Predator-Friendly Farming: Perceived Efficacy of Livestock Guarding Dogs in South Africa

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ABSTRACT Large wild carnivore predation on domestic livestock and the associated economic losses may increase persecution of carnivore populations. Livestock guarding dogs (LGDs) could provide effective mitigation by protecting stock from depredation but their cost-effectiveness has not been studied in South Africa. We assessed the costs and benefits of 97 LGDs working on 94 farms in South Africa between 2005 and 2011 by reviewing data collected from questionnaires on perceived depredation losses prior to and during LGD placement, rates of LGD behavioral problems, removals, and pre-senile mortality. Perceived livestock depredation ceased entirely in 91% of LGD placements, with mean annual financial savings of U.S. $3,189 per farm. However, landowners reported 28% of LGDs had behavioral problems, with inattentiveness being the most common. Seventeen percent (n = 16) of LGDs were removed from the program because of behavioral problems such as inattentiveness. Premature death was observed in 22% of LGDs, mostly caused by snake

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bites. If these problems can be addressed, LGDs offer an alternative to lethal methods of control and could potentially contribute to the long term avoidance of human-carnivore conflict in South Africa.

KEY WORDS *Acinonyx jubatus,* depredation, human-wildlife conflict, livestock guarding dog, South Africa.

One quarter of the world's mammal species are threatened with extinction (Baillie et al. 2004), with mega-faunal, slow-reproducing species being particularly susceptible (Mckinney 1997). Large carnivores, killed due to both real and perceived threats to game, livestock, and human health and safety, are especially vulnerable (Gittleman et al. 2001). Conservation of large carnivores is particularly problematic because it often places those who wish to restore carnivore populations at odds with others who may experience economic losses from livestock predation.

Humans have tried to limit livestock loss to carnivores using lethal and non-lethal methods (reviewed in Linnell et al. 1996). Although lethal techniques may provide effective short-term solutions for controlling predators (reviewed in Treves and Naughton-Treves 2005), their widespread application is not conducive to sustainable management of threatened carnivore species (Breitenmoser 1998). Thus there is a need to identify and evaluate cost-effective and practical non-lethal alternatives (Sillero-Zubiri and Laurenson 2001).

Livestock guarding dogs (LGDs) have been used in this capacity for nearly six millennia (Olsen 1985). However, because of the widespread extermination of carnivores during the previous two centuries, many farmers have lost the knowledge of how to protect their stock from predators using dogs (Linnell et al. 1996). Given the recovery and reintroduction of a number of carnivore populations, some livestock producers have expressed renewed interest for using LGDs. This started in Turkey in the 1970s (J. W. De Grazio, Denver Wildlife Research Center, unpublished report) and subsequently spread to North America (Linhart et al. 1979) and, more recently, Australia (Rigg, 2001) and Africa (Marker et al. 2005a).

In South Africa, predators are often killed to limit livestock depredation, causing many of the large carnivores to be extirpated from large portions of unprotected areas (Stuart et al. 1985). This has created a mesopredator release, where caracal (*Caracal caracal*) and black-backed jackal (*Canis melanogaster*) numbers have exploded, creating significant problems on small stock farming operations (Lloyd 2007). Due to the reduced intraguild competition because of a very limited number of lions (*Panthera leo*) and spotted hyenas (*Crocuta crocuta*) present, cheetahs have been able to remain on farmland to the north of the country (Marnewick et al. 2007). However, the perceived and real costs that predators place upon livestock farms leads many predators to be lethally controlled in this area. Being that there is a relatively small population of cheetah in South Africa, it is important that conservation efforts that include effective mitigation of human-wildlife conflict are practiced here.

Livestock guarding dogs could provide a twofold solution to resolve some of the main threats to carnivores such as cheetahs by: 1) offering a non-lethal method to limit depredation, thereby reducing the need for lethal persecution; and 2) allowing predators to roam freely on livestock farms, which increases potential habitat. Farmers perceived LGDs as being very successful for limiting livestock depredation due to cheetahs (*Acinonyx jubatus*) in Namibia (Marker et al. 2005a), which initiated a similar project in 2005 by a South African non-governmental organization (NGO), Cheetah Outreach, who provided, in partnership with The De Wildt Cheetah and Wildlife Trust, LGDs to farmers who have had livestock predated which helps to ameliorate livestock-carnivore conflicts (C. Stannard and L. Smith, Cheetah

Outreach, unpublished report). Although the results of these trials are promising, there have been problems with LGDs, which may limit their efficacy and subsequent adoption by others (Coppinger et al. 1983, Rigg 2005).

