TESTING THE EFFECTIVENESS AND COST-EFFICIENCY OF LIVESTOCK GUARDING DOGS IN BOTSWANA.

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ABSTRACT

Livestock guarding dogs (LSGDs) have been used for centuries to reduce depredation on livestock and more recently, to facilitate the conservation of threatened predator species. Conservation NGOs (non-government organisations) in southern Africa promote the use of Anatolian Shepherds as LSGDs. However, livestock farmers in Botswana have been using a variety of different breeds for this purpose, including the local mixed-breed "Tswana" dogs. Postal, telephonic and face-to-face interview questionnaires were administered to 108 livestock farmers in Botswana to gauge how their LSGDs were being used, in order to determine what factors contributed to the success and affordability of these dogs. Eighty-three percent of farmers had LSGDs which equaled or decreased livestock depredations on their farms, with an average reduction in livestock depredation of 75% per year. This equated to an average saving of US$2,017 annually per farm. The costs of purchasing (average US$27) and maintaining the 198 LSGDs in my study (average US$169/LSGD/year) were very low compared to other countries and helped contribute to the high profits obtained by farmers (average US$1,497/farm or US$789/LSGD). A unique investigation of different breeds was possible due to the diverse array of breeds in the sample (Anatolian Shepherds, Cross Breeds, Tswana dogs, Greyhounds and Pitbulls), with the crossbreed dogs (Crosses and Tswana LSGDs) performing the best. LSGDs that reduced depredation and had minimal behavioural problems were the most likely to incite positive changes in their owners in regards to attitudes towards predators. Sixty-six percent of farmers stated that they were more tolerant of predators since obtaining a LSGD, and 51% reported that they were less likely to kill predators since obtaining a LSGD. My results indicate that successful, well-behaved LSGDs are a cost-effective tool that has the ability to increase farm productivity and improve predator-farmer conflicts in Botswana. The methods recommended in my thesis, in particular the benefits of using local breeds of dog as LSGDs, can be implemented on farming practices the world over to assist farming productivity and to promote conservation efforts.

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CHAPTER 1 – General introduction

1.1 Introduction

Human wildlife conflict (HWC) threatens many species worldwide (Ogada *et al.,* 2003; Woodroffe, 2004; Lindsey *et al.,* 2005), with particularly severe conflicts arising when human lives or livelihoods are under threat from wildlife (Berg, 2001; Graham *et al.,* 2005; Woodroffe *et al.,* 2007). Traditionally, cattle, (*Bos taurus)*, goat, (*Capra hircus)* and sheep, (*Ovis aries*) farmers use techniques like herding and corralling animals at night to protect livestock from threats such as thieves and predators (Gusset *et al.,* 2009; Muir, 2009). The commercialization of firearms in the 19^{th} and 20^{th} centuries bolstered the availability, ease and popularity of lethal control as a means of controlling predators and many carnivore species became extinct in farmlands worldwide, as a result (Berg, 2001; Macdonald & Sillero-Zubiri, 2004; Fox & Papouchis, 2005). The subsequent decline in predator populations on farmlands rendered preventative farming practices like herding and corralling irrelevant and unnecessary, and modern farming continued to evolve with minimal threats from predators (Fox & Papouchis, 2005; Woodroffe *et al.,* 2005; Gehring *et al.,* 2010). When conservation efforts caused predator populations to rebound, farmers found the reestablishment of predators in some areas particularly challenging (Woodroffe *et al.,* 2005). Consequently, conflicts between livestock farmers and predators became widespread (Woodroffe *et al.,* 2005).

Human perceptions of wildlife greatly influence the degree of conflict between them. In the past centuries, many farmers had negative perceptions of carnivores, as all predators were suspected to be livestock killers and they served no palpable benefit on farmlands (Daly *et al.,* 2006; Kent, 2011). Research, however, has identified that livestock makes up only a small percentage of most predators' diets, and improved education has highlighted the important role that they serve in the ecosystem (Marker *et al.,* 2003b; Rigg, 2005). With the dissemination of this knowledge, some farmers have become more tolerant of predators on their farms; however, some farmers still continue to view all predators as pests (Kent, 2011).

The justification for the use of lethal control against predators is usually a farmers' perceived assumption of a threat to livestock that is often unsubstantiated (Rasmussen, 1999; Ogada *et al.,* 2003; Woodroffe & Frank, 2005). Deaths of livestock attributed to predators are often the result of more common causes such as disease, injury, stillbirths (Marker, 1999), and theft (Rasmussen, 1999). In some cases, the amount of lethal control used on predators has no relationship to the amount of livestock losses sustained and is merely determined by the farmers' attitudes towards the predator in question (Potgieter, 2011).

These perceptions can be influenced by pre-conceived prejudice, religion, cultural beliefs, false information or simple misdirection (Shivik, 2004; Hodkinson *et al.,* 2007; Dickman, 2010). Some species take the majority of blame for livestock losses (Camacho, 2006; Baker *et al.,* 2008; Kent, 2011). For example, due to their diurnal and wide-ranging behaviours, cheetahs (*Acinonyx jubatus)* and African wild dogs *(Lycaon pictus)* are often disproportionately blamed for livestock losses because they are more visible to farmers (Ogada *et al.,* 2003; Marker *et al.,* 2005a; Selebatso, 2006). Similarly, spotted hyenas (*Crocuta crocuta*) often incite negative perceptions due to their association with witchcraft (Dickman, 2005).

In order to address HWC holistically, it is important to consider both the actual losses to predators as well as the attitudes and perceptions of the farmers (and the reasons for these)(Rigg *et al.,* 2011). Improving environmental education so that farmers can accurately investigate the causes of livestock deaths is a good first step to alleviate conflict, and will help bridge the gap between the perceived and the real problems occurring with predators on their farms (Lindsey *et al.,* 2005; Selebatso, 2006).

Mitigating predator-farmer conflict has the potential to increase the productivity of livestock farming whilst at the same time increasing survival rates for predator species on farmlands (Kent, 2011; Rigg *et al.,* 2011; Thorn *et al.,* 2012). Promoting human wildlife coexistence is particularly important as farmlands often act as important wildlife corridors between protected areas (WWF, 2005; Statistics Botswana, 2013) and can be population sinks for predators that do not thrive within protected areas (Klein, 2007; Winterbach, *et al.,* 2012).

There are a variety of mitigation methods used by farmers around the world to minimize HWC. Ideally, mitigation methods should meet certain criteria to ensure that they are effective and worthwhile for farmers, while also benefiting other relevant stakeholders. Mitigation methods should adhere to as many as possible of the following criteria:

The mitigation methods should;

a) Selectively target the problem-causing predator/s (i.e. be discriminate rather than an indiscriminate form of control) (Marker *et al.,* 2003a; Woodroffe & Frank, 2005; Shivik, 2006).
b) Reduce livestock losses for a long period of time (Mitchell *et al.,* 2004; Shivik, 2006).
c) Be cost effective for the farmer, relative to the losses being experienced (Nyhus *et al.,* 2005; Woodroffe *et al.,* 2005; Shivik, 2006).
d) Be easy for everyday farmers to source and implement (Shivik, 2004).
e) Have minimal negative impacts on the environment (Pfeifer & Goos, 1982; Mitchell *et al.,* 2004; Shivik, 2006).
f) Be ethical and involve minimal harm and stress to the target species (Macdonald & Baker, 2004; Thorn *et al.,* 2012).
g) Be socially acceptable (Mitchell *et al.,* 2004; Shivik, 2006; Rigg *et al.,* 2011).
h) Adhere to local and international laws (Gehring *et al.,* 2010).

It is important to note that no one mitigation method is a panacea for all farms and all conflicts. The effectiveness of each method or combination of methods depends on complex array of factors such as the size of the farm, climate, livestock type, herd sizes, management techniques and predator populations (Hodkinson *et al.,* 2007). However, it is thought that a combination of two or more mitigation techniques will usually result in a significant reduction in livestock losses (Fox & Papouchis, 2005; Gehring *et al.,* 2010). With proper management and effective mitigation methods in place, co-existence between farmers and predators is possible even at high human densities (Linnell *et al.,* 2001).

There are numerous forms of lethal control that are used against predators; the most common being shooting, poisoning, hunting with dogs and trapping with either cages, snares or gin traps (Cilliers, 2003; Fox & Papouchis, 2005; Camacho, 2006). In general, lethal control is publically unacceptable (Gehring *et al.,* 2010), environmentally damaging (Woodroffe *et al.,* 2005) and is often illegal (Kleinkauf *et al.,* 1999; Graham *et al.,* 2005; Baker *et al.,* 2008). These factors are amplified if lethal control is used indiscriminately, as this is particularly damaging to the environment (Kent, 2011) and has been found to have negligible effects on future livestock losses (Marker *et al.,* 2003a; Fox & Papouchis, 2005; McManus *et al.,* 2014). In some areas, the extirpation of entire species has been witnessed, creating trophic cascades in the ecosystem with unexpected and sometimes severe ramifications (Berger, 2006). For example, farmer-induced local extirpation of large predators such as lions (*Panthera leo*), leopards (*Panthera pardus*), spotted hyenas and cheetahs in South Africa has caused over-population and subsequent severe conflicts with smaller meso-predators such as black-backed jackals (*Canis mesomelas*) and caracals (*Caracal caracal*)(Daly *et al.,* 2006; Hodkinson *et al.,* 2007; Thorn *et al.,* 2012). The environmental consequences of reducing or eliminating predators entirely from the ecosystem can also include an overall decrease of the health of game populations (Baker *et al.,* 2008; Lindsey *et al.,* 2005; Hodkinson *et al.,* 2007). Lethal control can also cause detrimental effects on the individual farm scale, with research showing that removing a resident predator can cause a sinkhole effect, attracting numerous neighbouring predators into the area and potentially causing more problems than previously experienced (Stahl *et al.,* 2001; Woodroffe & Frank, 2005; Baker *et al.,* 2008).

With public disapproval and legal restrictions limiting the use of lethal control in many countries, the use of non-lethal predator control measures are becoming more popular. Improved livestock management is now being seen as a primary tool for managing predator problems on farmlands worldwide and has the ability to reduce the need for lethal control (Ogada *et al.,* 2003; Woodroffe *et al.,* 2007; Kent, 2011). "Predator-friendly" farming methods are being implemented throughout the world to not only reduce livestock losses but also to conserve predator species and, at the same time, improving the health of rangelands and promoting sustainable farming (Sillero-Zubiri & Stwizer, 2004; Dickman, 2008; Kent, 2011). Practices such as herding (Rasmussen, 1999; Andelt, 2001; Muir, 2009), corralling livestock in large paddocks during the day or small corrals at night (Camacho, 2006; Selebatso, 2006; Gusset *et* *al.,* 2009), using breeding seasons (Marker, 1999; Rigg, 2001; Kent, 2011), maternity corrals (i.e. corralling heavily pregnant and calving mothers; Fox & Papouchis, 2005; Camacho, 2006), as well as corralling young (Marker, 1999; Rigg, 2001; Fox & Papouchis, 2005) and sick animals (Hodkinson *et al.,* 2007) are all techniques that are can reduce livestock predation, by minimizing the livestock's proximity to predators in areas and at times when livestock are most vulnerable (Woodroffe & Frank, 2005; Hodkinson *et al.,* 2007; Baker *et al.,* 2008).

Selecting breeds that are naturally aggressive to predators, or that are protective mothers can also assist in predator control (Rasmussen, 1999; Fox & Papouchis, 2005). Leaving horns on some livestock can also equip them with the ability to protect themselves against predators (Marker, 1999; Rigg, 2001). Maintaining a high standard of health of livestock is also important, because sick or injured animals are particularly susceptible to predation (Hodkinson *et al.,* 2007).

Apart from husbandry techniques, there are other non-lethal methods that can be implemented to reduce livestock predation. Protection and deterrent collars for livestock have been used with some success to limit depredation (Shivik, 2004; Fox & Papouchis. 2005; Hodkinson *et al.,* 2007). A variety of other deterrents have also been used including visual, audio and chemical deterrents as well as non-lethal projectiles (Ogada *et al.,* 2003; Fox & Papouchis, 2005; Hodkinson *et al.,* 2007). Many deterrents can be effective, however, they only work for a short period of time as predators often adapt quickly to the new stimulus (Smith *et al.,* 2000; Fox & Papouchis, 2005; Shivik, 2006). Using a combination of deterrents or an unpredictable rotation of different types of deterrents can improve their effectiveness (Linnell *et al.,* 1996).

Zoning has been used as way to minimize conflict with predators, by using fences to separate large portions of agricultural land from wildlife areas. This technique has had some success, though it can be financially prohibitive and fences can threaten ecosystem integrity by interrupting the natural movement of ungulate and predator species (Woodroffe *et al.,* 2005; Landry, 1999; Kent, 2011). This becomes particularly devastating in times of drought where large numbers of game can perish on fence lines if natural migration paths to water and food sources are cut (Jones

1999). Predator-proof fences can be used on individual farms, however, their high costs are difficult to meet for individual farm owners and they will restrict movements of wildlife on a small scale.

Using livestock guarding animals is a mitigation technique that has been found to be effective in many cases around the world. A number of different species have been found to adequately protect livestock from predators, including zebras (*Equus quagga*), horses (*Equus ferus*), ostriches (*Struthio camelus*)(Hodkinson *et al.,* 2007), baboons (*Papio ursinus*)(Marker-Kraus *et al.,* 2003) and jackals (Cheetah Conservation Botswana, unpublished data). The most commonly used guarding animals, however, are domestic dogs (*Canis lupus familiaris*)(Andelt, 2001; Rigg, 2001; Gehring *et al.,* 2010), donkeys (*Equus africanus*)(Marker, 2000; Andelt, 2001; Rigg, 2001), llamas (*Lama glama*) and alpacas (*Vicugna pacos*)(Meadows & Knowlton, 2000; Andelt, 2001; Franklin & Powell, 2006). Of these animals, domestic dogs are most commonly used as livestock guardians (Potgieter, 2011).

Apart from guarding livestock, dogs can also be used to deter predators by acting as "patrolling dogs" (Hansen, 2005; Hodkinson *et al.,* 2007; Gehring *et al.,* 2010). Used with a handler and usually on a leash, patrolling dogs effectively deter predators by leaving scent marks around the perimeter of a farm (Hansen, 2005; Hodkinson *et al.,* 2007; Gehring *et al.,* 2010). The presence of dogs and their scent marks creates an active biological deterrent to predators (Gehring *et al.,* 2010; Joubert, 2011) and can be particularly useful on large scale, unfenced pastures that are difficult for livestock guarding dogs (LSGDs) to work in (Green *et al.,* 1994; Hansen, 2005; Gonzalez *et al.,* 2012). Unlike LSGDs, patrolling dogs do not need to be bonded to the stock and therefore do not need special training. Although useful at providing some protection from predators, they are less effective at deterring predators than LSGDs and will not be likely to deter bears (*Ursus sp.*) or wolves (*Canis lupus*) from farmlands (Hansen, 2005).

LSGDs, on the other hand, can be characterized as dogs that live full time with the livestock and actively deter predators (Berry *et al.,* 2011). They achieve this by barking at the predator, interrupting the predators' hunting sequences and/or to alerting the herd to danger. They may also chase, attack and sometimes kill the intruder, though this is reported to be a rare occurrence (Lorenz & Coppinger, 1996). Like patrolling dogs, the presence of a LGSD and its scent marks also acts as a deterrent to predators (Hodkinson *et al.,* 2007; Gehring *et al.,* 2010).

According to the criteria listed above for ideal mitigation methods, LSGDs satisfy all eight criteria. They are effective at reducing livestock losses, are cost effective, simple to implement, selectively target the problem animals that threaten the livestock, have minimal impact on the environment, are ethical, only rarely cause injury or death to target species, and are socially acceptable and legal (Landry, 1999; Rigg, 2001; VerCauteren *et al.,* 2008).

The history of LSGDs can be dated back thousands of years to Europe and Asia where the dogs of herders would go with flocks of sheep to protect them against attacks from wolves, bears, stray dogs and from human thieves (Landry, 1999; Rigg, 2001; Andelt, 2004). Local breeds of dog were trained as puppies and naturally selected based on their abilities to survive harsh terrain and to protect livestock effectively (Urbigkit & Urbigkit, 2010; Berry *et al.,* 2011).

The extirpation of predators from many farming areas in the 19^{th} and 20^{th} Century rendered LSGDs superfluous in Europe, Asia and the Americas (Linnell *et al.,* 2001; Rigg & Gorman, 2001; Rigg *et al.,* 2011), and the local knowledge of how to implement these dogs was subsequently lost (Rigg, 2005). The need for LSGDs re-emerged after the predator populations returned to farming areas (Landry, 1999; Andelt, 2001; Gehring *et al.,* 2010), and their popularity subsequently grew (Berry *et al.,* 2011). In Colorado, USA, for example, the use of LSGDs amongst surveyed farmers increased from 7% in 1986 to 65% in 1993 (Andelt & Hopper, 2000). Programs specifically promoting LSGDs as a predator conflict mitigation tool are now being implemented in Europe, America and Africa (Landry, 1999; Andelt, 2001; Berry *et al.,* 2011).

The use of LSGDs is now being encouraged in Africa by predator conservation organisations (Landry, 1999; Gehring *et al.,* 2010; Potgieter 2011). In 1994, the Cheetah Conservation Fund (CCF) started the first LSGD program in southern Africa by importing Anatolian Shepherd dogs into Namibia from the USA (Berry *et al.,* 2011). Their promotion of this Turkish LSGD breed was very effective and soon other organizations in South Africa such as Cheetah Outreach and The Endangered Wildlife Trust also started programs using these dogs (Cheetah Outreach, 2013; Berry *et al.,* 2011). Other breeds are also being used, with the local "Tswana" breed of Botswana being promoted in a LSGD program run by Cheetah Conservation Botswana (Klein, 2007; CCB, 2008).

1.2 Motivation for the study

Large carnivores often come into conflict with humans as they have the ability to cause major damage to livestock (Berg, 2001). Conflict mitigation techniques that protect livestock are encouraged to combat this problem, as this approach benefits the farmers while at the same time protecting predators from reprisal killings (Ogada *et al*., 2003; Thorn *et al.,* 2012). LSGDs have been found to be highly effective at reducing HWC between carnivores and livestock farmers (Ogada *et al.,* 2003; Marker *et al.,* 2005b; Woodroffe *et al.,* 2007). However, little is known about the precise situations and conditions that make LSGDs most effective at reducing livestock losses and how successfully they promote the conservation of carnivores.

Although the history of the use of LSGDs worldwide has been documented in several papers (Landry, 1999; Rigg, 2001; Gehring *et al.,* 2010), none describe the use of LSGDs in sub-Saharan Africa prior to the 1970s and it is thought to be an underutilized tool in this area prior to the 1990s.

Botswana is unique because the modern use of LSGDs has evolved naturally rather than through the involvement of an outside organisation. Botswana farmers have selected the dogs and implemented training and placement strategies based on their own experiences and knowledge. Therefore, my study aimed to identify the key components that make LSGDs successful in Botswana by measuring the effectiveness of the LSGDs, assessing the factors which may have contributed to their performance, determining the costs and benefits involved in owning a LSGD and investigating whether LSGDs improve relationships between their owners and the predators on their farms.

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CHAPTER 2 - Study site and general methodology

2.1 General information about Botswana

My study is focused on the southern African nation of Botswana – a large country spanning 581 730km^2 with 39% of its landmass dedicated to the protection of wildlife and also vast areas devoted to agriculture (MWTC, 2001; Statistics Botswana, 2013b). Botswana is landlocked between South Africa, Zimbabwe, Namibia and Zambia (Figure 2.1) and lies between the latitudes of 20 and 29° E and longitudes between 17 and 27°S.

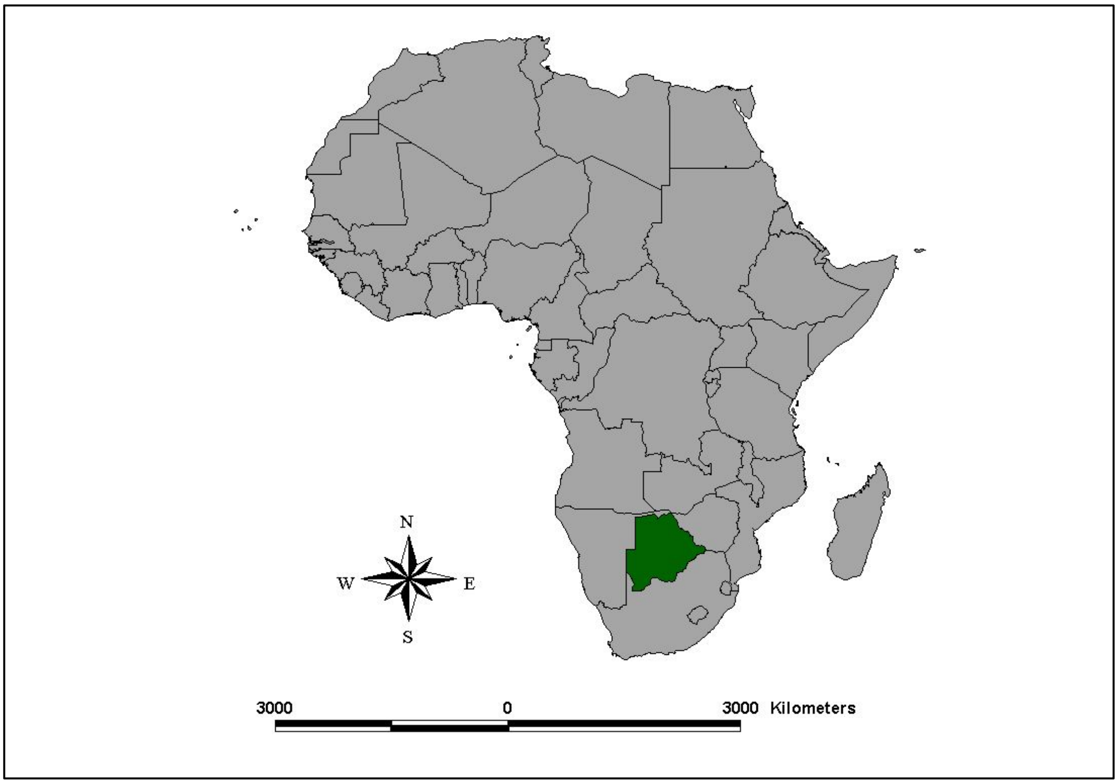

Figure 2.1: The location of Botswana (green polygon) in Africa.

