsible for 67% of the total losses due to diseases (Figure 5.2). The large financial losses due to a metabolic disorder or accidents in 2005 were contributed by the losses of mature Merino rams; four mature Merino rams that died added R8 000 to the total losses ascribed to accidents (R15 500).

Table 6.2 Direct financial implications for losses and mortalities for the four Merino flocks in the different treatments and the Merino shearing flock over a period of five years at the Glen AI

	Rand				
Year	Predation	Disease	Metabolic disorder & Accident	Theft	Total
2003	16 400	150	9 000	850	26 400
2004	46 800	4 100	14 100	3 600	68 600
2005	72 900	2 800	15 500	13 600	104 800
2006	25 800	1 900	13 900	1 800	43 400
2007	106 750	1 700	13 200	400	122 050
Total	268 650	10 650	65 700	20 250	365 250

In 2004, losses due to bloat contributed to 70% of the total losses in the Metabolic disorder & Accident category, 60% in 2005 and 100% in 2007 (Table 6.3). The Dorper sheep crawled through fences and had access to freshly harvested maize lands nearby, resulting in the high accidental losses in this year (2007). The number of Dorpers lost to metabolic disorders and accidents was 50% less in 2005 (see Table 5.8). However, financial losses remained high (Table 6.3), because 40% of the value was contributed by the loss of mature Dorper rams. The reasons for these deaths were unknown.

The direct financial impact due to predation varies from R16 400 in 2003 to R106 750 in 2007 for the four Merino flocks in the different treatments and the Merino shearing flock (Table 6.2). The minimum impact of R16 400 due to predation (in 2003) was still R900 more than the maximum financial impact due to metabolic disorders or accidents (in 2005). The impact recorded due to predation contributed to 74% of the total amount due to losses and mortalities over the five-year period (Table 6.2).

In the Dorper flock the direct financial impact due to predation varies from R15 400 in 2003 to R31 700 in 2007 (Table 6.3). The minimum impact of R15 400 due to predation (in 2003) was the same as the maximum impact due to theft (in 2005). The impact due to predation contributed to 65% of the total amount due to losses and mortalities over the five-year period (Table 6.3).

Table 6.3 Direct financial implications for the losses and mortalities in the Dorper flock over a period of five years at the Glen AI

	Rand				
Year	Predation	Disease	Metabolic disorder & Accident	Theft	Total
2003	15 400	900	8 000	600	24 900
2004	29 700	3 600	11 500	8 200	53 000
2005	31 700	2 200	12 100	15 400	61 400
2006	28 100	800	2 800	800	32 500
2007	27 500	0	3 600	1 800	32 900
Total	132 400	7 500	38 000	26 800	204 700

In 2005 the Merino lamb losses due to predation was 69% of the total direct financial losses (Table 6.4). The variation in rainfall in this year (Table 3.1) led to poor oats pastures. The sheep in Treatment AL-O&V, usually kept behind an electric fence, had to be returned to the veld for almost a month until the oats pasture was ready to be grazed and during this short period a number of lambs were lost to predators (Table 5.4). Huge losses due to predation on lambs in the Merino shearing group in 2005 (Table 5.5), also contributed greatly to the financial losses in this year (Table 6.4).

Table 6.4 Direct financial implications of lamb losses and mortalities before weaning for the four Merino flocks in the different treatments and the Merino shearing flock over a period of five years at the Glen AI

Year	Rand		
	Predation	Other causes	Total
2003	5 900	5 300	11 200
2004	5 200	6 800	12 000
2005	20 400	9 000	29 400
2006	7 200	6 300	13 500
2007	5 600	8 750	14 350
Total	44 300	36 150	80 450

Overall direct financial losses due to predation before weaning for the four Merino flocks in the different treatments and the Merino shearing flock was not markedly higher than the financial losses due to other causes (Table 6.4). As previously discussed (see section 3.5), more losses occurred with the lambs in Treatment SL-R&V and AL-O&V due to other causes, which contributed greatly to the financial losses. However, direct financial losses due to predation before weaning for the Dorper flock over a period of five years were markedly higher than the financial losses due to other causes (Table 6.5).

Table 6.5 Direct financial implications of lamb losses and mortalities before weaning for the Dorper flock over a period of five years at the Glen AI

Year	Rand		
	Predation	Other causes	Total
2003	22 200	400	22 600
2004	26 700	900	27 600
2005	40 400	4 800	45 200
2006	37 600	2 400	40 000
2007	8 100	6 300	14 400
Total	135 000	14 800	149 800

The direct financial impact due to predation varies from R8 100 in 2007 to R40 400 in 2005 for the lamb losses and mortalities before weaning for the Dorper flock. The minimum impact of R8 100 due to predation in 2007 was still R1 800 more than the maximum impact due to other causes. The direct financial impact due to predation contributed 90% to the total direct financial losses (Table 6.5).

The direct financial implications of the annual sheep losses (all age classes) as a result of predation are very high for all flocks at the Glen AI (Table 6.6).

Table 6.6 Direct financial implications of losses and mortalities for the four Merino flocks in the different treatments, the Merino shearing flock and the Dorper flock over a period of five years at the Glen AI

	Rand				
Year	Predation	Disease	Metabolic disorder & Accident	Theft	Total
2003	59 900	1 050	22 700	1 450	85 100
2004	108 100	7 700	33 300	11 800	160 900
2005	165 400	5 000	41 400	29 000	240 800
2006	98 700	2 700	25 400	2 600	129 400
2007	147 950	1 700	31 850	2 200	183 700
Total	580 050	18 150	154 650	47 050	799 900

The direct financial impact due to predation varies from R59 900 in 2003 to R165 400 in 2005 for the four Merino flocks in the different treatments, the Merino shearing flock and the Dorper flock over the period of five years. The minimum impact of R59 900 due to predation (in 2003) was still R18 500 more than the maximum impact due to metabolic disorders or accidents (in 2005). The financial impact due to predation contributed 73% to the total amount due to losses and mortalities, diseases contributed 2%, metabolic disorders or accidental mortalities 19% and stock theft 6% (Table 6.6).