The objective of our research was to identify the factors that may limit LGD efficacy. This research expands upon previous work on LGDs in southern Africa by calculating the perceived efficacy of LGDs to limit depredation through measuring reported changes in depredation values prior to and upon placement of LGDs and by calculating the financial savings of LGDs for limiting perceived depredation. Using previously collected data from questionnaires conducted by Cheetah Outreach's Anatolian Project Coordinator (hereafter denoted as 'Dog Officer') the following factors related to the efficacy of LGDs were evaluated: 1) ability to reduce reported depredation, including analysis into whether LGDs are more effective at guarding certain species of stock; 2) financial saving for limiting depredation; 3) frequency of behavioral problems; 4) incidence of pre-senile mortality (death before 10 years of age); and 5) frequency and cause of removal. Although we determined perceived rather than real depredation, it is the perceived loss that affect farmers' attitudes and behaviour towards predators (Marker et al. 2003).

STUDY AREA

Placement of LGDs occurs almost exclusively in the South African cheetah home range in the northern regions of the country. Some exceptions included placements in commercial farms in the Eastern Cape and a trial placement at a commercial wine estate in the Western Cape with a herd of springbok (*Antidorcas marsupialis*), the latter of which is not included in the subsequent analyses (Fig. 1). The study areas in the north of the country, where analyses were focused, are characterized by a semiarid savannah agricultural habitat (Buk and Marnewick 2010). Producers incorporated sheep, goats, cattle, or mixed livestock species in grazing operations ranging from 400 to 10,400 ha ($\bar{x}$ = 3,966 ha). Neighboring land uses included livestock producers, game ranches and nature reserves (C. Stannard and L. Smith, Cheetah Outreach, unpublished report).

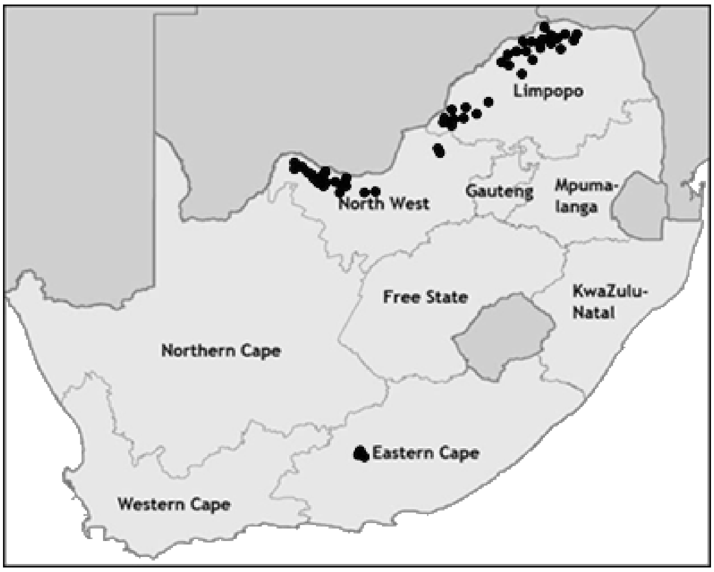

Figure 1. Placement by Cheetah Outreach of Anatolian shepherds (black circles) within South Africa, May 2005 – July 2011.

One Anatolian shepherd LGD is provided by the NGO free of charge to farmers that have been experiencing cheetah depredation, along with a year's supply of dog food and veterinary coverage and full reimbursement for neutering the puppy. This is to offset the prohibitively high initial costs of obtaining a LGD (Green et al. 1984). Puppies are raised by their mothers with sheep present from birth for at least the first 6-8 weeks of life with minimal human contact before being transferred to the selected farm that has experienced depredation. The dog is then kept on the farm with a small flock of their intended stock species for the next few months for imprinting to occur before being released out with the rest of the herd as per instructions from J. R. Lorenz (unpublished report, 1989). Between May 2005 and July 2011, 97 dogs were provided to farmers.