Botswana became an independent nation in 1966 after 80 years as the British Protectorate of Bechuanaland (MWTC, 2001; Mathuba, 2003). After the discovery of diamonds in 1967, the country went from one of the poorest in the world to one of the wealthiest in Africa (MWTC, 2001; Mathuba, 2003). The subsequent boom in the economy led to significant progress in the development of the nation (Chernichovsky, 1985; Acemoglu *et al.,* 2002). On the United Nations' Human Development Index (which takes into account life expectancy, literacy and education), Botswana showed a 44% improvement between independence and the turn of the 21st century (MWTC, 2001). The country is governed by a democratic political system that constitutionally supports equal rights and freedom of speech (MWTC, 2001). The government retains the country's traditional values, by not only hosting the President, the Attorney General and the House of Representatives, but also the House of Chiefs, who's responsibility it is to advise on issues of culture and tradition (MWTC, 2001). The predominant cultural groups in the country are the people of Botswana (known collectively as the Batswana), various tribes include the San, also known as the "Kalahari Bushmen" as well as people of Asian and European decent (MWTC, 2001). The two official languages are English and Setswana, with English being the official language of government (MWTC, 2001).

Botswana's dedication to the conservation of nature and the country's subsequent wildlife abundance has resulted in it being a popular tourist destination in Africa (MWTC, 2001; KCS, 2009). Botswana has a vast array of threatened wildlife species with some of the world's largest populations of African elephants (*Loxodonta africana*), cheetahs (*Acinonyx jubatus*), lions (*Panthera leo*) and African wild dogs (*Lycaon pictus*) (IUCN/SSC, 2007; KCS, 2009; IUCN, 2012). In addition, Botswana is home to spectacular scenery such as the world's largest inland wetland - the Okavango Delta (MWTC, 2001; Statistics Botswana, 2013b).

Botswana's land is divided into three main land use categories: communal land (54.8%), state land (41.8%) and freehold land (3.4%)(CSO, 2008; Statistics Botswana, 2013b). The communal lands are dominated by communal subsistence farming and are separated into Tribal Land and Forest Reserves (Mathuba, 2003).

The State Land of Botswana is segmented into national parks, wildlife reserves and urban areas (Mathuba, 2003; CSO, 2004). Between the state land and communal lands of Botswana, national parks, wildlife reserves and dual purpose wildlife management areas (WMAs that support both wildlife and agriculture) constitute 39% of Botswana's landmass, and are used strictly for non-consumptive tourism (Barnes, 2001; Mathuba, 2003; CSO, 2004)(Figure 2.2). Wildlife management areas are subdivided into concessions that can be leased from the government and used for tourism or other related commercial initiatives (Mathuba, 2003; Kent, 2011).

Although not strictly protected areas, WMAs act as buffer zones between wildlife reserves and farmlands (Mathuba, 2003; Kent, 2011). These areas are available for community based natural resource management (CBNRM) schemes, which promote the non-consumptive utilization of the environment while providing economic gains for rural communities (Mathuba, 2003; Statistics Botswana, 2013b). Controlled hunting areas were established in the concessions in order to promote “traditional” hunting activities in a sustainable manner (Mathuba, 2003). However, hunting ceased on these lands in 2013 due to concerns over diminishing wildlife populations (KCS, 2009).

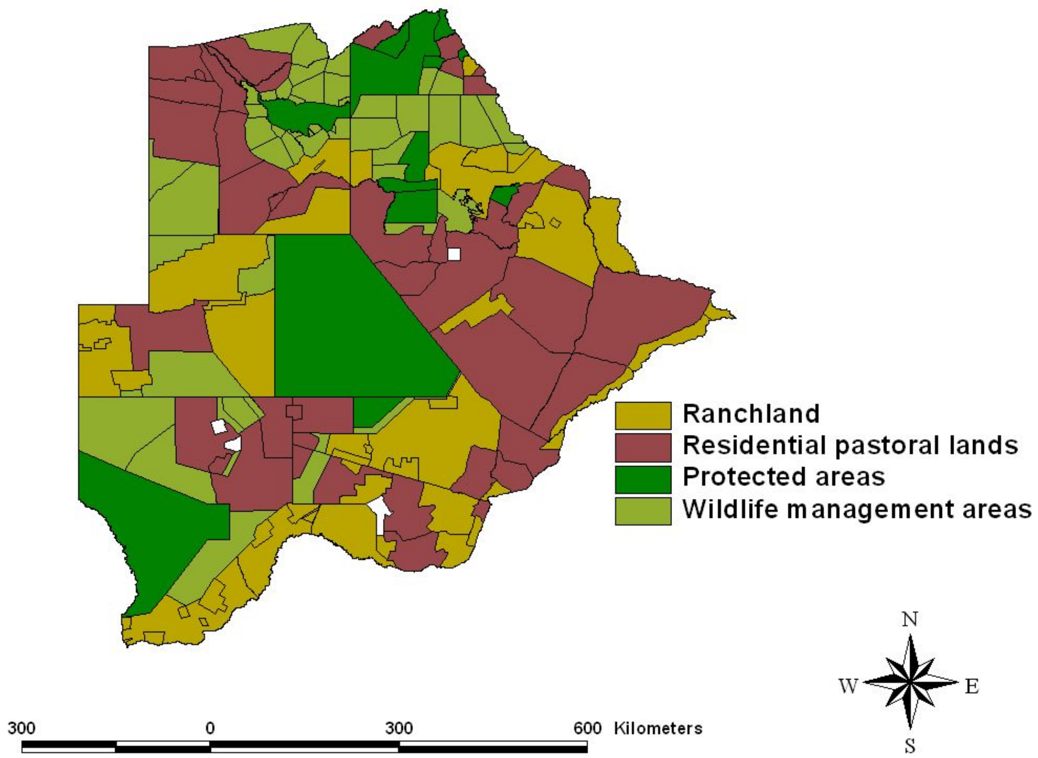

Figure 2.2 The distribution of different land uses in Botswana.

2.2 Environmental and human dynamics

Botswana is a semi-arid to arid country that is characterized by high temperatures and low, inconsistent rainfall (average annual rainfall is 425mm - MWTC, 2001; CSO, 2008; Statistics Botswana, 2013a; Statistics Botswana, 2013b)(Figure 2.3). The country has two distinct seasons, with high temperatures and high rainfall characterizing the summer months (November-January), with cooler temperatures and dramatically lower rainfall during the rest of the year (Statistics Botswana, 2013b)(Figure 2.4). Botswana's inconsistent rainfall both annually and inter-annually, and the country's reliance on natural resources makes it particularly vulnerable to environmental anomalies such as climate change and other climatic occurrences such as the southern ocean oscillation events (El Niño/La Niña, which cause droughts and flooding respectively; Klein, 2007; MWTC, 2001). During years of drought, crop production dips, livestock mortality increases, wildlife numbers plummet, food shortages abound, bush fires occur and cases of human wildlife conflict (HWC) increase due to wildlife coming into rural areas to find water and food (Statistics Botswana, 2013a; Statistics Botswana, 2013b).

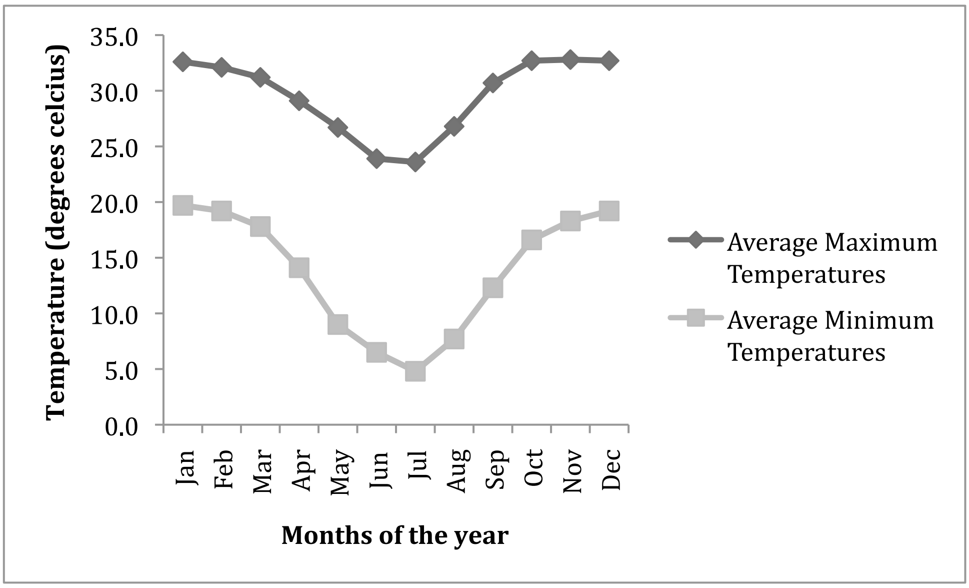

Figure 2.3: Botswana's average monthly maximum and minimum temperatures, 2002-2012. Data sourced from Botswana's Department of Meteorology.

The majority of Botswana consists of the flat sandveld of the Kalahari Desert, which hosts a variety of savannah habitat that is dominated by *Acacia* species (e.g. black thorn, *Acacia mellifera*; camel thorn, *Acacia erioloba*) and other various thorn bushes (e.g. Trumpet thorn, *Catophractes alexandri*; Buffalo thorn, *Ziziphus mucronata*; Devil thorn, *Tribulus terrestris*). The dry southwestern region has sparse vegetation, with some shrub savannah and rolling sand dunes. The saltpans in the central northeast region are mostly devoid of plant life. The further northeast in the country, the more vegetation is present, with the country progressing to open tree savannah, woodlands and deciduous forests as one moves northeast from the Kgalagadi. The

Okavango Delta in the northwest undergoes annually flooding events and is characterized by swampy vegetation such as grasses (e.g. papyrus – *Cyperus papyrus*), some tree species, (e.g. palms *Phoenix reclinata* and figs *Ficus sycomorus*) and surrounding wooden scrubland (mostly mopane – *Colophospermum mopane*) with patches of open grasslands and *Acacia* scrubland (Roodt, 1992).

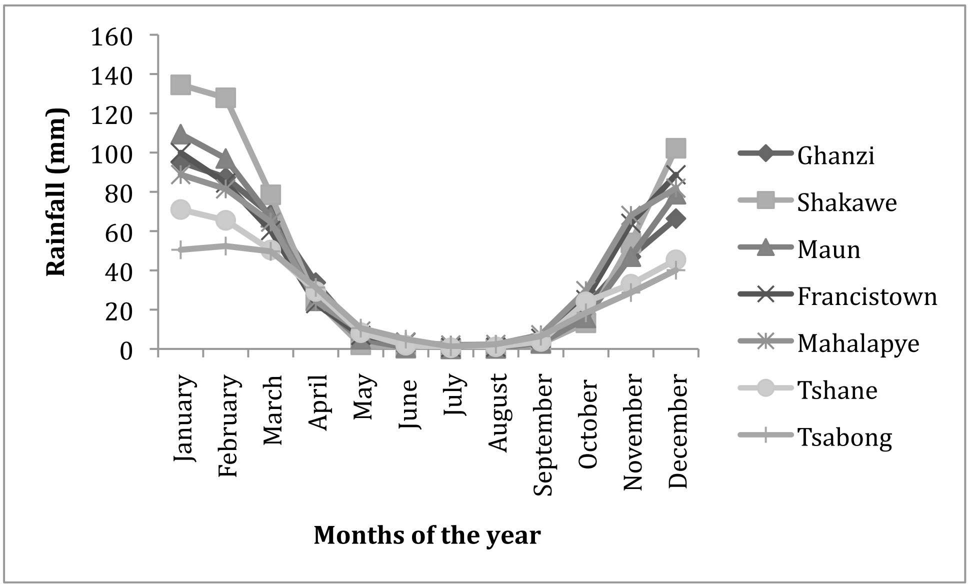

Figure 2.4: Monthly average rainfall for Botswana's towns, 1971-2000. Data sourced from Botswana's Department of Meteorology.

Botswana's economy and much of its population rely heavily on livestock farming, with meat and meat products bringing US$155.7 million into the economy in 2011 alone (CSO, 2011a; CSO, 2011b; Statistics Botswana, 2012). Official records indicate that the cattle (*Bos taurus*) population has outnumbered Botswana's human population since 1979, with the latest figures (2011) indicating populations of 2.55 and 2.02 million respectively (MWTC, 2001, Statistics Botswana, 2013a; Statistics Botswana, 2013c). Owning cattle is not only a source of income for many residents and a sign of wealth and prosperity, but the trade and slaughtering of cattle also has important cultural significance at ceremonies such as weddings and funerals (MWTC, 2001; Statistics Botswana, 2013b).

The inconsistent rainfall in Botswana is a major threat to livestock farming around the country (Reed *et al.,* 2006; Muir, 2009). Disease has also had considerable negative impacts, with several Foot and Mouth Disease outbreaks occurring over the last two decades (CSO, 2008; Statistics Botswana, 2013a). The establishment of the numerous veterinary cordon fences around the country has, however, limited these outbreaks (Klein, 2007). Overgrazing is also an ongoing problem for livestock farmers and one that threatens the integrity of the ecosystem as a whole (Statistics Botswana, 2013b). Overgrazing is particularly problematic on communal farmlands where there is no individual responsibility for the health of the land (Statistics Botswana, 2013b).

There are two distinct types of farming ventures in Botswana. Commercial farms are those that are located on the freehold lands or are part of the Tribal Grazing Land Policy farms on communal lands, and are usually fenced and utilized in a commercial facet (Statistics Botswana, 2013a). Traditional farming dominates the remaining agricultural landscape and is carried out on communal land (tribal lands or wildlife management areas), and is generally unfenced and farmed in a subsistence manner (Hemson, 2003; Statistics Botswana, 2013a). Cattle on both commercial and communal farmlands are usually managed with very little human involvement, with livestock left to wander unattended through the farmlands (Hemson, 2003; Muir, 2009). The majority of Botswana's farmers have small herds of cattle, goats (*Capra hircus*) and sheep (*Ovis aries*)) and farm them in a subsistence manner on communal farms (Statistics Botswana, 2013a).

By definition, subsistence farming yields little to no discernable profit for farmers. Figures indicate that in Botswana, keeping sheep was not a profitable enterprise on traditional holdings in 2011, with a lower average sale prices than the average costs per head of sheep for that year (Statistics Botswana, 2013a). In fact, farming on traditional land is so unprofitable that most traditional holdings rely on government remittance for economic sustainability (Statistics Botswana, 2013a).

Despite these worrying statistics, subsistence farming does still help to alleviate poverty in many areas (Statistics Botswana, 2013a) and the high number of elderly farmers (33% of all farmers in 2011 were over 65 years of age) indicates that farming is often adopted to provide supplementary income during retirement (Statistics Botswana, 2013a).

A diverse array of wildlife on farmlands causes significant levels of HWC (CSO, 2004), which leads to retaliation and pre-emptive killings of threatened species (CSO, 2004; Statistics Botswana, 2013b). The high levels of HWC in Botswana are likely due in part to the proximity of most farming communities to protected areas, which is known to increase the levels of conflict between farmers and wildlife (Gusset *et al.,* 2009; Kent, 2011). The presence of dangerous species such as elephants, hippopotamus (*Hippopotamus amphibius*), crocodiles (*Crocodylus niloticus*), lions and leopards (*Panthera pardus*) also amplifies the conflict (DWNP, 1992). Between 2008-2011, wild animals were responsible for the deaths of 39 people, not taking into account mortalities caused by snakes, scorpions or insects (Statistics Botswana, 2013b).

When depredation results in high proportionate economic loss, HWC is magnified, leading to a higher incidence of retaliation or pre-emptive killings of predators (Woodroffe *et al.,* 2005; Rust & Marker, 2013). The low economic standing of the rural population in Botswana may therefore be a contributing factor to the high levels of HWC in Botswana. Although commercial farmers are comparatively wealthier (CSO, 2008), they also experience high levels of conflict with carnivores (Selebatso *et al.,* 2008; Steyn & Funston, 2009), however, they are slightly more tolerant of predators than subsistence farmers (Selebatso *et al.,* 2008).

The Department of Wildlife and National Parks (DWNP) is primarily responsible for dealing with HWC incidences in Botswana (Hemson, 2003). Animals that threaten a person's life or livelihood (livestock or property) can be shot legally so long as it is outside of a protected reserve and does not involve illegal activities such as poisons or snares (DWNP, 1992). This allows the killing of threatened species, such as African wild dogs and lions (with the exception of cheetahs, which were protected under an addition to the legislation in 2005 – DWNP, 2005). The DWNP does, however, attempt to alleviate HWC in several non-lethal ways. Wildlife are encouraged to remain in protected areas during droughts by providing artificial water sources within the reserves, limiting wildlife numbers from converging onto farmlands in search of drinking water (Statistics Botswana, 2013b).

Botswana's DWNP pays out compensation to those farmers that can prove with physical evidence that a predator has killed their livestock (Hemson, 2003; DWNP, 2009), however, many farmers do not bother reporting losses due to the low pay outs compared to the value of stock, the slow return of payments and the restrictions of eligibility (Selebatso *et al.,* 2008). Nevertheless, large amounts of compensation are paid out to farmers each year (Statistics Botswana, 2013b).

2.3 General methodology

Previous studies on livestock guarding dogs (LSGDs) have used farmer interviews or surveys to gauge performance of the LSGDs (i.e. Andelt & Hopper 2000; Potgieter, 2011) based on the number of livestock saved from depredation (see Coppinger *et al.,* 1988; Andelt & Hopper, 2000; Potgieter, 2011) and the satisfaction of the owner (Green *et al.,* 1994; Marker *et al.,* 2005; Potgieter, 2011). Few studies have conducted cost benefit analyses of farmers owning LSGDs (Green & Woodruff, 1988; Andelt & Hopper, 2000; Smith *et al.,* 2000), or analysed the conservation benefit of having LSGDs (Potgieter, 2011).

As the respondents used for this study were LSGD owners throughout Botswana, in person interviews were impractical due to the large study area. In addition, because not all rural areas have cellular telephone coverage, it was unrealistic to use telephonic methods as the primary means of data collection. A web-based survey was also not an option in this scenario as few farmers have access to computers, or the Internet. As a result, postal surveys were chosen as the primary method of data collection. This method was also deemed appropriate, as research has suggested that postal surveys are ideal when investigating sensitive topics such as lethal predator control (Siemiatycki, 1979). Postal surveys do, however, bias against people who are illiterate (Knowledge Base, 2013). In an attempt to avoid this bias, 67 of the total 228 questionnaires were conducted via interviews during community visits associated with work of Cheetah Conservation Botswana (CCB) and an additional 40 surveys were conducted with non-respondents via the telephone. Interviews took place in rural communities where interviewers approached LSGD owners and conducted the interview by asking the questions and filling in the responses themselves, which allowed illiterate respondents to complete the questionnaire.

The survey was constructed using mostly closed-ended questions in order to obtain quantitative data, and pre-formatted scales were used to increase readability (Frohlich, 2001). Four-point scales were used to avoid neutral answers, however "Unknown" options were available for most questions to decrease the levels of non-response bias in individual questions (White *et al.,* 2005). A pilot study was conducted via a postal survey (n=33) and in person interviews (n=1) to increase readability, to improve the validity of the responses gained from the survey and to identify problems with the format (Frohlich, 2001). Some anomalies were identified, with 20 questions being rewritten or reformatted after the pilot survey was administered. Questions regarding cost-benefit analysis (Q18), farmer perceptions (Q42-45), predator presence on the farm (Q38) and training (Q13-15) were added after the pilot survey to increase the scope of the survey and three unnecessary questions were removed (see final questionnaire in Appendix A). Grounding questions (to establish ground-truthing within the questionnaire) were used throughout the survey to measure the validity of the responses (White *et al.,* 2005). Despite the literature indicating that short surveys result in higher response rates (Frohlich, 2001), the survey could be compressed to no less than five single-sided pages once completed. Translations were made from English into the two major written languages in the area (Setswana and Afrikaans) and the surveys were distributed in all three languages.

Between 2008-2011 CCB conducted an annual competition for "the best livestock guarding dog in Botswana" (CCB, 2011). From this competition, CCB produced a comprehensive network of LSGD owners from around the country. The competition had been advertised widely on Botswana's popular radio stations, allowing comprehensive exposure to farmers throughout the country. The network was, therefore, a good representation of LSGD owners in the country at that time and was likely to have a nominal distribution of respondents with little bias against literacy, socio-economic standing or location (rural vs. urban). This was not, however, a random sample of LSGD owners, and there may have been a bias towards farmers who were satisfied with their dogs, as those with ineffective LSGDs would be less likely to have entered the competition. The survey was administered to all the farmers on the network list who possessed either a valid postal address or a working telephone number.

