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A survey of farmers' experience using guard animals to control the impact of predators on farm livestock

For the degree MSc (Veterinary Science)

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Declaration:

I, Jolandie Botha, hereby declare that this dissertation: "**A survey of farmers' experience using guard animals to control the impact of predators on farm livestock "**which I hereby submit for the degree MSc Veterinary science at the University of Pretoria, is my own work and that all the sources that I used or quoted have been indicated with complete reference and acknowledgements. This dissertation has not been previously submitted by me for a degree at this or any other tertiary institution.

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Jolandie Botha 14/06/2018

A survey of farmers' experience using guard animals to control the impact of predators on farm livestock

By

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Degree: MSc Veterinary Science

Department: Production Animal Studies

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Abstract

South African farmers have struggled for many years with the loss of livestock on their farms due to predators such as black backed jackals (*Canis mesomelas*) and caracal (*Caracal caracal*). These farmers have been known to use both lethal and non-lethal methods to control these predators on their properties. This study investigates the use of livestock guarding animals (LGAs) as a non-lethal method of controlling predators on farms.

The study investigated the use of dogs, alpacas and donkeys on farms through the use of an online survey. Despite multiple appeals being sent out to different media outlets the response was modest. A structured, quantifiable and analysable questionnaire was sent to 34 farmers of whom 31 farmers completed the entire survey. The survey was used to gather information regarding the success of using these LGAs as well as the factors leading to their success and failure. There were 23 respondents who made use of dogs, eight who made use of alpacas and three using donkeys.

Many studies have been done in the past on the use of dogs to protect livestock, these studies were done in Europe, the United states of America, Australia and Southern Africa. The use of both donkeys and alpacas have not been studied to the same degree.

The hypothesis was that the use of LGAs (dogs, alpacas and donkeys), was successful in reducing predation by 50% or more on 75% or more of the farms surveyed. It was found that 21 of the 31 farmers who completed the survey said that predation decreased by 50% or more after acquiring a LGA. The factors leading to the success or failure in using these animals was determined for dogs, alpacas and donkeys individually.

The questionnaire was designed to gather information about the farms such their size, terrain, the proximity to other farms, towns and nature reserves, and the wildlife found on the farm. We then looked at what livestock were being farmed and what LGA is being used by the farmer and how many of them are being used with the livestock. The questionnaire then went on to collect information on conception rates, lambing percentages, weaning percentages and percentages of livestock lost due to disease, predation and other factors. Looking specifically at predation we wanted to find out how much predation the farmers would attribute to which predator, how they determined which predator was responsible and how the predation changed over the time they had been using the LGA. It was also important to determine what methods of lethal control had been used previously on the farm and what was still being used by the farmers. Finally, the questionnaire covered the factors that contribute to the success and failure of the LGA as well as the cost of keeping the LGA.

It was found that 33 of the 34 farmers had both sheep and cattle on their farms and only 11 farmed with goats. Nineteen of the farmers were farming on flat open plains. The farms were mostly in close proximity to other small livestock farms while others were on communal land. The number of LGAs used by the farmers were mostly determined by the size of the farm and the number of livestock.

Supervision with livestock was not used by many farmers; 56% said it was unnecessary while 26% always had supervision with their animals. The rest of the farmers only occasionally had supervision with their animals. It was also found that the number of farmers making use of lethal control methods on their farms decreased from 80.65% before acquiring a LGA to 64.52% after acquiring a LGA.

Predation was attributed to jackals on all farms, to caracal on 28 of the 31 farms of respondents that chose to answer this question, three farmers had problems with dogs and one farmer had predation due to leopards on his property. It was found that LGA had the greatest potential to decrease predation by jackals.

The factors that were important for the use of dogs were their management, training and feeding. It was also found that dogs had the greatest financial impact on farmers as they cost more to acquire and maintain. The mean annual running cost as given by farmers was R11970.05. It was also seen that they had the greatest impact in reducing predation. The mean change in predation was 64% when making use of dogs. It was also seen that the weaning percentage on these farms increased by 25.23%. There was a change seen in the conception rate as well as the lambing percentage but neither was as large as with the weaning percentage. This is consistent with the fact that more lambs would survive if a LGA is keeping predators away.

The factors that were listed as the most important factors in the use of alpacas were their temperament, the number of livestock you place with the alpaca and the age of the alpaca. The information collected on alpacas was small but showed that only four of the eight respondents saw an improvement on their properties after acquiring their alpaca. The cost of using an alpaca was not as significant as for dogs as they do not require extra housing or feed. The average running cost per annum for the use of alpacas was given as R525. There was no significant change in the conception rate, lambing percentage or weaning percentage of farmers making use of alpacas.

There were only three responses for farmers making use of donkeys therefore there is no clear trend in the data but it has been reported on. The factors that were given as important were the gender of the donkey, specifically jennies (females) being more suitable, the donkey's temperament, management and the number of livestock placed with the donkey. This was all in line with what was found in previous studies done on donkeys. Two of the three farmers using donkeys said that there was a 50% or more improvement in predation reduction on their farms. The average running cost of using a donkey was R2560 per annum.

From the study it can be seen that these LGAs are successful in reducing predation but that more can still be done to encourage the use of alpacas and donkeys and to determine how successful they are.

Introduction:

Predation has been regarded as a big problem on farms in South Africa for a long time. Due to predation, farmers lose a large portion of their potential profit every year; this will include the money spent on predator control and the cost of a lamb lost, which is currently R68/kg to R78/kg (Botha, 2017; Van Niekerk, 2010). Van Niekerk (2010) found that approximately R1.4 billion was lost every year to predation in the five major small livestock producing provinces in South Africa. Various means have been used by farmers in an attempt to reduce predation. These include lethal and non-lethal methods of predator control. Loss of livestock is mostly due to mesopredators such as black-backed jackals (*Canis mesomelas*) and caracals (*Caracal caracal*) that roam freely on farms (Avenant and Nel, 2002; Yarnell *et al.,* 2013). The reason for this increase in mesopredators is due to the removal of apex predators; this is known as mesopredator release (Avenant & Nel, 2002; Thorn *et al.*, 2012; Yarnell *et al*., 2013).

Lethal control methods such as snares, shooting, capturing and poisoning have been used for decades by farmers but none have shown a sustained reduction of the problem (Beinart, 1998). Predation has also become a public issue as many consumers do not approve of the lethal methods of control. Organizations such as the Landmark Foundation are working towards certifying producers as “Fair Game” producers. These are farmers with farms that strive to be wildlife friendly and that work to increase the biodiversity on their property (Smuts, 2015). Woolworths is working with the Landmark Foundation and a number of other organisations in placing these Fair Game products in their stores (Botha, 2015). For this reason the use of livestock guarding animals (LGA) used to protect livestock optimally was investigated. The research will establish the factors that contribute to making guard animals successful on some farms and elucidate why they fail on other. The LGAs investigated were dogs, alpacas and donkeys.

Literature review

Conflict between humans and wild carnivores has developed due to a loss of normal habitat and the need for a high protein diet by carnivores. Many predators are implicated in predation on farms and on communal land including lions (*Panthera leo)*, leopards (*Panthera pardus*), cheetahs (*Acinonyx jubatus*), spotted hyenas (*Crocuta crocuta*), brown hyenas (*Hyaena brunnea)*, wild dogs (*Lycaon pictus*), black-backed jackals (*Canis mesomelas*), caracals (*Caracal caracal*) and even vultures (Bridgeford, 2001; Georgette Lagendijk & Gusset, 2008; Thorn *et al*., 2012). Farmers often make use of the open veld also occupied by carnivores and this can alter what the carnivore hunts, turning from its normal prey, such as small wild mammals, to livestock, which are much easier to hunt and more numerous (Avenant & du Plessis, 2008; Kamler, Klare & Mac Donald, 2012; Treves & Karanth, 2003). In South Africa this is a major problem since 68.6% of the land is used for livestock and wildlife farming. In the North West province 41% of predation has been attributed to the black-backed jackals and 20% to caracals while the remainder is said to be due to apex predators such as leopards, cheetahs and brown hyenas (Thorn *et al*., 2012).

In South Africa most apex predators have been eradicated on farmlands. This may have led to the increase predation pressure by mesopredators and reduced ecosystem function seen on farms today (Humphries, Ramesh & Downs, 2016; Yarnell *et al*., 2013). This removal of large predators such as lions and leopards has led to the increase in human wildlife conflict as mesopredators are more resilient to eradication techniques. These mesopredators often have high intrinsic growth rates that allow them to respond positively to increased mortality rates (Minnie, Gaylard & Kerley, 2016). Hunting of mesopredators also causes an influx of individuals that immigrate from unhunted areas to these hunted areas as there is space that they can occupy (Minnie *et al.*, 2016).

Black-backed Jackal (*Canis mesomelas*):

Black-backed jackals (from here on referred to as jackals) are small canids with a black saddle pattern on their backs and weigh 5.4kg-10kg (Estes, 1991a). Jackals are known as mesopredators (Thorn *et al*., 2012). They are territorial with both a male and female protecting their territory. The mated pair will indicate their territory through vocalisation, scent marking and aggression towards other jackals (Jenner, Groombridge & Funk, 2011). They will usually have pups from the current breading season as well as subordinates, also known as helpers, from the previous litter that join them in the territory (Estes, 1991a; Viljoen, 2014a). The number of subordinates that remain with

the dominant pair may depend on factors such as food availability close to the den. It was observed by Jenner *et al.* (2011) while studying jackals in the Cape Cross Seal Reserve in Namibia that 43% of the dominant pairs where accompanied by between one and six subordinates. The number of subordinates increased the further the den site was from the seal colony. This was attributed to the fact that these dominant pairs require more assistance in providing food and care for new offspring (Jenner *et al.*, 2011). Jackals may live for six to eight years, becoming sexually mature at 11 months; mating takes place from May to August with a gestation period of 60 days. They may give birth to one to six pups (Estes, 1991a; Minnie *et al.*, 2016; Viljoen, 2014a). Jackals will have a den (also known as a burrow) with both an entrance route as well as an escape opening. Their territorial range may vary between 9 and $35\mathrm{km}^2$ (Viljoen, 2014a).

Their predominant prey consists of small to medium sized mammals such as rodents and small ungulates (< 50kg). They may also consume insects, fruit and carrion (Avenant & du Plessis, 2008; Estes, 1991a; Kamler *et al.*, 2012; Loveridge & Nel, 2004; Rowe-Rowe, 1976; Smith *et al.*, 2000). Jackals hunt by running up alongside their prey and biting at the neck and face; this often causes tears in the ears of the animal and bite marks on the neck. They will then tear open the groin of the prey and remove the stomach. They feed on the other organs by entering under the ribs (Viljoen, 2014b).

Jackals are opportunistic in their hunting, going for the more dominant prey species that is available. Kamler *et al.* (2012) found that jackals prefer wild ungulates (<50kg) over domestic sheep even during the lambing season. They also concluded that the number of wild prey species available will affect the consumption of and predation on domestic sheep. In this study, scat analysis showed that sheep were the dominant prey during winter and spring, making up 48% and 46% of the diet respectively (Kamler *et al.*, 2012). This is the same season in which many ewes lamb and most jackals have pups. This study revealed that mammals weighing 1 – 3kg were still selected above any ungulate species if large numbers were available. Avenant and du Plessis (2008) stated that jackals switched to larger prey such as sheep when they are available.

Yarnell *et al.* (2013) stated that, even in the presence of apex predators, jackals' dietary components remain similar. Therefore they will still forage opportunistically in all environments, they will still hunt livestock and small wild mammals as well as scavenge when possible (Yarnell *et al*., 2013). The jackals' opportunistic nature and foraging ability allows them to make use of a broad spectrum of prey, which aids them in having increased population sizes (Humphries *et al.*, 2016).

Caracals (*Caracal caracal*)

Caracals are medium sized felids weighing 8kg-20kg, with both the male and female being solitary in nature, having a home range between 6 and 30km^2(Avenant & Nel, 2002; Estes, 1991b; Smuts, 2008; Viljoen, 2014b). This will depend on food availability as well as the terrain. Caracals live for 10 - 15 years and they can mate at any time of the year but prefer to mate during summer. They have a gestation period of 80 days and may have one to four kittens at a time (Avenant & Nel, 2002; Estes, 1991b; Smuts, 2008; Viljoen, 2014b).

When hunting, caracals may stalk their prey and ambush it (Estes 1991b; Smuts 2008; Viljoen 2014b). The classic indications of a caracal kill are four puncture wounds on the neck or back with blood on the stomach or scratch marks on the shoulders or hindquarters. Caracals will not feed until the prey is dead; they will feed preferentially on the hindquarters and they are often described as "eating in a neat manner". They will not consume the intestines and often wool has been plucked out from the skin. If caracals have kittens they will call them to the prey rather than take it back to the den. When finished feeding, caracals will cover up the prey with dirt and grass (Avenant & Nel 2002; Viljoen 2014b; Smuts 2008).

In studies done by Avenant and Nel (2002) and Avenant and du Plessis (2008) they found that rodents were the predominant prey species of caracals and made up >70% of their diet. They also concluded in both studies that caracals switched from rodents to livestock during the lambing season, March to June, which is when rodent populations were at their lowest. This is also influenced by the increased need for food during this time as this is when most of the caracals have their kittens. They concluded that unlike other felids, caracals are opportunistic and generalist feeders, switching to the dominant prey available.

Effect of removing mesopredators

Some studies have been done to show what may occur if jackal and caracals are removed from farms. These have found that the removal of territorial caracals may result in the increased movement of caracals into the area. This also leads to increased reproduction and increased predation on farms as a result of a decrease in the natural prey available to caracals (Avenant & du

Plessis, 2008). This is also seen when a dominant female jackal is removed from her territory: all females in the area will enter oestrus and therefore increase the population of pups. The removal of the dominant pair of jackals may result in an influx of less dominant jackals into the territory. However, Blaum, Tietjen, and Rossmanith (2009) found that in the Kalahari region there was more livestock predation on farms when no predator control methods were used. They also found that intensive grazing practices decreased the number of mesopredators on farms.

Lethal Control

There is a substantial amount of research that has been done on the lethal control methods used on farms not only in South Africa but also in countries such as the United States of America (USA), Australia and in Europe. Many lethal methods such as snares, hunting, poisoning and trapping have been thought to lead to greater ecological damage (McManus *et al.*, 2014; Potgieter, 2011; Potgieter, Kerley & Marker, 2015) and are considered reprehensible by most consumers (Botha, 2015; Smuts, 2015). In South Africa the Landmark Foundation is supporting consumers by having "fair game" producers identified who comply with farming methods that will increase biodiversity and not needlessly harm wildlife (Smuts, 2015).

In a study done in the North West province by Thorn *et al.* (2012) it was shown that one third of farmers in the study used only lethal methods, one third used only non-lethal, 30% used both lethal and non-lethal and the remainder of farmers used no control against predators. It was found that the highest rate of predation was on farms where both lethal and non-lethal methods were used. The lowest predation was on farms that did not use any control methods. It is not clear whether there is less predation due to no use of control methods or if these farmers do not use control methods because they have little predation.

In the past lethal methods such as eradication or regulated harvest were considered the most effective ways to handle predation on farms. Projects that promoted eradication of predatory species from extensive areas have now largely been terminated. Regulated harvest is still in use in South Africa with many farmers still hunting predators either during the day or using lights at night (Kamler, Jacobsen & Macdonald, 2008; Shivik, 2004; Shivik, 2006; Treves & Karanth, 2003). Many of these farmers make use of hunting clubs to kill predators. Other methods such as poisoning of carcasses and gin traps have also been used by many farmers (Verdoorn, 2013). The only legal way in which to use poison is by using poison collars as this targets the trouble-causing animal (Verdoorn,

2013). The problem with most of the lethal methods is they do not exclude the non-target animals such as bat-eared foxes, jackals and caracals that do not actually harm livestock. They are also cruel and unacceptable to many people (Kamler *et al.*, 2008; Shivik, 2004; Shivik, 2006; Treves & Karanth, 2003).

An experiment has been done by Kamler *et al*. (2008) using soft catch traps for the removal of problem jackals. Soft catch traps are a form of gin traps with a rubber padding that prevents serious harm to the animal. They had an 88% capture rate of jackals and a 98% exclusion rate of non-target species. These jackals were euthanazed. It was found that it could be used successfully if set at the correct weight, which would be 25% of the animal's weight. These soft catch traps had to be checked often and recalibrated to make sure no non-target species where caught (Kamler *et al.*, 2008; Verdoorn & Gifinligtingsentrum, 2015). The problem with this method is that larger animals may be caught in these traps and get severe injuries as they struggle to get free (Kamler *et al.*, 2008).

In a study done by Minnie *et al.* (2016) they looked at areas where mesopredators such as jackals where being hunted compared to areas where they were not. They established that in the population of jackals on farms where hunting was occurring, there were more young animals whilst in reserves or non-hunted areas the animals were older. The young animals had an expanding population structure, unlike the older populations that had declining population structures. The young jackals showed low philopatry, which is the tendency to stay or habitually return to a specific area; this may have been due to the high mortality rates experienced in the hunted areas that reduced the jackals' social ties. This encourages dispersal of the young jackals. This study also showed that both groups had fecundity rates and litter sizes that were the same. This is not normally seen in unhunted populations as the older jackals will harass the young jackals, preventing them from reproducing until they are older and more established. The reason both the study populations showed the same fecundity rates and litter sizes was due to the hunted areas not having dominant pairs to control the young animals (Minnie *et al.*, 2016).

Non-Lethal Control

There have been a number of studies looking at alternative methods of controlling predators on farms which are non-lethal. The main focus of this project will be on LGA as they have been proven to be one of the most effective non-lethal control methods. Our focus will be on dogs, donkeys and alpacas.

Livestock guarding dogs:

Globally, livestock guarding dogs (LGD) have been used successfully for many centuries. These dogs were historically bred to aid in the coexistence of domestic sheep and grey wolves in Europe and Asia (Urbigkit & Urbigkit, 2010; Wilbanks, 1995). This has more recently been studied in many different countries such as the USA, Australia, Namibia, South Africa and throughout Europe. Most of the studies conducted have found that large breeds are most successful, with a dog that weighs 35 – 45 kg with a shoulder height of 65cm (Andelt, 2004). The dogs used as LGD often show similar characteristics such as intelligence, trustworthiness, attentiveness, aggression, self-confidence and protectiveness. (Wilbanks 1995; Yilmaz *et al*. 2015). LGD are not like herding dogs as herding dogs focus on gathering livestock and herding them to specific places whilst LGD are used for protection of livestock (Yilmaz *et al.*, 2015).