The cost of predation is mostly only taken as the direct losses of individuals, be it lambs or mature sheep. However, various additional fruitless expenditures must also be taken into account. The veterinary expenditure and costs incurred during basic management input for sheep lost because of diseases, metabolic disorders or accidents, or stock theft or caught by predators are based on the items presented in Table 6.7. The costs presented for veterinary supplies are based on the means obtained in October 2008 from different suppliers in Bloemfontein.

Table 6.7 A breakdown of veterinary and sundry costs per animal for the different age classes in the Merino and Dorper flocks over a period of five years at the Glen AI

			4-12 months		2 -tooth		Mature	
Veterinary supplies	Rand[1]	Lamb	Ewe	Ram	Ewe	Ram	Ewe	Ram
Tags	3.65	1						
Castrator ring	0.13	1						
Dosing[2]	2.40	1	2	2	2	2	2	2
Deadline	0.20	1	1	1	1	1	1	1
Multivax P	5.24	1	2	2	2	2	2	2
Blue tongue[3]	2.33		1	1	1	1	1	1
Blue udder	1.00				1		1	
Enzootic abortion	4.64				1		1	
Rev [1]	2.87			1				
Shearing cost	4.63		1	1	1	1	1	1
Total R/c		11.62	20.11	22.98	25.75	31.70	25.75	31.70

1 Values applied for 2003 - 2007

2 Treatment SL-R&V received an additional dosing per year

3 Not applied to the Dorper flock

Fruitless veterinary and sundry cost due to predation was the highest in 2005 (Table 6.8). However the financial losses due to predation did not differ markedly from losses due to other causes.

Table 6.8 Fruitless veterinary and sundry expenditure (in SAR) incurred before weaning for the four Merino flocks in the different treatments and the Merino shearing flock over a period of five years at the Glen AI

	Rand		
Year	Predation	Other causes	Total
2003	215	231	446
2004	104	135	239
2005	247	143	390
2006	96	84	180
2007	64	100	164
Total	726	693	1 419

Most of the lambs were caught by predators or died of other causes before the first Multivax P[2] inoculation and dosing at 35 days of age. These two input costs were, therefore, not taken into consideration when calculating veterinary costs lost before weaning. The direct

2 Multivax P: Inoculation of sheep against pulpy kidney, Pasteurella, tetanus, malignant oedema and blackquarter

veterinary costs when a lamb was lost before weaning (Tables 6.8 and 6.9), therefore, reflect the costs for a tag, a castrator ring (for tail docking) and Deadline. The veterinary expenditure before weaning of lambs in the Merino and Dorper flocks was the same.

The veterinary and sundry costs calculated for sheep losses in different age categories after weaning, as shown in Table 6.7, were done as follows:

4-12 months:	Direct costs before weaning (plus inoculations and dosing) as well as direct costs up to 12 months of age.
12-24 month (2-tooth):	Direct costs for the year in which the loss occurred.
>24 months (mature):	Direct costs for the year in which the loss occurred.

The production costs incurred are calculated on an annual basis in this study, namely from a lambing season until the next lambing season. Although sheep were caught throughout the year, most of the losses occurred just before the new lambing season started, namely between September to November (see section 5.3). If a lamb, for example, died at the age of five months it was classed in the 4-12 months category and the entire cost for that period was taken into account. The input cost for this specific individual may be overestimated but the majority of the losses occurred at the end of this age category. Therefore, if the total cost for the whole period in an age category was taken into consideration, a good reflection of the costs could still be obtained.

The ram lambs born from the Merino flocks in Treatments SL-R&V and AL-O&V were only on the pastures until weaning. After weaning they were managed on veld similarly to the rams in Treatments SL-V(C) and SL-V&S and the Merino shearing flock. Therefore, it was not necessary to give the young rams in Treatment SL-R&V an extra dosing such as was done with the two-tooth ewes (Table 6.7). At about 17 months of age these two-tooth maiden ewes were again placed on the planted pastures for their first breeding season.

Fruitless veterinary and sundry costs due to sheep losses as a result of predation were markedly higher compared to losses due to diseases, metabolic disorders or accidents and stock theft (Tables 6.10 and 6.11).

Table 6.9 Fruitless veterinary and sundry expenditure (in SAR) incurred before weaning for the Dorper flock over a period of five years at the Glen AI

Year	Rand		
	Predation	Other causes	Total
2003	442	8	450
2004	354	12	366
2005	402	48	450
2006	374	24	398
2007	71	56	127
Total	1 643	148	1 791

Table 6.10 Additional financial expenditure (in SAR) due to fruitless veterinary and miscellaneous expenses for the four Merino flocks in the different treatments and the Merino shearing flock over a period of five years at the Glen AI

Year	Rand				
	Predation	Disease	Metabolic disorder & Accident	Theft	Total
2003	3 944	32	674	130	4 780
2004	3 107	386	868	175	4 536
2005	3 581	95	577	331	4 584
2006	1 643	80	643	86	2 452
2007	3 401	95	363	26	3 885
Total	15 676	688	3 125	748	20 237

The shearing costs for the Dorper flock were slightly less, because the costs of the wool classers were not taken into account.

Table 6.11 Additional financial expenditure (in SAR) due to fruitless veterinary and miscellaneous expenses for the Dorper flock over a period of five years at the Glen AI

	Rand				
Year	Predator	Disease	Accident	Theft	Total
2003	1 097	52	382	23	1 554
2004	1 717	262	522	394	2 895
2005	1 008	70	267	304	1 649
2006	1 088	23	53	24	1 188
2007	770	0	93	47	910
Total	5 680	407	1 317	792	6 547

The annual cost of supplementary feeding and labour costs for the Merino ewes in Treatment SL-V(C) are shown in Table 6.12. The same costs were applicable for the Merino shearing flock and the Dorper flock because they also received a salt lick. The annual cost of supplementary feeding and labour costs for the Merino ewes in Treatment SL-V&S are shown in Table 6.13.