Large sample sizes increase the data range, improve statistical power and reduce deviations in the analysis, and this can be achieved by increasing the response rates of participants (Baruch & Holton, 2008). Response rates in my study were bolstered by including stamped, return envelopes with the postal surveys and by following non-respondents with phone calls and subsequent surveys in the mail (each respondent received between 1 and 3 follow-up surveys)(Frohlich, 2001). The telephone surveys were conducted with non-respondents after each round of postal surveys in an attempt to increase response rates (Siemiatycki, 1979; Baruch & Holton, 2008). Many respondents were unavailable when called, possibly due to poor cell service in the rural areas. Additional respondents were found during community visits by CCB staff and farmers' workshops during the data collection period of 2010-2013 (see Appendix B).

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CHAPTER 3 – Factors influencing the effectiveness of livestock guarding dogs in Botswana

3.1 Introduction

3.1.1 Introduction

There are many factors which influence the effectiveness of livestock guarding dogs (LSGDs) (Coppinger *et al*., 1988; Rigg, 2001; Marker *et al*., 2005b), including the dog's physical traits, the environmental conditions of the farm and the training and monitoring the LSGD receives throughout its life (Green *et al*., 1984; Andelt, 1999; Gonzalez *et al*., 2012).

When it comes to finding the most effective LSGDs, the trait that is most often contended within the literature is the best breed to use. Despite extensive research, LSGDs of varying breeds have in the past shown no difference in how effectively they guard livestock from predation (Green & Woodruff 1988a; Andelt, 1999; Ostavel *et al.,* 2009). However, some breeds have been associated with certain behavioural characteristics that may make them more desirable (e.g. higher levels of attentiveness and trustworthiness in Akbash dogs - Andelt, 1999) than other breeds (e.g. Anatolian Shepherds and Komondor dogs are known to chase game, bite people and occasionally attack livestock - Coppinger *et al.,* 1988; Green & Woodruff, 1988a; Green & Woodruff, 1990).

Local, mixed breed "mongrel" dogs (also referred to as "street dogs" or "landrace dogs") have previously been disregarded as being effective LSGDs by some researchers due of their lack of specific breeding (Marker *et al.,* 2005a; Rust & Marker, 2013). However, in some cases, mixed breeds have been found to be effective LSGDs if trained properly and fed well (Black & Green, 1985; Ribeiro, 2004; Gonzalez *et al*., 2012).

Smaller breeds, such as local, mixed breed dogs, are better suited for hot, arid conditions than larger LSGD breeds, which were originally bred to endure colder climates (e.g. Anatolian Shepherds; Gehring *et al.,* 2010; Berry *et al.,* 2011). Having small-sized LSGDs may also minimize damage to livestock and game, as small LSGDs would be more likely to be submissive to livestock and could cause less damage to wild game species if they develop hunting behaviours (Black, 1981; Potgieter, 2011). Smaller LSGDs may, however, be more susceptible to attacks by predators and may not be suitable to guard against large or aggressive predators (Bangs *et al.,* 2005).

The most fundamental element to a LSGD's success at protecting livestock is the bond that the dog forms with the livestock which it guards (Coppinger *et al.,* 1988; Rigg, 2001; Potgieter, 2011). To maximize bonding with the herd, the literature suggests that puppies should be placed with livestock in a corral (known locally as a kraal) at a young age, and should never be separated from its herd (Rigg, 2001; Andelt, 2004; Potgieter, 2011). There are also reports that allowing the puppy to suckle from the livestock will improve this bond (Black, 1981; Rigg, 2001; Gonzalez *et al.,* 2012).

Coppinger & Coppinger (1978) originally devised the concept of three distinct behavioural traits that are crucial for a LSGD to effectively deter predation. The three traits are "protectiveness" – a dog's ability to protect the herd from losses; "attentiveness" – the dog's ability to be vigilant and stay with the herd at all times; and "trustworthiness" – essentially the absence of unwanted behaviours such as biting and killing livestock (Landry, 1999; Rigg 2001; Potgieter, 2011). Other favourable behavioural traits include a calm disposition around livestock but being wary of or aggressive towards strange animals and people (Knowlton *et al.,* 1999; Sillero-Zubiri & Stwizer, 2004; Hansen, 2005; Stannard, 2006) and being highly active during dusk and dawn and throughout the night (Stannard, 2006). Aggressiveness towards predators, but submission towards the livestock is ideal. Submissive behaviours will facilitate training and the bonding with livestock, which will, in theory, reduce behavioural problems (Lorenz & Coppinger, 1996; Baker *et al.,* 2008). LSGDs that control the movement and dispersal of the livestock and contribute to bringing them back to the corral at night will be more effective at guarding the stock than a LSGD that tries to guard livestock that has dispersed widely (Black, 1981; Nowak & Mysłajek, 2005). A LSGD is expected to develop these traits instinctively with correct handling and very little training (Andelt, 2004).

The physical environment in which a LSGD is working can significantly limit its effectiveness (Fox & Papouchis, 2005). Rough terrain, dense bush and extreme heat can hamper the mobility of a LSGD, which can jeopardize its effectiveness (Green *et al.,* 1994; Fox & Papouchis, 2005; Berry *et al.,* 2011). In areas of extreme weather and terrain, it is imperative to select healthy LSGD puppies that can withstand rough habitats, and preferably breeds that are adapted to that particularly environment.

Having a human herder working with the LSGD is also thought to increase its effectiveness as it allows for better monitoring of the dogs' behaviours and swift responses to any behavioural or health problems (Rasmussen, 1999; Landry *et al.,* 2005; Potgieter, 2011). LSGDs that are accompanied by human herders have also been found to be less likely to suffer attacks from predators (Bangs *et al.,* 2005). When a herder is working with a LSGD, however, a delicate balance must be found that allows dog-human interactions such as health checks without compromising the bond between the LSGD and its livestock (Black & Green, 1985; Coppinger *et al.,* 1985; Lorenz & Coppinger, 1996).

It is generally accepted that a puppy will grow to become an effective LSGD if it is a healthy puppy sourced from good working bloodlines, is properly trained, frequently monitored, kept healthy and works within a suitable environment (Coppinger, *et al*., 1988; Green & Woodruff, 1990; Cheetah Outreach & De Wildt, 2005). The particulars of these fundamental ideals have not been thoroughly investigated in some cases and very few have been assessed in the context of southern Africa or within the rural, subsistence pastoralist communities, such as those that dominate Botswana.

3.1.2 Specific aims of this chapter

The objectives of this chapter were to determine the effectiveness of LSGDs and to assess which factors likely contribute to the success (or lack thereof) of LSGDs in Botswana. Effectiveness was measured by creating an index based on scoring the behavioural techniques a dog used to protect its herd, the overall satisfaction of the owner, the presence/absence of any behavioural problems and the number of livestock lost on the farm to predators before and after the dog began working. This chapter also aimed to identify the most common health and disciplinary problems and the major causes of mortality in LSGDs in Botswana.

3.2 Materials and methods

3.2.1 Data collection

See chapter two for a detailed description of the data collection.

3.2.2 Data handling

Between May 2010 and May 2013, a total 228 questionnaires were collected from 201 farmers across Botswana. Six additional questionnaires were not included in the final dataset because less than 25% of questions were answered or it was clear that the respondent had a pet dog rather than a LSGD. All pilot surveys (n=34) were also removed from the dataset prior to analysis. In the event that a farmer had completed more than one questionnaire, the earlier versions were removed from the analysis (n=27). In addition, any respondent who had completed less than half of the necessary questions required to generate each index (see below) was eliminated from the analysis because their responses were not sufficient to build index ratings (n=29)(Table 3.1). Further, respondents who incorrectly answered more than half of the paired, grounding questions (see below for an explanation) were also eliminated from the analysis (n=30), as the reliability of those respondents was believed to be questionable. Once this data filtering was completed, 108 valid questionnaires remained.

Table 3.1: Number of questionnaires removed from the analysis and the reasons for their removal.

Reason for removal	Number of surveys removed
Pilot	34
Doubles	27
Failed >50% grounding questions	30
Responded to <50% of index questions	29
Total	120

The results from the questionnaires were stored in a Microsoft Excel database with one row for each survey/farmer. In order to analyse the individual attributes of the dogs (for farmers with multiple LSGDs), the database was replicated and split so that each row contained information for each LSGD. A separate spreadsheet was developed for previously owned LSGDs that had been removed from working conditions (with one row per dog), in order to analyse removal rates and causes of mortality.

Indices were created for the effectiveness of the LSGDs (effectiveness index), health care given to the dogs (health care index), the herding behaviour exhibited by the dog (herding index), the training they received as puppies (training index), the amount of farm management used on the farm (management index) and the LSGD owners' attitudes towards predator conservation (conservation index) (Marker *et al.*, 2003; Klein, 2013)(Appendix C). Index scores were calculated by allocating values of between -3 and 4 according to the answers for each of the relevant questions (relevance based on previously conducted research in the field; Marker *et al.,* 2003; Klein, 2013)(see Appendix C for a detailed list of questions which were used to build each of the indices and how scores were calculated). For example, in the effectiveness index, when the farmers were asked if they were satisfied with their dog's performance, they were awarded a value of +1 if they answered "yes" and -1 if they responded "no". The values of all of the answers in each index were summed to create an index value for each respondent (Table 3.2).

Table 3.2 The potential maximum and minimum scores for each index and the questions used to generate each index.

Index	**Relevant questions**	**Minimum score**	**Maximum score**
Effectiveness	23, 27, 28, 29, 30, 31, 32, 33, 34, 35, 40, 41	-22	28
Health care	17, 19, 21	-7	14
Farm management	2, 13, 47	-3	16
Training	14, 15, 22, 23, 25	-7	8
Conservation	42, 43, 44, 45	-6	6
Herding	27, 31, 32, 33, 34	-4	10

The presence/absence of large predators on each farm was recorded and assessed based on the questions regarding predator movements on the farm over the preceding 12 months (Q37-Q39). Predator species that were considered to be particularly problematic for LSGDs were classified as “large predators”. These species were lions, (*Panthera leo*) spotted hyenas (*Crocuta crocuta*) and African wild dogs (*Lycaon pictus*). Leopards (*Panthera pardus*), cheetahs (*Acinonyx jubatus*), brown hyenas (*Hyaena brunnea*), black-backed jackals (*Canis mesomelas*) and caracals (*Caracal caracal*)) were not included in this group, as they were considered easier for a LSGD to guard against due to their size and behavioural characteristics (Cheetah Outreach, 2011).

Respondents were asked to rank predator species based on the extent of past experienced with each predator (Q37, 38). When farmers were asked which predator species were causing the biggest problems on their farms (i.e. problem predators), scores were allocated to those species mentioned, with a score of nine for most problematic species and decreasing values given for subsequent species mentioned (Selebatso, 2006). For example, if a farmer listed his most problematic predators as lions, leopards and jackals; then lions received a score of nine, leopards eight and jackals seven. These scores were summed for each predator species to assess their potential impact on farms. The same method was used to score species when the farmers were asked to rank predators that were present on their farms but were not causing problems (i.e. non-problem animals).

A similar scoring system was established for reported livestock depredations in the past 12 months (Q39) in order to allow comparisons between the farmers’ perceptions of predators with the number of actual incidences of livestock attacks that were reported. For each attack on livestock that was reported, the predator responsible was given a score of nine. For example, if a farmer reported that a goat (*Capra hircus*) had been killed by a cheetah, and a sheep (*Ovis aries*) had been killed by black-backed jackals, then both jackals and cheetahs received a score of nine. Values were then summed for each predator species in order to assess their potential impact on the farms.

The diets given to the LSGDs were converted into a numerical score. A balance of various food items is beneficial for LSGDs (Cheetah Outreach & De Wildt, 2005; Potgieter *et al*., 2013), thus, the different foods a dog received were all given a value and those values summed to form an overall diet score for each LSGD (Potgieter *et al*., 2013). Nutritional foods such as tinned dog food, dog food pellets or meat were assigned a value of 2, and less-nutritional food products such as maize meal (pap), milk, bran and bonedust (shavings of bones) received a value of 1 (Cheetah Outreach & De Wildt, 2005). The highest possible diet score awarded was 8 and a minimum of 0 was allocated when no food items were specified.

The different breeds of LSGDs were assessed against many different factors such as the effectiveness and behavioural and health problems associated with LSGDs. The different breeds of dog were categorized in a variety of ways to enable these assessments (Table 3.3). "Crosses" were classified as those dogs which were reported as being crossed with other breeds (e.g. a Tswana cross Bulldog was classified as a "Cross"). After this, five categories of breeds remained (i.e. Anatolian Shepherd, Tswana, Greyhound, Pitbull and Crosses). Although the sample sizes for Greyhounds and Pitbulls were small (n=7 and n=3 respectively) they were included in the analyses. To eliminate any errors associated with the small sample sizes of Pitbulls and Greyhounds, all of the breeds were also grouped into different categories such as "purebreeds" (which included Anatolian Shepherds, Greyhounds and Pitbulls) and "crossbreeds" which were classified as Crossed LSGDs and Tswana LSGDs (Table 3.3). "Tswana" dogs are the local street dogs of Botswana – a medium-sized mixed breed with a short coat and pointed muzzle (Figure 3.1). Although coat colour varies, body shape and size are fairly consistent. Most mixed breed dogs from the region which fall within this size and shape are referred to as Tswana dogs.

Figure 3.1 Two examples of Botswana's local "Tswana" breed of dog. Although coat colour can vary dramatically, the general size and shape of Tswana dogs is consistent.

Table 3.3 How each breed of LSGDs in Botswana was grouped for data analysis.

<table>
<tr><th>Breed</th><th colspan="2">Group Classifications</th></tr>
<tr><td>Greyhound</td><td rowspan="3">Purebreeds</td><td rowspan="4">Non-Tswana</td></tr>
<tr><td>Pitbull</td></tr>
<tr><td>Anatolian Shepherd</td></tr>
<tr><td>Crosses</td><td rowspan="2">Crossbreeds</td></tr>
<tr><td>Tswana</td><td>Tswana</td></tr>
</table>

For the statistical analyses, categorical data obtained from the surveys for each LSGD's age and size were converted into continuous data by taking the median value for each category (i.e. where the size of the LSGD was small = 1 - 12kg = 6kg; where the age was 18 months - 3 years = 27mths). All statistical analyses were conducted using Statistica 10.0 and Statistica 12 software (Statsoft; Tulsa; OK; USA). Results were considered statistically significant when $p < 0.05$.

3.2.3 Non-response bias and ground truthing

Non-response bias is a measure to assess whether non-randomized samples of respondents are biased in comparison to a random selection of the population (Berg, 2005; White *et al.,* 2005). Respondents who do not complete an initial round of surveying are believed to be representative of the general population (Armstrong &

Overton, 1977; Lindner, 2002). Therefore, one can assess non-response bias by comparing data from early respondents (i.e. those that respond to a first wave of surveys that were sent out) to those that responded to subsequent waves of surveys (Lindner, 2002). Mann Whitney U-tests were used to compare the results of a sample of questions (Q1, 5, 10, 15, 19, 25, 30, 35, 40 and 45) between the early and late respondents in order to test for non-response bias.

Furthermore, the test-retest method of measuring reliability (known as ground-truthing) was used on 25 of the repeat surveys (White *et al.,* 2005), using a selection of questions that were unlikely to change considerably over time (e.g. farm type, how the dog was trained, etc. Q1, 2, 3, 4, 7, 8, 9, 10, 12, 13, 17, 19, 22, 23, 24, 25, 26, 30, 34, 40, 41, 47). Respondents were scored based on how similar the answers to the same questions were to each other over the two surveys (scores of 2 were allocated if the two responses were the same, -1 for slightly different answers and -2 for very different answers). The values for all the selected questions within a survey were added to given an overall score to assess how similar the two survey's responses were to each other. These scores were also analysed against the length of time between surveys using a Spearman Rank Correlation test.

The theory of test-retesting was also used to evaluate reliability within each survey, using pairs of similar questions placed throughout the survey ("grounding questions"). For example, question 2 and question 47 both asked whether the respondent owned a livestock guarding donkey (White *et al.,* 2005). When answers to paired grounding questions did not correspond within the same survey, it was noted on the dataset. Respondents whose answers did not match for more than half of the paired questions were considered unreliable and were eliminated from the analysis (Table 3.1).

3.2.4 Data analysis

a) Factors influencing the effectiveness, behaviour and health of LSGDs

Twenty-three variables were investigated in relation to the effectiveness of each dog (using the "effectiveness index" as a measure of effectiveness), including traits of the dog itself (age, sex, size, breed, whether the dog was sterilized, whether the dog had working parents), factors relating to the environment in which the dog worked (farm type, other management used on the farm, the health care provided for the dog, what livestock the dog was guarding, how many head of livestock the LSGD was guarding, how long the owners had used LSGDs, how many LSGDs the farmer owned, whether large carnivores were present on the farm, whether herders assisted the LSGDs and what diet the dog was fed) and training conditions (the presence of herders and other LSGDs during training, the age the LSGD was initially placed in the corral and what age it was when it first left the corral to go with the livestock into the veldt (grazing fields), whether it suckled from the livestock and whether it was fed inside the corral). Categorical variables such as the breed of the dog and the type of farm the dogs were used on were compared with effectiveness using Kruskal-Wallis or Mann-Whitney U-Tests, depending on the number of categories within each independent variable (Conover & Iman, 1981). When the relationship of a continuous variable such as the age or the size of the dog was compared with the effectiveness index, Spearman Rank correlations were used (Conover & Iman, 1981).

In order to gauge which factors may possibly cause the development of behavioural problems in LSGDs, I awarded values for each behavioural problem individually (chasing/injuring game, chasing/injuring livestock, and abandoning the livestock) and by calculating a total "behavioural score" by summing the three values for each behavioural problem (Table 3.4). These values were tested against a variety of the individual LSGD's characteristics and environmental factors. When analyzing behavioural problems in relation to categorical independent variables that had only two categories (such as sex, the presence of herders and whether the LSGD was sterilized), a Mann-Whitney U-Tests were used. When the independent variable had more than two categories, e.g. breed, then Kruskal-Wallis tests were used. In the event of a continuous independent variable (such as age, size, the number of livestock the LSGD protected and the Health Care Index value), Spearman Rank correlations were used to identify relationships between the variables.

Table 3.4 How scores were created to gauge the behavioural problems of each LSGD in order to conduct comparative analyses with the data.

Questions	Answers	Value awarded
Does your LSGD chase/injure game	Yes – often	-2
	Yes – rarely	-1
	No - never	1
Does your LSGD chase/injure your livestock	Yes – often	-3
	Yes – rarely	-2
	No - never	3
Does your LSGD leave the livestock	Yes – often	-2
	Yes – rarely	-1
	No - never	1

In order to gain some understanding of the factors which may have caused health problems in LSGDs, I compared the number of health problems displayed by each LSGD with a variety of factors including age, sex, breed, size and whether the dog was sterilized. When categorical independent variables were analysed in relation to the health problems score for each dog, either Mann-Whitney U-Tests (when only two categories were present in the variable e.g. sex) or Kruskal-Wallis tests (when there were more than two categories in the variable, e.g. breed) were used. In the event of a continuous independent variable (such as the age or size of the dog), Spearman Rank correlations were used to identify relationships between the variables.

Local, mixed breed dogs have been touted as being ineffective as guardians due to their tendencies towards herding behaviours (Marker *et al.,* 2005b). Thus, I analysed the relationship between effectiveness (i.e. the effectiveness index) and the herding tendencies exhibited by the dog (i.e. the herding index) using a Spearman Rank correlation. Similarly, differences among breeds were compared with the herding index scores using a Kruskal-Wallis test. I also tested the effectiveness of the LSGD (Effectiveness Index) and its disciplinary problems (disciplinary problems score) against the amount of psychological and behavioural change the LSGD incited in its owner towards predators (Conservation Index), and this was investigated using Spearman Rank correlation tests.

b) Modeling the best training protocol for effective LSGDs

The training process of a LSGD puppy has long been associated with the effectiveness of the adult dog, and can contain a multitude of factors (Black & Green, 1985; Coppinger *et al*., 1985; Rigg, 2001; Andelt, 2004). As such, a general linear model was used to identify which training factors influenced the effectiveness of a dog later in its life (Burnham & Anderson, 2002; Symonds & Moussalli, 2011). A set of variables that were likely to influence effectiveness were selected based on previous research (Symonds & Moussalli, 2011). Five predictor variables were used, two of which were categorical (presence of a herder with the dog while it was in training – Ginsberg & Macdonald, 1990; and whether the puppy suckled from the livestock – Black, 1981; Rigg, 2001; Gonzalez *et al.,* 2012) and three continuous variables (the age of the dog when it was placed in the corral – Green & Woodruff, 1988a; Landry, 1999; Rigg, 2001; Coppinger & Coppinger, 2001; when the dog went into the veldt for the first time – Cheetah Outreach & De Wildt, 2005; and the number of other LSGDs the puppy was trained with – Rigg, 2001; VerCauteren *et al*., 2012).