The dogs used most often are Anatolian Shepherd dogs. Other breeds that can be used include the Great Pyrenees, Transmontano mastiff, Komondor, Maremma, Shar Planinetz, Karakachan dog and the Central Asian Ovcharka (Urbigkit & Urbigkit 2010; Wilbanks 1995). The guidelines for raising these dogs for effective use on farms are well established. These are as follows:

- The dog should be introduced to livestock at the age of six to eight weeks and raised in enclosures with the livestock that are to be guarded (Andelt, 2004; Marker, Dickman & Schumann, 2005; Smith *et al.*, 2000; Wilbanks, 1995).
- There should be a separate enclosure where the dog is fed (Andelt, 2004; Marker *et al.,* 2005; Smith *et al.*, 2000).
- If the dog shows any behavioural problems such as play behaviour with the livestock they should undergo correctional training; this may include placing the dog on a leash in the enclosure (Andelt, 2004; Marker *et al.,* 2005; Smith *et al.*, 2000).
- These dogs should not be exposed to excessive contact with people but should not show aggression to the handlers of the livestock or other farm workers. If these dogs do not have enough contact with people they may become too shy to be handled Andelt, 2004; Marker *et al.,* 2005; Smith *et al.*, 2000; Urbigkit & Urbigkit, 2010).

- Some sources say the dog should not have contact with other dogs (Anon 2015b) whilst other sources say this has no effect on the LGD (Andelt, 2004; Marker *et al.,* 2005; Smith *et al.*, 2000).
- In the past the LGD were chosen for breeding through dog fights or wrestling. This was used mostly in central Asia to determine if the dogs would be effective in defending a flock against wolves. The dog had to show controlled aggression to be selected; if the dog whimpered or showed submission it would not be used. Similarly, if the dog showed blind fury it is not used. This method was mostly used to select Ovcharka dogs but shows the importance of temperament in these dogs in the selection and training to protect livestock (Urbigkit & Urbigkit 2010).

The LGDs keep predators away as they become territorial. They will bark at a predator, become aggressive and have been known to fight off predators (Andelt, 2004; Marker *et al.*, 2005). Problems that have been observed with LGD are as follows;

- Injuring and killing livestock through play (Andelt, 2004; *Anon*, 2015; Marker *et al.*, 2005; Smith *et al.*, 2000)
- Not guarding livestock, but rather staying at the house (Andelt, 2004; Marker *et al.*, 2005; Smith *et al.*, 2000)
- They may be overly aggressive towards people (Andelt, 2004; Marker *et al.*, 2005; Smith *et al.*, 2000)
- Become ill or die prematurely (Andelt, 2004; *Anon*, 2015; Marker *et al.*, 2005; Smith *et al.*, 2000)
- Cause destruction to property (Andelt, 2004; *Anon*, 2015; Marker *et al.*, 2005; Smith *et al.*, 2000)

Most of these are behavioural problems that can be controlled and prevented through proper training (Marker *et al.*, 2005; Smith *et al.,* 2000; Wilbanks, 1995). A concern for many farmers is that one could put in a great financial investment with no guarantee of a return (Smith *et al*., 2000). The number of LGD used per flock can also differ greatly depending on the breed of sheep. In America they found that placing two to five dogs with 1000 ewes and their lambs was most effective; the sheep in this case are a gregarious breed, the western white-faced sheep (Urbigkit & Urbigkit, 2010).

Many European countries, such as Bulgaria, Poland and Sweden where LGD are used, the farmers receive some compensation if they are losing livestock but they are expected to have a dog for

protection in order to receive this compensation. These dogs often also work with a shepherd and an intensive winter farming system that changes to extensive farming in the summer (Yilmaz *et al.*, 2015).

It has been found that sheep that graze in the presence of a LGD will travel further in a day than those that do not have a LGD present. This allows them to have a more varied intake of nutrition and may even lead to better health and weight gain. This may be the result of the livestock not having to be as attentive to their surroundings while feeding as they are being kept safe from predators (Webber *et al.*, 2015).

Alpacas:

There is very little information on the use of alpacas as a livestock protection animal. Most information gathered is on the use of llamas rather than alpacas but as both are camelids and closely related the information could be of use. Research done in both Australia and USA shows that alpacas become territorial and are therefore effective guarding animals. Alpacas use middens to mark their territories and will patrol the area they consider their territories. This means they are not always with the flock of sheep or herd of goats but will be more alert and look for any threats (Kingwill, 2016). At night the flock/herd tends to lie around the alpaca for protection (Kingwill, 2007).

Alpacas also have an inherent dislike of canids. Alpacas will first emit a loud whistling alarm call followed by chasing the predator and trampling them with their front legs and biting at them (Andelt, 2004; Kingwill, 2007; Kingwill, 2016; Lawrie, 2004; Mahoney & Charry, 2004; Smith *et al.*, 2000; Wilbanks, 1995). It has been observed by some producers that the alpacas or llamas will round up the herd of sheep and place themselves between the sheep and the predator (Meadows & Knowlton 2000). They may also provide passive protection as many small predators will move away if they have been detected by an alert alpaca (Meadows & Knowlton 2000). Some studies have found that only one alpaca should be used per flock or enclosure, since when they are placed together they tend to flock together and not guard the livestock (Andelt, 2004; Lawrie, 2004; Mahoney & Charry, 2005; Smith *et al.*, 2000).

In a personal communication Sally Kingwill (2016) advised that in South Africa some farmers make use of four to six alpacas in a 3000 hectare area depending on the terrain in which they are found.

Other farmers use two alpacas for every 250 sheep or goats. The greatest problem experienced with alpacas is that they tend to attempt to mate with the ewes. There is also doubt as to whether they will protect livestock against larger predators (Andelt, 2004; Lawrie, 2004; Mahoney & Charry, 2005; Smith *et al.*, 2000).

The advantages of having an alpaca rather than a LGD are as follows (Meadows & Knowlton, 2000):

- Greater longevity
- Less training is required
- Faster adaptation to being a guarding animal
- Fewer management considerations such as food requirements
- Easier to use along with other depredation methods

Donkeys:

The use of donkeys as a LGA has not been studied in any great depth. Most studies with donkeys have been done in the USA and may be out of date. Donkeys are used because they have an inherent dislike of canids as well as a natural herding instinct (Wilbanks, 1995). The donkey selected should be medium to large in size and the temperament should be suitable to keeping predators away. The donkey's temperament can be tested by placing it in an enclosure with a dog and seeing its reaction towards the dog.
Donkeys are most effective when raised in the following manner:

- Raised with a flock from weaning age (Andelt, 2004; Green, 1989; Smith *et al.*, 2000).
- Not raised with any dogs or placed in enclosures that are in close proximity to any other donkeys, horses or mules (Andelt, 2004; Green, 1989; Smith *et al.*, 2000).
- Herding dogs are not used around the donkeys (Wilbanks, 1995).
- The donkey is placed with approximately 200 sheep in a small pasture to be most effective (Wilbanks, 1995).
- One gelding or one jenny (female donkey) that may have a foal with her with each flock or in each enclosure. Intact males should not be used as they may be too aggressive, especially towards new born lambs. Intact males may also

jump fences to find jennies in heat (Andelt, 2004; Green, 1989; Jones, 2008; Smith *et al.*, 2000; Wilbanks, 1995).

- During the lambing season the donkey should be removed or separated from the flock as they may disrupt the lambing process or the bonding between the ewe and her lamb (Andelt, 2004; Anon, 2015b; Green 1989).

When a donkey sees something that may be threatening to the flock it will first freeze and stare (Jones, 2008). Donkeys will then control predators by chasing, kicking, biting and stamping on them in addition to emitting a loud alarm call. Donkeys must be prevented from feeding on any extra feed given to the livestock especially if it contains Rumensin as they are monogastrics, not ruminants. There is doubt as to whether they can truly control larger predators as they may feel threatened themselves when these predators approach (Andelt, 2004; Green, 1989; Smith *et al.*, 2000). Donkeys may also suffer from boredom if they are not kept active (Jones, 2008).

Other (non-lethal) methods:

In some countries, compensation or insurance is used to stop farmers using lethal methods to control predators. The farmers are given a sum of money either to aid them in the use of non-lethal control methods or to compensate for the livestock lost. Countries that use these compensations are Switzerland, Poland, Bulgaria and many other European countries (Rigg *et al.*, 2011; Shivik, 2006).

Aversion tactics:

Aversion tactics can also be used for predator control. These include disruptive stimuli such as lights in a field, sound, or a combination of both. These aversion tactics are often only effective for a period of 6 weeks before the predators adapt and are no longer affected. Aversion techniques such as playing a radio in the field at night may also influence the behaviour of the livestock and not only the predators (Shivik, 2004; Shivik, 2006; Wilbanks, 1995).

Animal armour:

Animal armour has also been used in the past. This is where a farmer places a collar on the animal's neck for protection; it prevents predators getting to the trachea of the livestock when biting. The problem with this method is that the predators adapt to these methods, which makes it inefficient in the long run (Shivik, 2004; Shivik, 2006).

Alert collars:

Farmers can also make use of cell phone alert collars. If the farmer has a strongly flocking breed such as Merinos he only needs to use one collar per flock of animals as they will come together when threatened. In a non-flocking species such as Dorpers, more than one collar may be required per flock as they do not come together when threatened. The collar will send a message to the farmer if the flock is disturbed. This message includes GPS coordinates, which allows the farmer to find the flock much faster. This method allows the farmer to target only the guilty animals rather than kill all predators on the farm (Lotter, 2016).

Fencing and enclosures:

Placing livestock in specific enclosures or pastures during critical times has also been used. In this method animals are moved to pastures that have a history of less predation during the lambing season (Shivik, 2004). These enclosures may also be rendered predator proof by using jackal proof fencing or electric fences (Anon, 2015a; Beinart, 1998; Bezuidenhout, 2009). The best form of protection is using total confinement; this is when the animals are taken into a building such as a shed during lambing and kept there for a number of weeks to allow the lambs to increase in size before going into the pasture. The biggest drawback with this method is its high cost of implementation and labour costs (Shivik, 2004; Shivik, 2006; Wilbanks, 1995).

Predator proof fences have a section made from mesh wire to prevent jackals from entering a camp (Beinart, 1998; Bezuidenhout, 2009). The electric fence should be set up in such a way that it does not apply a lethal shock to the animal. They should have an earth wire at 10cm then an electric wire at 20cm above the ground and another 15cm above the top of the fence line (Anon, 2015a). The problem experienced with these fences is the cost involved in maintaining them (Bezuidenhout, 2009). Using these methods along with LGAs may be one of the most effective ways to protect livestock in a sustainable non-lethal manner (Shivik, 2004; Shivik, 2006).

Methodology:

Problem or Hypothesis:

In South Africa, lethal methods of predator control have been used for many years but this has become a method of control that is less accepted by consumers and conservationists. Equally importantly these methods have also not shown any sustainable control of predators. In order to control predators effectively on farms, LGAs can be used; this is more sustainable and has more support from both consumers and conservationists. The factors that contributed to either the success or failure of using these LGAs were identified.

The hypothesis was that the use of LGAs (dogs, alpacas and donkeys), was successful in reducing predation by 50% or more on 75% or more of the farms surveyed.

Objective:

1 To establish a list of factors that are important in the use of LGAs.
2 To establish if farmers have been able to reduce livestock predation on their farms by 50% or more with the use of LGAs.
3 To compare the use of the different LGAs.

Experimental design:

A questionnaire was set up on "Survey Monkey" (Anon n.d.) for the collection and analysis of the data. The questionnaire was formulated in such a way that quantifiable and analytical information could be collected from the participating farmers. For the study the ideal respondent was a small stock farmer living in southern Africa, preferably South Africa, who had been using LGAs such as dogs, alpacas and donkeys for two or more years, and farmers should have a record of the situation on the farm prior to use of the LGA as well as data after their use.
For the survey, different reliable sources were used to identify potential respondents. A general appeal was sent to a number of popular media including Farmers Weekly, Veeplaas, Stock Farm and Landbouweekblad. These magazines are distributed in many stores in South Africa and can also be delivered by mail, therefore a large diverse reader base had access to the appeal. National wool

growers association (NWGA) and Red meat producers organisation (RPO) were also requested to get support from their farmers to complete the survey. These appeals were sent out numerous times. Contact was also made with breeders of livestock guarding dogs, alpacas and donkeys in order to make contact with farmers. The appeal was also broadcast on two different occasions on two different radio stations; the first was Kosmos Radio in Namibia and the second was Pretoria FM agricultural segment. From these appeals the survey was sent to willing participants, that matched our criteria, for them to complete. The respondent had access to the survey for as long as was required to complete it. Once it was complete they could not go back and change any answers given.

Method:

The questionnaire was set up consisting of 26 questions in English and Afrikaans. The majority of these questions were those sent to the RMRD-SA when applying for funds for the study which was applied for by Prof Bath. The questions where set up to gain insight into the use of different LGA used by small stock farmers in South Africa. Some questions were used to establish the number of livestock on the farm, where these farms are located and how many LGA are used. Questions that would indicate what natural prey is available on these farms was also given. This would be followed by questions on the conception rate, lambing percentage and weaning percentage as these would show us if there was an improvement in livestock numbers on the farms and at which point improvement can be seen. Questions on how many livestock are being lost to either predation, disease or other causes gave insight into how great the problem with predation is in relation to the others. The change in losses after acquiring a LGA also needed to be established along with how effective the LGA is in reducing predation. Factors that are important in the management of these animals needed to be established and this was done by asking the farmer what they perceived was important and then giving them a list of factors to rank. The survey is attached as Addendum 1.

After the questionnaire was set up it was evaluated by Prof Bath, Dr Leask and Dr Fosgate, an attempt was also made to send it to the humanities department for evaluation as they have more experience in questionnaire based studies but they were unable to assist in evaluating the questionnaire.

Different magazines including Landbouweekblad, Farmers Weekly, Veeplaas and Stock Farm were contacted to place an appeal for farmers to help with the questionnaires. The ideal was to collect surveys from 73 farmers. This was established through using a sample size calculation as seen below.

The hypothesised proportion was determined by the ideal of 75% of respondents experiencing success in the use of LGAs on their farms.

n = uncorrected sample size for each group

P= hypothesised proportion

e = desired error limit or precision for the estimated P

α = level of significance (1 – confidence level)

$$n = \frac{P\,(1-P)(Z_{1-\frac{\alpha}{2}})^2}{e^2}$$

P = 0.75

α = 0.05

e = 0.1

$$n = \frac{(0.75)\,(1-0.75)(Z_{1-\frac{0.05}{2}})^2}{0.1^2}$$

$$n = \frac{(0.75)\,(0.25)(1.96)^2}{(0.1)^2}$$

$$n = 72.03$$

$$n = 73$$

However, only 34 farmers were willing to respond to the appeal despite multiple attempts to get more farmers to fill in the questionnaire. The farmers contacted the researcher directly and was then sent a link to the survey to complete. They had access to the survey until they completed it and it could be paused and returned to if it was necessary. Respondents completed these surveys between June 2016 and March 2017. Of the 34 respondents 31 questionnaires were completed and could be used for all questions.

The number of responses from farmers using donkeys was very poor, with only three completed surveys. For this reason, the data collected from these respondents cannot be compared to the other two groups. There were eight responses from farmers using alpacas and 20 responses from farmers using livestock guard dogs that were completed, with another 3 that were not completed

fully. Due to few responses for alpacas and donkeys their data is considered separately although for some of the questions the data is included together with that of the dogs.

The majority of the results have been analysed using the mean, mode, median, range and standard deviation. This was done by hand or making use of Microsoft excel. Prof Kidd from Stellenbosch University assisted with the analysis of questions for which a statistical program was necessary to do analysis. Results for question 8 were analysed using spearman rank order correlation (Lund & Lund, 2018). Question 13 and 14 were analysed using one way ANOVA (Sajid, 2016). Question 22 and 23 were analysed using an independent T-test (Lund & Lund, 2018a) and confidence intervals. The data is represented in the form of tables and figure with raw data being available as appendix 2. The questions were processed first in groups of which LGA was being used and then for certain questions all the results were considered together. There were some areas where due to the misunderstanding of the question some data could not be used. In the instances where it was clear that the question was misunderstood the respondents answer was not considered with the rest of the data. In the case were the question was misunderstood by all farmers the analysis was changed to suite the data.

Results:

This study looked at the use of three different LGAs, **donkeys, alpacas** and **dogs.** There was a total of 34 respondents, 23 of these were from respondents who made use of **dogs**, 3 of the 23 did not complete their surveys, 8 respondents used **alpacas** and 3 used **donkeys**. The responses for alpacas and donkeys was too few and therefore the data cannot be fully analysed but some insight is gained from these responses. The data collected for the use before and after making use of LGAs would be focused on the two years before and two years after acquiring the LGA.

The results are given in groups of related questions. The questions can be found attached as addenda A and the raw data in addenda B. Farms are identified by LGA used (D = Dog, A = Alpaca, E = Donkey) and questions identified by a Q followed by the number.

Table 1.1 below shows the number of responses to each question for each of the different LGAs.

Table 1.1: Number of responses to each question for each LGA

Question	Dogs	Alpacas	Donkeys
1	23	8	3
2	22	8	3
3	22	8	3
4	23	8	3
5	23	8	3
6	19	8	1
7	23	8	3
8	23	8	3
9	23	8	3
10	21	8	3
11	22	8	3
12	21	8	3
13	20	7	3
14	20	7	3
15	20	8	3
16	19	8	3
17	20	6	3
18	21	8	3
19	21	8	3
20	21	8	3
21	20	8	3
22	21	7	3
23	19	8	2
24	20	7	3
25	20	7	2
26	20	8	3

Initial information (all responses):

Details regarding the farm (Q 1 – 4):

The sizes of the farms varied greatly as well as the terrain they are found on. For the respondents using **dogs** the majority of the farms where on Flat open plains (13) with an average farm size of 5141.5 hectares. There were two farmers who indicated they were using communal land for their animals.