Table 6.12 Annual cost of supplementary feeding (salt lick) and labour costs for the Merino ewes in Treatment SL-V(C) at the Glen AI

Input cost for the Merino ewes in Treatment SL-V(C)					
	Unit	Quantity	R/Unit	Total	R/sheep
Salt (NaCl)	kg	1.83	0.84	1.54	1.54
Labour	h	123.00	5.65	694.95	9.93
Total					11.47

1 (5 g/day for 52 weeks) (De Waal, 1989)

2 One labourer/1000sheep/year @ 40 working hours/week

The calculation for labour costs in all treatments were done as indicated above. These costs were calculated as if a labourer spent 90% of his time working with matters regarding stock management. The labour cost for sheep on planted pastures were double the costs for sheep on veld as they were handled more. Hooves had to be clipped more regularly and sheep had to be dosed more often due to a higher concentration of parasites on the pastures. High moisture content of about 80% (Theron, 1994; Strauss, 2009, unpublished data) often prevailed in the rye-grass pasture, often caused diarrhoea. The diarrhoea mostly occurred with the 2-tooth ewes after they were first mated on the rye-grass. Although the Merino ewes quickly adapted to the high moisture conditions of the rye-grass it was still necessary to crutch these ewes more often to prevent blowfly attacks. Due to the occurrence of a high number of multiple births more labour was also required. This caused the higher labour costs on the planted pastures (see Tables 6.14 and 6.15).

Table 6.13 Annual cost of supplementary feeding and labour costs for the Merino ewes in Treatment SL-V&S at the Glen AI

	Energy-production lick[1], NaCl[2] and Labour[3]				
	Unit	Quantity	R/Unit	Total	R/sheep
Maize	kg	250.00	2.64	660.00	
Maxiwol concentrate	kg	200.00	4.05	810.00	
Salt	kg	50.00	0.84	42.00	
Lime[4]	kg	6.00	0.75	4.50	
Direct lick cost		506.00		1516.50	73.43
Salt (NaCl)	kg	1.33	0.84	1.12	1.12
Labour	h	131.00	5.65	740.15	10.57
Total cost					85.12

1 Started six weeks before lambing commenced and continued eight weeks after lambing at 250 g/ewe/day.
2 (5 g/day for 266 days) (De Waal, 1989)
3 One labourer/1000sheep/year @ 40 working hours/week
4 Included at 1% in the lick to prevent acidosis that can be caused by a high intake of maize.

The lick costs per ewe increased markedly in the last few years for Treatment SL-V&S, especially the cost of maize and Maxiwol provided in the licks.

Although the labour costs were taken to be double on planted pastures it was only calculated for the period when the ewes were grazing the pastures. For example, the ewes in Treatment SL-R&V were on the rye-grass for nine months and the ewes in Treatment AL-O&V were on the oats for six months. Double labour costs were calculated for these months and for the remainder of the year labour costs were calculated as for veld (Tables 6.14 and 6.15).

Table 6.14 Annual production costs per ha of rye grass under irrigation for the Merino ewes in Treatment SL-R&V at the Glen AI

Rye-grass (*Lolium multiflorum* and *L. perenne*)						
Inputs	Product	Unit	Quantity	R/Unit	R/ha	R/ewe
Fuel[1]	Diesel	liter	85.00	9.26	787.10	
Fertilization[2]	N	kg	252.00	29.91	7 537.32	
Seed[3]	Midmar/Dargle	kg	20.00	30.10	602.00	
Irrigation	Eskom	mm	1200.00	0.90	1 080.00	
Irrigation	Water	mm	1200.00	0.63	756.00	
Mechanical	Repair		1.00	360.64	360.64	
Irrigation	Repair		1.00	241.50	241.50	
Labour[4]		h	48.00	5.65	271.20	15.95
Direct production costs (pasture and labour)					11 635.76	684.46
Salt lick		kg	31.11	0.84	26.13	1.54
Labour		h	8.00	5.65	45.20	2.66
Total production costs (intensive & extensive)						688.66

1 Similar to Table 4.22, plus 2 liters per activity extra.
2 (85 kg N was applied x 3) (R8374.80/t) (Price/ton obtained in 2008)
3 Midmar was only available until 2006
4 (17ewes/ha for nine months) (one labourer/1000sheep/year @ 40 working hours/week)

The lick cost per ewe was calculated as follows:

- (n days lick was provided) x (250 g of lick/ewe/day) = kg/ewe for the period
- (kg/ewe) / (total kg of lick ration) x (total lick costs)

The labour costs can vary depending on the irrigation system being used. At the Glen AI a dragline system was used resulting in higher labour costs compared to, for example, a pivot. However, no labour cost was taxed for irrigation. The mechanical repair cost (Table 6.14) was based on the mechanical repair costs for oats pasture (Table 6.15) plus R8 per activity extra because three extra activities were required on the rye-grass when fertilizer was given. Soil samples were collected before the planting of the pastures. Due to high phosphate levels in the soil, the pastures were given only nitrogen. The nitrogen was applied in three intervals, starting with 85 kg of nitrogen before winter. The other two 85 kg N applications were given in two intervals in spring, usually after a camp was grazed (Table 6.14).