Upon dog placement, the farmer is offered comprehensive information on effective LGD care and training methods including advice for dealing with any potential behavioral or health problems they may encounter with the dog. The Dog Officer maintains regular contact with the farmer, visiting the property once a month in the first year of dog placement, quarterly for the second year and annually thereafter to assess on-going livestock depredation, dog health and behavioral problems. A behavioral problem is defined when either the owner reports undesirable behavioral traits to the Dog Officer, or if the Dog Officer notices such behavior on his visits, which are based upon those laid out by Coppinger and Coppinger (1980), i.e. lack of attentiveness, trustworthiness or protectiveness. The farmer is advised to contact Cheetah Outreach immediately if any behavioral problems are observed in their LGDs, ensuring that these can be dealt with in the most efficient manner. Behavioral problems are noted in Cheetah Outreach's biannual LGD progress report, which also includes any follow-up corrective training undertaken, reasons for removal or death of a LGD, and frequency of depredations (C. Stannard and L. Smith, Cheetah Outreach, unpublished report).

METHODS

Face-to-face structured questionnaires were conducted by the Dog Officer directed towards potential new LGDs owners to determine whether the farm was suitable for LGDs. Questions included the farmer's perceived annual livestock depredation rate, the type of stock on the farm, the size of the farm, the number of livestock in each herd, and other relevant data related to the types of farming practices used. Follow-up face-to-face semi-structured questionnaires were then undertaken by the Dog Officer during the LGD monitoring visits to the farm, which included questions directed towards the dog owner on the total amount of depredation experienced since dog placement, any behavioral problems experienced, whether the dog was removed and the reason(s) for this, whether the dog had died and the cause of death and the length of LGD placement. Unfortunately no data were available to the authors on the exact age of the dogs in relation to when livestock depredation took place therefore no analyses could be performed on this variable.

We determined any changes in perceived annual depredation frequencies upon LGD placement by using values of depredation noted from results from the initial questionnaire prior to placement along with data from the follow-up questionnaires, of which were published in the 2 most recent LGD reports that list Cheetah Outreach's LGDs (D. Cilliers, Endangered Wildlife Trust, unpublished report; C. Stannard and L. Smith, Cheetah Outreach, unpublished report). These reports included results from all LGD placements from the entire study range from May 2005 to July 2011. Depredation values prior to LGD placement are based upon study farmers' perceptions of depredation for the year preceding placement. Given the structure of the follow-up questionnaire, depredation values upon placement were recorded for the entire duration of dog placement rather than per year. We therefore calculated annual depredation rates upon LGD placement by dividing the total confirmed depredations during the entire timeframe of LGD ownership by the number of years the dog had been present. It is not clear whether the reported annual depredation prior to LGD placement was a typical value for that farm, thus the calculated effectiveness of LGDs for reducing depredation was based on the assumption that this was indeed typical.

We determined the ability for LGDs to protect certain stock species more effectively than others by comparing depredation frequencies during LGD placement as calculated above dependent on whether either large (cattle) or small (goats and sheep) stock species were guarded. Where both large and small stock were guarded, these data points were not included in the analysis ($n = 1$). The reported LGD behavioral problems, cause of pre-senile mortality, and cause of removal data were analysed from data collected by the follow-up questionnaire.

Using 5 June 2011 market prices for livestock sales in South Africa (B. Smuts, Landmark Foundation, personal communication), we calculated direct annual cost of depredation i.e., the annual number of livestock depredated upon multiplied by the market value per animal, for each stock species using the above annual depredation values prior to and during LGD placement. Annual financial savings during LGD placement were calculated by subtracting the mean annual costs of depredation during LGD placement from the mean of annual costs of depredation of all stock species prior to LGD placement.

We carried out all analyses using MINITAB VERSION 16 (Minitab Inc., Quality Plaza, 1829 Pine Hall Road, State College, PA). Data were tested for normality using the Anderson-Darling test and non-parametric tests were used for data that were not normally distributed. A 1-way paired *t*-test was used to test for a directional difference between the means of the 2 populations to test for a difference between annual depredations before compared with during LGD placement. A Kruskal-Wallis test was used to test whether depredation values varied during LGD placement depending on species of stock guarded. Due to the small number of instances of reported livestock depredation after LGD placement ($n = 5$), it was not possible to conduct statistical analyses on factors such as size of farm, number of LGDs or stock protected that may have influenced livestock depredation during LGD placement. The significance level for all tests was set at 0.05. Data were reported as mean (± SE) unless otherwise stated. Questions not answered by respondents were deemed non-responses and were therefore eliminated from the analysis, hence why the sample size changed throughout analysis.