A multiple regression analysis was then conducted to assess which combination of these variables provided the best possible training model for a LSGD, using the Akaike Information Criterion (AIC, Burnham & Anderson, 2002; Symonds & Moussalli, 2011). A preliminary model-building analysis was conducted using Statistica. Each model contained a unique combination of variables and was awarded an AIC value based on the likelihood that the model was a true indicator of effectiveness. These raw AIC values are meaningless for comparing models, therefore delta AIC ($\triangle$ AIC) values were calculated by subtracting the smallest AIC value in the dataset from each model's AIC value. These values are comparable to each other, with the lowest $\triangle$ AIC value indicating the best model in the set (Symonds & Moussalli, 2011). Further, Akaike weights (w_i) can be used to identify the relative importance of a particular model in the set, with the higher numbers indicating how close a model is to being a true indicator of the dependent variable. Akaike weights were calculated using the following formula:

$$w_i = \exp(-\triangle \text{AIC}/2)/\text{sum of all the model values}$$

The relative importance of each individual variable was established by summing the Akaike weights of every model in which the variable of interest appeared (Symonds

& Moussalli, 2011). If the resulting value was close to 1, then that particular variable was relatively more important in predicting the dependent variable (i.e. producing an effective LSGD).

3.3 Results

3.3.1 Non-response bias

No significant difference was found between the early and late respondents, indicating an absence of a non-response bias ($Z = 0.52$, $df = 44$, $p = 0.61$). However, when respondents (those that completed surveys) were compared with non-respondents (those that were approached in person and who represented the “general population”) there was a significant difference, indicating a degree of non-response bias in my study. When further investigated, I found that non-respondents owned significantly more livestock than respondents ($Z = -2.76$, $df = 104$, $p = 0.005$) and consequently non-respondents had more livestock losses to predators before they owned a LSGD ($Z = -1.98$, $df = 87$, $p = 0.047$). Non-respondents were also significantly more likely to give positive responses when asked about lethal control measures than respondents ($Z = -2.12$, $df = 92$, $p = 0.03$). However, using interviews as a data collection tool for non-respondent data is likely to be a confounding factor in this instance (Berg, 2005).

3.3.2 Ground truthing

When individual farmers completed repeat questionnaires, they were tested for ground truthing. All but one of the 25 farmers had more than half their questions verified by repeated accuracy. Although the average time between surveys was considerable 12 ± 9 months (range: 1-29 months), there was no correlation between the time between surveys and the variation in the surveys ($r_{(24)} = -0.02$, $p = 0.92$). There were some minor differences between repeat surveys (such as a change in the number of LSGDs owned), however this may be attributed to changes on the farms during the interim between surveys. For example, four farmers had obtained extra dogs since conducting the first survey, three had lost dogs and one farmer had moved farms, making the follow up results different without compromising their accuracy.

3.3.3 Response rates

Of the 250 farmers from Cheetah Conservation Botswana (CCB)'s LSGD network list who had a viable postal address, only 48 responded to the initial pilot postal survey (19.2%). During the data collection period, 103 new LSGD owners were discovered through the work of CCB and questionnaires were administered to them in subsequent mail outs. When considering that repeat surveys were administered to most non-respondents (average 2.91 questionnaires were administered to each farmer), a total of 824 surveys were administered to a total of 353 farmers with 228 being returned, yielding a response rate of 27.5% per survey and 56.9% per farmer (Appendix B). Most (74.1%) of the participants responded to the first wave of surveys that they received. The remaining 52 farmers (25.8%) completed their surveys during the second (n=47) or third (n=5) waves of surveys.

After the removal of invalid questionnaires (see Methods), the remaining 108 farmers owned a total of 198 LSGDs with an average of 1.83 ±1.16 LSGDs per farmer (range: 1-9). The vast majority of the farmers (n=101, 93.5%) had been using LSGDs for less than 10 years. However, five farmers reported using dogs for longer than that, with three of them reporting to have used LSGDs for over two decades. The respondents were widely distributed across the country, from rural areas to urban and semi-urban areas (Figure 3.2). There was a notable absence of respondents from the tribal land in the southwest and the north-west of the country. The population density in the northwest is quite low and the majority of the landscape in that region is taken up by tourism concessions that are not used for agriculture. Work carried out by CCB indicates there is still a considerable number of farmers using LSGDs in both the south-west and north-east regions of Botswana, however few of these ended up in the final selection of questionnaires. Because these are some of the most remote areas of Botswana it is likely that an inability to access postal services and poor rural cell reception is the reason why questionnaires were not prevalent from these regions.

3.3.4 Demographics of the LSGDs

The majority of the dogs used by respondents were males (n=128, 64.6%) with females making up 33.8% (n=67)(n=3 LSGDs reported "unknown"). There were a variety of breeds, with the local Tswana breed making up the majority (n=126), followed by Crosses (n=39), Anatolian Shepherds (n=22), Greyhounds (n=7) and Pitbulls (n=3)(Figure 3.3). The ages of the dogs were not normally distributed, with 57.5% of dogs being under 3 years of age (n=114)(Figure 3.4).

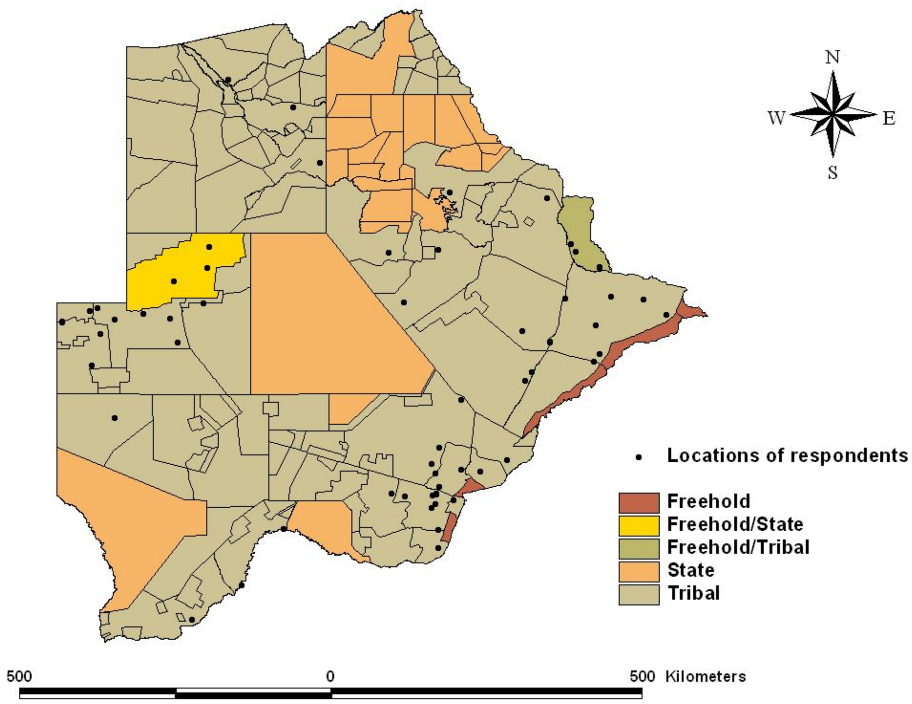

Figure 3.2: Botswana's various land uses and the spatial distribution of the respondents of this study.

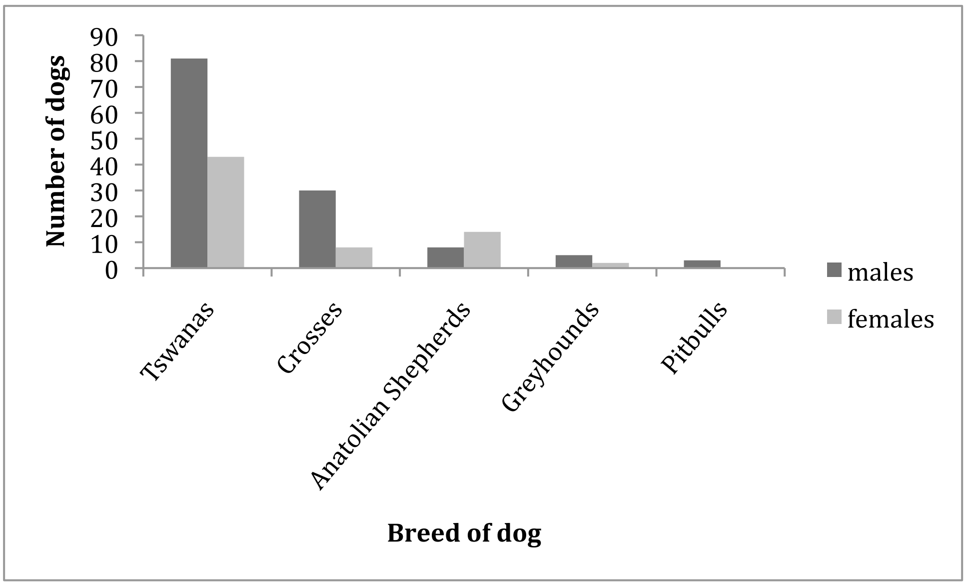

Figure 3.3: The different breeds and distribution of sexes of LSGDs used by livestock farmers in Botswana.

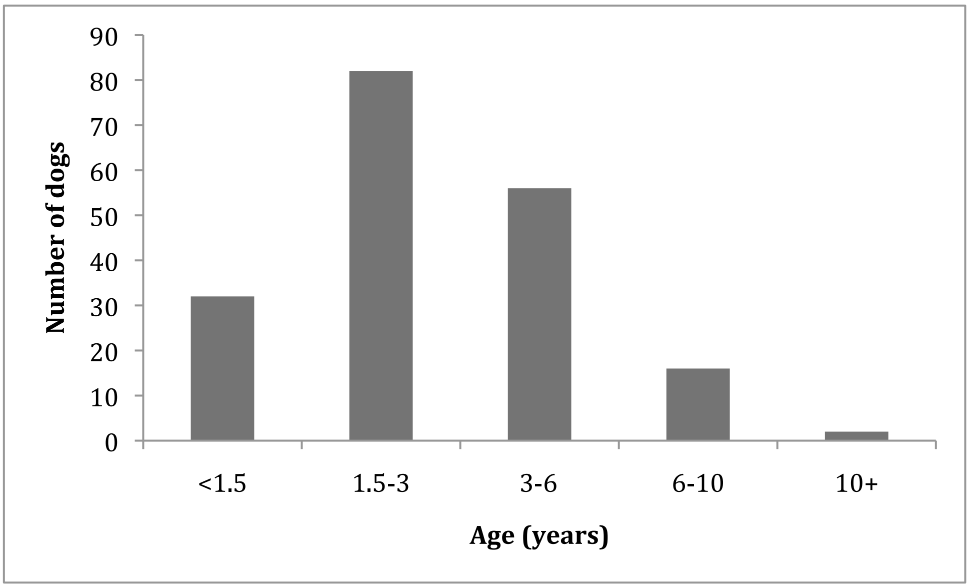

Figure 3.4: The distribution of the ages of LSGDs owned by the respondents in Botswana.

3.3.5 Livestock losses and the effectiveness of LSGDs

a) Livestock losses

Most farmers (70.4%, n=76) had experienced livestock losses to predators before they owned a LSGD. Twenty-two farmers (20.3%) did not specify the number of livestock lost on their farms both before and after obtaining a LSGD, most (n=19) stating that they were unsure about the exact number of losses they were experiencing on their farm. This left 86 farmers with usable data for the analysis of the change of livestock depredations on farms.

On average farmers were losing 14 livestock per year before they obtained a LSGD (±16, range: 0-80) and this dropped to an average of 3 livestock losses per farm, per year after obtaining a LSGD (±11, range: 0-100). The LSGDs in this study were effective at protecting livestock, with 82.5% of farmers (those who reported numbers of livestock losses; n=86) reporting a reduction in the number of livestock lost to predators since getting a LSGD (n=71) with 13.9% (n=12) of farmers keeping their losses consistent since getting a LSGD (most of these farmers (n=11) started with no losses and remained free of depredation after getting a LSGD). For those farmers that experienced decreases in depredation, the average reduction was 12.2 ±14.2 head of livestock per year (range: 2-75), which equated to an average reduction in depredation of 85.0%. For the 2.7% of farmers (n=3) who experienced an increase in the amount of livestock lost to predators since getting a LSGD, the average increase was 10.7 ±9.0 head of livestock lost to predators per year (range: 2-20; 75% increase). When all of the farmers were analysed together (those that had increases, decreases or the same depredation rates), the LSGDs in my sample were likely to cause a reduction in depredations by an average of 75.3%.

b) Effectiveness

The breed of the dog was found to have a significant influence on how effective the LSGD was at guarding its livestock, with Crosses and Greyhounds performing the best out of all the breeds ($H_{(5, 197)} = 17.12$, $p = 0.004$)(Figure 3.5). Purebreed dogs (i.e. Anatolian Shepherds, Greyhounds and Pitbulls) were found to be significantly less effective than crossbreed dogs (Tswana and Crosses)($Z = 2.19$, $df = 194$, $p = 0.02$). When compared directly with each other, Tswana dogs were significantly more effective than Anatolian Shepherds ($Z = 3.35$, $df = 141$, $p = 0.0008$). The dog breed was found, however, to have no effect on the degree to which the dog displayed herding tendencies ($H_{(4, 197)} = 2.87$, $p = 0.57$).

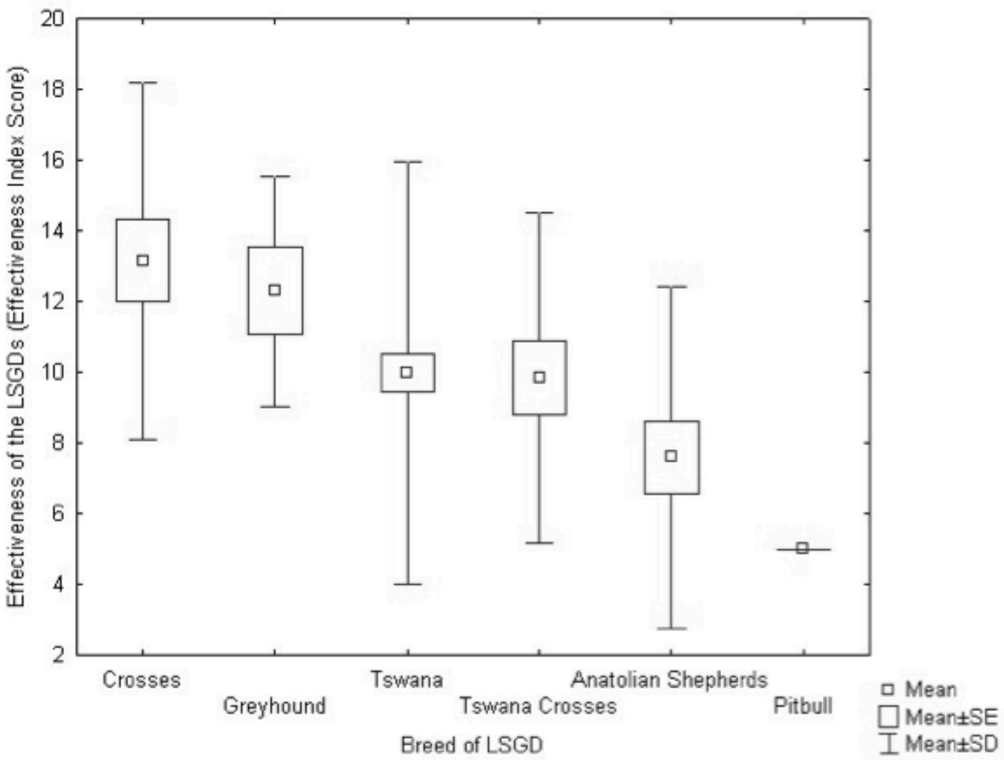

Figure 3.5 The comparative effectiveness between different breeds of LSGDs in Botswana (using the effectiveness index score as a measure of effectiveness).

Sterilized dogs were significantly more effective than LSGDs that were intact (Z = -2.9, df = 183, p = 0.003). In addition, whether the dog was sterilized or not had no influence on the number of behavioural problems it displayed (Z = -0.46, df = 179, p = 0.64). The parentage of the dog was another significant contributor to effectiveness (Z = 4.58, df = 176, p = <0.00001). However, the results strongly supported the null hypothesis that LSGDs that had non-working dog parents were more effective compared to LSGDs that had parents which were also LSGDs.

Although the ages of the LSGDs ranged from less than 18 months to over 10 years, the age of the LSGD had no influence on its effectiveness at guarding livestock ($r_{(184)} = -0.08$, $p = 0.23$). There was, however, a significant linear relationship between the LSGD's age and the dog's likelihood to chase game animals, with younger LSGDs being more likely to display this undesirable behaviour ($r_{(183)} = -0.17$, $p = 0.02$). Similarly, the LSGDs in this study were a wide range of sizes (<12kg to over 45kg; mean 17kg) and yet, size had no relationship to effectiveness ($r_{(182)} = -0.001$, $p = 0.98$). Size did influence behavioural problems, however, with smaller dogs displaying more disciplinary problems in general ($r = _{(179)} = 0.20$, $p = 0.006$) and chasing livestock in particular ($r_{(179)} = 0.20$, $p = 0.007$). The sex of the dog did not influence its effectiveness ($Z = 0.69$, $df = 193$, $p = 0.48$).

3.3.6 Environmental considerations

The majority (72.2%, n=78) of farmers' surveyed were subsistence farmers farming on communal lands, and LSGDs were found to be significantly more effective on these farms than on fenced, commercial properties ($Z = -2.24$, $df = 179$, $p = 0.02$). LSGDs that were on farms where large predators were present were more effective than dogs that did not face the threat of large carnivores ($Z = 2.28$, $df = 194$, $p = 0.02$). Farmers had a variety of livestock types that the LSGDs guarded (cattle (*Bos taurus*), goats and sheep), but the majority of farmers were using LSGDs with goats (n=87, 80.5%) or a combination of goats and sheep (n=17, 15.7%)(Figure 3.6). The effectiveness of the dog did not differ significantly based on the type of the livestock which it was guarding ($H_{(4, 198)} = 3.65$, $p = 0.45$).

The average number of livestock which each dog guarded was 55 ±105.1 (range: 5-1038) and there was a significant negative linear correlation between the number of livestock that was guarded by each dog and the LSGDs' effectiveness ($r_{(193)} = -0.22$, $p = 0.002$)(Figure 3.7). In addition, there was a positive correlation between the numbers of livestock a dog guarded and the number of disciplinary problems displayed by the LSGD ($r_{(196)} = -0.15$, $p = 0.02$). Dogs that worked alone were equally as effective as dogs that worked in groups ($Z = 1.29$, $df = 178$, $p = 0.20$), and even when guarding large herds (>100 animals/LSGD), LSGDs working with other dogs were found to be no more effectiveness than LSGDs working alone ($Z = -0.20$, $df = 56$, $p = 0.84$).

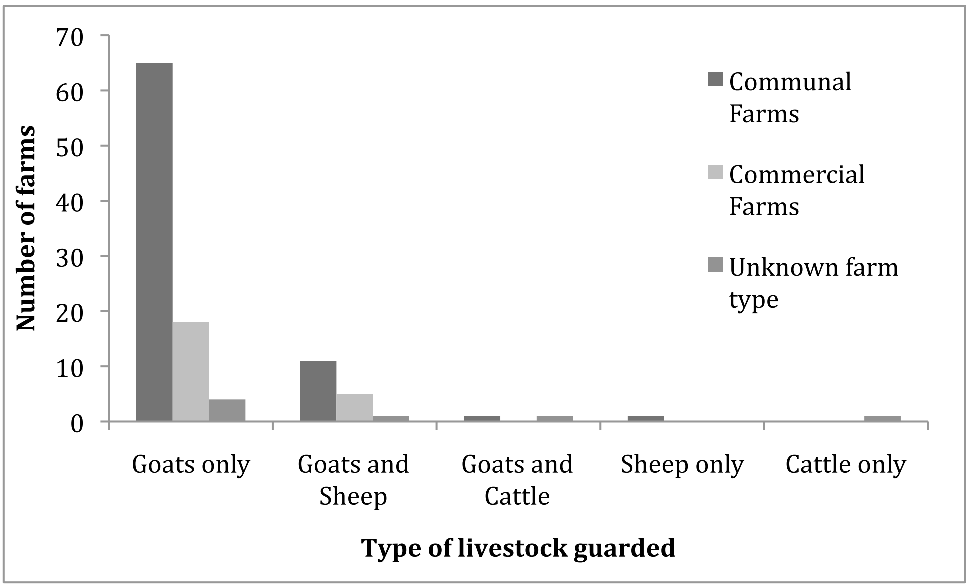

Figure 3.6 LSGDs and the type of livestock they protected on surveyed commercial and communal farms in Botswana.