Table 6.15 Annual production costs per hectare of oats pasture under dry land conditions for the Merino ewes in Treatment AL-O&V at the Glen AI

Oats (*Avena sativa*)[1]						
Inputs	Product	Unit	Quantity	R/Unit	R/ha	R/ewe
Fuel	Diesel	Liter	79.00	9.26	731.54	
Fertilization	N	kg	28.00	29.91	837.48	
Seed		kg	30.00	6.16	184.80	
Irrigation	Eskom	mm	0.00	0.0	0.00	
Irrigation	Water	mm	0.00	0.0	0.00	
Mechanical	Repair		1.00	336.64	336.64	
Irrigation	Repair		0.00	0.0	0.00	
Labour[2]		h	23.00	5.65	129.95	
Total					2 220.41	185.03
Salt lick		kg	21.96	0.84	18.47	1.54
Labour		h	12.00	5.65	67.80	5.65
Total					2 306.68	192.22

1 Dry land oats (GWK, 2008) and (SENWES, 2008)

2 (12 ewes/ha for 6 months) (one labourer/1000sheep/year @ 40 working hours/week)

Exceptionally high fertilization prices were obtained when calculations was done in 2008. This resulted in high cost per hectare and per ewe on the rye-grass. However, even if the fertilization price was halved the direct production costs per hectare was still high at R7 867.10/ha and R466.97/ewe (Total production cost/ewe). This cost per ewe was still 58% of the direct economical value for a breeding ewe in 2007 (Table 6.1)

A monetary value per ewe was calculated based on the input for the labour, lick and pasture costs for each treatment (Tables 6.16 to 6.20). These costs are shown separately from veterinary costs because veterinary costs are direct costs while labour, lick and pasture costs are calculated as the average cost per ewe per treatment. For example, when a lamb was lost to predators after it was weaned on the rye-grass and moved to the veld, this lamb was on the rye-grass for four months. Although the ewe received input costs for a year to produce the lamb, the whole input cost (labour, lick and pasture) per ewe could not be taxed to the lamb. Therefore, specific input cost was calculated for an individual. The number of sheep per LSU was calculated for each age category based on an average body weight. The number of sheep per mature ewe was calculated and multiplied with the value per ewe as shown in

Tables 6.12 to 6.15. The body weight of rams used in the flocks was not known. Therefore, the average weight of all the rams in different age categories was used for all the treatments.

Table 6.16 Calculation of the number of sheep per mature ewe for the Merino flock in Treatment SL-V(C) at the Glen AI

Sheep type	Body weight (kg)	LSU	Sheep/LSU	n sheep/mature ewe	R/Value
Before weaning (35 days)[1]	10	0.06	16.67	3.33	0.29
Weaning lamb (4 months)[2]	23	0.11	9.09	1.82	2.10
Ewe (4–12 months)[3]	33	0.14	7.14	1.43	5.35
Ram (4–12 months)	42	0.17	5.88	1.24	6.17
Ewe (2–tooth)[4]	41	0.17	5.88	1.18	9.72
Ram (2–tooth)	51	0.20	5.00	1.00	11.47
Mature ewe	52	0.2	5.00	1.00	11.47
Mature ram	68	0.24	4.17	0.83	13.82

1 Calculations for the lamb losses before weaning (35 days of age). The reason for using the weight of the lambs on 35 days of age is due to the fact that most of the lambs were caught by predators or died due to other causes before this age. Therefore [(1 Mature ewe/3.33 (lambs before weaning) x Total production costs (Table 6.12) x (1/12) (month)]

2 Calculation for the weaned lamb losses: [1 Mature ewe/1.82 (weaned lamb) x Total production costs (Table 6.12) x (4/12) (month)]

3 Calculation for a ewe loss in age category 4-12 months: [1 Mature ewe/1.43 (4-12 months ewe) x Total production costs (Table 6.12) x (8/12) (month)].

4 Calculation for the 2-tooth ewe losses: [1 Mature ewe/1.18 (2-tooth ewe) x Total production costs (Table 6.12) x (12/12)]

When the young ram lambs were weaned they were put with the mature rams. Sexual interference between the mature rams and 2-tooth and younger rams occurred and together with continuous fights between the rams impeded the feed intake of the young rams, resulting in poor growth. However, it was the only solution to keep the rams together because when the young rams were separated from the mature rams, predation increased on the young rams. The rams are all kept intact to provide own rams for the Glen AI flocks and also to donate breeding rams to emerging farmers. The large ram flock was managed as a "weather" flock to provide additional fleeces for wool classification courses conducted at the Glen AI.

The calculations used for the results presented in Table 6.16 were also used for the Merino sheep in Treatments SL-V&S, SL-R&V and AL-O&V as well as for the rams. Extra calculation was necessary for the Merino ewes in age categories 4 -12 months and 2 tooth, due to the fact that it was grazing veld or pastures at different times (Tables 6.18).

The body weight for the ewes and rams in different age categories had an effect on the value of the sheep (Tables 6.16 - 6.20).

Table 6.17 Calculation of the number of sheep per mature ewe for the Merino flock in Treatment SL-V&S at the Glen AI

Sheep type	Body weight (kg)	LSU	Sheep/LSU	n sheep/mature ewe	R/Value
Before weaning (35 days)[1]	11	0.06	16.67	3.50	2.03
Weaning lamb (4 months)[2]	26	0.11	9.09	1.91	14.86
Ewe (4–12 months)[3]	35	0.15	6.67	1.40	5.46
Ram (4–12 months)	42	0.17	5.88	1.24	6.17
Ewe (2–tooth)[4]	41	0.17	5.88	1.24	14.20
Ram (2–tooth)	51	0.20	5.00	1.05	10.92
Mature ewe	55	0.21	4.76	1.00	85.12
Mature ram	68	0.24	4.17	0.88	13.03

1 Calculations for the lamb losses before weaning (35 days of age). The reason for using the weight of the lambs on 35 days of age is due to the fact that most of the lambs were caught by predators or died due to other causes before this age. Therefore [(1 Mature ewe/3.33 (lambs before weaning) x Total production costs (Table 6.12) x (1/12) (month)]

2 Calculation for the weaned lamb losses: [1 Mature ewe/1.82 (weaned lamb) x Total production costs (Table 6.12) x (4/12) (month)]

3 Calculation for a ewe loss in age category 4-12 months: [1 Mature ewe/1.43 (4-12 months ewe) x Total production costs (Table 6.12) x (8/12) (month)].