Alpacas were used in flat open plains and in mountain areas with an average farm size of 6625 hectares. The farms on which **donkeys** were used appeared to be smaller with an average size for farms on open plains being 970 hectares.

Table 2.1 (Q1 + 2): The mean, median, range for the size of farms on different terrains

	Terrain (number of responses)	Mean (SD)	Median	Range
Dogs	Overall (23)	4316.19 (5645.17)	2500	190 – 2600
	Flat open plains (13)	5141.5 (6979.96)	2500	25810
	Mountains (6)	2700 (2058.15)	2400	4300
	Bushveld (3)	Communal	Communal	-
Alpacas	Overall (8)	6625 (2454.08)	6425	2600 - 10000
	Flat open plains (4)	6587.5 (2473.99)	5900	5450
	Mountains (4)	6662.5 (3152.08)	7025	7400
Donkeys	Overall (3)	686.67 (722.31)	440	120 - 1500
	Flat open plains (2)	970 (749.53)	970	1060
	Bushveld (1)	120	120	-

It is evident from the responses to question 3 that most farmers (28) share their fences with other small stock farmers, 11 farms were close to Nature reserves and the least number of farms (5) were those close to cities/towns. Table 2.2 gives a summary of the results to this question.

Table 2.2 (Q3): Areas that are found close to the farms of respondents

	Nature reserve	City/town	Other small stock farm
Dogs	7	3	17
Alpacas	2	1	8
Donkeys	2	1	3
Total	11	5	28

Question 4 identify three species of wildlife occurring most often on the farms these were steenbok (*Raphicerus campestris*), scrub hares (*Lepus saxatilis*) and rodents. Figure 1.1 shows the wildlife found most often on the farms.

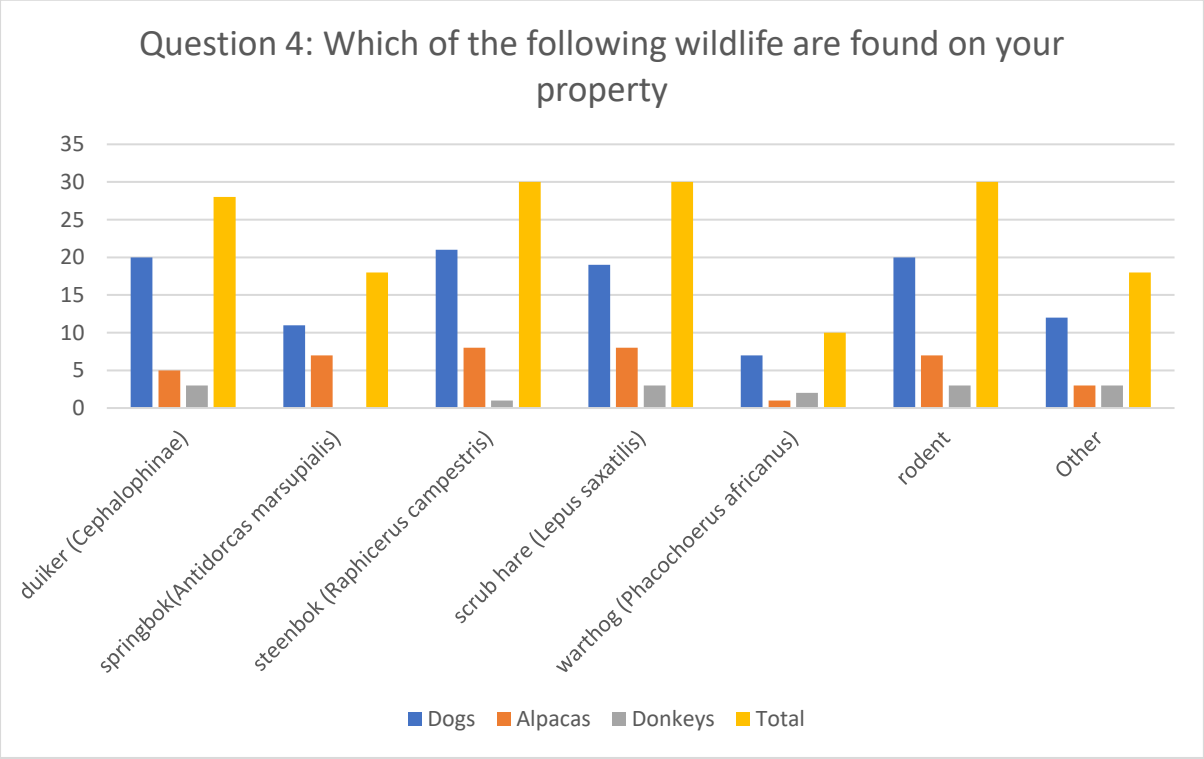

Figure 1.1 (Q4): Wildlife found most commonly on the farms of the respondents.

There were 18 respondents who said they had other wildlife occurring on their property; these were:

- rock hyrax (*Procavia capensis*) (5)
- rabbits (5)
- porcupine (*Hystrix cristata*) (5)
- mountain reedbuck (*Redunca fulvorufula*) (5)
- kudu (*Tragelaphus strepsiceros*) (4)
- meerkat (*Suricata suricatta*) (3)
- blesbok (*Damaliscus pygargus phillipsi*) (3)
- springhare (*Pedetes capensis*) (3)
- bushbuck (*Tragelaphus sylvaticus*) (2)
- bushpig (*Potamochoerus larvatus*) (2)
- common reedbuck (*Redunca arundinum*) (2)
- fallow deer (*Dama dama*) (1)
- aardvark (*Orycteropus afer*) (1)
- aardwolf (*Proteles cristata*) (1)
- bat-eared fox (*Otocyon megalotis*) (1)
- cape fox (*Vulpes chama*) (1)
- African wildcat (*Felis silvestris lybica*) (1)
- blackfooted cat (*Felis nigripes*) (1)
- bontebok (*Damaliscus pygargus*) (1)
- gemsbok (*Oryx gazella*) (1)
- oribi (*Ourebia ourebi*) (1)
- Vervet monkey (*Chlorocebus pygerythrus*) (1)
- guinea fowl (*Numididae*) (1)
- cape ground squirrel (*Xerus inauris*) (1)
- grey rhebok (*Pelea capreolus*) (1)

Dogs:

Details regarding livestock and LGA numbers (Q 5 – 12):

The farmers who answered the questionnaire varied in the livestock they have on the farm as well as the number of livestock they had. One of the reasons why some farmers have a small number of livestock is due to the communal farmers who answered the questionnaire. The smallest number of sheep farmed was 20; this farmer was also farming with 60 goats, and all on communal land. The largest number of sheep was 5500; this farmer did not farm with any other livestock. Five of the respondents had other livestock on the farm, these were pigs, horses, donkeys, springbuck and oryx.

Table 3.1 (Q5): Number of livestock farmed by each respondent using **dogs**

	Mean (SD)	Median	Range
Sheep	1259 (1279.12)	900	20 - 3000
Goats	158 (343.34)	0	0 - 1300
Cattle	265 (366.69)	150	0-1500

The number of livestock on each farm was placed into groups as seen in figures 2.1 to 2.3. This allows for a visual representation of the number of farmers in each group. The largest percentage (31%) of farmers had 1 – 500 sheep on their farms. The majority (65%) of the farmers had no goats on their farms and 91% of the farmers had 1 – 500 cattle on their farm.

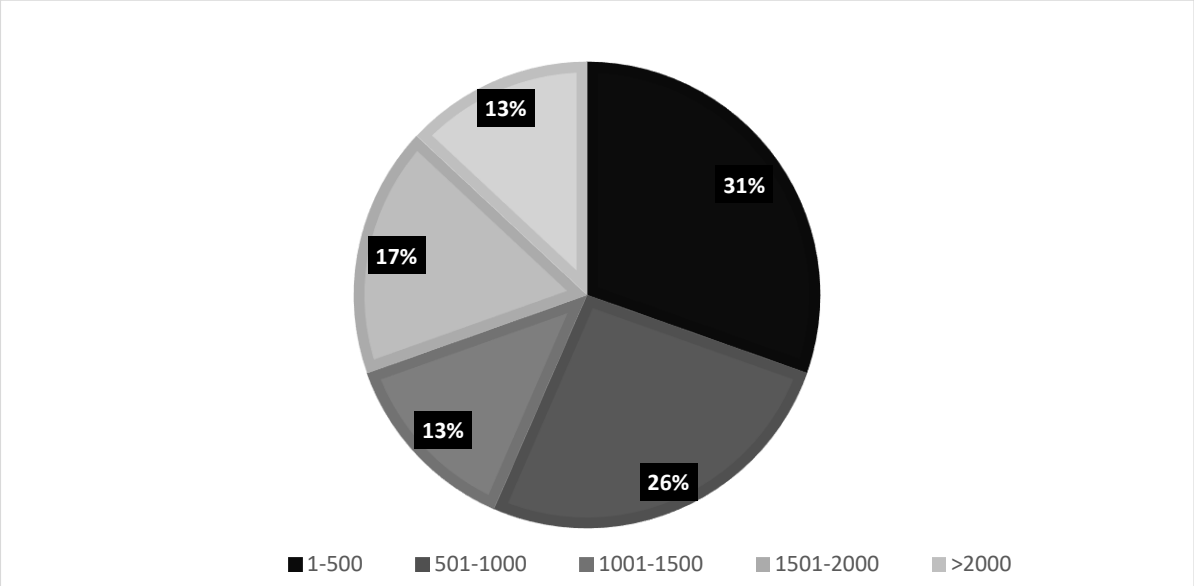

Figure 2.1 (Q5): Number of sheep on farms using **dogs**

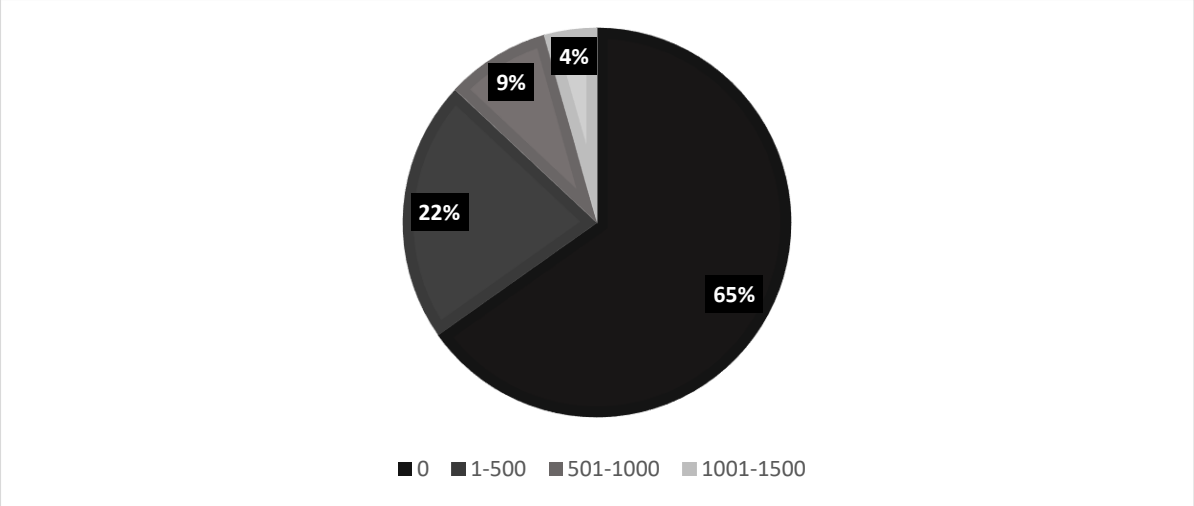

Figure 2.2 (Q5): Number of goats on farms using **dogs**

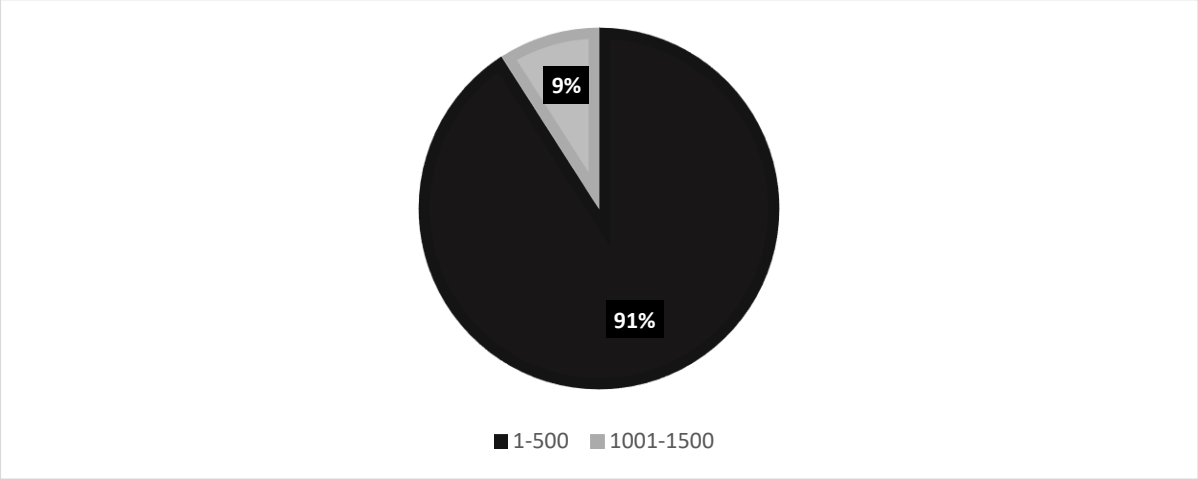

Figure 2.3 (Q5): Number of cattle on farms using **dogs**

Question 6 shows us that there were 6 respondents using **dogs** that had supervision regularly while 13 had no supervision and 4 occasionally used supervision with the **dogs**.

The maximum number of **dogs** (Q8) used by respondents was 7 on farm D21 but only 1 of the 7 was used for protection while the others were used for breeding.

For question 9 the majority (16) of respondents making use of **dogs** indicated they placed more than 150 livestock with each **dog**. Two respondents using **dogs** only placed 101 – 150 livestock with their **dogs** while 2 placed less than 50 livestock with their **dogs**. The other three respondents using **dogs** placed between 51 and 100 livestock with the **dogs**.

The first respondent (D1) only farms with wethers and therefore question 10, 11 and 12 did not apply to him. Respondent number four (D4) said his conception rate changed from 1 to 2, this is an outlier and will not be considered in the discussion; the question was most likely misunderstood. Of the remaining responses, 4 (D8, D16, D21 and D22) said they had an improvement in their conception rate after using **dogs** on the farm. The most significant change was for respondent 21 (D21) where the conception rate went from 80% to 140% this can be seen in figure 2.4. Figure 2.4 shows the remaining 15 (68.18%) respondents had no change in conception rate on their farms, which is to be expected. The average change in conception rate was 6.42%.

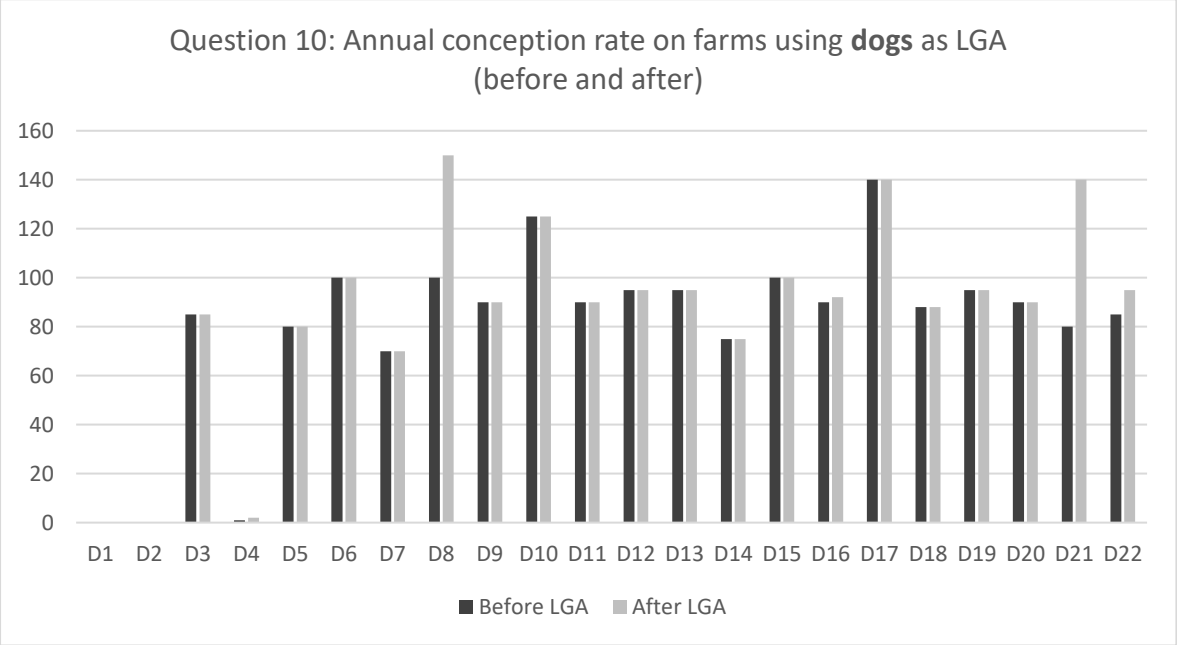

Figure 2.4 (Q10): The annual conception rate on farms using dogs as LGAs (before and after)

There were 8 respondents (D4, D8, D9, D13, D16, D20, D21 and D22) who had an increase in lambing percentage after using **dogs** while 1 respondent (D17) had an insignificant decrease in lambing percentage from 140% to 138%. Figure 2.5 shows that the remaining 12 respondents did not have a change in their lambing percentage. The average change was 8.52%.