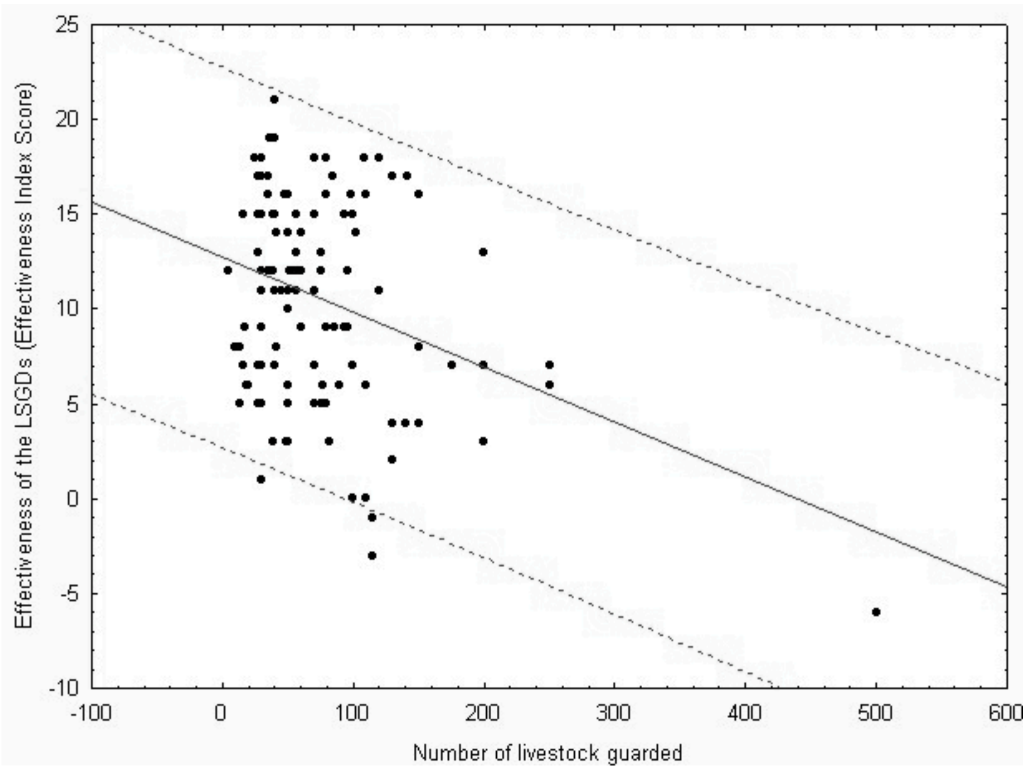

Figure 3.7 The relationship between the effectiveness of the LSGDs and the size of the herd it was guarding.

All farmers (n=108) were using husbandry techniques that are promoted by conservation and holistic farming organizations to reduce livestock losses to predators (Ogada *et al.,* 2003; Woodroffe *et al.,* 2007; Gusset *et al.,* 2009; Muir, 2009; Kent, 2011). Of the seven husbandry techniques listed, 25% (n=28) were using only LSGDs and no other techniques, and only one farmer was using them all. Nighttime corralling was the most regularly used husbandry technique (n=53 farmers, 49.1%), and daytime corralling (n=3, 2.8%) was the least popular management tool amongst the respondents (Figure 3.8). Forty farmers (37.0%) were using herders, however, this was found to decrease the effectiveness of the LSGD ($Z = 3.06$, $df = 182$, $p = 0.002$), which contradicted popular thought (Rasmussen, 1999; Landry *et al.,* 2005; Potgieter, 2011) and the proposed hypothesis.

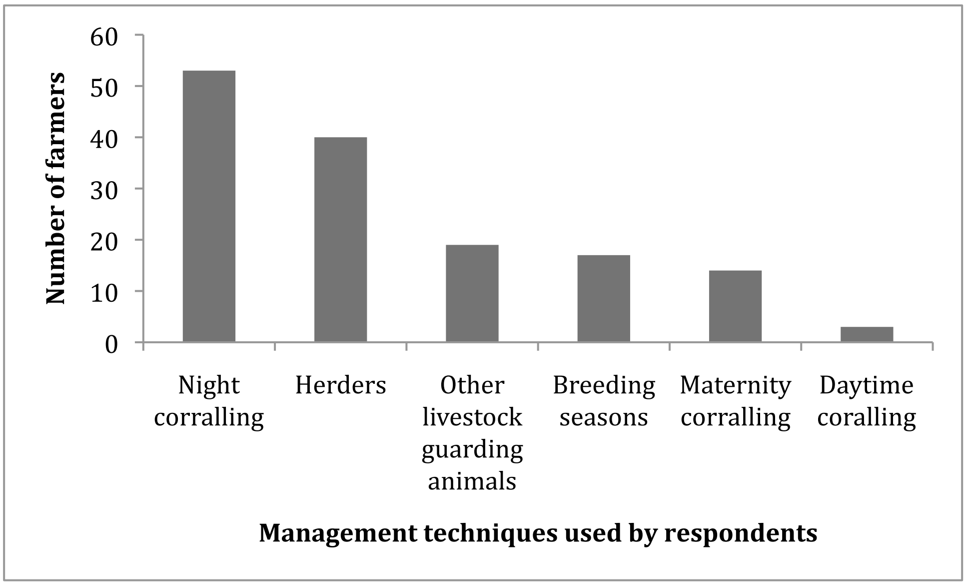

Figure 3.8: The variety of livestock husbandry techniques used by the respondents on Botswana farms to protect their animals against predation.

3.3.7 Training

Two training models stood out as being the "best" combination of predictors for training effective LSGDs (i.e. values approaching 0)(Table 3.5). Models are considered to be good when △AIC values are below 2 and reasonable if they are below 6 (Burnham & Anderson, 2002; Symonds & Moussalli, 2011).

When the impact factors for each individual variable were calculated independently (by summing the Akaike weights), two variables were identified as being the most important in the models - having herders with the LSGD while it was being trained and the number of other LSGDs that accompanied the puppy while it was being trained (Table 3.5). Further testing (using Spearman Rank Correlations and Mann Whitney U Tests) identified that the number of dogs which the LSGD was trained with had a positive correlation with its effectiveness ($r_{(185)} = 0.15$, $p = 0.048$), however, having a herder while the dog was in training showed no significant correlation ($Z = 1.39$, $p = 0.16$, $df = 186$).

Table 3.5 Results from the multiple regression analysis indicating the 24 most likely training models that best predicted an effective LSGD. The two best models are shaded in grey.

Model number	Variable 1	Variable 2	Variable 3	Variable 4	Variable 5	Variable 6	AIC	Δ AIC	w_i
1	# dogs	Herder	Suckled	1*2			819.58	0	1
2	# dogs	Age corralled	Herder	1*2			819.58	0	1
3	# dogs	Herder	1*2				819.62	0.04	0.98
4	# dogs	Age corralled	Herder	Suckled	1*2		819.88	0.3	0.86
5	Age corralled	Herder	Suckled	1*2			820.3	0.72	0.7
6	Herder	Suckled	1*2				820.37	0.79	0.67
7	Age corralled	Herder	1*2				820.42	0.84	0.66
8	Herder	1*2					821.01	1.43	0.49
9	Age corralled	Age veldt	Herder	Suckled	1*2		821.25	1.67	0.43
10	# dogs	Age corralled	Age veldt	Herder	Suckled	1*2	821.39	1.81	0.4
11	# dogs	Age corralled	Age veldt	Herder	1*2		821.44	1.86	0.39
12	# dogs	Age veldt	Herder	1*2			821.54	1.96	0.38
13	# dogs	Age veldt	Herder	Suckled	1*2		821.56	1.98	0.37
14	Age corralled	Age veldt	Herder	1*2			821.87	2.29	0.32
15	Age veldt	Herder	Suckled	1*2			822.21	2.63	0.27
16	# dogs	Herder					822.81	3.23	0.2
17	Age veldt	Herder	1*2				823	3.43	0.18
18	# dogs	Age corralled	Herder				823.75	4.17	0.12
19	# dogs	1*2					824.51	4.93	0.08
20	# dogs	Suckled	1*2				824.59	5.01	0.08
21	# dogs	Age veldt	Herder				824.75	5.17	0.08
22	# dogs	Herder	Suckled				824.8	5.22	0.07
23	# dogs						824.86	5.28	0.07
24	# dogs	Age corralled	1*2				825.53	5.95	0.05

1*2 indicates a combination of two variables - the number of other LSGDs and the presence of a herder

Table 3.6 The rating of the importance of predictor variables (impact factors) for the training of an effective LSGD in Botswana.

Variable	Impact Factor
# LSGDs trained with	0.99
Presence of a herder	0.97
Age placed in corral	0.51
Suckled from goats	0.50
Age went into veldt	0.31

It has been suggested that placing a LSGD in with the livestock at an early age can facilitate bonding with the herd and consequently minimize behavioural problems later in life (Landry, 1999; Coppinger & Coppinger, 2001; Rigg, 2001), however, the age the dogs were initially placed with the livestock did not influence the disciplinary problems score ($r_{(176)} = -0.02$, $p = 0.74$), nor the amount the dog chased/injured game ($r_{(176)} = 0.007$, $p = 0.092$), chased/injured livestock ($r_{(176)} = -0.08$, $p = 0.28$) or abandoned the livestock ($r_{(176)} = 0.10$, $p = 0.19$).

There was a significant positive correlation between the length of time that a farmer had been using LSGDs and the effectiveness of their dog ($r_{(194)} = 0.19$, $p = 0.006$), indicating that experience is an important contributor to owning a successful LSGD.

3.3.8 Problems and removals of LSGDs

a) Health problems

Of all the LSGDs in the survey, 36.4% (n=72) had experienced health problems, ranging from parasites (n=34), diseases (n=19) and physical injuries (n=19). Anatolian Shepherds were proportionately more likely than other breeds to suffer from parasites (31.8% of Anatolian Shepherds) and Greyhounds were the most likely breed to suffer from diseases (28.6% of Greyhounds) or injury (28.6% of Greyhounds). Crosses were the most likely breed to display no health ailments (69.2% of Crosses had no health problems), followed by Tswana LSGDs (64.3%)(Figure 3.9). Of the 19 cases of injuries reported, those that were caused by other animals were the most common, (73.7% of all injuries, n=14), with snakes (unspecified species)(n=6), hyenas (unspecified species)(n=3), monitor lizards

(*Varanus niloticus*)(n=2), porcupines (*Hystrix africaeaustralis*)(n=2) and other dogs (n=1) being the perpetrators. The number of accidental injury sustained by a LSGD did not correspond to whether the dog was young or old (<>18mths - $Z = 0.27$, $df = 165$, $p = 0.79$; <>36mths $Z = 0.11$, $df = 165$, $p = 0.91$), as had been previously suggested (Lorenz & Coppinger, 1996; Rigg, 2001).

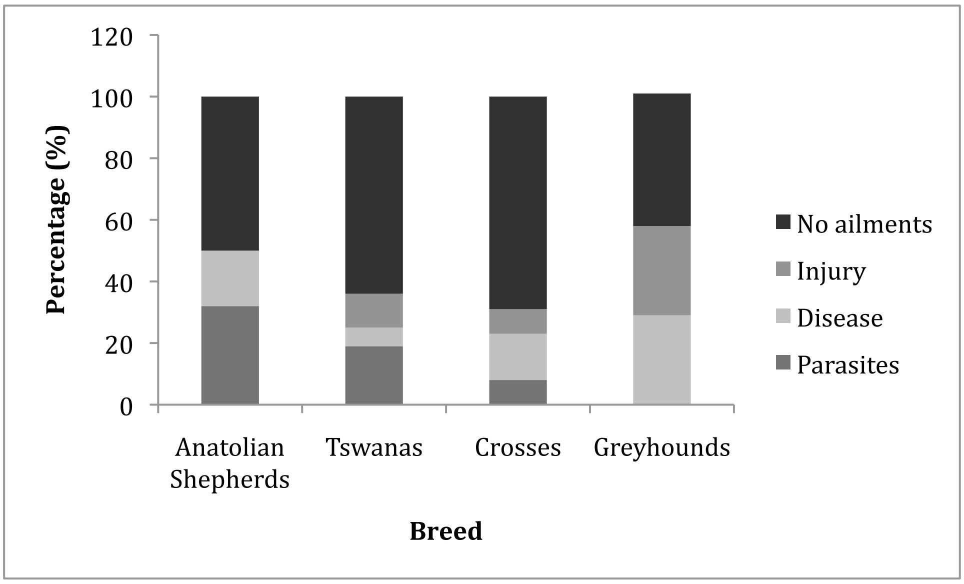

Figure 3.9 The proportion of health problems amongst the different breeds of LSGDs in Botswana. Note that Pitbulls were not included due to a small sample (n=3) all of which were owned by the same farmer.

Most farmers who reported diseases in their LSGDs were unaware of the cause (n=16, 84.2%). Distemper and eczema were the only two diseases that were specifically reported (n=2 each). The parasites that were reported to cause the most problems in LSGDs were ticks (94.1% of reported parasite problems).

The health care provided to the LSGDs (health index score) had a strong positive correlated with effectiveness ($r_{(197)} = 0.30$, $p = 0.00001$), as did the diet provided to the dog ($r_{(197)} = 0.24$, $p = 0.0006$). The health care provided to the LSGD was significantly different between breeds with Anatolian Shepherds and Crosses receiving the most health care ($H_{(4, 197)} = 18.41$, $p = 0.001$). When breeds were grouped, purebred dogs were found to receive significantly more health care than crossbreed dogs ($Z = 3.85$, $df = 195$, $p = 0.0001$)(Figure 3.10). And when tested against each other, Anatolian Shepherds received significantly better health care than

Tswana LSGDs ($Z = -4.73$, $df = 144$, $p = <0.00001$)(Figure 3.11). LSGDs that were fed on a diet made up of only maize meal (pap) were significantly less effective than LSGDs that were fed a balanced diet (a balanced diet was considered a diet that consisted of more than one of the food options listed in Q17)($Z = 4.0$, $df = 196$, $p = 0.00006$).

The health of the LSGDs (i.e. number of health problems) was not related to the age ($r_{(162)} = -0.03$, $p=0.66$) or size of the LSGD ($r_{(157)} = 0.12$, $p=0.14$), nor was there a difference in the number of health problems between the sexes ($Z = 0.21$, $df = 165$, $p = 0.83$).

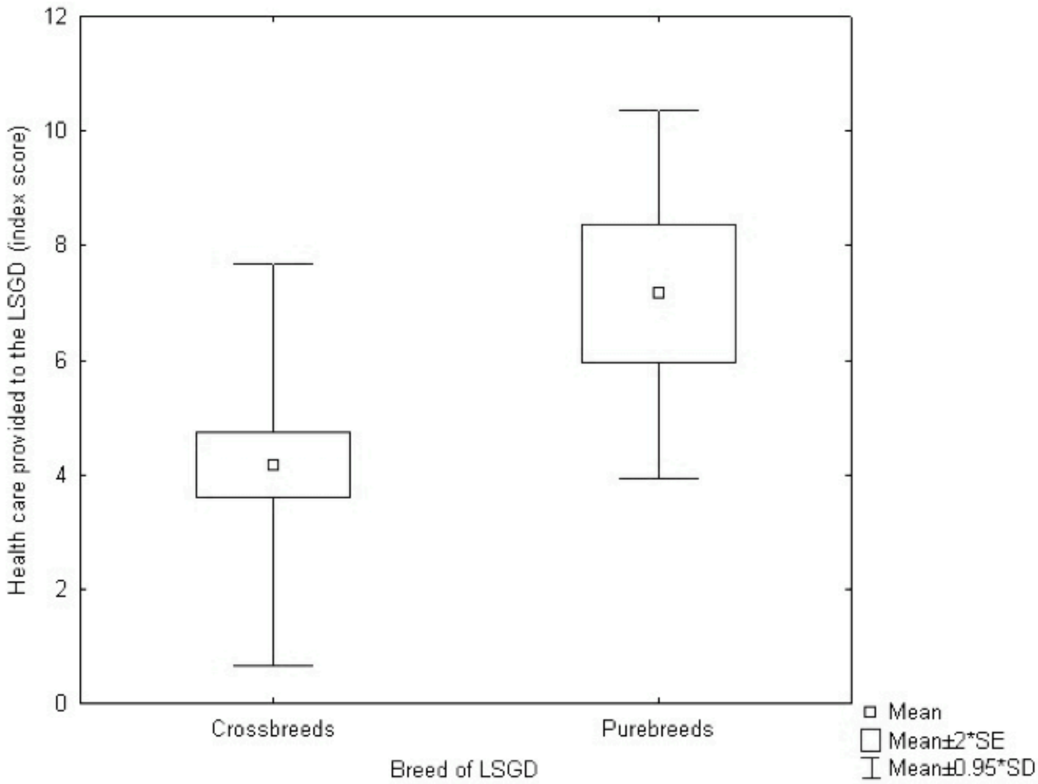

Figure 3.10 The amount of health care given to crossbreeds and purebred LSGDs in Botswana.

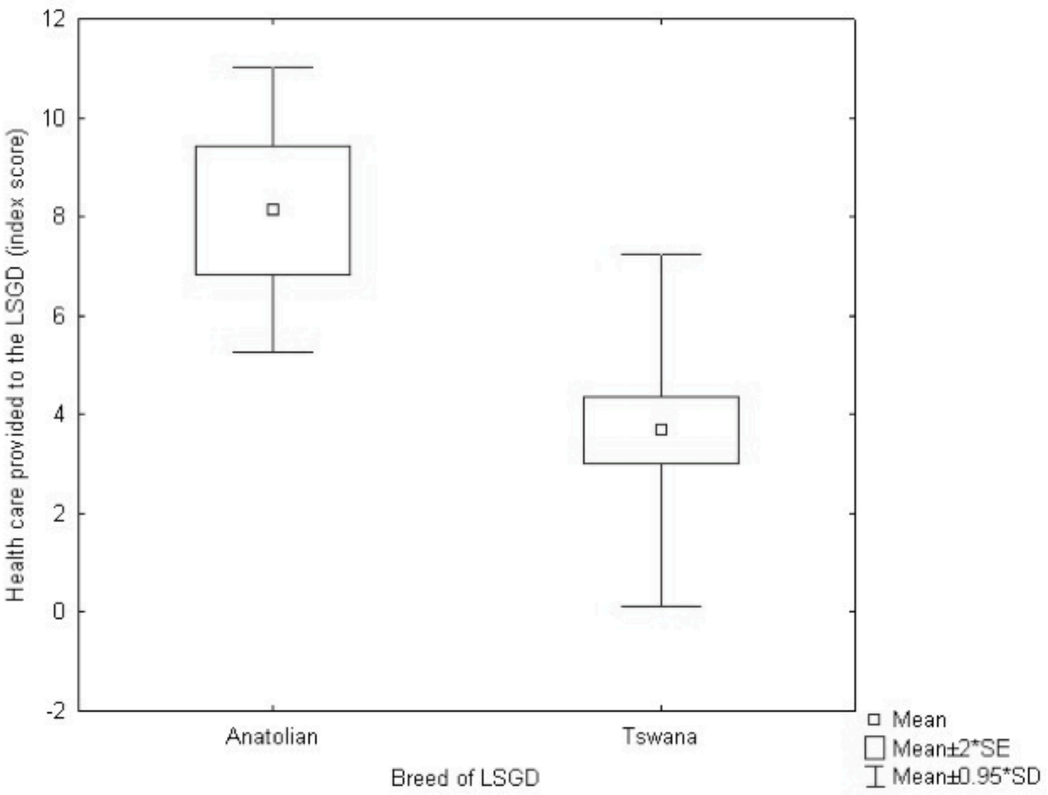

Figure 3.11 The comparison between the Health care index scores of Tswana and Anatolian Shepherd LSGDs in Botswana.

b) Disciplinary problems

Sixty-two percent of the LSGDs owned by respondents were reported to have disciplinary problems (n=123), with 30.1% of these being reported as rare occurrences (n=37)(Figure 3.12). The most commonly reported disciplinary problem was LSGDs chasing and injuring livestock (n=69, 56.1% of dogs surveyed) and LSGDs leaving the livestock (n=68, 55.3%).

The incidences of disciplinary problems were significantly different among the different dog breeds, with Anatolian Shepherds being more likely to display disciplinary problems than the other breeds ($H_{(4,\ 192)} = 19.05$, $p = 0.0008$), especially leaving the livestock ($H_{(4,\ 192)} = 17.45$, $p = 0.002$). Purebred LSGDs were also significantly more likely to chase game than their crossbreed counterparts ($Z = 1.8$, df $= 191$, $p = 0.01$).

Contrary to popular belief, LSGDs that were accompanied by herders were more likely to chase game than LSGDs that were unaccompanied ($Z = 1.85$, $df = 177$, $p = 0.007$). The sex, size, age, health care, diet, whether the dogs were sterilized or not and how many livestock each dog was guarding had no effect ($P > 0.05$ in all cases) on the number of behavioural problems displayed.