4 Calculation for the 2-tooth ewe losses: [1 Mature ewe/1.18 (2-tooth ewe) x Total production costs (Table 6.12) x (12/12)]

The input cost for the age category 4 - 12 months were drastically lower due to the fact that the weaned lambs were on the veld and therefore the same production costs in Treatment SL-V(C) (Table 6.12) implied also during this period (Table 6.18).

Table 6.18 Calculation of the number of sheep per mature ewe for the Merino flock in Treatment SL-R&V at the Glen AI

Sheep type	Body weight (kg)	LSU	Sheep/LSU	n sheep/mature ewe	R/Value
Before weaning (35 days)	13	0.07	14.29	3.43	16.73
Weaning lamb (4 months)	30	0.13	7.69	1.84	124.76
Ewe (4–12 months)[1]	39	0.16	6.25	1.50	5.10
Ram (4–12 months)	42	0.17	5.88	1.41	5.42
Ewe (2–tooth)[2]	46	0.18	5.56	1.33	263.31
Ram (2–tooth)	51	0.20	5.00	1.20	9.56
Mature ewe	67	0.24	4.17	1.00	688.66
Mature ram	68	0.24	4.17	1.00	11.47

1 Calculation for a ewe loss in age category 4-12 months: [1 Mature ewe/1.50 (4-12 months ewe) x Total production costs (Table 6.12) x (8/12) (month)(on veld)].

2 Calculation for the 2-tooth ewe losses: [1 Mature ewe /1.33 (2-tooth ewes) x Total production costs (Table 6.12) x (6/12) (2-tooth ewe for 6 months on veld)] + [1 Mature ewe /1.33 (2-tooth ewes) x Total production costs (Table 6.14) x (6/12)(2-tooth ewe for 6 months on pasture).

Table 6.19 Calculation of the number of sheep per mature ewe for the Merino flock in Treatment AL-O&V at the Glen AI

Sheep type	Body weight (kg)	LSU	Sheep/LSU	n sheep/mature ewe	R/Value
Before weaning (35 days)	14	0.07	14.29	3.29	4.87
Weaning lamb (4 months)	35	0.15	6.67	1.53	41.87
Ewe (4–12 months)	42	0.17	5.88	1.35	5.66
Ram (4–12 months)	42	0.17	5.88	1.35	5.66
Ewe (2–tooth)[1]	48	0.19	5.26	1.21	7.90
Ewe (2–tooth)[2]	48	0.19	5.26	1.21	34.38
Ram (2–tooth)	51	0.20	5.00	1.15	9.98
Mature ewe	63	0.23	4.35	1.00	192.22
Mature ram	68	0.24	4.17	0.96	11.95

1Calculation for the 2-tooth ewe losses (caught by predators): 1 Mature ewe /1.21 (2-tooth ewes) X Total production costs (Table 6.12) x (10/12) (2-tooth ewe for 10 months on veld)

2 Calculation for the 2-tooth ewe losses (disease, metabolic disorder & accident and theft): [1 Mature ewe /1.21 (2-tooth ewes) x Total production costs (Table 6.12) x (10/12) (2-tooth ewe for 10 months on veld)] + [1 Mature ewe /1.21 (2-tooth ewes) x Total production costs (Table 6.15) X (2/12) (2-tooth ewe for 2 months on pasture).

The 2-tooth Merino ewes in Treatment AL-O&V were for 10 months on the veld and if a loss due to predation occurred during this period, only that costs were taken into account.

However, if a 2-tooth sheep died in the 2 month period that it was on the pastures, the cost for the entire year was taken into account (Table 6.19).

Calculations for the Dorper flock ewes (Table 6.20) were based on the calculations for the Merinos in Treatment SL-V(C) (Table 6.12), except for the mature rams, because their body weights were very similar, except for the mature rams.

Table 6.20 Calculation of the number of sheep per mature ewe for the Dorper flock at the Glen AI

Sheep type	Body weight (kg)	LSU	Sheep/LSU	n sheep/mature ewe	R/Value
Before weaning (35 days)	13	0.07	14.29	3.43	0.28
Weaning lamb (4 months)	30	0.13	7.69	1.84	2.08
Ewe (4–12 months)	39	0.16	6.25	1.50	5.09
Ram (4–12 months)	42	0.17	5.88	1.41	5.42
Ewe (2–tooth)	46	0.18	5.56	1.33	8.62
Ram (2–tooth)	51	0.20	5.00	1.20	9.56
Mature ewe	67	0.24	4.17	1.00	11.47
Mature ram	90	0.29	3.45	0.82	13.99

In Table 6.21 the financial expenditure due to fruitless expenses (lick and labour) for the five Merino flocks before weaning was not higher than R438 in a year and for the Dorper flock (Table 6.22) it was not higher than R32.

Table 6.21 Additional financial expenditure (in SAR) due to fruitless expenses (lick and labour) for the five Merino flocks before weaning at the Glen AI

	Rand		
Year	Predator	Other Causes	Total
2003	47	391	438
2004	28	377	405
2005	88	295	383
2006	23	214	237
2007	15	198	213
Total	201	1 475	1 676

Table 6.22 Additional financial expenditure (in SAR) due to fruitless expenses (lick and labour) for the Dorper flock before weaning at the Glen AI

	Rand		
Year	Predator	Other causes	Total
2003	31	1	32
2004	25	1	26
2005	28	3	31
2006	26	1	27
2007	5	4	9
Total	115	10	125

To highlight the big variation in production cost, fruitless expenses incurred (lick, labour and pasture) as a result of sheep losses due to predation, disease, metabolic disorders or accidental mortalities and stock theft are shown separately for the sheep in the different treatments (Tables 6.23 to 6.28).