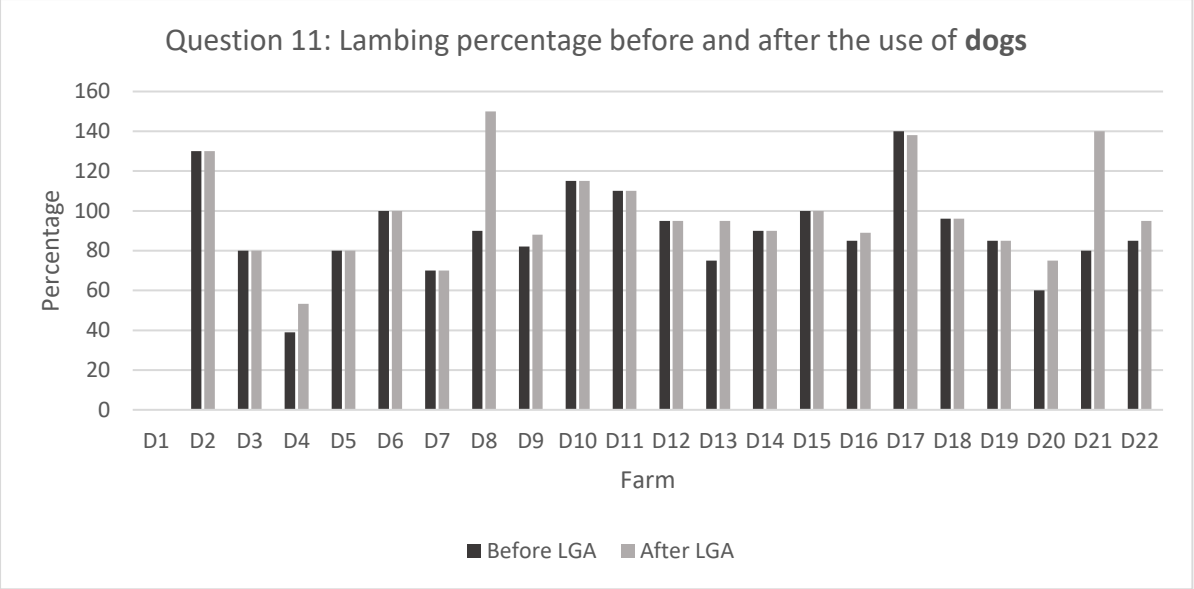

Figure 2.5 (Q11): Lambing percentage before and after the use of **dogs**

Only 1 respondent's (D5) weaning percentage remained the same before and after acquiring a **dog** as protection. The remaining 19 farmers all experienced an increase in weaning percentage after acquiring a **dog**. It can be seen in figure 2.6 that the greatest change was seen in respondent 7 (D7) where weaning percentage went from 5% to 100%. The average change is 25.23%. The change in weaning percentage is similar to the improvement in losses due to predation (Qs 13+14) which was 25.5%. Weaning percentage in comparison to conception rate and lambing percentage had a considerable change.

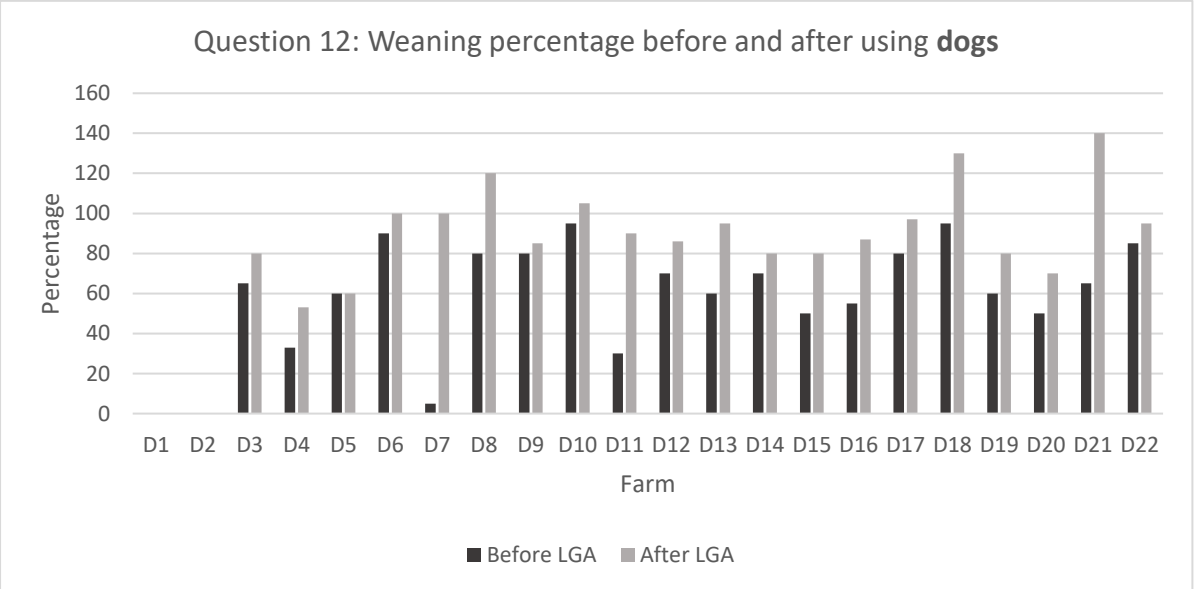

Figure 2.6 (Q12): Weaning percentage before and after the use of dogs

Livestock losses and predation (Q 13 – 20)

For farmers using **dogs** as LGA only one respondent (D8) said their losses due to disease decreased after acquiring a LGA (Q13 +14). Predation decreased on 19 of the 20 farms by an average of 25.5% (range 0 to 80%) as seen in table 4.1. This is similar to the change in weaning percentage (Q12) which was 25.23%. For the 'others' category (classified as anything else that caused the death of the livestock) only 1 respondent (D2) said losses decreased.

Table 4.1 (Q13 +14): The percentage of livestock lost due to disease, predation and other reasons before and after using **dogs**

	Mean change	**Range of change**
Disease	0.5%	0 – 10%
Predation	25.5%	0 – 80%
Other	0.5%	0 – 10%

The loss of ewes, lambs and rams before and after acquiring a **dog** was difficult to analyse as the questions (Q15+16+17) were not stated clearly and may have been misunderstood by some of the farmers. We were hoping to determine how large a percentage of the losses seen on the farms was either ewes, lambs or rams and if this changed. The way this was understood by most farmers seems to have been the percentage of losses of ewes, lambs and rams on their farms before and after acquiring the dog. Looking at the data from this perspective there was a clear trend showing a decrease in loss of lambs, ewes and rams on the farms as seen in table 4.2. The average change for loss of ewes was 4.5% (range from 0% to 20%). The average change for loss of lambs was 20.5% (range from -10% to 90%). The average change for loss of rams was 5% (range from 0% to 40%).

Table 4.2 (Q15 + 16 + 17): The data collected for livestock lost before and after using livestock guarding **dogs**

	Mean Change	**Range of change**
Ewes	4.5%	0 – 20%
Lambs	20.5%	10 – 90%
Rams	5%	0 – 40%

Question 18 and 19 was stated in such a manner that it was again misunderstood for this reason only the trends seen will be discussed. Four of the respondents (D10, D11, D12 and D15) making use of **dogs** did not see a change in the attribution of predation from before to after using the **dogs**.

Three respondents (D80, D19, and D20) had an increase in predation attributed to jackals after acquiring **dogs**. The other 13 respondents saw a decrease in predation they could attribute to jackals while 4 of the 13 attributed more predation to other animals including caracals and dogs. One farmer experienced an increase in the predation he could attribute to dogs after acquiring **dogs** on his farm; it changed from 30% to 80% while his predation by jackals decreased from 60% to 10%. There were 3 respondents who said they experienced predation due to animals other than Jackals, caracals, dogs and leopards. This percentage of predation attributed to "Other" did not change on 2 of the 3 farms after acquiring **dogs**.

There were three methods that were used most often to identify the predators the farmers had on their property (Q20). For farmers making use of dogs these where using tracks (17), looking at the killing pattern (15) and 14 used the feeding pattern.

Methods of predator control and its effectiveness (Q 21 -23):

The majority (16) of the respondents made use of lethal control methods (Q21) before and after acquiring dogs. Five of the respondents stopped using lethal control methods after they acquired their dog.

Of the respondents making use of dogs 17 (80.09%) respondents said that predation on their farms decreased by 50% or more since acquiring their dog (Q22). The remaining 4 (19.05%) respondents did not have a decrease of 50% or more in predation on their farms.

The mode for respondents using **dogs** was 91-100% for overall decrease in predation (Q23). The smallest decrease seen overall by respondents using **dogs** was 0-10%. The decrease seen in the first and second year after acquiring the **dog** and then overall is seen in table 5.1.

Table 5.1 (Q23): How much predation decreased on each farm in the first and second year and overall after acquiring LGA

		Mean	Mode	Range
Dogs	First year	53	31 – 40%	0 – 100 (100%)
	Second year	60	91 - 100%	0 – 100 (100%)
	Overall	64	91 – 100%	0 – 100 (100%)

Specifics on LGAs (Q 24-26):

Extra costs were experienced by all the farmers who use **dogs** but none of them experienced extra costs in all categories. The average initial cost (table 6.1) when acquiring a **dog** as a LGA is R5291.5, this includes training and cost of sourcing the animal. Running costs (table 6.2) per annum is

R11970.05 on average. D20 provided the cost of acquiring either an adult dog or a puppy. The cost used in calculations was that of acquiring a puppy (R3000) as this is the age the animal is normally sourced. The cost of acquiring an adult dog according to D20 is R7000. The factors rank in the following order as contributing to cost:

1. Maintenance
2. Sourcing of the animal
3. Veterinary fees
4. Human supervision
5. Damage to property
6. Housing
7. Training
8. Breeding of more animals

Table 6.1 (Q23): Initial costs of acquiring a dog as LGA.

	Sourcing of the animal (R)	**Training (R)**	**Total (R)**
Mean (SD)	5071.5 (9828.65)	250 (550.12)	5291.5 (9787.37)
Range	0-45000 (45000)	0-2000 (2000)	0-46000(46000)

Table 6.2 (Q23): Running costs for the use of dogs as LGA.

	Maintenance (R/Year)	**Breeding (R/Year)**	**Veterinary (R/Year)**	**Housing (R/Year)**	**Damage to property (R/Year)**	**Human supervision (R/Year)**	**Total (R/Year)**
Mean (SD)	6639 (6416.65)	180,5 (493.78)	1943 (3467.52)	868.42 (3666.07)	960 (1670.30)	1422.55 (3739.47)	11970.05 (10474.94)
Range	0-22000	0-2000 (2000)	0-15000 (15000)	0-16000	0-5000 (5000)	0-16000	1510-84000 (82490)

Respondents were asked to give a list of factors (Q25) that attributed to the success or failure of using **dogs**. These were as follows:

- Training (11)
- Handling / management of the dog (5)
- Owner's attitude (4)
- Dog's attitude and temperament (4)
- Ensure the self-feeder is always filled (3)
- Breeding (2)
- Action taken by the owner to any problems experienced
- Make sure the dog is parasite free
- Sometimes the sheep do not flock together; this means that a jackal will distract the dog and the rest of the jackals will attack the flock
- If camps are centred around the house dogs may have a tendency to go to the house instead of with the flock
- Dogs may fight for dominance
- Maintenance of the dog
- Little human interaction with the dog but often checking their condition
- Good communication and relationship with your neighbours
- Ensure dogs remain with the livestock
- The first year is the most important
- Is the dog spayed/neutered
- Type of sheep
- One farmer found that only 3 out of 10 dogs were 100% successful
- One farmer said that failure is often due to the owner/handler of the dog

Two of the respondents who use **dogs** did not understand the question and mentioned that they measure the success or failure of the **dog** through the lambing percentage, mortality on the farm and weaning percentage.

When presented with a list of factors (Q26) to assign importance to the following was seen for respondents using **dogs.**

For the use of **dogs** the most important factors were:

1. Management
2. Training

The least important factors were:

1. The number of animals placed with the dog
2. The sex of the dog.

Figure 3.1 shows the ranking of each factor that was listed in the questionnaire.

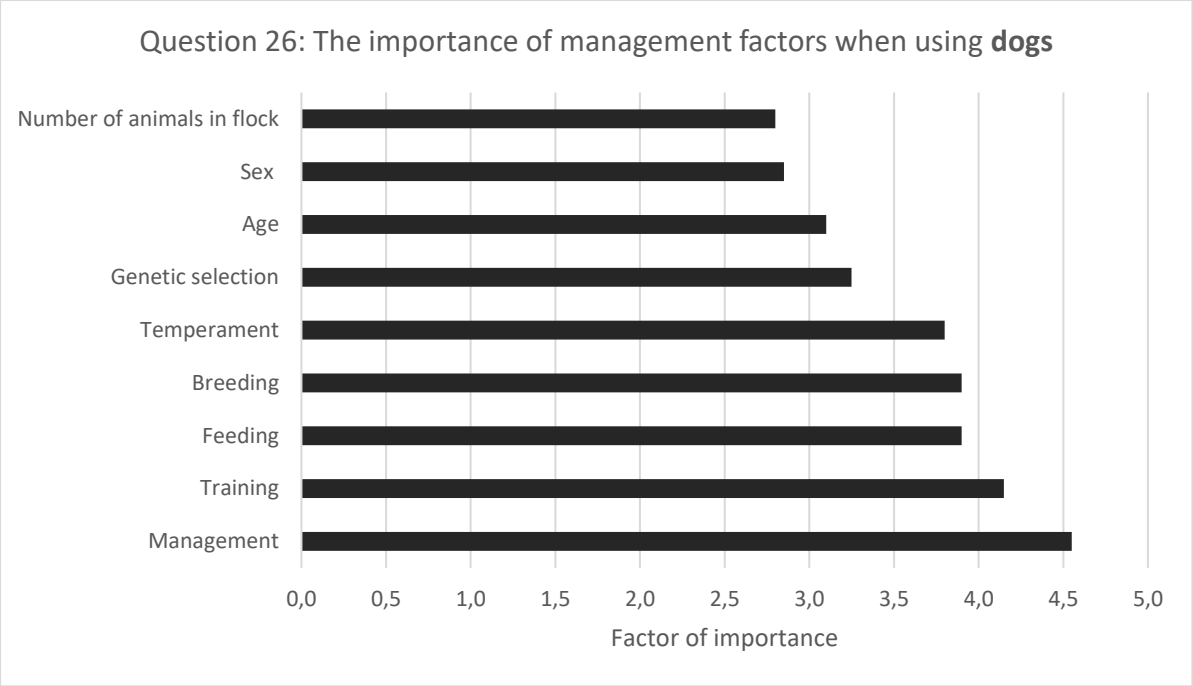

Figure 3.1 (Q26): The importance of management factors when using **dogs**

Alpacas and donkeys:

Details regarding livestock and LGA numbers (Q 5 – 12):

The farmers using **alpacas** all farmed with sheep and cattle. Three of the eight respondents farmed with sheep and goats. Only one farmer also farmed with antelope; these antelope included springbuck, oryx, blesbuck and bontebok.

The majority (4) of the farmers using **alpacas** had 2000 or more sheep on their farms while two had 501-1000 sheep, 5 of the farmers had no goats while 3 had goats and only one farmer had cattle on his farm. This is shown in Table 7.1.

Table 7.1 (Q5): Number of livestock farmed by each respondent using **alpacas**

	Mean (SD)	Median	Range
Sheep	2185 (1230.13)	2200	600-3700
Goats	49 (103.85)	0	0 - 300
Cattle	245 (222.53)	140	37 - 600

All of the respondents using **donkeys** farm with cattle. None of the respondents using **donkeys** farmed with goats, while one farmer had only cattle on his farm. There was one respondent who also farms with chickens and ostriches. The largest number of sheep on the farms was 550 while the largest number of cattle was 450.

Question 6 shows us that two respondents using **alpacas** said they had supervision with their animals and 6 respondents said they did not use supervision. Of the respondents using **donkeys,** one said they had supervision with their livestock and two said they sometimes had supervision with their animals.

The maximum number of **donkeys** (Q8) used by a respondent was 10. When looking at the respondents using **alpacas** there was one respondent whose answer could not be used, this was A7 and the answer was excluded from any calculations. Of the responses that could be used, the maximum number of **alpacas** used was "12 – 20".

Six respondents making use of **alpacas** indicated in question 9 that they placed more than 150 livestock with the **alpacas**. The remaining two respondents placed 101 – 150 livestock with their **alpacas**. All three respondents making use of **donkeys** only place between 51 and 100 livestock with each **donkey**.

In response to question 10 only one farmer (A7) using **alpacas** as LGA reported an increase in conception rate after using the **alpacas** this was from 92% to 95%; the other 7 had no change in conception rate. The average conception rate was 99%. Three respondents (A2, A3 and A7) making use of **alpacas** had an increase in lambing percentage after making use of **alpacas**. The greatest improvement was from 88% to 105% (A7). The other 4 respondents had no change in their lambing percentage. Only one respondent (A8) that is making use of **alpacas** as LGA had a weaning percentage that remained the same, the other 7 respondents had an increase in weaning percentage. The greatest change (A7) was from 80% to 102%. The average change was 11.5%

Of the Respondents making use of **donkeys** one respondent (E1) had an increase in conception rate and lambing percentage (120% to 140%), one (E2) had a decrease in conception rate and lambing percentage (90% to 70%) and one respondent had no change in conception rate or lambing percentage after using **donkeys**. There were two respondents (E1 and E3) making use of **donkeys** who recorded an increase in weaning percentage. The greatest change (E1) seen was from 95% to 130%.

Livestock losses and predation (Q 13 – 20)

The results for question 13 and 14 showed that predation decreased on 4 of the 8 farms that make use of **Alpacas**. One respondent (A3) chose not to answer this question. The average change was 10% (range from 0 to 40%) as seen in table 8.1. This change is similar to the change in weaning which was 11.5% (Q12).

Table 8.1 (Q13 + 14): The percentage of livestock lost due to disease, predation and other reasons before and after using **alpacas**

	Mean change	**Range of change**
Disease	0%	0%
Predation	10%	0 – 40%
Other	0%	0%

Predation decreased by 10% on all three farms using **donkeys.** None of the farmers reported having losses on their farms due to disease or any other cause.

As with the responses for dogs these questions (Q15+16+17) were not understood as intended. Only 4 of the 8 respondents (A1, A2, A4 and A6) using **alpacas** said they had a decrease in loss of lambs. In all four cases the losses only decreased to the grouping one lower than originally selected. The remaining 4 respondents did not report a change in losses for any of their animals. The average change was 5% (range from 0% to 10%).