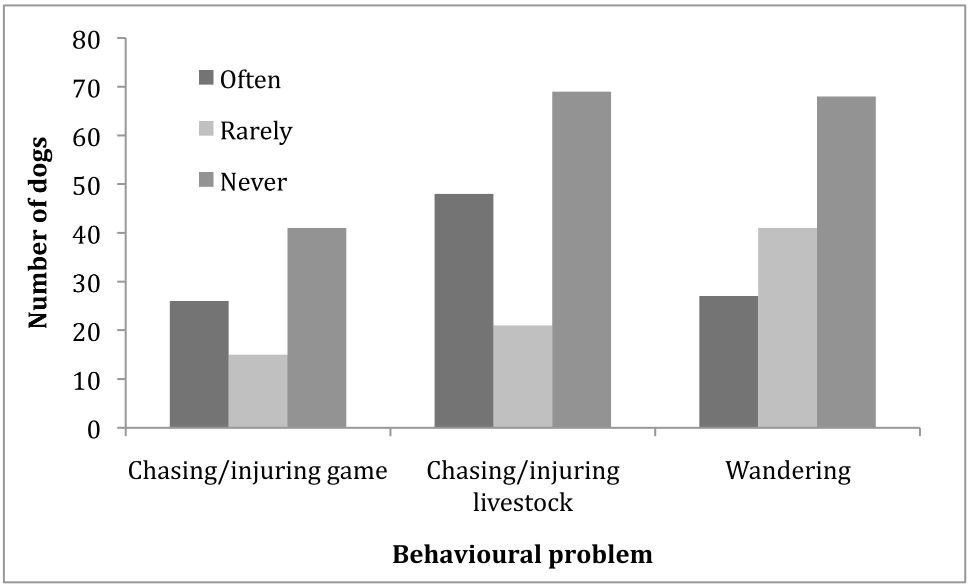

Figure 3.12 Reported cases of behavioural problems and how often they occurred in LSGDs in Botswana.

c) LSGD removals

Of the 108 farmers surveyed, 63.0% (n=68) had previously owned a LSGD that was no longer working on their farm. These 68 farmers reported the removal (deaths and non-fatal removals) of 107 dogs for a variety of reasons (Figure 3.13). Eighty-six percent of all the removals were mortalities (n=92), the most common causes being old age (n=22, 23.9% of removals), poisoning (n=13, 14.1%), snakebite (n=8, 8.7%) and disease (n=6, 6.5%). Eleven of the dogs were killed by their owners in the wake of insurmountable disciplinary problems (12.0%). Rarely were LSGD reported to have been killed by predators (n=6, 6.5% of all mortalities). Two LSGDs were killed by leopards, one dog was killed by a lion and three were killed by domestic dogs. The non-lethal removal of LSGDs was reported in only five cases, because of disciplinary problems (n=4) and disease (n=1)(Figure 3.13).

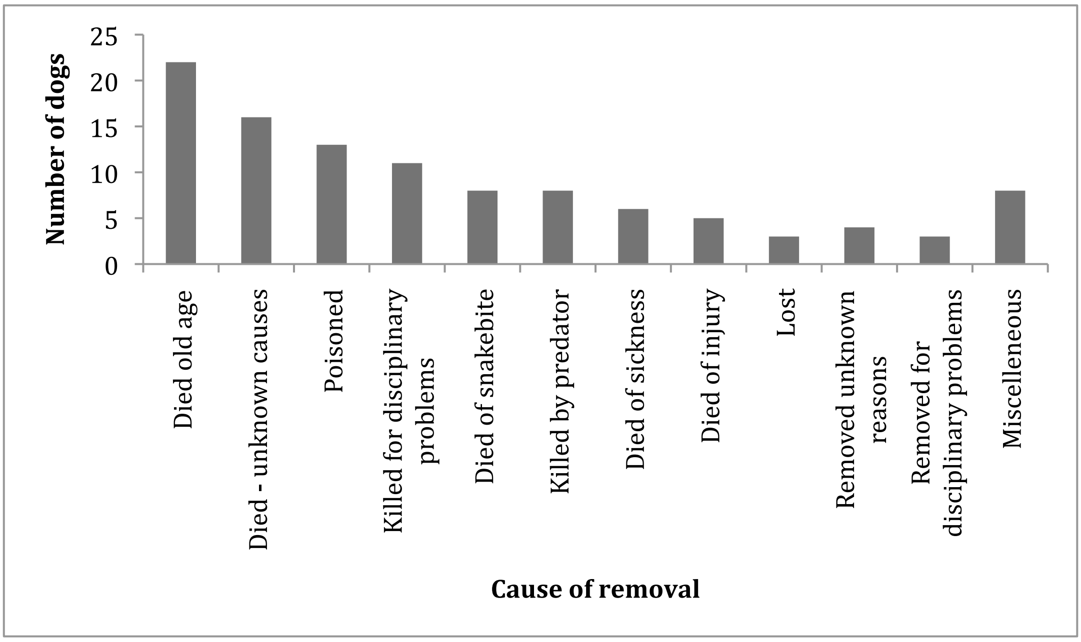

Figure 3.13 Causes of removals (both mortalities and non-lethal removals) of LSGDs previously owned by the respondents.

3.3.9 Predator problems, tolerance and lethal control

A range of predators were reported to be on the respondents' farms including lions, leopards, cheetahs, black-backed jackals, caracals, African wild dogs, and spotted and brown hyenas. Black-backed jackals were ranked as the most significant problem predator species and brown and spotted hyenas were ranked second and third, respectively (Figure 3.14). Black-backed jackals were also the most frequently implicated in attacks on livestock in the 12 months preceding the survey (n=17, 41.5%), followed by caracals (n=4), cheetahs (n=3) and hyenas (n=3). Interestingly, black-backed jackals and hyenas were also classified as the top ranked species to be present on the farms without causing problems.

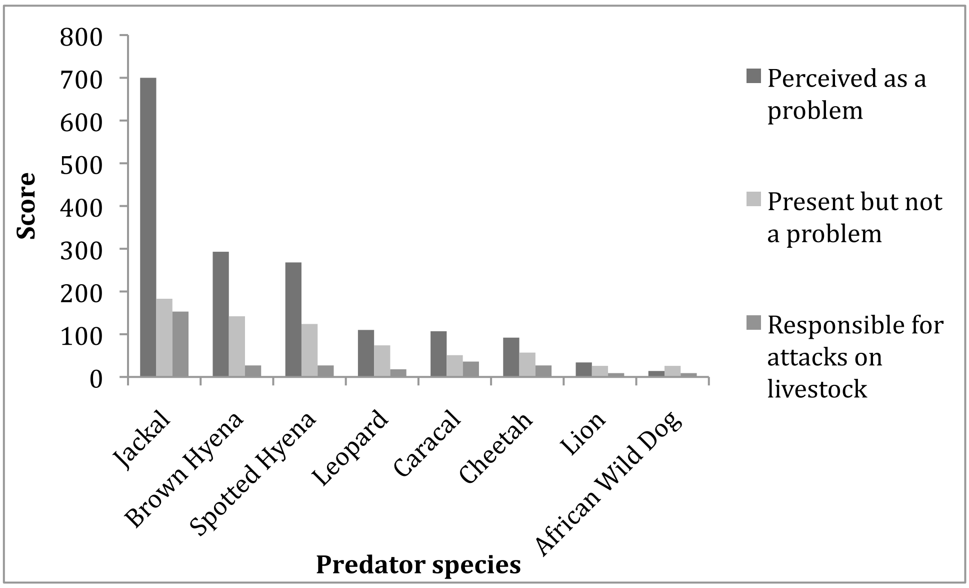

Figure 3.14 Predator species on farms and their role as problem or non-problem animals based on respondent perception and reported attacks on livestock in Botswana.

3.4 Discussion

My study has revealed several factors that contribute to the success of LSGDs. The most effective LSGDs in this study were found to be crossbreed dogs that were sterilized, those that were provided good health care including a good diet, those that came from non-working bloodlines and that were working with no human supervision (i.e. herders) on communal farmlands where large carnivores were present. Puppy training that involved other LSGDs and human supervision also improved the effectiveness of LSGDs, and the more experience a farmer had with keeping LSGDs, the more effective their LSGDs were. Despite being understudied, the local Tswana breed of dog was found to be very effective at guarding livestock, performing better in many facets compared with Anatolian Shepherds – a known LSGD breed (Rigg, 2001; Marker *et al.,* 2005b; Cheetah Outreach, 2013). LSGDs had to be effective at guarding livestock in order to elicit a positive change of behaviour in their owners towards conserving predators. Most farmers reported becoming more tolerant of predators and that they would be less likely to use lethal control on predators, now that they owned a LSGD.

It is interesting to note that despite claims that LSGDs must be large to protect livestock (e.g. Rust & Marker, 2013), my data revealed no significant relationship between the size of the dog and its effectiveness. Even in the presence of large carnivores, smaller LSGDs effectively guarded their livestock. This is particularly relevant for farms with hot climates where smaller LSGDs would be better equipped to thermoregulate effectively (Coppinger & Coppinger, 2001) or where large dogs are unavailable.

My data revealed, however, that smaller LSGDs were more likely to display disciplinary problems, in particular chasing livestock, though these results may have been confounded by young, inexperienced LSGDs being classified as "small" compared to more experienced, fully-grown, "larger" LSGDs. This theory is bolstered by the fact that younger LSGDs in my study were more likely to chase game than older dogs, and confirms reports from other studies that younger LSGDs can display behavioural problems before they reach maturity (Coppinger *et al*., 1988; Andelt, 2001; Stannard, 2006).

Although local, mixed breeds of LSGD have been found to work effectively in the USA (Black, 1981) and South America (Gonzalez *et al.,* 2012), only one other study has tested them against pure breed LSGDs (Coppinger & Coppinger, 1978), with no discernable differences found in the effectiveness between the different breeds. My results indicated that not only were the crossbreeds healthier and more effective than the purebred LSGDs, but that Botswana's local Tswana dogs were significantly more effective than Anatolian Shepherds. Interestingly, this was despite Tswana dogs receiving significantly lower health care, suggesting that they are more robust than other breeds working in the area. Furthermore, Tswana dogs did not suffer from more health problems than other breeds, despite receiving much less health care, indicating once again that their general sturdiness makes them more suitable to farmers who cannot provide high levels of care.

It must be noted that apart from Anatolian Shepherds, all of the purebred dogs that were recorded in this study were not traditional LSGD breeds. In fact, the other breeds reported in the surveys (Greyhounds and Pitbulls) are traditionally hunting and fighting dogs (Coppinger & Coppinger, 2001) and these breeds may display hereditary behaviours that may be inappropriate for guarding livestock (Berry *et al.*, 2011). The crossbreed dogs that were found to be more effective than the purebred dogs consisted mostly of Tswana dogs, with crosses between Tswana and other breeds such as Bulldogs (n=5), Rotweilers (n=1), Ridgebacks (n=1), German Shepherds (n=1) and Greyhounds (n=3). Interestingly, when these purebred dogs were crossed with Tswana dogs, the resulting LSGDs were found to be highly effective guardians despite one side of their heritage being from hunting dog breeds. It is possible that these Crosses contain appropriate balances of characteristics between the aggressive temperament and stamina of hunting dogs with the calm disposition and submissive nature of Tswana dogs.

The poor performance of Anatolian Shepherds in my study is consistent with previous studies that have found Anatolian Shepherds to be untrustworthy in Africa and the USA (Coppinger *et al.,* 1988; Green & Woodruff, 1990; Potgieter, 2011). Their ineffectiveness is possibly due, in part, to their large size hampering them in the particularly hot climate of Botswana. The fact that they were most likely to suffer from parasites could be attested to their long, thick coats facilitating attachment of parasites and also making ticks harder to locate. Their high levels of behavioural problems compared with other breeds is consistent with anecdotal evidence in the region that Anatolian Shepherds are difficult to train and are high maintenance (pers. obs.). Anatolian Shepherds have worked successfully in the cooler climate of South Africa when implemented with very regular monitoring and training provided free of charge by conservation organisations (Cheetah Outreach, 2013). Such a service is unobtainable to most farmers in Botswana due to the vast dispersion of farmlands in the country making non-government support difficult.

The accepted definition of a LSGD is a dog that remains with the herd at all times and protects them from predation by either territorial marking, or by distracting, scaring away or killing predators (Linnell *et al.,* 1996; Gehring *et al.,* 2010; Berry *et al.,* 2011). Theoretically, guarding livestock would therefore be facilitated by a LSGD with herding tendencies, whereby they can control the movement and dispersal of the livestock and also contribute to bringing the livestock back to the corrals at nights (Black, 1981; Nowak & Mysłajek, 2005). Results from my study indicate that herding behaviours were not associated either positively or negatively with the effectiveness of the LSGDs, or with certain breeds such as the local Tswana dogs, as has been previously suggested by Marker *et al.* (2005a) and Rust & Marker (2013). These results quell the argument that local dogs are ineffective guardians because they display herding tendencies.

The heritage of a LSGD has always been considered an important element in an effective LSGD (Green & Woodruff, 1990; Rigg & Gorman, 2001; Berry *et al.,* 2011). However, the data from my study suggest that dogs from working parents were not as effective as LSGDs who's parents were pets. This suggests that upbringing and training are more important in the development of a LSGD than specific breeding. This result also confirms the importance of sterilizing LSGDs. Some organisations recommend not sterilizing LSGDs so that they can be bred to produce more effective lines of LSGDs (Rigg, 2001; Rigg, 2005), with previous reports stating that this does not influence effectiveness (Green & Woodruff, 1988b; Marker *et al.,* 2005c; Gonzalez *et al.,* 2012). The fact that sterilized dogs in my study were significantly more effective than intact LSGDs, indicates that sterilization is important to facilitate livestock guarding, as well as minimizing unwanted litters and helping to reduce the spread of sexually transmitted canine diseases (Coppinger & Coppinger, 2001). Sterilization also eliminates the risk of behavioural problems when LSGDs are in heat, such as abandoning the livestock in search of mates, or when a bitch becoming ineffective while she is giving birth and caring for young puppies (Lorenz & Coppinger, 1996; Rigg, 2005; Stannard, 2006). Sterilizing LSGDs will, therefore, improve LSGD effectiveness and minimise behavioural difficulties associated with breeding, without compromising the ability to breed future generations of effective LSGDs.

There was no significant difference between the effectiveness of LSGDs working alone to those that worked in groups, even when large herds were being guarded. Van Bommel and Johnson (2012) recommend multiple dogs for herds over 100 head of livestock. However, I found that in these large herds, multiple dogs did not necessarily improve the security of the livestock. Potgieter (2011) raised the concern that groups of LSGDs may be more likely to kill wildlife, in particular solitary carnivores like cheetahs. The likelihood of game being attacked in my sample was no higher when groups of LSGDs were working together, than when solitary LSGDs were involved. However, my survey did not distinguish between herbivore and carnivore species in questions regarding the hunting of game species, and this is a topic of potential future investigation.

There are conflicting reports as to whether the effectiveness of a LSGD is different on fenced or non-fenced farms (Green & Woodruff, 1988a; Hansen & Smith, 1999; Smith *et al.,* 2000). Hansen and Smith (1999) and Green & Woodruff, (1988b) stated that LSGDs were more effective in fenced pastures, where herds were less likely to scatter and predators may be restricted by perimeter fences. My results contrast with these findings, with LSGDs in this study being more effective on communal lands, which tend to be large, unfenced areas. The fact that large predators have been eradicated from many commercial farming areas of Botswana may have influenced these results, especially considering that the presence of large predators was found to increase the effectiveness of LSGDs.

Interestingly, LSGDs were found to be significantly more effective on farms where large predators were present. Green *et al*. (1994) suggested that this would be due to the fact that farms with large predators may be more likely to lose more livestock before obtaining a dog than farms without large predators. As such, owning a dog would result in a much larger decrease in losses to predators, increasing the dog's effectiveness score. However, it was discovered in my sample, that farms with large predators present had comparable levels of losses as those without large predators before LSGDs were obtained, effectively challenging this theory. It is possible that the presence of large carnivores would force LSGDs to be more vigilant, thereby enhancing effectiveness. Nevertheless, it is encouraging to find that despite the generally small size of LSGDs in my study (average size of 17kg), LSGDs can effectively guard livestock in the presence of lions, spotted hyenas and African wild dogs.

The age at which the initial training of a LSGD should take place was founded on notions of canine behaviour and socialization processes, but has rarely been directly tested (Green & Woodruff, 1988a; Landry, 1999). My study indicates that the age at which a LSGD goes through its training is not linked to how effective the LSGD will be later in life (Rigg, 2005). For example, a LSGD that is initially placed with the livestock at 8 weeks of age can grow up to be equally as effective as a LSGD that was initially placed at 8 months of age. These results do not necessarily mean that placing puppies with livestock at 6-12 weeks of age is incorrect or will have a negative impact on the dog's development (Lorenz *et al.,* 1986; Green & Woodruff 1990; Andelt, 1999; Landry, 1999; Ostavel *et al.,* 2009; Potgieter, 2011). However, my results indicate that bonding between the LSGD and livestock is not dependent on these developmental stages in a dogs' life and can occur at any age. There are records of unsuccessful attempts to introduce adult dogs as LSGDs (Black & Green, 1985). My sample contained only four dogs that were introduced after six months of age and as such, I cannot make assumptions about adult dog introductions. The fact that age is not necessarily crucial in LSGD introductions and training indicates that there can be more flexibility in the LSGD training process than previously thought. This means that dogs of various ages can be introduced as LSGDs and this may enable more farmers to adopt the use of LSGDs.

My results indicate that the most important elements of training a LSGD are having experienced LSGDs present with the novice to guide it in its training, and having a herder present to monitor behavioural and health issues and apply swift disciplinary measures as needed (Potgieter, 2011). Training a new LSGD puppy with an already experienced LSGD has been previously identified as being beneficial by Black (1981), Lorenz & Coppinger (1996) and Mertens & Promberger (2000), and may be particularly important in areas where human supervision is minimal, such as in Botswana (Mertens & Promberger, 2000). However, it has been suggested that training more than one puppy together can lead to "pack behaviour", exacerbating behavioural problems such as hunting game and injuring livestock (Śmietana, 2005; Rigg, 2005). My results indicate that this was not the case in Botswana. The use of herders when a dog is in training may be pivotal to their development, however the ongoing use of herders was found to be detrimental to their guarding, with interactions with humans during the adult stage of the LSGDs life possibly compromising the bond that the dog has with its livestock, negatively affecting their ability to guard. It is therefore the suggestion of the author that herders should be implemented in the LSGDs' initial training phase and gradually removed as the dog matures and becomes effective as a guardian. Other techniques suggested previously to improve the effectiveness of LSGDs, such as sourcing puppies from healthy, working bloodlines (Green & Woodruff, 1990; Andelt, 1999; Rigg, 2001; Landry *et al.,* 2005; Berry *et al.,* 2011), feeding the LSGD in the corral and allowing the puppy to suckle from lactating livestock (Black, 1981; Rigg, 2001; Gonzalez *et al.,* 2012) were found to have no bearing on the effectiveness of the LSGD.

Most of the dogs in my study (62.1%) had a history of behaving badly. Forty-five percent of LSGDs were responsible for harassing game and livestock, which is comparable to the 40% recorded by Potgieter (2011) and Coppinger *et al*. (1988), but more than the 25% found in Green *et al.* (1984). Unlike many other studies in Europe and the USA, very few LSGDs in my study were reported to have attacked humans (n=1, 0.5%, compared to 2% in Potgieter, 2011 and 37% in Rigg, 2005). However, this is likely due to the low human population density of Botswana reducing the likelihood of LSGDs coming into contact with people. Similar to the other studies, most of the behavioural problems displayed by Botswana LSGDs were displayed rarely.

My data did indicate that younger LSGDs were more likely to chase game, however, this may be due to a lack of discipline before the LSGD is properly trained (Landry et al., 2005; Stannard, 2006). Unlike Potgieter (2011) my results did not indicate a surge of behavioural problems amongst older LSGDs (39-63 months).

Similar to Coppinger *et al*. (1988) and Green and Woodruff (1988a and 1990), Anatolian Shepherds were found to have significantly higher incidences of behavioural problems than other breeds in my dataset. Purebred dogs were also found to be more likely than crossbreed dogs to chase game, however this may be due to inbred aggressive traits of Greyhounds and Pitbulls. Interestingly, the presence of a herder significantly increased the likelihood that the dog would hunt game. Subsistence poaching is common in southern Africa (KCS, 2009), and it is possible that herders may either be training the LSGDs to hunt game or are simply turning a blind eye to it so that they can consume the game meat from the dogs' kills (Potgieter *et al*., 2013).

Behavioural problems can be minimised by improving training techniques, selecting appropriate breeds and providing strict monitoring of the LSGD (Lorenz *et al.,* 1986;

Landry, 1999; Rigg, 2005). For example, conditioning a LSGD puppy to harmless wildlife in the area can reduce the amount of aggression shown towards herbivorous game species (Rigg, 2001). When behavioural problems are unable to be corrected, some success has been achieved with relocating the LSGDs to new herds on other farms (Rigg, 2005; CCF, 2009; Cheetah Outreach, 2013). This should be investigated and trialed as a first response before the common practice of culling is considered. Some badly behaved LSGDs can also be re-homed as pets as an alternative to being culled (Rigg & Gorman, 2001; Landry *et al.,* 2005; Cheetah Outreach, 2013). Although the non-lethal removal of LSGDs in the wake of irreversible behavioural problems is preferable to culling, in my sample they were rare (four LSGDs that were rehomed due to behavioural problems compared to 11 LSGDs that were culled for the same reason). The availability and replaceable nature of the Tswana dogs may contribute to their disposability, leading farmers to simply cull those that are behaving badly, rather than re-homing them. This does contribute to the overall strong selection pressure undergone by Tswana dogs in Botswana, effectively contributing to an improvement in the health of these dogs while wheedling out bad behaviours in the LSGD population. The number of LSGDs culled for irreversible behavioural problems in this study is relatively low compared to those of other studies, further indicating that Botswana's LSGDs suffered fewer insurmountable behavioural problems (my study reported 4% of all dogs were culled, compared to 32% of placed dogs in Hansen, 2005; 17% in Green *et al*., 1984 (NEFC); 16% in Lorenz *et al*., 1986; 10% in Green and Woodruff, 1990; 8% in Marker *et al*., 2005c). Because the proportion of dogs in my study with behavioural problems were similar to other studies, but fewer dogs were removed because of this (killed or non-lethally removed), indicates that Botswana's LSGDs may be more responsive to discipline than other LSGDs. This may be due to the average small size of LSGDs in this study (17kg) making them easier to discipline than larger LSGDs, as theorized by Black (1981).