Table 6.23 Additional financial expenditure (in SAR) due to fruitless expenses (lick and labour) for the Merino flock in Treatments SL-V(C) at the Glen AI

	Rand				
Year	Predation	Disease	Metabolic disorder & Accident	Theft	Total
2003	217	0	23	12	252
2004	178	12	37	0	227
2005	221	0	84	0	305
2006	92	19	21	0	132
2007	152	0	0	0	152
Total	860	31	165	12	1 068

Table 6.24 Additional financial expenditure (in SAR) due to fruitless expenses (lick and labour) for the Merino flock in Treatments SL-V&S at the Glen AI

	Rand				
Year	Predation	Disease	Metabolic disorder & Accident	Theft	Total
2003	1 622	0	119	0	1 741
2004	1 209	31	85	0	1 325
2005	619	0	0	0	619
2006	212	0	85	0	297
2007	672	0	85	0	757
Total	4 334	31	374	0	4 739

Table 6.25 Additional financial expenditure (in SAR) due to fruitless expenses (lick, labour and pasture) for the Merino flock in Treatments SL-R&V at the Glen AI

	Rand				
Year	Predation	Disease	Metabolic disorder & Accident	Theft	Total
2003	3 520	130	1 647	0	5 297
2004	7 492	911	2 699	0	11 102
2005	6 899	271	1 481	0	8 651
2006	5 788	689	2 460	0	8 937
2007	8 782	130	2 206	0	11 118
Total	32 481	2 131	10 493	0	45 105

Table 6.26 Additional financial expenditure (in SAR) due to fruitless expenses (lick, labour and pasture) for the Merino flock in Treatments AL-O&V at the Glen AI

Year	Rand				
	Predation	Disease	Metabolic disorder & Accident	Theft	Total
2003	1 050	0	200	48	1 298
2004	248	48	262	0	558
2005	883	0	20	0	903
2006	48	0	2 017	0	2 065
2007	585	48	779	0	1 412
Total	2 814	96	3 278	48	6 236

Table 6.27 Additional financial expenditure (in SAR) due to fruitless expenses (lick and labour) for the Merino shearing flock at the Glen AI

	Rand				
Year	Predation	Disease	Metabolic disorder & Accident	Theft	Total
2003	417	0	113	17	547
2004	317	12	62	64	455
2005	189	0	23	132	344
2006	129	0	25	31	185
2007	219	12	21	12	264
Total	1 271	24	244	256	1 795

Table 6.28 Additional financial expenditure (in SAR) due to fruitless expenses (lick and labour) for the Dorper flock at the Glen AI

	Rand				
Year	Predator	Disease	Metabolic disorder & Accident	Theft	Total
2003	327	19	138	12	496
2004	513	65	195	130	903
2005	403	32	115	133	683
2006	369	12	26	12	419
2007	351	0	43	23	417
Total	1 963	128	517	310	2 918

The total fruitless expenses for predation were 75%, 69%, 77%, 52% and 78% of the total fruitless expenses for the five years 2003 to 2007, respectively (Table 6.29). The highest total fruitless expenses for metabolic disorders and accidents were in 2006 when it contributed to 34 % of the total expenses.

As indicated previously in several tables, the individual financial expenditure due to fruitless expenses for the five Merino flocks and the Dorper flock was not markedly high. However, as seen in Table 6.29, the total expenses are markedly high and have an effect on the annual total financial losses (Table 6.30).

Table 6.29 Total financial expenditure (in SAR) due to fruitless expenses for the five Merino flocks and the Dorper flock at the Glen AI

Year	Rand				
	Predation	Disease	Metabolic disorder & Accident	Theft	Total
2003	12 929	233	3 927	242	17 331
2004	15 292	1 727	5 255	763	23 037
2005	14 568	468	3 056	900	18 992
2006	9 888	823	5 653	153	16 517
2007	15 087	285	3 948	108	19 428
Total	67 764	3 536	21 839	2 166	95 305

Fruitless expenses (Table 6.29) contributed 11% to the total financial losses due to predation, 16% to the total financial losses due to diseases, 12% to the total financial losses due to metabolic disorders or accidental mortalities and 4% to the total financial losses due to stock theft.

The total annual financial losses are shown in Table 6.30.

The financial impact due to predation (average R129 562/annum) was markedly higher compared to losses due to diseases (average R4 337/annum), metabolic disorders or accidents (average R35 299/annum) and stock theft (average R9 843/annum) (Table 6.30).

Predation contributed 72% to the total amount, diseases 2%, metabolic disorders or accidents 20% and stock theft only 6% (Table 6.30).

Table 6.30 Total annual financial losses (in SAR) for the Merino flock in four treatments, the Merino shearing flock and the Dorper flock at the Glen AI

Year	Rand				
	Predation	Disease	Metabolic disorder & Accident	Theft	Total
2003	72 829	1 283	26 627	1 692	102 431
2004	123 392	9 427	38 555	12 563	183 937
2005	179 968	5 468	44 456	29 900	259 792
2006	108 588	3 523	31 053	2 753	145 917
2007	163 037	1 985	35 798	2 308	203 128
Total	647 814	21 686	176 489	49 216	895 205

It is evident that not only the direct value of a sheep must be taken into account when determining the financial loss. Some of the ewes, although they were highly fertile and produced at optimum levels, could not raise even one lamb in a production cycle of six years, was mainly due to predation. It should be noted that production costs in this study are taken into account for only one production year, or up to the month in which the loss occurred. Therefore the financial impact can even be higher if the costs were calculated over a six year period in which the ewe could not produce a single lamb.