All 3 respondents using **donkeys** reported a decrease in losses for their lambs after acquiring the **donkey**. The greatest improvement (E2) was from 91-100% losses to 0-10%.

Only trends are given for questions 18 and 19 due to ambiguity of the questions. Four respondents (A1, A3, A4 and A7) making use of **alpacas** did not indicate a change in predation attributed to jackals and caracals. The remaining 4 respondents saw a shift in their predation, since for all four predation attributed to jackals changed. Two of these respondents said there was an increased

amount of predation they could attribute to caracals. Only one of the respondents experienced predation by leopards and this did not change after acquiring an **alpaca**.

Respondent number one (E1) for **donkeys** had a shift in predation from majority predation by jackals before acquiring **donkeys** to all predation by caracals after acquiring **donkeys**. It can be seen that respondent E2's predation by jackals before changed to "No predation" after acquiring **donkeys**. The third respondent attributed predation equally to jackals and caracals before and after acquiring **donkeys**.

Methods of predator control and its effectiveness (Q 21 -23):

All respondents making use of **alpacas** used lethal methods of control before and after acquiring their **alpaca**. Only one respondent using **donkeys** used lethal methods both before and after acquiring his **donkey**.

Only two respondents making use of **alpacas** and two using **donkeys** had a decrease in predation of 50% or more (Q22).

Respondents with **alpacas** gave the greatest overall reduction as 71-80% (A7) while the mode for overall decrease was 0-10%. The respondents using **donkeys** said their predation decreased by 81-100%.

Table 9.1 (Q23): How much predation decreased on farms in the first and second year and overall after acquiring LGA

		Mean	Mode	Range
Alpacas	First year	20	11 – 20%	0 – 40(40%)
	Second year	23	0 – 10%	0 – 80 (80%)
	Overall	23	0 – 10%	0 – 80 (80%)
Donkeys	First year	80	-	61 – 100 (40%)
	Second year	85	-	71 – 100 (30%)
	Overall	90	-	81 – 100 (20%)

Specifics on LGAs (Q 24-26):

The respondents who use **alpacas** all agreed that there were no extra costs for housing, damage to property, training or human supervision. The average initial cost when acquiring an alpaca was R6062.50 the average running cost (table 10.1) per annum is R525.

Table 10.1 (Q24): Running cost for using **alpacas** as LGA.

	Maintenance (R/Year)	Breeding (R/Year)	Veterinary (R/Year)	Housing (R/Year)	Damage to property (R/Year)	Human supervision (R/Year)	Total (R/Year)
Mean (SD)	87.5 (191.49)	375 (786.80)	62.5 (108.73)	0	0	0	525 (734.32)
Range	0-500 (500)	0-2000 (2000)	0-120 (120)	0	0	0	0-2000 (2000)

The respondents who make use of **donkeys** on their farm all agreed that there were no extra costs for breeding, housing, damage to property and training. The average initial cost of acquiring a donkey is R1833.33 and the average running costs (table10.2) per annum is R2560.

Table 10.2 (Q24): Running cost of using **donkeys** as LGA.

	Maintenance (R/Year)	Breeding (R/Year)	Veterinary (R/Year)	Housing (R/Year)	Damage to property (R/Year)	Human supervision (R/Year)	Total (R/Year)
Mean (SD)	1526.67 (1795.59)	0	366.67 (550.76)	0	0	666.67 (1154.70)	2560.01 (3498.97)
Range	500-3600 (3100)	0	0-1000 (1000)	0	0	0-2000 (20000)	500-3600 (3100)

Respondents using **alpacas** listed the following as factors for success or failure (Q25).

- Use smaller camps with a single alpaca per camp (3)
- Alpaca should have the right temperament (aggressive) (2)
- Management of the alpaca (2)
- The alpaca should always be present with the lambs
- You should have the correct LGA for the problem animal
- Terrain
- Secure fences
- Regular human activity in proximity of the camps
- Predators getting used to the LGA
- Alpacas are not always suited for the task

The respondents who used **donkeys** listed the following as factors determining success or failure of the **donkeys**. Only two of the three respondents answered this question.

- The donkey's natural instinct to protect against specific problem predators
- Low management of LGAs
- Low cost of LGA
- They should be brought up with sheep to form bonds with sheep
- Donkeys eat little of the same grazing as sheep, eating mostly tougher grasses and bushes

Given a list of factors to assign importance to (Q26) the following was given.

In the case of **alpacas**, the most important factors were:

1. Temperament
2. The number of animals placed with alpacas
3. The age of the alpaca

The least important factor was their training.

The complete list and ranking can be seen in figure 4.1.

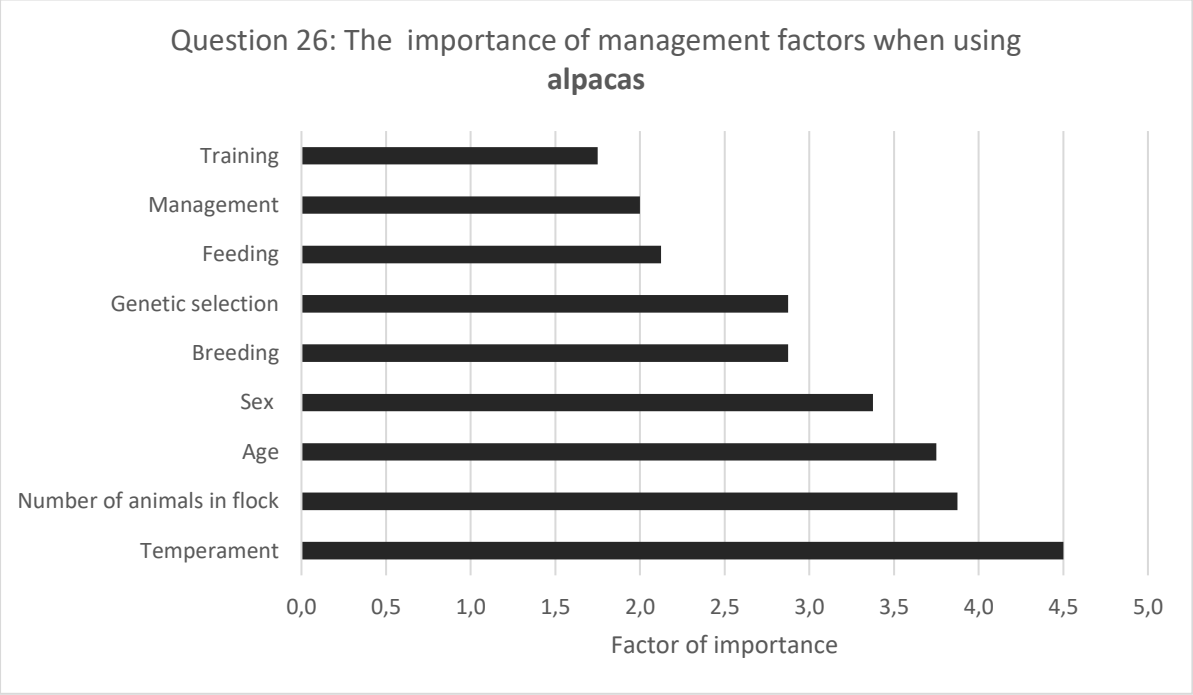

Figure 4.1 (Q26): The importance of management factors when using alpacas

For the use of **donkeys** the most important factors were:

1. Sex of the animal
2. Temperament
3. Management of the animal
4. The number of livestock placed with the donkey

The least important factors for **donkeys** were:

1. Training
2. Breeding (genetic selection)

In figure 4.2 below we can see the full lit and its ranking.

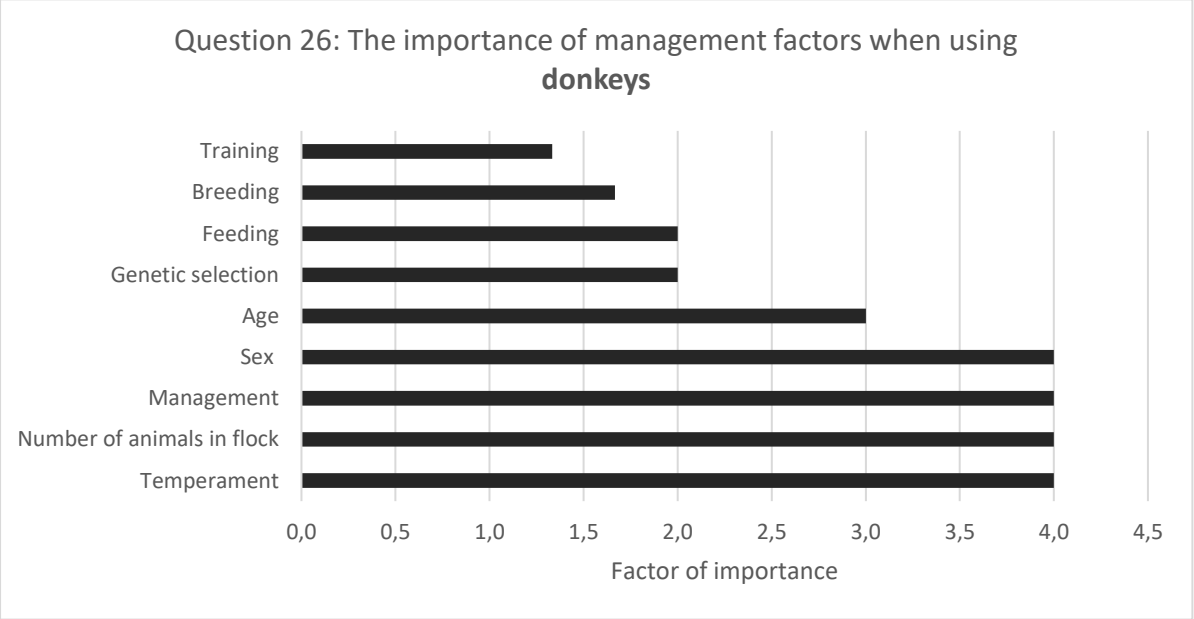

Figure 4.2 (Q26): The importance of management factors when using **donkeys**

All responses:

Details regarding livestock and LGA numbers (Q 5 – 12):

Of the 34 responses to question 5, 33 farmers had sheep, there were 11 farmers who had goats on their farms and 29 of the 31 had cattle on the farm. Only 6 of the 31 farmers had other livestock on their farm, these were kudu, bontebok, blesbuck, oryx, chickens, ostriches, springbuck and horses. Of the respondents 10 farmed with sheep, goats and cattle with two of these also having other livestock on their farms. Only one of the farmers had only cattle on his farm.

Figure 5.1 shows that the 26% of all respondents had between 501 and 1000 sheep on their farm followed by 23% having 1 – 500 sheep.

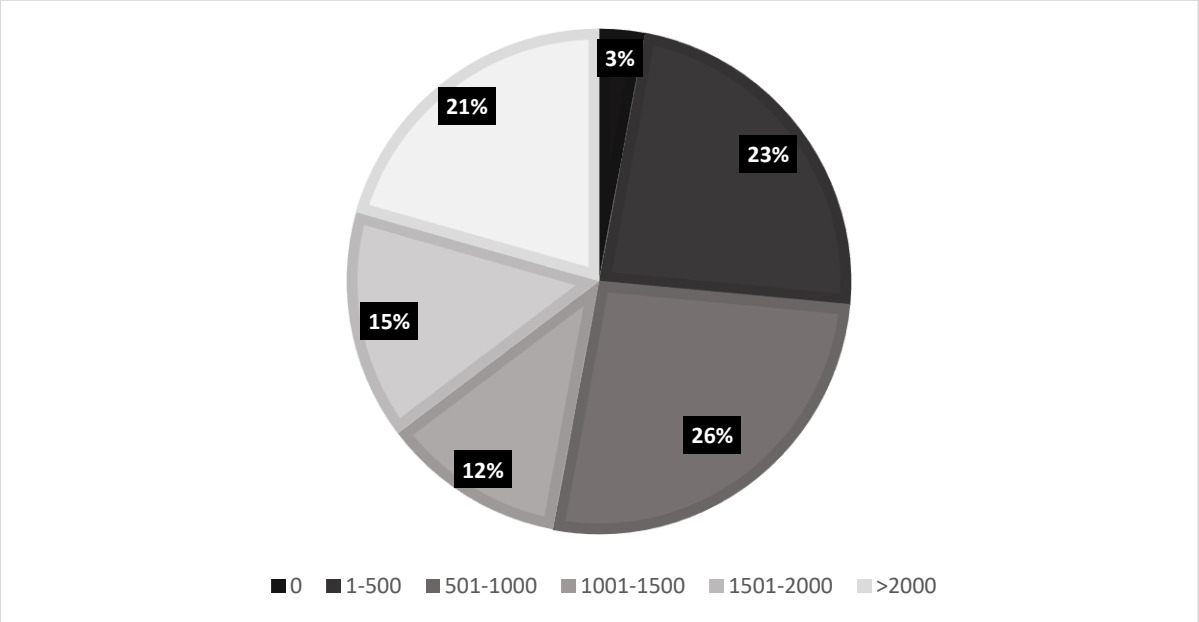

Figure 5.1 (Q5): Number of sheep on the farms of all respondents

Of all 34 responses to question 6, 19 said they do not arrange supervision of their livestock while 9 said they had full time supervision of their animals this is seen in table 11.1. The 6 respondents who provided supervision occasionally used it at the following times:

- during lambing, by bringing the ewes in at night to camps closer to home (2)
- stock counts daily in the morning or on a regular basis (2)
- during the day
- see all stock every 4 to 6 days

Table 11.1 (Q6): Respondents who had supervision of their LGAs

	Dogs	Alpacas	Donkeys	Total
Yes (%)	6 (17.65)	2 (5.88)	1 (2.94)	9 (26.47)
No (%)	13 (38.24)	6 (17.65)	0	19 (55.88)
Sometimes (%)	4 (11.76)	0	2 (5.88)	6 (17.65)
Total	23	8	3	34

Table 11.2 shows that farmers that made use of dogs where using less LGAs on their farms than those making use of alpacas or donkeys.

Table 11.2 (Q8): The number of LGAs used on each farm

		Mean	Median
Dogs	Number of animals	2.78	2
	Farm size (ha)	4316.19	2500
Alpacas	Number of animals	6	5
	Farm size (ha)	6625	6425
Donkeys	Number of animals	5.33	4
	Farm size (ha)	686.67	440

Figure 5.2 below shows the correlation between the farm's size and the number of LGA that are being used on these farms. On the Spearman correlation (r=0.33 p=0.06) it can be accepted that there is a positive correlation between the two as would be expected although this is a weak correlation.

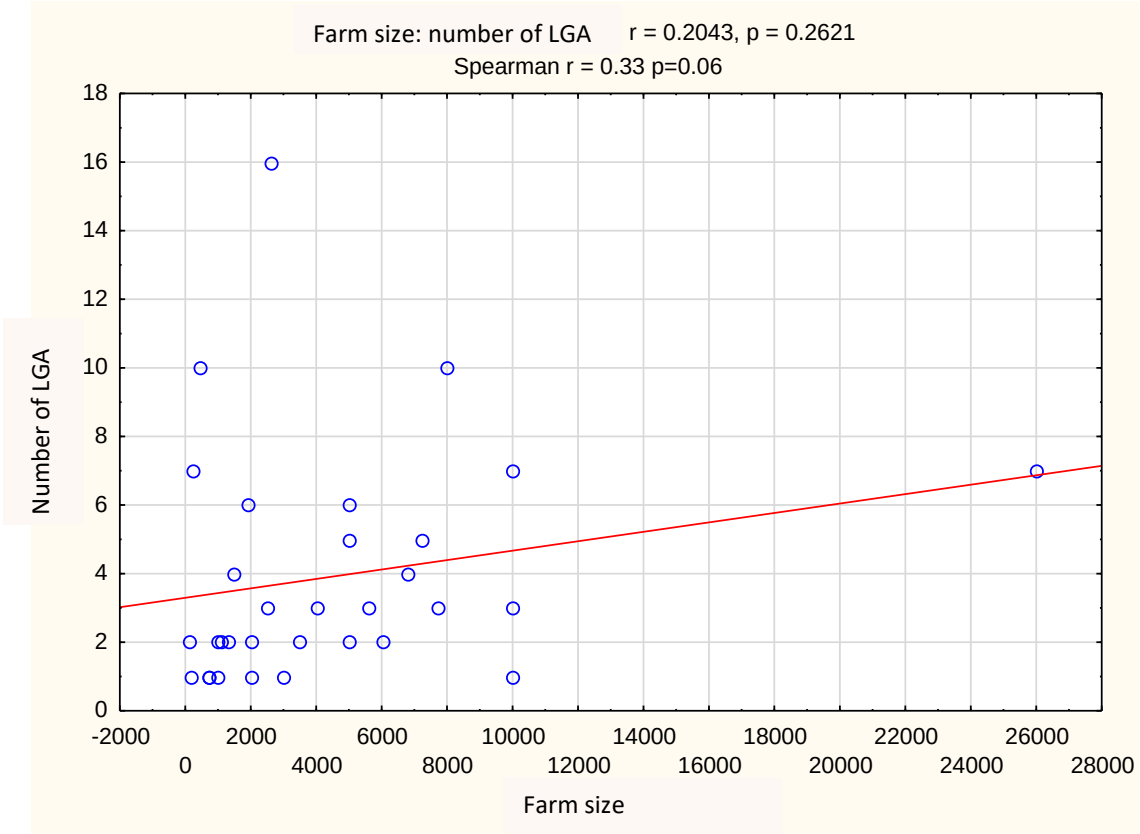

Figure 5.2 (Q8): Correlation between farm size and number of LGA used

Table 11.3 shows that most farmers place more than 150 livestock per LGA. The respondents making use of donkeys were the only ones who did not indicate this.