RESULTS

Changes in Level of Perceived Depredation

Perceived annual depredation rates were lower during LGD placement compared with before placement (Fig. 2 [$P \leq 0.001$, $n = 70$, $T = 10.48$, $\bar{x}$ difference between pairs = 19.85]).

Perceived annual depredation was reduced by a range of 33.3-100% during LGD placement ($\bar{x}$ = 98.3% ± 1.0) across all farms.

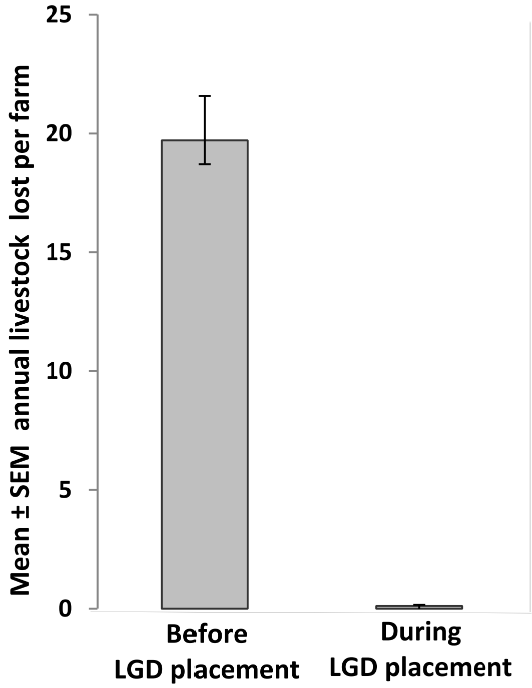

Figure 2. Histogram of mean ± SEM annual depredation frequencies on 70 farms before and during livestock guarding dog (LGD) placement in South Africa.

The percentage of annual stock lost to predators prior to LGD placement ranged between 2-50% ($\bar{x}$ = 17.4%, *n* = 28); during LGD placement this ranged from 0-2% ($\bar{x}$ = 0.1%, *n* = 26). No farm experienced an increase in depredation upon LGD placement.

LGD Application

The mean length of LGD placement was 2.33 years (range 1 – 6 years). Of 74 LGD placements with data provided on the stock guarded by dogs, 57% (*n* = 42) guarded sheep, 31% (*n* = 23) goats, 11% (*n* = 8) cattle, and 1% (*n* = 1) guarded a mix of goats and sheep. No difference was found between depredation loss of different species during LGD placement (P = 0.958, df 2, *n* = 70, H = 0.31), therefore we concluded that livestock species has no effect on efficacy of the LGDs.

Financial Loss

Mean financial loss from depredation decreased following LGD placement (Table 1). Each LGD saved on average U.S. \$3,189 ± \$302 per farm annually due to a reduction in depredation for all livestock species.

Table 1 Mean ± SE (and range [a]) of annual cost [US \$] of depredation before and during livestock guarding dog (LGD) placement on 94 farms in South Africa, May 2005 – Jul 2011 (*n* = 70)

Livestock farm type	Mean annual financial loss due to depredation [b]	
	Before LGD placement	During LGD placement
Cattle	5,127 ± 1,315 (1,783-11,889)	0
Sheep	3,222 ± 384 (0-14,416)	5 ± 3 (0-99)
Goats	2,449 ± 386 (357-5,945)	8 ± 6 (0 - 119)
Sheep and goats	1,486±0 (1,486)	0

[a] Range stated in brackets.

[b] Value rounded to the nearest dollar (USD), converted from South African Rand (ZAR) using currency conversion rates of 1:6.7 USD:ZAR as of 5 June 2011.

Behavioral Problems and Removal

Out of 97 dogs analysed, 27 (28%) were reported to have behavioral problems at least once during the study period (Fig. 3). ‘Owner-related’ problems refer to non-compliance from the farmer. An ‘unknown’ behavioural problem referred to a dog recorded that had behavioral problems with no further information provided in the Dog Officer’s reports.