7. Conclusions

The broad aim of the Free State Wool Sheep Project was to "develop profitable and sustainable wool farming production systems on the resource combination of the Glen Agricultural Institute". However, the huge impact of predation on the flocks made it impossible to evaluate the economical viability and sustainability of the Merinos in Treatments SL-V(C), SL-V&S, SL-R&V and AL-O&V as envisaged in the protocol of the Free State Wool Sheep Project at the Glen Agricultural Institute (Glen AI).

The following paragraphs list the main conclusions drawn from this study:

7.1 Ewe productivity was negatively influenced by predation. The black-backed jackal specifically, had a big impact on the sheep flocks at the Glen AI. Predation contributed to 72% of the total annual financial losses, diseases 2%, metabolic disorders or accidents 20% and stock theft only 6%. Therefore, the financial impact due to predation (average R129 562/year) by far 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).

7.2 The total Merino and Dorper flock size shrunk from 1 130 sheep to 552 sheep over 9 years. From 1999 until 2007 a total of 747 lambs suckling and 1 422 post-weaned lambs were lost to predation. The reproductive Merino and Dorper ewes that were available for mating decreased from 506 ewes in 2003 to 316 ewes in 2007. There was an average of 38 ewes per year less for breeding purposes over this five-year period Due mostly to predation. The total amount of R647 814 lost due to predation is very high if it is taken into account that the data was collected on a relative small number of sheep in the Merino and Dorper flocks at the Glen AI. Furthermore it is only for a period of five years from 2003 until 2007.

7.3 Fruitless expenses contributed to 11% of the total financial losses due to predation, 16% of the total financial losses due to diseases, 12% of the total financial losses due to metabolic disorders or accidents and 4% of the total financial losses due to stock theft. These expenses have to be included when financial losses are calculated.

7.4 Farmers usually know how many small stock were stolen in a year, but data of losses due to specific predators, diseases and metabolic disorders or accidents are grossly lacking (H.N. van Niekerk, 2009; unpublished data). Furthermore, only the direct cost of small stock losses is usually taken into account, but the production cost is neglected. If the data of the losses reflected in this study were obtained from a private sheep enterprise, the farmer would be facing major financial difficulties.

7.5 Due to predation, some of the ewes in the five Merino flocks at the Glen AI could not raise one lamb in a six year production cycle. The only income from such a breeding ewe over the six year period was the wool produced. Also, the genetic losses due to predation are estimated as considerably more than the direct financial losses. Furthermore the Dorper flock was genetically built over a period of almost 30 years by developing a well-adapted sheep being able to produce at optimum levels (De Waal & Combrinck, 2000). Therefore the input of dedicated breeding and record keeping over almost 30 years was lost during the last few years as reported in this study, mostly due to the impact of predation.

7.6 The Merino flocks at the Glen AI were severely impacted by predation. Therefore it will soon be necessary for the Department of Agriculture, Free State to purchase wool sheep to provide training material, namely wool fleeces for wool classification courses. The purchasing of other sheep (Wool and Mutton) for the Glen AI must not only provide in the needs of training and technology transfer, but also in the needs of small stock research. However, a large component of the genetics of the two sheep breeds at the Glen AI has been lost for the future, mostly due to the effect of predation.

7.7 The Merino flock in Treatments SL-V&(C), SL-V&S, the Merino shearing flock and the Dorper flock suffered big losses due to predation on veld. In all the Merino flocks and the Dorper flock most post weaning losses due to predation was in the age category 4-12 months (368 losses), 2-tooth (38 losses) and mature sheep (324 losses), from 2003 until 2007. The Merino flock in Treatment SL-R&V was on veld from middle December to middle March, but was also effected by predation during these three months. Most losses in the Merino flock in Treatment SL-R&V occurred in the age category 4-12 months. During this time the sheep in this treatment was on natural veld and was again put on the rye-grass at the age of two-tooth (between 17-18 months). However, the Merino flock in Treatment SL-R&V was the only flock that could sustain the number of 70 ewes per treatment as described in the protocol of the Free State Wool Sheep Project.

7.8 Similar to the other Merino flock treatments on veld, the Merino flock in Treatment AL-O&V could also not maintain the desired number of 70 ewes per treatment. These ewes were on the oats pastures for six months of the year. When they were returned to the veld again, losses occurred. Most losses occurred during the peak predation seasons, namely September to November and March and April. The Merino flock in Treatment AL-O&V in the age category before reaching 17-18 months (2-tooth), had to endure three of the high peak predation seasons whereby huge sheep losses occurred mainly due to black-backed jackal. The Merino flock in the same age category in Treatment SL-R&V had to endure only two of these high peak predation seasons. This had an effect on the replacement ewes in both treatments on planted pasture.

7.9 Although predation was mostly responsible for the deterioration in production and reproduction, other factors such as general sheep management and variation in climate conditions also played an important role. A good rainy season in 2006 resulted in the ewes in all the sheep flocks, especially the older ewes, being in a better body condition. This resulted in better animal production and reproduction. Dry seasons had the opposite effect. Old ewes that were kept longer in a flock due to a lack of replacement ewes were mostly affected during dry seasons. A drop in body weight for especially the older ewes were recorded during mating in a dry season, which had a negative influence on production and reproduction. If these ewes conceived in a dry season, the shortage of available food put even more stress on the ewe to provide in her nutrient requirements as well as that of the fetus. This extra stress resulted in a break in the wool fibre and therefore it had a negative influence on the wool quality and income from the wool as well. It also resulted in still born lambs and/or lambs that grew poorly. Weaker lambs are normally produced by the older ewes and, in some incidents, 2-tooth ewes. This resulted in lambs not being able to walk with ewes soon after birth and thus becoming easy targets for predators. This was usually the case with the Merino flock in Treatments SL-V(C), SL-V&S, Merino shearing flock and the Dorper flock.