Table 11.3 (Q9): The number of respondents who placed a certain number of animals with their LGA

	Respondents farming with					
Number of livestock	**Dogs**	**%**	**Alpacas**	**%**	**Donkeys**	**%**
<50	2	8.69	0	0	0	0
51-100	3	13	0	0	3	100
101-150	2	8.69	2	25	0	0
>150	16	69.57	6	75	0	0

Livestock losses and predation (Q 13 – 20)

When considering all data a substantial decrease in predation was seen on respondents farms after acquiring a LGA on a confidence level of 95%, this is shown in figure 6.1. The decrease was from a mean of 33.33% to 12.67%. This is a 38% decrease.

Table 12.1 (Q13 +14): Mean and standard deviation of predation before and after acquiring LGA

	Mean	**Standard deviation**
Before LGA	33.33	27.05
After LGA	12.67	12.51

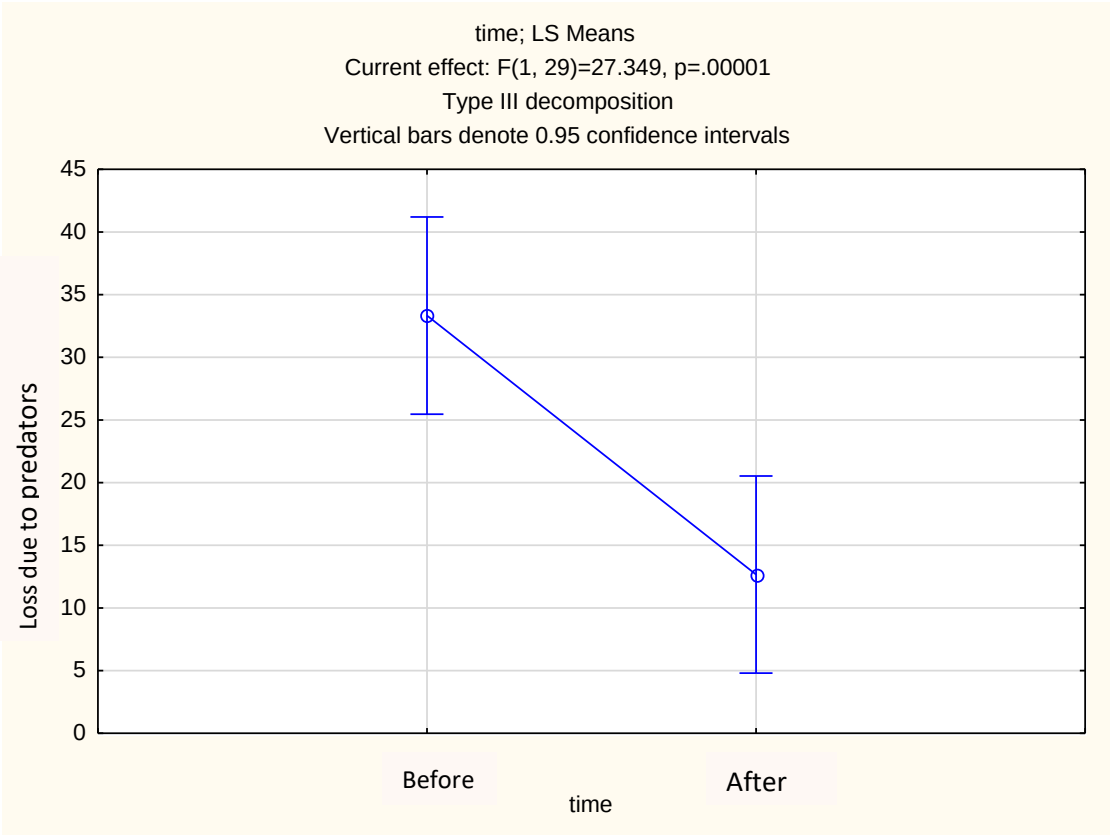

Figure 6.1 (Q13 +14): Predation losses before and after using LGA

The two methods used most often to identify the predators on the farms (Q20) are the animals' tracks (80.65%) and the killing pattern (80.65%). The method least used to identify predators on these farms is the advice of an expert (19.35%) with only 6 respondents making use of this method. Table 12.2 shows the proportions of each method being used.

Table 12.2 (Q20): How respondents identified the predators on their farms

	Dogs	Alpacas	Donkeys	Total	%
Track	17	7	1	25	80.65
Killing pattern	15	7	3	25	80.65
Feeding pattern	14	4	2	20	62.52
Post-mortem examination	8	4	0	12	38.71
Saw hunting	7	2	1	10	32.26
Scat	7	2	0	9	29.03
Advice from expert	3	1	2	6	19.35

Methods of predator control and its effectiveness (Q 21-23):

Overall there was 25 (80.65%) respondents that used lethal control methods before acquiring their LGA and only 20 (64.52%) after acquiring their LGA. The change can be seen in table 13.1.

Table 13.1 (Q21): The use of lethal methods of control on farms

		Dogs	Alpacas	Donkeys	Total	%
Before LGA	**Yes**	16	8	1	25	80.65
	No	4	0	2	6	19.35
After LGA	**Yes**	11	8	1	20	64.52
	No	9	0	2	11	35.48

The respondents that made use of lethal control methods before and after acquiring LGA gave the following as their methods of control:

- Hunting (21)
- Poison (11)
- Gin traps (7)
- Cage traps (6)
- Night calling of predators (1)

From the data it can be seen that most of the farmers making use of **lethal** methods choose to hunt the predators. This hunting may be species or animal specific; some farmers also only do night hunts while others choose to do dog hunts. The second most used method of **lethal** control is poison. This is illegal in South Africa and will be considered further in the discussion. There were also three respondents who mentioned using aversion tactics, which are **non-lethal**, on their farms such as radios, or scent aversion chemicals.

Considering all responses for question 22 we can see that 21 (67.74%) respondents had a decrease in predation of 50% or more. This reduction of 50% or more on 67.74% of the farms falls into the confidence interval of $0.60<p<0.90$, therefore we can reject the null hypothesis and accept the alternative hypothesis that using LGAs decreases predation by 50% or more on 75% of the farms.

Table 13.2 (Q22): Has predation on the farm reduced by 50% or more after acquiring a LGA?

		Dogs	Alpacas	Donkeys	Total
Number	**Yes (%)**	17 (80.95)	2 (28.57)	2 (66)	21 (66.67)
Number	**No (%)**	4 (19.05)	5 (71.43)	1 (33)	10 (33.33)

It can be seen in figure 7.1 that there was a mean overall decrease of 75.53% in predation on farms where respondents said that the LGA was successful in decreasing predation by 50% or more, while the mean overall decrease in predation was 12.78% on farms where respondents said the LGA was not successful in reducing predation by 50% or more. This supports the rejection of the null hypothesis that LGA do not decrease predation by 50% or more. We can therefore accept the alternative hypothesis.

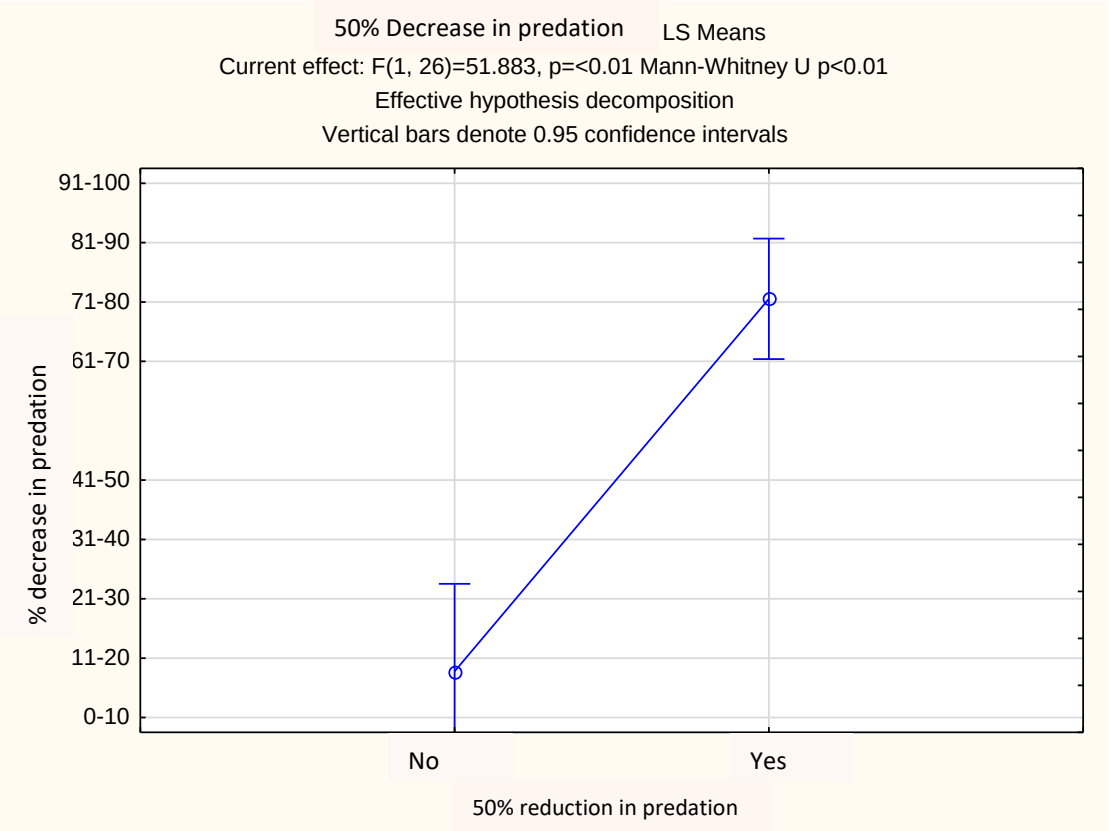

Figure 7.1 (Q22 +23): The overall decrease in predation experienced by farmers who said they had success with LGA in comparison to those who did not have success

Specifics on LGAs (Q 24-26):

Comparing the three LGA for importance of management factors (Q26) it can be seen that dogs are the only one for which the number of livestock placed with them is of least importance. Training is only seen as highly important with the dogs but management of the LGA is important for both dogs and donkeys. Temperament of the LGA is important for both the donkeys and alpacas. The sex of the animal is only highly important in donkeys. The genetics and breeding of the LGA was not of high importance for any of the LGA's.

Discussion:

There was difficulty in this study due to two main factors, the first is the ambiguity of many of the questions, the second is the small sample size. Having made use of 'Survey Monkey' a couple of problems emerged, the biggest problem was that the survey had to be kept anonymous. For this reason if an answer was not answered in accordance to the question stated contact could not be made with the respondent.

This study focused of small stock farmers in South Africa. These farmers had sheep, goats, cow and other livestock on their farms. The majority of the respondents farms where on flat open plains which may be due to this terrain being easier to utilise. The terrain that was least identified amongst respondents was bushveld. Two of the four respondents who selected this option were farming on communal land. The farmers making use of communal land wrote this in their survey rather than give hectares for the property. Bushveld is defined in the Collins English dictionary (2012) as an area of low altitude in northern South Africa, having scrub vegetation. Sheep are grazers and therefore do not thrive in these environments while goats are browsers and would do much better in bushveld areas.

The majority of farmers had other small stock farmers as neighbours. While talking to different farmers and in e-mail communication with others they often indicated that their neighbours were not using LGA. Some of the farmers on neighbouring farms also contacted me: these farmers suspected some of their livestock losses was due to dogs on the neighbouring farms.

There were 11 respondents (39.29%) who said they were close to nature reserves. Due to these protected areas being close to these farms there may be more natural prey found in the area of these farms but also more predators. The different wildlife species that are found on farms are most commonly steenbok, scrub hares and rodents. These species are small mammals that are common prey for predators such as jackals and caracals (Avenant & Nel, 2002; Avenant & du Plessis, 2008; Estes, 1991a; Kamler *et al.*, 2012; Loveridge & Nel, 2004; Smith *et al.*, 2000; Rowe-Rowe, 1976).

It was also seen in the results that the number of LGA used on the farms increased depending on the size of the farms. This is to be expected as with a larger size farm there may be an increased number of livestock and flocks or herds needing protection. The increased size of the property may also lead to larger camps and more areas for the livestock to roam and therefore a greater need for more LGA. The larger farmlands may also have more predators as they cover more territories.

There were many of the respondents who did not have supervision with their LGA. Those that had supervision with their LGA may have had human supervision for the majority of the day while others

only occasionally had supervision such as during counting of the animals or during the lambing season. This question was ambiguous as it was not stated what would be considered as always having supervision and what would be considered as only sometimes. There was a farmer who contacted me who said in his experience the farmers keep dogs as company rather than to protect the livestock as these farmers always have supervision with their dogs (Anatolians and Lesotho dogs). This farmer has often experienced losses due to these dogs.

Looking at factors such as conception rate, lambing percentage and weaning percentage in the two years before and after acquiring a LGA we can see if there was an improvement on the farms. These will be discussed in each group of LGA individually. Weaning percentage is the most important of the three as this indicates that fewer juvenile livestock died between lambing and weaning, which is the time they are most vulnerable to being killed by predators due to their size. This is important as most predation experienced on the farms was on lambs (Questions 15,16,17). The greatest improvement in predation rate was seen in that of lambs on farms. Although we see an increase in weaning percentage it is not as extensive as would be expected with the decrease in predation. This may be due to respondents working from recollection not from collected data.

Due to questions 15 - 19 being misunderstood by respondents and also stated in a confusing manner the data collected is not very valuable. There are trends that can be seen emerging from this data when considered as the change in percentage of overall ewes, lambs and rams lost on the farm. Trends such as the decrease in loss of lambs and to a lesser extent on ewes and rams can be seen. There was less predation on rams and ewes seen on farms this is to be expected as they are larger and often stronger than lambs. Many farmers did not experience any loss of rams before or after acquiring LGA. The ewes are often most vulnerable after they have lambed as they will try to protect their lamb (Morgan & Arnold, 1974). Lambs are most vulnerable as they are small and weak for the first couple of weeks. This makes them easy prey for predators. Having a LGA improves the chances of the ewes and lambs not being predated on as they are bonded and the LGA will protect them by chasing predators away (Andelt, 2004; Marker *et al.,* 2005; Potgieter, 2011).

A trend can be seen that predation attributed to jackals decreased on farms. This may be due to the inherent dislike that both alpacas and donkeys have of canids along with the dogs being territorial especially towards other canids (Andelt, 2004; Green, 1989 ;Kingwill, 2007; Mahoney & Charry, 2005; Marker *et al.,* 2005). This may indicate that LGAs are especially useful in controlling jackals on farms. In comparison, the predation attributed to caracals did not significantly decrease. This may be due to caracals shy nature and their nocturnal habits (Estes, 1991b). Due to caracals using a stalking

method when hunting it is also likely that the LGA may not be aware of their presence until it is too late.

The results show that 67.74% of respondents said they had a 50% or more decrease in predation on their farms after acquiring the LGA. The link between the large mean decrease (75.53%) in predation and those respondents that experienced the LGA as being effective is important as it indicates that LGA may be successful in decreasing predation. It is important to note that they will only be successful if the correct management is applied. This idea and how they the factors influence the success or failure should be further investigated. Each of the three LGAs discussed have their own management factors that are ranked as most significant and are discussed later.

The identification of predators is very important in order to target the correct predators on the farms. Through the use of methods such as track identification and looking at both killing and feeding patterns farmers have identified predators on their properties. These are often the simplest ways of identifying predators as they are all visual methods. It is important though that farmers learn to assess if the predator was scavenging on livestock that died of causes other than predation or if the predator is responsible for killing the livestock (Humphries *et al*., 2016; Kamler *et al*., 2012). This is important as often predators are blamed because their tracks are found around a carcass even though they had only been opportunistic in feeding on the carcass. This identification can be done by seeking the assistance of a professional to identify how the livestock died as well as which predator was feeding on the carcass. The correct identification can assist farmers who choose to remove predators from their farms either through lethal methods or with cages to remove the correct problem animals.

The majority of the respondents made use of lethal control methods on their farms both before and after acquiring a LGA. The use of lethal methods such as gin traps, poisoning and hunting were often used. Methods of hunting often used are night hunts, dog hunts, eradication or selective removal. In many areas of sub-Saharan Africa a permit cannot be issued for hunting caracals, but due to caracals being considered a problem animal in South Africa they can be removed from properties without a permit (Avgan, Henschel & Ghoddousi, 2016). There was only a small number of farmers who stopped using lethal control methods after acquiring a LGA.

It is important to note that it is illegal to use poison on farms. Using poison (Carbofuran, Compound 1080 or Strychnine) on predators is normally done through placing a poisoned carcass in the veld for the predator to consume. The problem with this is that other non-targeted species and innocent animals will often also die due to this poison; one example of this is vultures as they consume carcasses (Bridgeford, 2001). There are also farmers who specifically target the vultures through the

poisoned (carbofuran) carcasses as they think the vultures are the cause of lamb losses on their farms (Bridgeford, 2001; Koenig 2006).

Dogs:

From the data (Q 22) it can be seen that the dogs are considered to be effective in reducing predation on farms by 50% or more, with 17 respondents saying they were successful in doing this. The mean overall decrease in predation on these farms was 64% (Q 23). There was a decrease seen in predation allocated to both jackal and caracals by these respondents. This supports that the dogs help decrease predation on farms. Due to the decreased predation these farmers experienced they saw an increase in their weaning percentage. The dogs where likely able to protect the lambs from predators until they were weaned to a greater extent than could be done before acquiring the dog.

There was a varied response to the number of livestock that should be placed with each dog. Sixteen respondents said they place more than 150 livestock per dog. This is consistent with literature that states that they would place 2-5 dogs with 1000 livestock (Urbigkit & Urbigkit, 2010). This variation may be due to the breed of sheep the farmer has as some breeds like Dorpers are non- flocking species and tend to spread out over the veld; these breeds may require more dogs for protection as one dog cannot be around the entire flock. Merinos have stronger flocking habits and it may be possible to place a large flock with one dog for protection. The number of livestock with each dog will also be influenced by the size of the paddocks as a larger paddock can feed more sheep than a smaller paddock. In a study done by Webber *et al.* (2015) they found that sheep would travel longer distances in a day when they were accompanied by a dog.