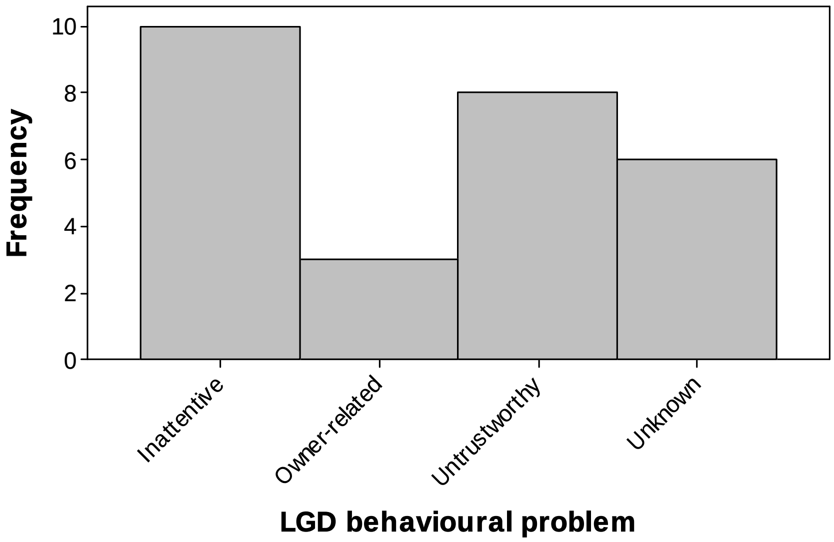

Figure 3. Histogram of reported frequencies of behavioural problems noted by Cheetah Outreach's Dog Officer in 26 livestock guarding dogs (LGDs) placed on South African farms, May 2005 – July 2011.

Five out of the 27 (19%) LGDs that previously had behavioral problems responded well to corrective training and the problems disappeared. Of those dogs with recorded behavioral problems, 44% (n = 12) were removed from the program because corrective training did not resolve the problem. As of December 2010 there were 6 LGDs (10%) under corrective training for behavioral problems out of 58 working LGDs.

Out of 97 dogs analysed, 16 (17%) were removed (Fig. 4). The most common cause of removal was due to unresolved behavioral problems (n = 10, 63%). The remaining four dogs were removed for reasons not related to behavior.

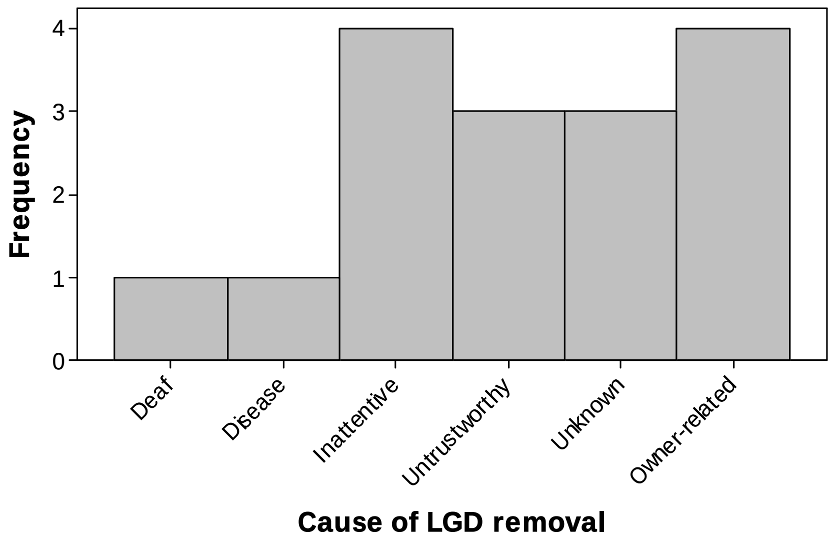

Figure 4. Histogram of frequencies and causes of 16 livestock guarding dog (LGD) removals in South Africa, May 2005 – July 2011.

Pre-senile Mortality

Twenty-one of 97 LGDs (22%) died prematurely, 5 (24%) of which were accidentally killed. These accidental deaths were caused by snaring, falling off a vehicle, heavy metal poisoning, a puppy being stepped on by a goat, and electrocution. There were 11 cases (52%) of dogs being killed by snake bites. Two dogs were intentionally killed by individuals other than the owner; one was shot by a neighbor, another poisoned by a farm worker. Two dogs were predated upon - one by a hyena, another by a leopard. One dog's cause of pre-senile death was unknown.