7.10 The camps available for all five Merino flocks and the Dorper flock at the Glen AI were divided in groups of three. One third of the camps were rested for a full season, while the second third were actively grazed during the growing season and the last third being utilised during winter and early spring. However, this grazing system and stocking rate of the Glen AI (6 ha/LSU) could not be sustained. The stocking rate decreased sharply due to sheep losses and cattle had to be used to graze the long grass a bit shorter to suit the grazing preference of sheep, e.g. in 2006 after a good rainy season.

7.11 Despite the fact that the stocking rate was far below the recommended norm, production and reproduction was still negatively influenced. With more food available it actually should have been the opposite. According to Jones and Sandland (1974) the production per animal and per hectare will increase substantially as the stocking rate decreases until an ideal stocking rate is obtained. At Glen the ideal stocking rate is 5.78 ha/LSU according to Fouché *et al*. (1985). At this level animal production is at an optimum level and will decrease if the stocking rate increases. The Merino flocks in Treatments SL-V(C) and SL-V&S, the Merino shearing flock and the Dorper flock had to stay in certain camps for long periods, especially during lambing. Some of the camps had jackal-proof fencing while others were protected with extra fencing to minimize entry by predators. Usually these camps were rested during the year and when the ewes on natural pastures started to lamb, they were moved to the "better" camps. These camps could not prevent the predators from entering, but mostly prevented sheep from crawling through the fences and grazing all over Glen. Some of the Dorper ewes, however, always found a gap in the fence, leaving their lambs behind. Most losses occurred due to predation when the ewes were separated from their lambs.

7.12 After the lambs were weaned they were moved out of the "secure" area, to other camps. Not many losses due to predation were recorded during January and February. However, this lapse in predation did not last long before more losses occurred again during March and April. During these months they were brought back to the "secured" fenced area. Although losses still occurred in the "secured" area the sheep could be better managed and slightly fewer losses occurred. If some of these ewes (4-12months) were still alive the following lambing season, they were kept with the ewes in lambing. Fewer losses occurred when all the sheep were together in a camp than when separated. If ewes in the age category 4-12 months were outside the "secure" area, they were normally the first to get caught. To prevent such losses, the ewes in this age category had to graze the same camps as the ewes in lambing. Over time, these camps were overgrazed.

7.13 Overgrazed camps resulted in replacement ewes not growing at a satisfactory rate as it should be. Some of the 2-tooth Merino ewes (18-months) in all four treatments and the Merino shearing flock were still less than 40 kg. These ewes were the only replacement ewes and had to be placed within the treatment flocks to ensure that enough ewes were available for mating. This resulted in poorer lambing, fecundity and weaning percentages. Fertility in two-year old ewes is lower than for other age groups. Also, the higher mortality experienced in lambs of two-year old ewes can be ascribed to the smaller, weaker lambs produced by these ewes (Fourie & Heydenrych, 1983).

7.14 The 2-tooth ewes in the Merino flock in Treatment SL-R&V had a weight advantage over the other treatment flocks. The Merino ewes in Treatment SL-R&V were mated on the rye-grass, resulting in a rapid weight gain and a better lambing percentage. Poor management led to rye-grass not being planted on time and the ewes were forced to be mated on veld, the replacement ewes did not experience the rapid weight gain, resulting also in poorer production and reproduction.

7.15 During the early spring there is too much material available on the rye-grass pasture for the ewes and their lambs allocated to Treatment SL-R&V. The lambs which were still totally dependant on the ewes for milk, did not have a marked effect on the intake of dry matter (DM) of the pasture, at this stage. In this way a large quantity of DM is lost because of trampling and the rye-grass could not be grazed down to 10 cm as defined by the methodology of the Free State Wool Sheep Project. Long shoots, which quickly started to seed, were left on the pastures. This makes it difficult to wean the lambs on the rye-grass, because above-mentioned problem causes the grass to produce seed too early, resulting in a shorter grazing period and lower weaned weights.

7.16 In the short term it seems that sheep grazing planted pastures in a secure area will prevent losses due to predators. However, rising costs especially for fuel, labour and fertilizers make it difficult to be profitable. If weaned lambs were put on the rye-grass it would be more profitable (Kynoch 1990). By putting pre-weaned lambs on the rye-grass, there is still a possibility of losses due to predators until weaning.

7.17 The Merino ewes in Treatment SL-S&V did not perform markedly better than the Merino ewes in Treatment SL-V(C). However, Merino ewes at five years and older were more likely to raise a lamb compared to the Merino ewes in Treatment SL-V(C). The lambs in Treatment SL-V&S gained weight faster than the lambs in Treatment SL-V(C) up to 35-days of age after which the weight gain (compensatory growth) were almost the same for both these treatments. This was the case only in the dry season or when sheep were grazing in overgrazed camps. The overgrazed camps were usually those that were surrounded by jackal-proof fencing. However, it was not possible to draw the conclusion tat supplementary feeding had a definite effect on the performance of lambs in Treatment SL-V&S, because too few lambs were weaned.

7.18 Good infrastructure plays an important role in livestock farming. If sheep handling facilities are lacking or deteriorating without improving it, e.g. fences, proper management is not possible. Management of the natural resource is very important. Usually a farm has a small stock management program that caters for the mating and lambing seasons, dosing and inoculation. A predator management program to reduce the impact of predation is usually lacking.

7.19 A drastic and immediate approach of all role-players in the sheep industry regarding the impact of predation is urgently needed. It is generally accepted that different control methods will have different levels of efficiency when used on different damage-causing animals. Therefore, the farmer needs to know which predator is responsible for every killing. It is also important to budget for animal damage control management.

7.20 According to the results of this study, the black-backed jackal were responsible for 70% of the post-weaning losses due to predation, vagrant dogs 20% and caracal only 10%. If a farmer has this type of information he will be able to know which predator is the main culprit and will implement different control measures accordingly.

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