The running cost as well as the initial cost (Q 24) when using dogs is the highest of all three LGAs. This is due to many extra factors such as cost of housing, training, supervision and damage to property which are not added costs for the other two LGA. Due to the dogs requiring different feeding to the sheep this also adds to the maintenance cost of the animal. Training of the dog is considered an initial cost. The training of the dog is very important as this will in part determine the success of the animal. This training involves the placement of the puppy with a small flock of sheep and correcting behavioural problems (Andelt, 2004; Marker *et al.*, 2005; Smith *et al.*, 2000; Wilbanks, 1995). Due to the high running cost of dogs farmers may be less likely to make use of them although some farmers may see it as beneficial to acquire a dog at such a cost due to the added protection to their livestock and the people on the farm. One of the largest contributors to the cost of the dogs is the average cost of acquiring them, R5071.50, but this is not an annual

expenditure. The dogs used are normally large dog breeds and they have a lifespan of 10-12 years (Lorenz 1989).

A factor of concern (Q 25) with dogs is that if they are not trained properly and not fed well they may hunt the livestock they should be protecting. One respondent experienced an increase in predation by dogs after acquiring a dog (Q 19). This has also been seen in past studies (Andelt, 2004; Anon, 2015a; Marker *et al.*, 2005; Smith *et al.*, 2000). Another factor of concern (Q 25) is that the dog may stay at home rather than guard the livestock. This may be due to improper training or too much human interaction. This is seen as a factor in the data as well as in other studies (Andelt, 2004; Marker *et al*., 2005; Smith *et al*., 2000). Training of a livestock guarding dog requires a lot of patience. The farmer needs to start training the puppy at six to eight weeks by placing it amongst the livestock it will be protecting in a smaller enclosure. The process of training the puppy takes time and the dog will only be fully trained when it is approximately 18 months to two years of age. During this time the farmer should pay close attention to the animal's behaviour and correct it as is necessary (Andelt, 2004; Marker *et al.*, 2005; Smith *et al.*, 2000; Wilbanks, 1995). The most important factor is not to over-socialise the dog with people otherwise they bond to the people and not the livestock. Factors such as the breed of the dog, the owner's attitude towards the dog as well as the handling of the dog were important to farmers. From the list of important factors that make the dogs successful, the three most important were the following:

1. Management
2. Training
3. Feeding

It is important to note that all three of these factors are management related factors, while some other factors to consider were breed, temperament and genetic selection which are not management factors but rather factors relating to the dogs themselves. The last factor that is important with dogs is that they may also be considered as a lethal form of protection. This is because they may bite and kill the predators on the farm (Potgieter *et al*. 2015).

Alpacas:

It is evident from the data (Q 22) that the respondents making use of alpacas did not see a 50% or more reduction in predation, with five of the seven respondents who chose to answer this question saying that they did not see a decrease in predation. This does not mean they did not experience a decrease in predation but it was not considered to be significant. This is seen in the results showing an increase in weaning percentage on the farms. This means more lambs made it to the weaning age

than did before acquiring the alpaca. The greatest loss of livestock was the number of lambs although there was an improvement in lamb losses after acquiring the alpacas. Some of the respondents indicated that there was a decrease in jackal predation on the farms, this could be attributed to the inert dislike that alpacas have of canids (Andelt, 2004; Kingwill, 2007; Kingwill, 2016; Lawrie, 2004; Mahoney & Charry, 2004; Smith *et al.*, 2000; Wilbanks, 1995). Two respondents said they had increased predation by caracals after acquiring their alpacas, this was likely unrelated to the use of alpacas. The respondent (A6) who had predation on his farm from leopards did not see a change in this. This may indicate that alpacas could be successful in keeping jackals and other small canids away from the livestock but that they are less successful in keeping away large felines (Andelt, 2004; Lawrie, 2004; Mahoney & Charry, 2005; Smith *et al.*, 2000).

Two of the respondents using alpacas only placed 101-150 livestock with their alpaca while the other six respondents place more than 150 livestock with the alpacas. This is consistent with the suggestion from an expert as well as in literature that 250 livestock should be placed with 2 alpacas (Andelt, 2004; Kingwill, 2016). This again may vary according to the breed of sheep placed with the alpaca and whether they have a flocking nature or not. Many sources suggest that you should not place more than one alpaca in a camp as they will flock together rather than look after the sheep (Andelt, 2004; Lawrie, 2004; Mahoney & Charry, 2005; Smith *et al.*, 2000).

Factors leading to the success of alpacas (Q 25) is the use of smaller camps, their temperament and their management. During personal communication Ms Sally Kingwill also suggested that smaller camps are more suited to the use of alpacas (Kingwill, 2016). The smaller cams would prevent livestock from moving far away from the alpaca and increase the likelihood of the alpaca being close when a predator approaches. One farmer said that alpacas are not always suited to the task of protecting against predation. This may be true especially in the case of larger predators (Andelt, 2004; Lawrie, 2004; Mahoney & Charry, 2005; Smith *et al.*, 2000).

The three factors with the highest importance noted in Question 26 were as follows:

1. Temperament
2. The number of livestock placed with the animal
3. Age of the alpaca.

It is interesting to see that these are not management factors as can be see with the use of dogs.

The running costs associated with alpacas is much less than that associated with dogs, while the initial cost is the highest (R6062.50). Alpacas have a life span of 15 – 20 years this means they live longer than dogs and their initial cost would be more favourable (Meadows & Knowlton,

2000).The respondents did not list any extra cost for the following factors: housing, damage to property, training and human supervision. This is due to the alpacas living amongst the livestock. Alpacas also do not require any extra feeding as they consume the same feed as sheep.

Donkeys:

From examination of the data from the donkeys it can be seen that all three respondents were in agreement that donkeys should be placed with 51-100 livestock (Q 9). This is less than is indicated in literature which states that farmers can place up to 200 livestock with the donkeys (Wilbanks, 1995). The data (Q 13,14) also shows that all three respondents saw an improvement on their farms with a reduction in predation. Due to the low response with this LGA it cannot be said the use of these donkeys is truly effective but it is supported by literature and shows potential however there is doubt if they can keep larger predators away (Andelt, 2004; Green, 1989; Jones, 2008; Smith *et al.*, 2000).

The respondents making use of donkeys saw an improvement on their properties in the amount of predation. This was seen in two of the farmers also having an increase in weaning percentage. All three farmers experienced the greatest loss in lambs which improved for all three after acquiring the donkey.

There was variety in the predators that are responsible for predation on these farms. Due to the small number of responses a clear analysis cannot be given as to how the donkeys influence predation by the different species. From literature though we know donkeys have an inert dislike of canids and this may help them in decreasing predation by jackals (Andelt, 2004; Green, 1989; Smith *et al.*, 2000).

From the data (Q 24) it can be seen that the running cost of acquiring a donkey as a LGA was not too expensive. The initial cost of acquiring a donkey (R1833.33) was low in comparison to that of both dogs and alpacas. This is especially beneficial when considering they have a lifespan of more than 20 years. The respondents did not have any extra cost required for breeding, housing, damage to property and training of the animals. Donkeys feed on the same grazing as sheep and this is therefore not an additional cost for the farmers.

In communication with the Donkey Sanctuary they expressed concern that there was no housing or shade provided for the donkeys in the field especially in the Karoo. They were also concerned that the donkeys they have come across were malnourished and dehydrated (Sherwin, 2016). This is very

important as any animal that is in the veld should be taken care of. All livestock and guard animals should have water and food readily available.

The farmers indicated that factors that were important to them in using donkeys was that they were low cost animals and that they did not require extra feeding (Q 25). This is supported in literature which states that farmers using donkeys do not have to provide special feed for them but only need to make sure they do not eat any feed with rumensin as they are monogastrics unlike sheep (Andelt, 2004; Green, 1989; Smith *et al.*, 2000). It was said that the donkeys should be raised amongst the livestock in order to form a strong bond and protect against predators.

The most important factors (Q 26) contributing to the success of using donkeys were the following:

1. Gender of the donkey (normally a female is better)
2. Temperament
3. Management
4. Number of livestock placed with the donkey

These factors are supported in the literature as being important. It is important that the donkeys have the right temperament to chase away predators; this is tested by placing a donkey in an enclosure next to a dog and seeing if it tries to chase the dog away (Andelt, 2004; Green, 1989; Smith *et al*., 2000). It is important that the donkey used is a gelding or a jenny but not an intact male as they are more aggressive towards lambs and ewes (Andelt, 2004; Green, 1989; Jones, 2008; Smith *et al.*, 2000; Wilbanks, 1995).

Conclusions and Recommendations:

There were a number of factors that led to difficulties in this study. The first was the use of "Survey Monkey" (Anon n.d.), when setting up the survey it was set up as anonymous and the farmers could not be contacted to clarify answers to certain questions. If "Survey Monkey" is to be used again in a study the researcher should make sure that they include an area where the respondents details can be included but ensure this would not be made public. Due to the survey being ambiguous in many cases and the sample size being small some of the questions do not offer a lot of value. In the future questions should be clarified for example it can be clarified what should be classified as occasional supervision with livestock and what is considered as always having supervision. Another factor that may have influenced the study is the fact that many farmers would have made use of recollection to answer the questions rather than collected data. Therefore, the study is heavily influenced by personal bias from the respondents.

The data combined for all three LGAs show that 21 of the 31 respondents who completed the survey had success in decreasing predation on their farms by 50% or more. This is a 67.74% success rate. Of these, most responses came from farmers using dogs with a trend of success emerging with 17 of 20 respondents being successful. The success can be seen in that the mean change decrease in predation was 75.53% on farms of respondents saying they had success and only 12,78% for farmers stating they did not have success. It appears from the limited data that alpacas are the least successful LGA with 5 of the 7 respondents who completed this question saying they were unsuccessful. The use of alpacas and donkeys as LGA cannot be properly evaluated due to the poor response but trends could be seen in the responses and should be further investigated.

From the data it can be seen that there are many different factors that may contributing to the success of each LGA and any farmer who wants to make use of these should be willing to consider these factors and work with the LGA to optimise protection on the farm. Further study should be done on how the factors rated and given by farmers influence the effectiveness of LGAs. More research needs to be done in order to establish guidelines for the use of donkeys and alpacas as these are not well studied and not widely used as LGAs. Any farmer who wants to make use of dogs should be prepared to spend time training the dog and be willing to spend the extra money for the use of these animals.

Overall, the study shows that the use of LGAs can lower predation losses on farms and certain factors are considered more important in the use of these LGAs.

Recommendations:

- Any questionnaire should be carefully constructed, tested and revised as the respondents interpret questions differently and this may result in data that cannot be used or fully analysed as is the case with Questions 15 to 19.
- There should be a method of identifying respondents so that any necessary clarification of questions or answers can be made.
- Collecting enough responses from a diverse group of farmers is important and although every effort was made to collect data from as many farmers as possible not enough data were collected regarding alpacas and donkeys for reliable interpretations and conclusions.
- For any future studies, more data should be collected from farmers making use of donkeys and alpacas as these two LGAs are not well studied. Further study could also focus on how different factors influence the effectiveness of the LGA.
- The data that have been collected from this study can be used by farmers as a basic guideline for important factors contributing to the success or failure of each LGA.

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Addenda A:

Livestock guarding animal Questionnaire

Your participation in this survey is greatly appreciated. The questions are related specifically to the use of dogs or donkeys or alpacas as livestock guarding animals (LGA) and their use for the two years before and two years after acquiring your LGA. This questionnaire consists of 26 questions which should take approximately 20 min to answer. Please take note of the following to ensure the ease of answering the questions.

- When using "Survey Monkey" please click the on appropriate answer
- When multiple answers can be given it is indicated with a square block on "survey monkey" and a circle for a single answer. For this document it is indicated with a * at the end of the question.
- If an appropriate response is not listed please select the "other" option and give an appropriate alternative

Farm details:

1) What is the size of the farm in hectares (to the closest whole number)?

   _____

2) What is the terrain on the farm?

   a) Bushveld

   b) Mountain

   c) Flat open plains

3) Is the farm close to *

   a) Nature reserve
   b) Cities/towns
   c) Other small stock farms
   d) Wildlife farms

4) Do you have any of the following wildlife on your farm? *

   a) Springbok
   b) Duikers
   c) Steenbok
   d) Scrub hares
   e) Warthogs
   f) Rodents (Rats)
   g) Other Please specify _____

5) Which livestock do you farm with and how many?

   a) Sheep, _____
   b) Goats, _____
   c) Cattle, _____
   d) Other, _____

6) Do you have any supervision with your livestock?

   a) Yes
   b) No
   c) Sometimes, Please specify when _____

7) What Livestock guarding animal (LGA) do you make use of?

   a) Dog
   b) Donkey
   c) Alpaca

8) How many LGA do you have on your farm?

   _____

9) How many Livestock do you place per LGA in a camp or paddock?

   a) <50
   b) 51-100
   c) 101-150
   d) >150

10) What was your annual **conception rate** to the closest whole number (number of scanned lambs or kids / 100 ewes or does)?

    a) Before LGA _____
    b) After LGA _____

11) What was your **lambing percentage** to the closest whole number (number of lambs born / number of ewes mated x100)?

    a) Before LGA _____
    b) After LGA _____

12) What was your **weaning percentage** (Number of lambs weaned /number of ewes mated x100)?

a) Before LGA _____

b) After LGA _____

<u>Livestock losses</u>

13) What **percentage** of livestock did you lose annually **before** using LGA due to

a) Disease

0-10 11-20 21-30 31-40 41-50 51-60 61-70 71-80 81-90 91-100

b) Predators

0-10 11-20 21-30 31-40 41-50 51-60 61-70 71-80 81-90 91-100

c) Other (e.g. Injury)

0-10 11-20 21-30 31-40 41-50 51-60 61-70 71-80 81-90 91-100

14) What **percentage** of livestock did you lose annually **after** using LGA due to

a) Disease

0-10 11-20 21-30 31-40 41-50 51-60 61-70 71-80 81-90 91-100

b) Predators

0-10 11-20 21-30 31-40 41-50 51-60 61-70 71-80 81-90 91-100

c) Other (e.g. Injury)

0-10 11-20 21-30 31-40 41-50 51-60 61-70 71-80 81-90 91-100

15) Which **percentage** of these losses were ewes/does?

a) Before LGA

0-10 11-20 21-30 31-40 41-50 51-60 61-70 71-80 81-90 91-100

b) After LGA

0-10 11-20 21-30 31-40 41-50 51-60 61-70 71-80 81-90 91-100

16) Which **percentage** of these losses were lambs/kids?

a) Before LGA

0-10 11-20 21-30 31-40 41-50 51-60 61-70 71-80 81-90 91-100

b) After LGA

0-10 11-20 21-30 31-40 41-50 51-60 61-70 71-80 81-90 91-100

17) Which **percentage** of these losses were rams/bucks?

a) Before LGA

0-10 11-20 21-30 31-40 41-50 51-60 61-70 71-80 81-90 91-100

b) After LGA

0-10 11-20 21-30 31-40 41-50 51-60 61-70 71-80 81-90 91-100

18) What **percentage** (to the closest round number) of predation **before** using LGA would you attribute to the following

a) Black-backed jackals _____
b) Caracal _____
c) Dogs _____
d) Leopard _____
e) Baboon _____
f) Others _____

19) What **percentage** (to the closest round number) of predation **after** using LGA would you contribute to the following

a) Black-backed jackals _____
b) Caracal _____
c) Dogs _____
d) Leopard _____
e) Baboon _____
f) Others _____

20) How did you identify the predators involved (please mark all relevant options) *

a) Scat / faeces
b) Spoor/ footprint
c) Saw it hunting
d) Killing pattern
e) Feeding pattern
f) Post mortem examination
g) Advice from experts

Methods of control:

21) Do/did you make use of lethal methods of control (e.g. hunting, snares, poisoning etc.)

a) Before LGA: Yes / No (Please specify if Yes_____)

b) After LGA: Yes / No (Please specify if Yes _____)

22) Has the use of LGA been successful in decreasing predation by 50% or more?

a) Yes

b) No

23) By what percentage has predation been reduced?

a) In the first year after using LGA:

0-10 11-20 21-30 31-40 41-50 51-60 61-70 71-80 81-90 91-100

b) Second year after using LGA:

0-10 11-20 21-30 31-40 41-50 51-60 61-70 71-80 81-90 91-100

c) Overall after using LGA:

0-10 11-20 21-30 31-40 41-50 51-60 61-70 71-80 81-90 91-100

Livestock guarding animal specifics:

24) What is the added cost of the LGA (Rand Per year)?

a) Maintenance feeding R_____

b) Breeding more LGA R_____

c) Veterinary R_____

d) Housing R_____

e) Damage to both property and animals R_____

f) Sourcing the animal (buying costs) R_____

g) Training R_____

h) Human supervision R_____

25) What determines the success or failure of an LGA? Please list in order of importance.

_____

_____

_____

26) How important are the following for an LGA (1= minimal, 5= extremely)

a) Breed (1 - 5) _____

b) Sex (1 - 5) _____

c) Age (1 -5) _____

d) Genetic selection (Breeding selection) (1 - 5) _____

e) Temperament (1 - 5) _____

f) Feeding (1 - 5) _____

g) Training (1 – 5) _____

h) Management (1 - 5) _____

i) Number per flock (1 - 5) _____

Addenda B:

Raw data is shown in the tables below. Questions are shown as Q followed by the number, the individual farms are indicated as follows D= Dogs, A= Alpacas, E= Donkeys.

Table 1 (Q1+2): the size of the farm as well as the terrain it was found on.