DISCUSSION

Livestock guarding dogs were successful in eliminating reported livestock depredation entirely on over 90% (*n* = 66 out of 70 farms with usable data) of the South African farms investigated. Moreover, in cases where livestock losses were not completely eradicated following the placement of a LGD, perceived losses due to predation were reduced by at least 80%, with only one exceptional case experiencing a reduction of only 33% due to a very low rate of depredation both before and during LGD placement. Reported decreases in livestock depredation were noted on many farms that had owned LGD puppies for less than a year, showing that even young dogs were able to work effectively at deterring predators. One farmer reported 35 goats lost the year prior to LGD placement; this was reduced to zero directly upon LGD placement, with no further losses recorded on this farm during the study period.

The overall perceived economic benefits of the reduced depredation achieved on the majority of farms were substantial, with one farmer estimated to have saved U.S. $14,415 per year (Table 1). An average annual saving across the study population was calculated at U.S. $3,189, which is similar to that reported previously (Andelt and Hopper 2000). Considering that the average annual upkeep for a LGD after the first year of life is approximately U.S. $540-620 (real worth, Andelt 1984, Green et al. 1984), the use of LGDs therefore represent a mean net financial saving upwards of U.S. $2,500.

The potential influence of stock species was investigated in regards to their relative risk of depredation. Interestingly, the incidence of losses of small stock species (sheep and goats) to predators was similar to that of large stock species (cattle) during LGD placement. As such, LGDs appear to be equally successful at reducing depredation of both large and small stock species and may therefore be a viable and relevant form of effective predator control for a range of farmed animal species.

The efficacy of a LGD for reducing livestock depredation was dependent upon its successful placement on each farm. However, LGDs may be removed from farms due to a variety of reasons and in the present study the proportion of failed placements resulting in the dog's removal was reasonably high (over 15%, compared with just 8% in a study by Marker et al. [2005b]). The most common reason for removal was due to behavioral problems, which accounted for over 60% of removals in the current study. Pre-senile mortality was also relatively common, with snake bites accounting for over half of such deaths.

According to Pfeifer and Goos (1982), the failure to reduce depredation by LGDs may occur when under the following situations: 1) the dog is less than 6 months old; 2) the stock are too dispersed for the dog to guard effectively; 3) the dog is ill; or 4) the dog lacks attentive behavior. These situations were observed in the current study, with the exception of ill-health causing failure to guard. Age appeared to be an important factor when considering failed guarding cases in the current study, as the majority of depredation took place on farms with dogs under the age of 1. Livestock guarding dogs are considered to be most effective once they reach maturity at approximately 2 years of age (Green et al. 1994). Therefore a dog's guarding behavior should not be anticipated to reach peak performance until this age and it follows that a number of depredation incidences in the current study took place prior to the LGD reaching adulthood. Additional depredations were observed in one case where the herd split itself into two groups, thereby making it difficult for the dog to guard both herds. In this situation, we advised for the placement of a second LGD on this farm to prevent this from happening in the future.

Inattentiveness was the most common behavioral problem reported and accounted for a considerable number of dog removals. However, it is unclear whether any depredations took place due directly to the dog's inattentive behavior. Dogs are reported to exhibit more successful LGD behavior when they are introduced to livestock no later than 6 weeks of age (Pfeifer and Goos 1982, Black and Green 1984, Coppinger and Coppinger 1993). If a dog has not imprinted upon its herd species by this time, it is far more likely to become inattentive when guarding (Pfeifer and Goos 1982, Coppinger et al. 1983). As dogs in this study were bonded with herds prior to and during this critical socialisation period, it is unlikely that this was the cause of the inattentive behavior noted here. Likewise, all dogs in the present study were neutered at 8 months of age, indicating that sexual behaviors such as roaming (R. Lüthi, WWF, pers. comm.) are unlikely to explain the inattentiveness observed here.