My study has indicated that poor health in a LSGD could compromise its effectiveness, as found in Nowak and Mysłajek (2005) and Fox and Papouchis (2005) and may be the cause of behavioural problems in LSGDs (Marker *et al.,* 2003; Potgieter, 2011). Dogs that are underfed or malnourished were found to be more likely to abandon livestock by Potgieter (2011) because they did not have the energy to stay with the herd. In contrast, my study found that neither the diet nor the amount of health problems the dog sustained significantly influenced the amount of behavioural problems, including whether the dog abandoned its herd. However, when the respondents listed a variety of solutions as to how they combated behavioural problems in their LSGDs, 11 farmers listed feeding their dog properly as the solution to their LSGDs' behavioural problems, indicating that malnourishment was the cause of these undesirable behaviours.

The fact that so many dogs were being fed a diet of maize meal (pap) alone is likely a consequence of the low-income status of farmers in Botswana. Few dogs were being provided with proper dog food, however, the results indicated that as long as the dog was getting some foodstuffs other than maize meal, the diet did not affect a LSGDs' ability to guard livestock.

There are many threats to the health and lives of LSGDs. Injuries and illnesses in LSGDs should be avoided at all costs as treatment can be costly and dogs may be unable to guard the livestock while they are recovering. Mortalities are especially problematic as having to source and re-train replacement LSGDs is time-consuming and leaves the herd unprotected while the replacement LSGD is undergoing training. The health problems that LSGDs suffered in my study (parasites, disease and injury) were similar to other programs around the world, in particular, those in southern Africa (Cheetah Outreach & De Wildt, 2005; Marker *et al*., 2005a; CCF, 2009). Only a third of LSGDs in my sample were reported to have health problems, with most of the problems being preventable with regular medical care (e.g. parasites accounted for 47.2% of health concerns and disease 26.3%). This implies that the population of LSGDs in Botswana was relatively healthy, despite the difficult climate and terrain, indicating strong LSGD genetics for the region. There were also a large number of farmers that were unsure of why their dog was ill, indicating that increased education and better access to veterinary care professionals would be highly beneficial to LSGD owners in Botswana.

Injuries obtained by the LSGDs from carnivores were fairly common (n=14), contradicting the idea that LSGDs do not commonly engage in physical confrontation with predators (Lorenz & Coppinger, 1996; Gehring *et al.,* 2010; Urbigkit & Urbigkit, 2010). However, only six dogs were reported to be killed by predators (6.5% of mortalities). This is much less than Cheetah Outreach's LSGD project in nearby South Africa where 20% of mortalities were attributed to other animals (Cheetah Outreach, 2013) and Bangs *et al*. (2005) who reported 18 cases of LSGDs killed by wolves (Bangs *et al.,* 2005). The LSGDs in my study may have been displaying protective behaviours but not in an overly aggressive manner, leading to only minor altercations with predators as opposed to lethal interactions.

Green and Woodruff (1990) suggested that roaming behaviour may be the cause of accidental injuries such as vehicle strike, being shot, being caught in traps or poisoned. However, my results indicated that there was no relationship between roaming behaviours and health problems or injuries.

The incidence of death and injury due to snakebite is not a common problem for LSGDs outside of Africa, however in southern Africa it can account for up to half of all LSGD deaths. In Cheetah Outreach's LSGD study in South Africa between 2005-2013, 21 LSGDs died of snakebite, representing 6.8% of their placed dogs and 51% of all deaths (Cheetah Outreach 2013). LSGDs in my study were much less affected by snakebite (n=8, 9% of mortalities; n=6, 8% of health problems). Anatolian Shepherds (used exclusively in the Cheetah Outreach study) may be naturally more inquisitive than the other breeds represented in my study, making them more susceptible to snakebite. However, the sample of snakebites in my study was too small to analyse this effect. In 2011, Cheetah Outreach adopted snake aversion training for their Anatolian Shepherds in a bid to minimize the numbers of their LSGDs dying from snakebite. For expensive LSGDs working in areas where venomous snakes are prevalent, aversion training may be an important element of a LSGD's upbringing and has shown some success with Cheetah Outreach's dogs (Cheetah Outreach, 2013). However, it is likely to be too expensive and inaccessible for low-income farmers and is unlikely a viable option in Botswana for this reason.

No quantifiable age range of effectiveness has been established for LSGDs, and as such, dogs of all ages were included in the analysis (<18mths - >10 years). Green *et al.* (1994) stated that young, adolescent and old dogs were less effective than those in their prime. In addition, Potgieter (2011) found that once mature, LSGDs improved in effectiveness. My study contrasts with the findings of both of these studies in that no significant relationship existed between age and the effectiveness of the LSGDs. This also reveals that LSGDs below 18 months of age in Botswana were effective at guarding against predators, which contradicts evidence from studies with purebred European LSGDs that indicate that dogs will not be effective until they are 1.5-2.5 years of age (Coppinger *et al.,* 1988; Green & Woodruff, 1990). The sample contained a notable bias towards younger LSGDs, with 57.5% of dogs aged below 3 years of age, which is similar to the 64% found by Green and Woodruff (1988a). Because the expected distribution would be that approximately 50-60% of dogs would be below 6 years of age (with the expected lifespan being 12 years – Green *et al.,* 1984; Lorenz *et al.,* 1986), the skewed proportions indicates that removals and deaths are fairly common after the age of three.

The number of farmers reporting a decrease in livestock losses since having their LSGDs equated to 83.5% of respondents (22 farmers did not respond to these questions), which is comparable to other studies conducted around the world (75% - Ribeiro & Petrucci-Fonseca, 2005; 80% found in Green *et al.,* 1984; 96% - van Bommel & Johnson, 2012). When considering the exact numbers of livestock losses to predators, the LSGDs in my study resulted in an average reduction in losses of 75.3%, which is comparable to Pfiefer & Goos (1982; 93%), and Coppinger *et al.* (1988; 64%). It can be concluded, therefore, that LSGDs in Botswana are an effective means at reducing livestock losses to predators. Considering that the majority (75.3%) of all dogs in the study were Tswana dogs (n=126 pure Tswana dogs and n=23 Tswana crossbreeds), the local Tswana breed of Botswana appears to be an effective LSGD breed, displaying significantly better guarding abilities than Anatolian Shepherds, a well known and widely-used LSGD breed.

Recommendations born out of my results include placing the emphasis on training and monitoring LSGDs rather than its bloodlines. The fact that local Tswana dogs have been found to be more effective, healthier and better behaved than purebred dogs like Anatolian Shepherds, despite poorer health care, opens up the possibility of LSGD ownership to farmers who previously were unable to source or provide the care needed for purebred LSGDs. This means that subsistence farmers, who are particularly vulnerable to conflict with wildlife (Selebatso, 2006), can be encouraged to use local breeds of dogs to reduce their livestock losses to predators. In light of potentially significant reductions of livestock depredation, these subsistence farmers may, consequently, kill fewer predators, thereby promoting carnivore conservation (see Chapter 4). Educating farmers about the most effective LSGD training techniques should improve LSGD effectiveness in the long run. Promoting proper health care and diet would also be particularly helpful in improving the effectiveness of LSGDs in Botswana. The availability preventative veterinary care would significantly improve the working lives of LSGDs in Botswana, further bolstering their effectiveness.

Identifying factors that influence the effectiveness of a LSGD enables us to provide farmers with the recipe that will produce the most successful LSGDs, leading to the highest levels of satisfaction in the farmers and consequently more positive ramifications for the conservation of predators on farmlands. Those factors that can limit behavioural problems, increase longevity, and minimise injuries, illnesses and accidents, can also contribute to making the LSGD as effective as possible. When dealing with human wildlife conflict, having mitigation methods that are effective and straightforward are absolutely necessary to instill an ideal of predator-farmer coexistence with this and future generations of livestock farmers.

3.5 References

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CHAPTER 4 – Costs and benefits associated with using livestock guarding dogs on livestock farms in Botswana

4.1 Introduction

4.1.1 Introduction

Any method of predator control must be cost effective to be desirable for livestock farmers (Woodroffe, 2004; Shivik 2006). To be economically beneficial for the owner, the costs of purchasing and maintaining a livestock guarding dog (LSGD) cannot outweigh the value of the livestock that the LSGD saves throughout its life (Leader-Williams & Hutton, 2005). The cost of purchasing a LSGD, of medical treatments, food and costs associated with training the LSGD must all be considered when assessing the financially viable of LSGDs (Landry, 1999).

In Botswana, famed LSGD breeds such as Anatolian Shepherds, Maremmas or Great Pyrenees are very difficult to source. Purebred or rare LSGD breeds like these will also incur the highest cost for purchasing (e.g. Anatolian Shepherds can be US$600 each; Marker *et al.,* 2005b) and even in the rare cases when these purebreeds are available, they are often out of the financial reach of low-income subsistence farmers who dominate the agricultural industry in Botswana (Statistics Botswana, 2013). This discourages some farmers from using LSGDs as a predator conflict mitigation tool. Other farmers will seek out atypical breeds to guard livestock, and crossbreeds such as the local, mixed breed "street dogs" (known locally as "Tswana" dogs) are most often used to guard livestock from predators in Botswana. Local dogs can be obtained easily and for a very low cost and even sometimes for free (Black 1981; Berry *et al.,* 2011; Gonzalez *et al.,* 2012).

For larger LSGDs (over 40kg), maintenance costs, especially food costs, can be prohibitive, resulting in malnourishment of the LSGDs if the owner fails to meet the dog's food requirements (Landry *et al*., 2005; Potgieter, 2011). Smaller dogs (under 25kg) require much less food (approximately 40% the amount as a large dog; Rust & Marker, 2013) and should therefore be cheaper to maintain (Cheetah Outreach & De Wildt, 2005). It has been recommended that for farmers who cannot afford the maintenance costs of large imported breeds like Anatolian Shepherds, smaller, local breeds of dogs could be used as a cheaper alternative (Potgieter, 2011; Rust & Marker 2013).

The most profound financial benefits of owning a LSGD is their ability to reduce the number of livestock killed or injured by predators. This will save farmers considerable money, especially if predators are targeting expensive stock or causing large numbers of losses. Evidence of LSGDs significantly reducing livestock losses to predators has been found in the USA (Black & Green, 1985; Andelt, 2001, 2004), Europe (Sillero-Zubiri & Stwizer, 2004; Gehring *et al.,* 2010a), Africa (Marker *et al.,* 2005b; Potgieter, 2011) and Australia (van Bommel & Johnson, 2012). Furthermore, most studies that have specifically analyzed the costs and benefits of LSGDs have found LSGDs to be economically beneficial to farmers by saving them more money in livestock saved from depredation than money spent on the LSGD (Green *et al.,* 1984; Coppinger *et al.,* 1988). However, in areas where predation on livestock is infrequent, LSGDs may not be able to save enough livestock to justify the costs of maintaining the dog (Green *et al.,* 1984). It should also be noted that the financial benefits of owning a LSGD may not become apparent until the LSGD is mature and has been guarding the stock for some time, as initial purchasing and training costs can be significantly higher than general maintenance costs (Green *et al.,* 1994; Gehring *et al.,* 2010b).

In addition to saving money on reduced livestock losses, an effective LSGD will also reduce a farmers' need to rely on other predator control methods, which saves them money and time (Andelt, 1992). LSGDs may also reduce stress in the herd, as the livestock no longer have to be as vigilant for predators. This can result in improved condition and possible improved breeding success (Rasmussen, 1999; Potgieter, 2011). Other benefits of having a LSGD include the expulsion of wildlife that may cause damage to farm infrastructure, and the exclusion of predators that may pose a threat to human life (Green *et al.,* 1984; Ostavel *et al.,* 2009).

The environmental impacts of having LSGDs are often alluded to but rarely quantified. The greatest environmental benefit of having an effective LSGD is their ability to reduce conflict between predators and livestock farmers, and in particular, reducing a farmers' tendency to use lethal means to control predators (Green & Woodruff, 1990; Marker *et al.,* 2005a). This is particularly beneficial where livestock farmers are persecuting large numbers of threatened predator species (Potgieter, 2011). Even where livestock losses are not significantly reduced, LSGDs have still been found to increase a farmer's peace of mind, a feat that is likely to improve perceptions of predators, further alleviating conflict (Green *et al.,* 1984; Ostavel *et al.,* 2009; Potgieter, 2011). An important environmental consideration when using LSGDs is the fact that hunting wildlife is a common behavioural problem associated with LSGDs (Coppinger et al., 1988; Hansen & Smith, 1999; Cheetah Outreach & De Wildt, 2005; Marker *et al*., 2005a; Rigg, 2005; Vercauteren *et al*., 2008; Potgieter, 2011). However, close monitoring and strict discipline can help to minimize these occurrences (Black, 1981; Ribeiro, 2004).

4.1.2 Specific aims of this chapter

The aims of this chapter were to 1) identify and quantify the costs associated with purchasing and maintaining a LSGD, 2) gauge the direct and indirect benefits which can be derived from having a LSGD, 3) determine the factors (e.g. LSGD characteristics, farm characteristics) that influence costs and the benefits reaped by LSGDs and 4) determine to what degree LSGDs influence the perceptions of their owners in regards to predators, in order to assess how LSGDs may contribute towards the conservation of carnivores.

4.2 Materials and methods

4.2.1 Data Collection

See chapter two for a detailed description of the data collection methods.

4.2.2 Data Handling

See chapter three for a detailed description of the data handling methods.

All monetary values for my study were converted from Botswana Pula (BWP) into US dollars (US$) at the conversion rate at the time of analysis (July 2013) of

1BWP:US$0.11 (www.exchange-rates.org). When comparing similar studies from around the world, economic figures from other studies were converted into 2013 US dollar rates by factoring in currency conversions and inflation rates.

When determining the purchase price of the LSGDs in my sample, those LSGDs that were bred by their owners were removed from the analysis, as purchase costs for these LSGDs were impossible to determine. LSGDs that were found or given to the owners were classified as having a purchase price of $0.

In Botswana's agricultural sector, most livestock is sold either as live animals (at auction or privately) or for slaughter. As such, the monetary values awarded to each livestock species - cattle (*Bos taurus)*, goats (*Capra hircus)* and sheep, (*Ovis aries*) - were calculated using Botswana's average slaughter prices for livestock (Statistics Botswana, 2013) combined with the average prices from auction sales (from Botswana's largest agricultural exhibition - the Ghanzi Agricultural Show; Vorster Auction Service, 2013). The final value awarded for each type of livestock was the average between those two prices (Table 4.1). For producers who were farming with mixed herds, the average between the values of the two types of livestock was used (e.g. the average between 1,457BWP and 1,871BWP was used for producers who had goats and sheep).

Table 4.1 Value placed on cattle, goats and sheep in Botswana based on average slaughter and live sale prices.

	Average slaughter price		Average live sale price		Average value	
	BWP	US$	BWP	US$	BWP	US$
Sheep	516**	57	2,397*	264	1,457	160
Goats and Sheep	548	60	2,779	306	1,664	183
Goats	580**	64	3,161*	348	1,871	206
Goats and Cattle	1,838	202	5,992	659	3,915	431
Cattle	3,096**	341	8,823*	971	5,960	656

Data source:
* Average sale prices from Ghanzi Agricultural Show 2013 (Vorster Auction Service, 2013)
** Average sale price from Statistics Botswana, 2013.

The financial benefits of having a LSGD were measured in a variety of ways. The “money saved” (Green *et al.,* 1984; Coppinger *et al.,* 1988; Andelt & Hopper, 2000; Rust *et al.,* 2013) was calculated by taking the number of livestock lost to predators annually since getting a LSGD from the average number of livestock lost annually to predators before having a LSGD. The relevant monetary values for the livestock species in question were then awarded to this number of livestock to establish the “money saved” value (Formula 1). This value was calculated for each farm and also for each LSGD (whereby the value of money saved for each farm was divided by the number of LSGDs on that farm – Formula 2).

Formula 1:

$$MS_f = (LL_b - LL_a) \times V$$

Where:

MS_f = Money saved per farm (per year)

LL_b = Average number of livestock lost annually before getting a LSGD

LL_a = Average number of livestock lost annually after getting a LSGD

V = Monetary value of the livestock (specific species owned by the farmer)

Formula 2:

$$MS_d = \frac{MS_f}{n_d}$$

Where:

MS_d = Money saved per LSGD (per year)

MS_f = Money saved per farm

n_d = Number of LSGDs on farm

Analyzing the gross financial profits made on each farm and by each LSGD was also used to assess the benefits of owning a LSGD. Profit was calculated per farm by subtracting the annual maintenance costs for all the LSGDs owned by the farmer from the money saved on livestock on each farm (Formula 3). Profit per LSGD was calculated by subtracting the annual costs for that LSGD from the money saved annually by that LSGD (Formula 4).

Formula 3:

$$P_f = MS_f - (C_d \times n_d)$$

Where:

P_f = Annual profit per farm

MS_f = Money saved per farm per year

C_d = Annual maintenance costs per LSGD (food, medical and other costs)

n_d = Number of LSGD owned

Formula 4:

$$P_d = MS_d - C_d$$

Where:

P_d = Annual profit per LSGD

MS_d = Money saved per LSGD

C_d = Annual maintenance cost per LSGD

4.2.3 Non-response bias and ground truthing

Non-response bias and ground-truthing analyses were carried out using the same methods described in Chapter 3, using the questions relating to the costs and benefits of owning a LSGD (Q18, 35, 36).

4.2.4 Data Analysis

In order to assess what factors influenced costs, the purchase and all maintenance costs (i.e. food, medical and other miscellaneous costs) of each LSGD were recorded and analysed in relation to a variety of variables. When categorical variables were analysed against costs (e.g. breed, age), Kruskal-Wallis and Mann Whitney U Tests were used. When continuous variables (age, size, number of health problems) were tested against costs, Spearman Rank Correlations were used. Age was used as a continuous variable as well as being broken down into categories (<>6 years of age) to analyse costs between young (<6 years old) and older LSGDs (>6 years).

The money saved and profit gained on each farm and for each LSGD was analysed in relation to several categorical variables (breed, age, sex, size, sterilization status, heritage, farm type, type of livestock guarded, presence of large carnivores on their farm, presence of a herder working with the LSGD, the LSGD receiving a pap-only diet verse a diet of varied foodstuffs, whether the LSGD was working alone or with other LSGDs and whether the livestock to LSGD ratio was more than 100 livestock per LSGD) using Kruskal-Wallis and Mann Whitney U tests. The money saved and profits for each farm and each LSGD was also tested against several continuous variables (number of LSGDs working together, health care score, training index score, management index score, herding index score, diet score, number of health problems, purchase cost of LSGD, the amount of money spent on the LSGD, including food and medical care, the number of livestock per LSGD and how long the farmer has been using LSGDs) using Spearman Rank Correlations.

4.3 Results

4.3.1 Non-response bias

No significant differences were found in the results between early and late respondents, with the exception of questions regarding medical costs. Initial respondents were found to have reported significantly higher medical costs than non-respondents ($Z = 2.25$, $df = 91$, $p = 0.02$). Similarly, early respondents were also found to report higher medical costs than those who responded in later rounds of the questionnaire ($Z = 3.16$, $df = 39$, $p = 0.002$).

4.3.2 Ground truthing

When individual farmers completed more than one questionnaire, the repeat results were tested for ground truthing. All but one of the 25 farmers had more than half their questions verified by repeated accuracy. Although the average time between questionnaires was considerable (mean: 12 ± 9 months, range: 1-29 months), there was no correlation between the time between questionnaires and the variation in the answers given ($r_{(24)} = -0.02$, $p = 0.92$). There were some minor differences between repeat questionnaires (such as a change in the number of LSGDs owned), however this may be attributed to changes on the farms between the questionnaires. For example, four farmers had obtained extra LSGDs since conducting the first questionnaire, three had lost LSGDs and one farmer had moved farms, making the follow up results different but without compromising their reliability. Although questions regarding the costs of LSGDs were not in the initial questionnaires and therefore could not be specifically tested in this case, the high level of consistency between the repeat questionnaires for non-cost-related questions indicates that the answers from these questionnaires were reliable.

4.3.3 Costs of having a LSGD

a) Obtaining a LSGD

The fact that many LSGDs in my study were given to the owners (n=75, 37.9%), bred by the owners themselves (n=70, 35.3%) or found (n=4), and that only 48 LSGDs (24.2%) were purchased, made the average purchase cost very low (mean: US$26.85 ±53.28; range: 0-220)(Figure 4.1). Purchase costs were significantly related to the breed of the LSGD ($H_{(4, 114)} = 17.57$, $p = 0.002$). Tswana LSGDs had the lowest average purchase price of all the breeds at US$13.65 (±36.46, range: 0-165), followed by greyhounds (mean: US$13.75 ±27.50, range: 0-55)(Figure 4.2). Anatolian Shepherds (mean: US$78.55 ±99.70, range: 0-220) and Crosses (mean: US$51.00 ±67.75, range: 0-187) were the most expensive of the breeds to buy. The purchase price of the LSGD did not, however, significantly influence the effectiveness of the LSGD later in life ($r_{(113)} = 0.06$, $p = 0.50$).