Farm	Dogs		Farm	Alpacas		Farm	Donkey	
D1	26000	Flat	A1	8000	Mountain	E1	440	Flat
D2	2000	No response	A2	5000	Flat	E2	120	Bush
D3	4000	Flat	A3	10000	Mountain	E3	1500	Flat
D4	Communal land	Bush	A4	6050	Mountain			
D5	2000	Flat	A5	2600	Mountain			
D6	190	Flat	A6	10000	Flat			
D7	Communal land (1000)	Bush	A7	4550	Flat			
D8	1100	Flat	A8	6800	Flat			
D9	7200	Flat						
D10	2500	Flat						
D11	5000	Mountain						
D12	7700	Flat						
D13	3000	Flat						
D14	10000	Flat						
D15	3500	Mountain						
D16	5000	Mountain						

D17	700	Mountain						
D18	700	Mountain						
D19	1000	Flat						
D20	1900	Flat						
D21	250	Flat						
D22	5600	Bush						
D23	1300	Mountain						
Mean (SD): 4316.19 (5645.17)		Range: 190 - 26000	Mean (SD): 6625 (2454.08)		Range: 2600 - 10000	Mean (SD): 686.67 (722.31)		Range: 120 - 1500
Median: 2500			Median: 6425			Median: 440		

Table 2.1 (Q5): Number of livestock farmed by each respondent using **dogs**

Farm	Sheep	Goats	Cattle	Other
D1	5500	0	0	no
D2	100	150	100	springbuck and oryx
D3	1000	0	200	no
D3	20	0	60	no
D5	30	0	140	no
D6	130	0	15	donkeys and horses
D7	40	60	140	no
D8	570	0	220	no
D9	2000	0	1500	horses
D10	3000	0	500	no
D11	500	600	200	no
D12	2800	1300	150	no
D13	1500	0	150	no
D14	900	0	15	no

D15	2000	120	1200	no
D16	1500	30	90	no
D17	600	0	120	no
D18	800	0	120	no
D19	1600	0	75	no
D20	1500	150	200	horses
D21	70	0	200	no
D22	2000	1000	400	no
D23	800	0	350	Pigs
Mean (SD)	1259 (1279.12)	158 (343.34)	265 (366.69)	
Median	900	0	150	
Range	20 - 3000	0 - 1300	0-1500	

Table 2.2 (Q5): Number of livestock farmed by each respondent using **alpacas**

Farm	Sheep	Goats	Cattle	Other
A1	3000	0	500	no
A2	1700	0	40	no
A3	3700	0	180	no
A4	1500	0	600	no
A5	600	300	100	no
A6	700	30	100	no
A7	2700	60	400	no
A8	3580	0	37	antelope
Mean	2185 (1230.13)	49 (103.85)	245 (222.53)	
Median	2200	0	140	
Range	600-3700	0 - 300	37 - 600	

Table 2.3 (Q5): Number of livestock farmed by each respondent using **donkeys**

Farm	Sheep	Goats	Cattle	Other
E1	550	0	20	Chicken and ostrich
E2	0	0	50	no
E3	350	0	450	no
Mean	300 (278.39)	0	173 (240.07)	
Median	350	0	50	
Range	0 - 550	0	20 - 450	

Table 3 (Q8): The number of livestock guarding animals used on each farm

	Dogs			Alpacas			Donkeys		
	Farm	**Number of animals**	**Farm size (ha)**	**Farm**	**Number of animals**	**Farm size (ha)**	**Farm**	**Number of animals**	**Farm size (ha)**
	D1	7	26000	A1	10	8000	E1	10	440
	D2	2	2000	A2	6	5000	E2	2	120
	D3	3	4000	A3	7	10000	E3	4	1500
	D4	2	Communal land	A4	2	6050			
	D5	1	2000	A5	12 - 20	2600			
	D6	1	190	A6	3	10000			
	D7	2	Communal land (1000)	A7	-	4550			
	D8	2	1100	A8	4	6800			
	D9	5	7200						
	D10	3	2500						

	D11	2	5000						
	D12	3	7700						
	D13	1	3000						
	D14	1	10000						
	D15	2	3500						
	D16	5	5000						
	D17	1	700						
	D18	1	700						
	D19	2	1000						
	D20	6	1900						
	D21	7	250						
	D22	3	5600						
	D23	2	1300						
Mean		2,78	4316.19		6	6625		5,33	686.67
Median		2	2500		5	6425		4	440
Range		1 - 7	190 - 26000		2 - 20	2600 - 10000		2 - 10	120 - 550

Table 4.1 (Q13 +14): The percentage of livestock lost due to disease, predation and other reasons before and after using **dogs**

Farm		Before Dogs	After Dogs		Before Dogs	After Dogs		Before Dogs	After Dogs
D1		0-10	0-10		11-20	0-10		0-10	0-10
D2		0-10	0-10		0-10	0-10		11-20	0-10
D3		0-10	0-10		31-40	11-20		0-10	0-10
D4		0-10	0-10		51-60	11-20		0-10	0-10
D5		0-10	0-10		21-30	0-10		0-10	0-10
D6		0-10	0-10		21-30	0-10		0-10	0-10
D7		0-10	0-10		91-100	0-10		0-10	0-10
D8		11-20	0-10		11-20	0-10		0-10	0-10
D9		0-10	0-10		21-30	11-20		0-10	0-10
D10	**Disease**	0-10	0-10	**Predators**	11-20	0-10	**Others**	0-10	0-10
D11		0-10	0-10		61-70	11-20		0-10	0-10
D12		0-10	0-10		11-20	0-10		0-10	0-10
D13		0-10	0-10		21-30	0-10		0-10	0-10
D14		0-10	0-10		21-30	11-20		0-10	0-10
D15		21-30	21-30		91-100	51-60		21-30	21-30
D16		21-30	21-30		31-40	0-10		21-30	21-30
D17		0-10	0-10		91-100	11-20		0-10	0-10
D18		0-10	0-10		21-30	0-10		0-10	0-10
D19		0-10	0-10		11-20	0-10		0-10	0-10
D20		0-10	0-10		11-20	0-10		0-10	0-10
	Mean Change	0.5%		Mean Change	25.5%		Mean Change	0.5%	
	Range of change	0-10%		Range of change	0 - 80%		Range of change	0-10%	

Table 4.2 (Q13 + 14): The percentage of livestock lost due to disease, predation and other reasons before and after using **alpacas**

Farm		Before Alpacas	After Alpacas		Before Alpacas	After Alpacas		Before Alpacas	After Alpacas
A1	**Disease**	0-10	0-10	**Predators**	0-10	0-10	**Others**	0-10	0-10
A2		0-10	0-10		21-30	0-10		0-10	0-10
A3		-	-		-	-		-	-
A4		0-10	0-10		31-40	21-30		0-10	0-10
A5		0-10	0-10		31-40	21-30		0-10	0-10
A6		0-10	0-10		21-30	21-30		0-10	0-10
A7		31-40	31-40		81-90	41-50		0-10	0-10
A8		0-10	0-10		0-10	0-10		0-10	0-10
	Mean change	0%		Mean change	10%		Mean change	0%	
	Range of change	0%		Range of change	0 – 40%		Range of change	0%	

Table 4.3 (Q13 + 14): The percentage of livestock lost due to disease, predation and other reasons before and after using **donkeys**

Farm		Before Donkeys	After Donkeys		Before Donkeys	After Donkeys		Before Donkeys	After Donkeys
E1	**Disease**	0-10	0-10	**Predators**	11-20	0-10	**Other**	0-10	0-10
E2		0-10	0-10		11-20	0-10		0-10	0-10
E3		0-10	0-10		31-40	21-30		0-10	0-10
	Mean change	0%		Mean change	10%		Mean change	0%	
	Range of change	0%		Range of change	0 -10%		Range of change	0%	

Table 5.1 (Q15 + 16 + 17): The data collected for livestock lost before and after using livestock guarding **dogs**

Farm	Ewes Before	Ewes After	Lambs before	Lambs after	Rams before	Rams after
D1	0-10	0-10	0-10	0-10	0-10	0-10
D2	91-100	91-100	-	-	0-10	0-10
D3	0-10	0-10	31-40	11-20	0-10	0-10
D4	0-10	0-10	51-60	11-20	0-10	0-10
D5	11-20	0-10	21-30	11-20	21-30	0-10
D6	11-20	0-10	21-30	0-10	0-10	0-10
D7	0-10	0-10	91-100	0-10	0-10	0-10
D8	41-50	21-30	41-50	21-30	0-10	0-10
D9	11-20	0-10	21-30	0-10	0-10	0-10
D10	0-10	0-10	81-90	81-90	0-10	0-10
D11	41-50	21-30	71-80	21-30	61-70	21-30
D12	0-10	0-10	21-30	11-20	0-10	0-10
D13	0-10	0-10	31-40	0-10	41-50	0-10
D14	0-10	0-10	91-100	91-100	0-10	0-10
D15	31-40	21-30	71-80	51-60	0-10	0-10
D16	0-10	0-10	51-60	11-20	0-10	0-10
D17	0-10	0-10	0-10	11-20	0-10	0-10
D18	11-20	0-10	31-40	0-10	0-10	0-10
D19	0-10	0-10	11-20	0-10	0-10	0-10
D20	0-10	0-10	11-20	0-10	0-10	0-10
	Mean change	4.5%	Mean change	20.5%	Mean change	5%
	Range of change	0 – 20%	Range of change	-10 – 90%	Range of change	0 – 40%

Table 5.2 (Q15 + 16 + 17): The data collected for livestock lost before and after using **alpacas**.

Farm	Ewes Before	Ewes After	Lambs before	Lambs after	Rams before	Rams after
A1	0-10	0-10	21-30	11-20	0-10	0-10
A2	0-10	0-10	11-20	0-10	0-10	0-10
A3	0-10	0-10	91-100	91-100	0-10	0-10
A4	0-10	0-10	81-90	71-80	0-10	0-10
A5	0-10	0-10	81-90	81-90	0-10	0-10
A6	0-10	0-10	21-30	11-20	0-10	0-10
A7	0-10	0-10	81-90	81-90	0-10	0-10
A8	0-10	0-10	71-80	71-80	0-10	0-10
	Mean change	0	Mean change	5%	Mean change	0
	Range of change	0	Range of change	0 – 10%	Range of change	0

Table 5.3 (Q15 + 16 + 17): The data collected for livestock lost before and after using **donkeys**

Farm	Ewes Before	Ewes After	Lambs before	Lambs after	Rams before	Rams after
E1	0-10	0-10	61-70	0-10	0-10	0-10
E2	0-10	0-10	91-100	0-10	0-10	0-10
E3	0-10	0-10	81-90	71-80	0-10	0-10
	Mean change	0	Mean change	53.3%	Mean change	0
	Range of change	0	Range of change	10 – 90%	Range of change	0

Table 6.1 (Q18 + 19): Predation attributed to the specific predators before and after making use of **dogs.**

	Jackal		Caracal		Dogs		Leopard		Other	
Farm	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**
D1	60	40	40	60	0	0	0	0	0	0
D2	50	0	50	0	0	0	0	0	0	0
D3	95	50	5	5	0	0	0	0	0	0
D4	53	20	0	0	0	0	0	0	0	0
D5	60	10	10	10	30	80	0	0	0	0
D6	50	10	50	0	0	0	0	0	10	10
D7	95	0	0	0	0	0	0	0	0	0
D8	80	1	10	1	10	5	0	0	0	0
D9	95	90	5	10	0	0	0	0	5	0
D10	75	75	10	10	5	5	0	0	0	0
D11	70	70	30	30	0	0	0	0	0	0
D12	60	60	40	40	0	0	0	0	0	0
D13	60	5	40	5	0	0	0	0	0	0
D14	50	80	50	20	0	0	0	0	0	0
D15	65	65	20	20	0	0	0	0	15	15
D16	75	2	25	10	0	0	0	0	0	0
D17	95	50	5	45	0	5	0	0	0	0
D18	95	0	5	0	0	0	0	0	0	0
D19	99	100	1	0	0	0	0	0	0	0
D20	50	60	45	40	5	0	0	0	0	0

Table 6.2 (Q18 + 19): Predation attributed to the specific predators before and after making use of **Alpacas**.

	Jackal		Caracal		Dogs		Leopard		Other	
Farm	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**
A1	50	50	50	50	0	0	0	0	0	0
A2	20	5	10	5	0	0	0	0	0	0
A3	80	80	20	20	0	0	0	0	0	0
A4	90	90	10	10	0	0	0	0	0	0
A5	50	30	50	70	0	0	0	0	0	0
A6	70	50	10	10	0	0	10	10	0	0
A7	75	75	25	25	0	0	0	0	0	0
A8	80	75	20	25	0	0	0	0	0	0

Table 6.3 (Q18 + 19): Predation attributed to the specific predators before and after making use of **donkeys.**

	Jackal		Caracal		Dogs		Leopard		Other	
Farm	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**
E1	80	0	20	100	0	0	0	0	0	0
E2	100	0	0	0	0	0	0	0	0	0
E3	90	90	10	10	0	0	0	0	0	0

Table 7.1 (Q23): How much predation decreased on each farm in the first and second year and overall after acquiring LGA

	Farm	First year	Second year	Overall
Dogs	D1	0-10	21-30	21-30
	D2	31-40	81-90	91-100
	D3	31-40	31-40	31-40
	D4	0-10	11-20	11-20
	D5	71-80	51-60	81-90
	D6	91-100	91-100	91-100
	D7	91-100	91-100	91-100
	D8	71-80	91-100	91-100
	D9	31-40	21-30	11-20
	D10	-	-	-
	D11	61-70	71-80	61-70
	D12	11-20	0-10	0-10
	D13	81-90	91-100	91-100
	D14	0-10	0-10	0-10
	D15	41-50	41-50	41-50
	D16	71-80	71-80	61-70
	D17	81-90	81-90	81-90
	D18	31-40	51-60	91-100
	D19	41-50	51-60	81-90
	D20	81-90	91-100	91-100
	Mean	53	60	64
	Range	0-100 (100%)	0-100 (100%)	0-100 (100%)
Alpacas	A1	11-20	11-20	11-20
	A2	11-20	0-10	0-10
	A3	0-10	0-10	0-10
	A4	11-20	11-20	11-20
	A5	11-20	21-30	21-30
	A6	31-40	31-40	31-40
	A7	31-40	71-80	71-80
	A8	11-20	0-10	0-10
	Mean	20	23	23
	Range	0 – 40 (40%)	0 – 80 (80%)	0 – 80 (80%)
Donkeys	E1	61-70	71-80	81-90

	E2	91-100	91-100	91-100
	E3	-	-	-
	Mean	80	85	90
	Range	61 – 100 (40%)	71 – 100 (30%)	81 – 100 (20%)

Table 8.1 (Q24): Extra costs to using **dogs** as livestock guarding animals, the average for each in the bottom row.

Farm	Maintenance (R/Year)	Breeding (R/Year)	Veterinary (R/Year)	Housing (R/Year)	Damage to property (R/Year)	Human supervision (R/Year)	Total (R/Year)
D1	1000	0	1000	0	4000	1000	7000
D2	18000	0	1000		0	0	19000
D3	4320	0	500	0	0	0	4820
D4	100	50	160	0	1200	0	1510
D5	15000	2000	0	0	5000	16000	38000
D6	1200	0	800	16000	0	0	18000
D7	2400	600	300	0	4000	400	7700
D8	4500	0	1000	0	0	0	5500
D9	22000	0	3000	0	0	6000	31000
D10	6500	0	400	0	2000	3000	11900
D11	6000	0	500	0	0	0	6500
D12	3000	0	0	0	0	0	3000
D13	4000	0	200	0	0	50	4250
D14	0	0	500	0	3000	2000	5500
D15	400	0	1500	0	0	0	1900
D16	3360	960	1000	0	0	0	5320
D17	8000	0	1000	500	0	1	9501
D18	6000	0	6000	0	0	0	12000
D19	12000	0	5000	0	0	0	17000
D20	15000	0	15000	0	0	0	30000
Mean (SD)	6639 (6416.65)	180,5 (493.78)	1943 (3467.52)	868.42 (3666.07)	960 (1670.30)	1422.55 (3739.47)	11970.05 (10474.94)
Range	0-22000 -22000	0-2000 (2000)	0-15000 (15000)	0-16000 -16000	0-5000 (5000)	0-16000 -16000	1510-84000 (82490)

Table 8.2 (Q24): The initial costs associated with acquiring a **dog**

Farm	Sourcing of the animal (R/Year)	Training (R/Year)	Total
D1	5000	2000	7000
D2	0	0	0
D3	0	0	0
D4	0	0	0
D5	45000	1000	46000
D6	2500	0	2500
D7	0	0	0
D8	600	0	600
D9	0	0	0
D10	330	0	330
D11	4000	0	4000
D12	3000	1000	4000
D13	4000	1000	5000
D14	3000	0	3000
D15	4500	0	4500
D16	5500	0	5500
D17	12000	0	12000
D18	4000	0	4000
D19	5000	0	5000
D20	3000	0	3000
Mean (SD)	5071.5 (9828.65)	250 (550.12)	5291.5 (9787.37)
Range	0-45000 (45000)	0-2000 (2000)	0-46000 (46000)

Table 8.3 (Q24): Extra costs to using **alpacas** as livestock guarding animals, averages for each in the bottom row

Farm	Maintenance (R/Year)	Breeding (R/Year)	Veterinary (R/Year)	Housing (R/Year)	Damage to property (R/Year)	Sourcing of the animal (R/Year)	Training (R/Year)	Human supervision (R/Year)	Total (R/Year)
A1	200	1000	20	0	0	0	0	0	1220
A2	0	0	300	0	0	5000	0	0	5300
A3	0	0	0	0	0	7000	0	0	7000
A4	-	-	-	-	-	-	-	-	-
A5	0	2000	25	0	0	5000	0	0	7025
A6	0	0	0	0	0	24000	0	0	24000
A7	500	0	35	0	0	7500	0	0	8035
A8	0	0	120	0	0	0	0	0	120
Mean	87.5 (180.77)	375 (744.03)	62.5 (103.79)	0	0	6062.5 (7903.15)	0	0	6587.5 (7758.35)
Range	0-500 (500)	0-2000 (2000)	0-120 (120)	0	0	0-24000 (24000)	0	0	120-24000 (23880)

Table 8.4 (Q24): Extra costs to using **donkeys** as livestock guarding animals, averages for each in the bottom row

Farm	Maintenance (R/Year)	Breeding (R/Year)	Veterinary (R/Year)	Housing (R/Year)	Damage to property (R/Year)	Sourcing of the animal (R/Year)	Training (R/Year)	Human supervision (R/Year)	Total (R/Year)
E1	3600	0	1000	0	0	5000	0	2000	11600
E2	480	0	100	0	0	500	0	0	1080
E3	500	0	0	0	0	0	0	0	500
Mean	1526.67 (1795.59)	0	366.67 (550.76)	0	0	1833.33 (2753.79)	0	666.667 (1154.70)	4393.33 (6247.89)
Range	500-3600 (3100)	0	0-1000 (1000)	0	0	0-5000 (5000)	0	0-2000 (20000	500-11600 (11100)