The use of Anatolian shepherds in this study may have introduced some breed-specific factors influencing guarding efficacy. For example, other studies have found Anatolian shepherds to be less protective and trustworthy than other breeds (Coppinger et al. 1983, Green 1989, Timm and Schmidt 1989, Green and Woodruff 1990) and Green and Woodruff (1980) found that Great Pyrenees and Komondors can become successful LGDs even if they are introduced to sheep at 6 months old or older. Other predator conservation NGOs in southern Africa are trialling different breeds of LGDs such as Boerboel dogs and mixed breeds to determine whether this affects the success of their LGD programs (Marker et al. 2005c, D. Cilliers, Endangered Wildlife Trust, unpublished report). The results of such studies may have substantial implications for future resource investment in LGD programs.

The relatively high frequency of inattentive behavior reported here when compared with Coppinger et al. (1983) may also be due to lack of engagement with the training program by the farmer. Indeed, although the success of a LGD depends partly on canine genetics and imprinting (Coppinger et al. 1987), one study has indicated that the farmer's commitment to the program is a more important factor for determining the success of the dog (Rigg 2005). This theory is supported by an observation in our study where one dog that was reported to have behavioral problems was transferred to an alternative farm and subsequently worked extremely effectively. Furthermore, nearly 1 in 5 of the dogs with behavioral problems responded well to corrective training. This highlights the need for on-going and regular communication and training of dogs and the farmers involved in order to increase the likelihood of a successful placement.

Similar to other studies (Lorenz and Coppinger 1986; Ribeiro and Petrucci-Fonseca 2005), pre-senile mortality was observed in a number of LGDs prior to reaching 10 years of age (over 20% of dogs studied). Snake bites and accidents were the most common causes of death, which has also been found in other studies (Lorenz et al. 1986, Green 1989, Green and Woodruff 1990, Marker et al. 2005a). In a study of domestic dogs, snake bites were the most frequent cause of poison-related deaths (Case 2005) and it appears from our study that LGDs are at similar risk. As such, snake aversion conditioning would be a beneficial addition to LGD training programs. Predation may be an unavoidable risk for LGDs and was the cause of 10% of LGD pre-senile deaths in the current study, which is comparable to a previous study (Ribeiro and Petrucci-Fonseca 2005). Protective spiked collars similar to those worn by Anatolian shepherds in Turkey (Rigg 2001), or the placement of puppies on farms with working adults may help reduce such deaths as puppies learn how to avoid dangerous situations quicker (Black and Green 1984). Unfortunately, purposeful killing of LGDs by humans accounted for 10% of LGD deaths in the current study, which is a similar result to that found by Marker et al. (2005a). Limiting inattentive behavior by constructing dog-proof fencing or by using shock collars (Timm and Schmidt 1989) to decrease roaming onto neighboring properties (Lorenz et al. 1986) may also assist in preventing pre-senile deaths caused by humans. However, influencing the behavior of humans rather than that of the dogs is more likely to reduce this type of pre-senile death. Previous studies have indicated that LGDs have been purposefully killed by neighbors or hunters (Green and Woodruff 1990, Jenkins 2003, Marker et al. 2005a, Ribeiro and Petrucci-Fonseca 2005), possibly as they were regarded as a threat to livestock, game, or pets (Rigg 2005). Community outreach and education programs could be the most effective method of combating this problem.

It is possible that livestock depredations decreased in this study due to other variables unrelated to LGDs, or instead of the LGD placements. These alternative explanations may include factors such as an increase in natural prey numbers causing predators to revert to their preferred dietary choice, i.e. from livestock to wild prey (Rasmussen 1999, Hoogesteijn 2002, Woodroffe et al. 2005) or a possible bias in reporting or recording livestock depredation by farmers (Green and Woodruff 1983). It could also be that improved livestock husbandry practices were implemented during the study period. However, given that the intended conservation goal for using LGDs is to reduce lethal control of predators, we applaud any farmer that chooses to improve their livestock management that would reduce depredation and thus concurrently reduce the need to kill predators. Further research will be needed to understand the extent these factors play in influencing depredation.

MANAGEMENT IMPLICATIONS

As many large carnivore populations continue to decline, it is imperative that conservationists develop effective solutions to reduce threats to their existence and improve tolerance amongst the people living with these species; livestock guarding dogs could well be part of this solution. It is clear that from the literature and this present study that LGDs can provide an effective non-lethal predator control for many livestock farms across the world (Andelt 1984, Hansen 2005, Marker et al. 2005b, Otstavel et al. 2009) and their use should be encouraged where local conditions allow.

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