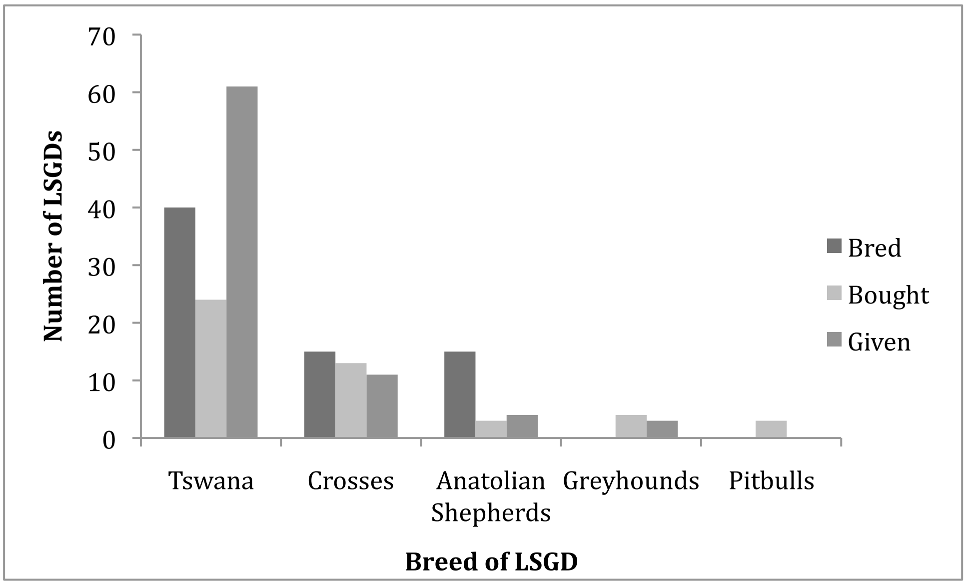

Figure 4.1 The various breeds of LSGDs and how they were obtained for use on livestock farms in Botswana.

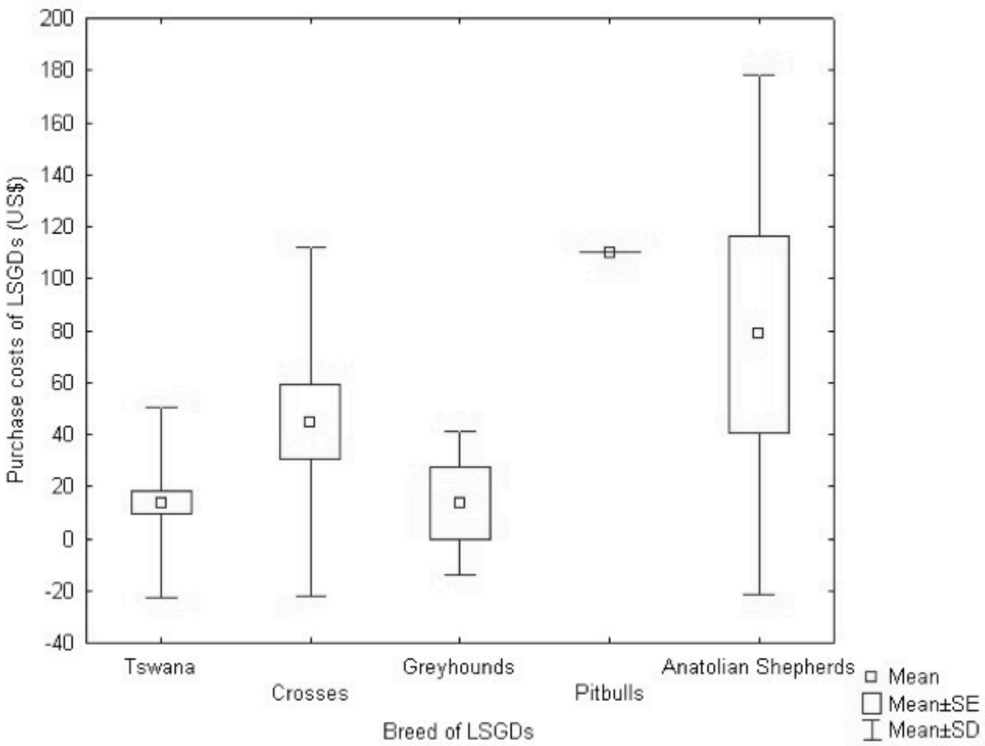

Figure 4.2 The purchasing cost of LSGDs of varying breeds working on farms in Botswana.

b) Food costs

Food costs made up the highest proportion of the total maintenance costs for LSGD owners, with an average of US$126/LSGD/year, (±190.82, range: 0-1,100) making up 73.0% of the total annual cost of having a LSGD (Figure 4.3). Crosses were found to be the most expensive breed to feed ($H_{(3, 163)} = 10.34$, $p = 0.02$)(Figure 4.4) with their average food costs of US$255 (±352.01, range: 6-1100) being double that of the overall average. Over half of LSGDs (60.9%) were fed for less than US$100 per year (n=103). This figure is very low and is likely due to the fact that many farmers fed their LSGDs inexpensive food such as human's leftovers and maize meal (Figure 4.5).

LSGDs under six years of age cost significantly more to feed than older LSGDs ($Z = -3.27$, $df = 157$, $p = 0.001$)(Figure 4.6). Interestingly, food costs were not significantly correlated with the size of the LSGD ($r_{(154)} = -0.12$, $p = 0.13$), and did not impact upon the effectiveness of the LSGD ($r_{(165)} = -0.04$, $p = 0.63$).

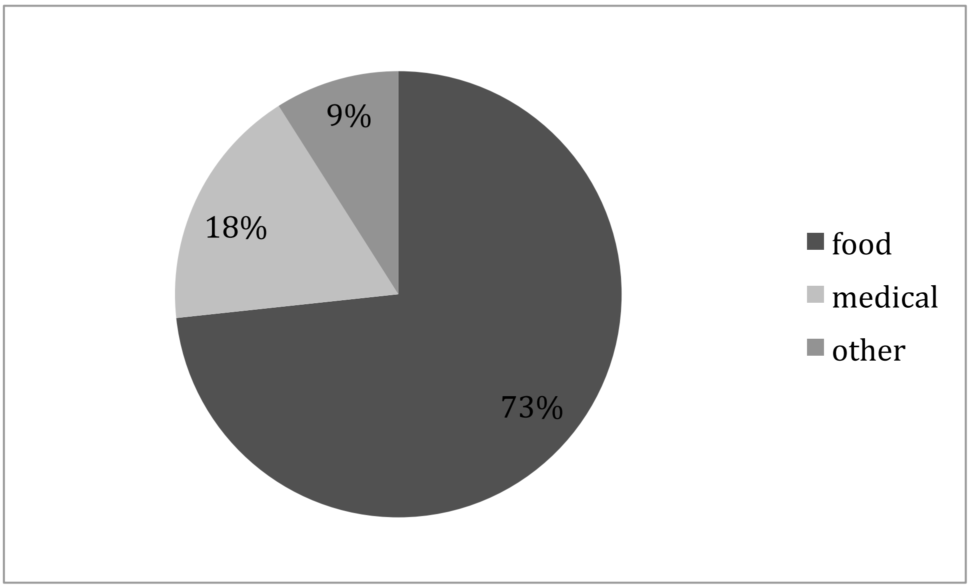

Figure 4.3 The proportions that food, medical and miscellaneous costs made up of the annual maintenance costs of LSGDs in Botswana.

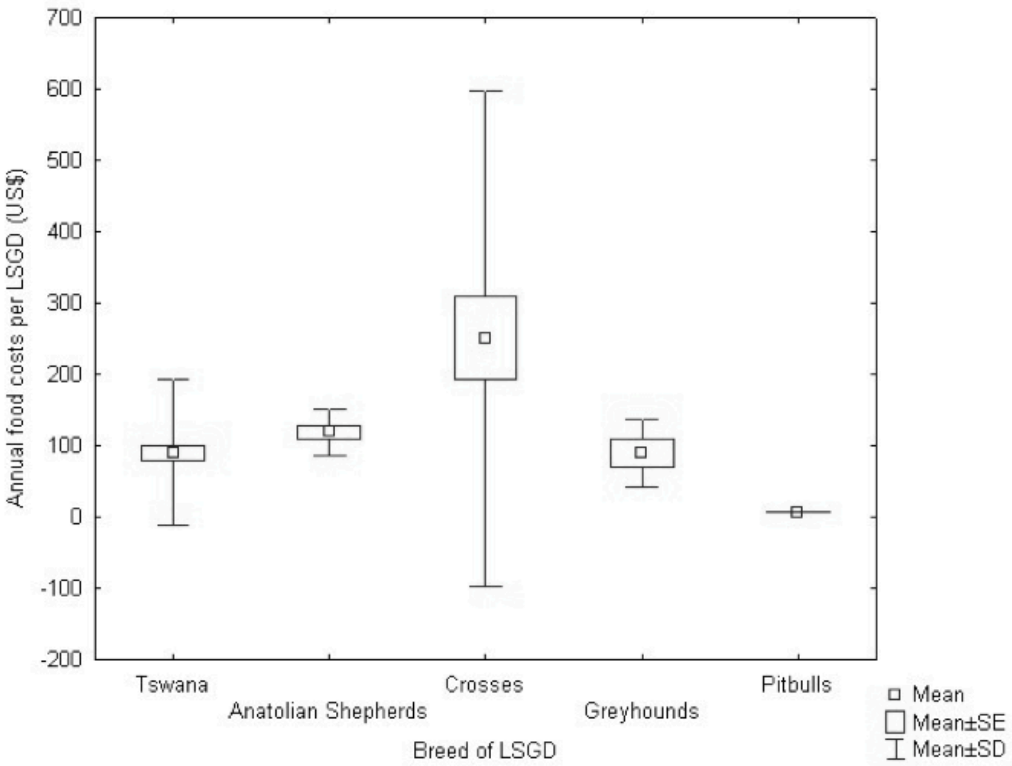

Figure 4.4 The differences between the annual food costs for different breeds of LSGDs used on farms in Botswana.

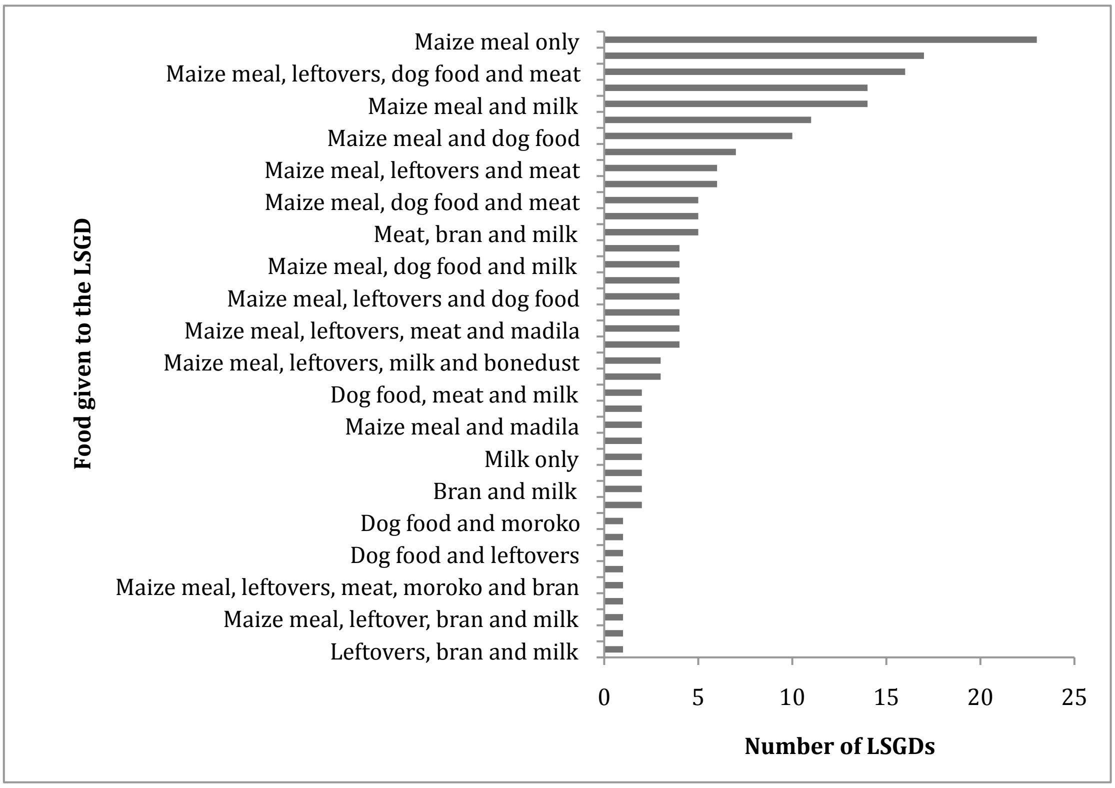

Figure 4.5 The various food combinations that were given to LSGDs in Botswana.

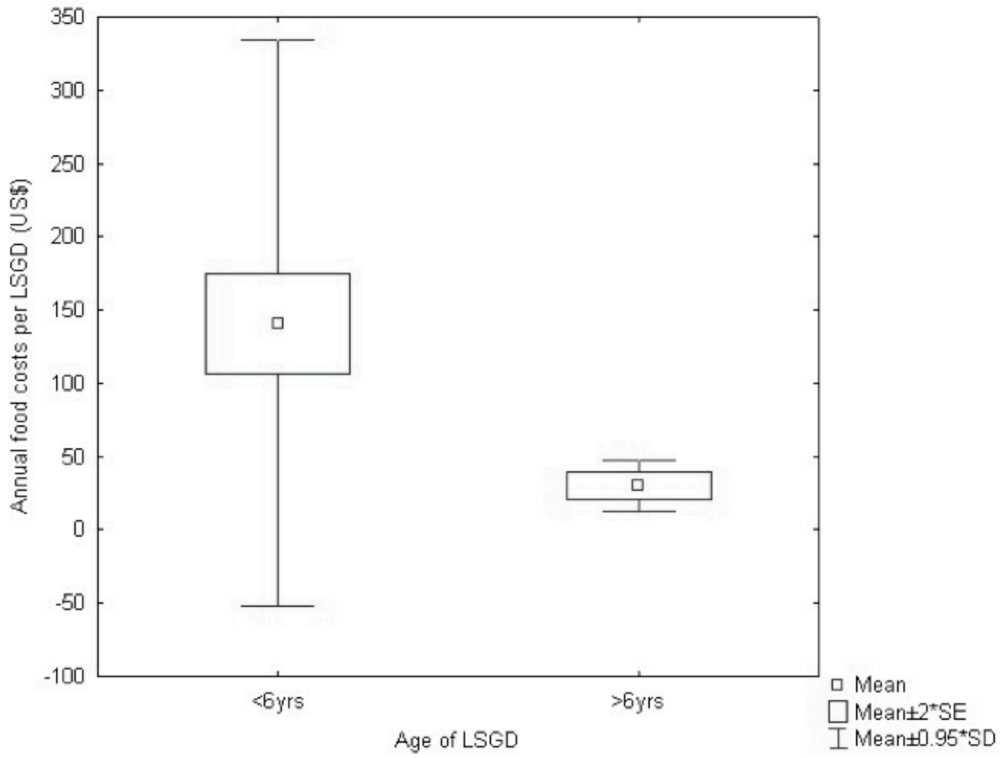

Figure 4.6 Annual food costs for young (<6 years) and old (>6 years) LSGDs in Botswana.

c) Medical costs

Medical costs comprised an average 18% of a farmers' annual maintenance costs for their LSGDs (mean: US$30 ±79.87, range: 0-660), however it is interesting to note that 46% of all LSGDs had no money spent on them for medical reasons. There were significant differences in the amount of money spent on medical care for the different breeds. Greyhounds and Tswana LSGDs had higher medical costs than Crosses, Pitbulls and Anatolian Shepherds ($H_{(3, 165)} = 9.81$, $p = 0.02$)(Figure 4.7). No significant relationship was found between the age of the LSGD and the medical costs incurred ($r_{(162)} = 0.02$, $p = 0.84$), nor between the medical costs spent and the overall effectiveness of the LSGD ($r_{(168)} = 0.06$, $p = 0.47$).

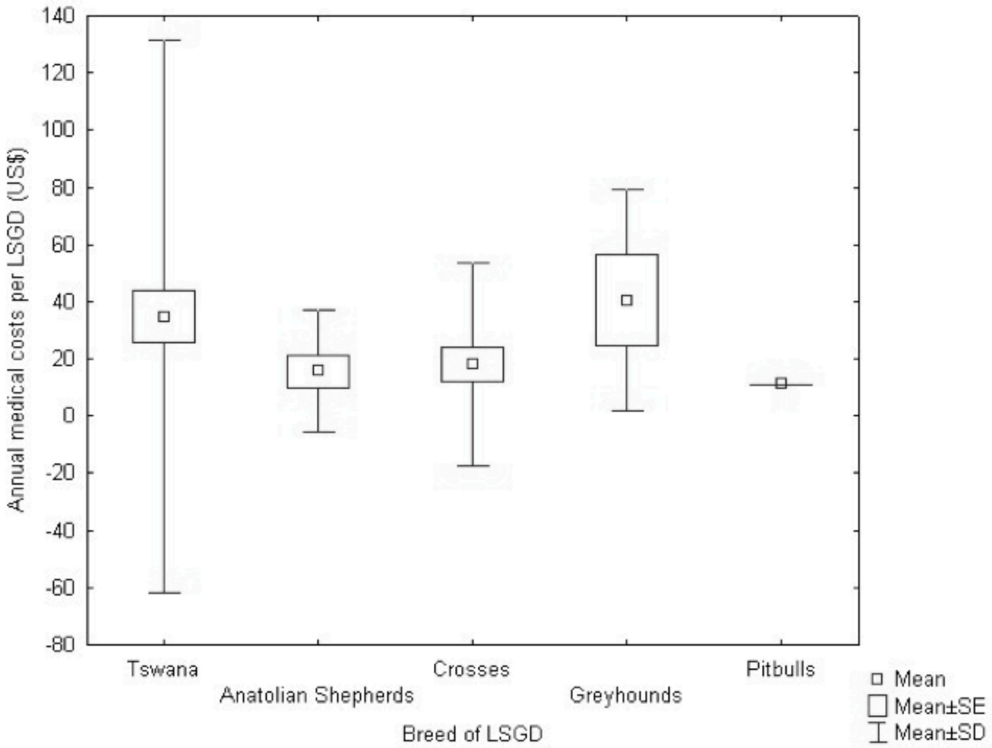

Figure 4.7 Average annual medical expenses for different breeds of LSGDs in Botswana.

d) Miscellaneous costs

Seventeen LSGDs incurred additional miscellaneous costs, at an average cost of US$15 (±95.48, range: 0-1128) per LSGD. The sources of these costs ranged from equipment associated with keeping their LSGD (n=2), to costs incurred due to the LSGD killing (n=1) and injuring livestock (n=5). Nine farmers noted that they had incurred additional costs, but did not specify what the sources of these costs were.

e) Total costs

When food, medical and miscellaneous costs were combined, the average annual maintenance cost of a LSGD was US$169 per LSGD (±249.19, range: 0-1320)(Table 4.2). Total maintenance costs for Crosses were significantly higher than the other breeds ($H_{(3, 165)} = 8.83$, $p = 0.03$), with their annual costs being, on average, 73% (US$123) more expensive than the average for all the breeds combined. Tswana LSGDs had the lowest annual maintenance costs with an average of US$138 per LSGD (±188.95, range: 0-1293). There were significant differences among annual maintenance costs of LSGDs of different ages ($H_{(4, 161)} = 10.85$, $p = 0.03$), with the costs increasing from a LSGD's infancy until middle age, then decreasing dramatically after the LSGD was 6 years old (Figure 4.8).

Table 4.2 The average purchase costs and annual maintenance (food, medical and miscellaneous) costs of using a LSGD in Botswana in US dollars (US$).

Breed		Purchase	Food	Medical	Other	Total maintenance costs
All breeds	Range	0-220	0-1100	0-660	0-1128	0-1320
	Average	26.85	125.93	30.41	15.44	168.57
	SD	53.28	190.82	79.87	95.48	249.19
Anatolian Shepherds	Range	0-220	50-165	0-55	0	50-220
	Average	78.55	122.3	22.6	0	144.9
	SD	99.7	30.79	24.73	0	50.64
Crosses	Range	0-187	6-1100	0-193	0-165	6-1350
	Average	51	254.85	18.55	18.85	292.3
	SD	67.75	352.01	35.96	53.26	414.95
Greyhound	Range	0-55	39-165	0-83	0-55	55-248
	Average	13.75	88.92	40.33	20.17	149.42
	SD	27.5	48	38.37	27.32	101.62
Pitbull	Range	110*	7.26*	11*	0*	18.25*
	Average	110	7.26	11	0	18.25
	SD	0	0	0	0	0
Tswana	Range	0-165	0-550	0-660	0-1128	0-1293
	Average	13.65	90.1	35.46	16.75	138
	SD	36.46	101.7	97.14	116.32	188.95

* The data contained only three Pitbull LSGDs which were owned by the same farmer – hence the monetary values associated with these three LSGDs were exactly the same and therefore a range does not exist.

Considering that the maximum lifespan of a working LSGD is between 10-12 years (Lorenz *et al.,* 1986), the average expected maintenance cost for a LSGD throughout its life (if it lives to old age) equated to between US$1,680 - 2,016. The different in maintenance costs between the breeds would become particularly pronounced if a LSGD was to live to 12 years of age, especially when the purchasing price was also taken into account. For example, Crosses would incur a maintenance cost of US$3,559 over 12 years, compared to Tswana LSGDs which would cost US$1,670 over 12 years (Figure 4.9).

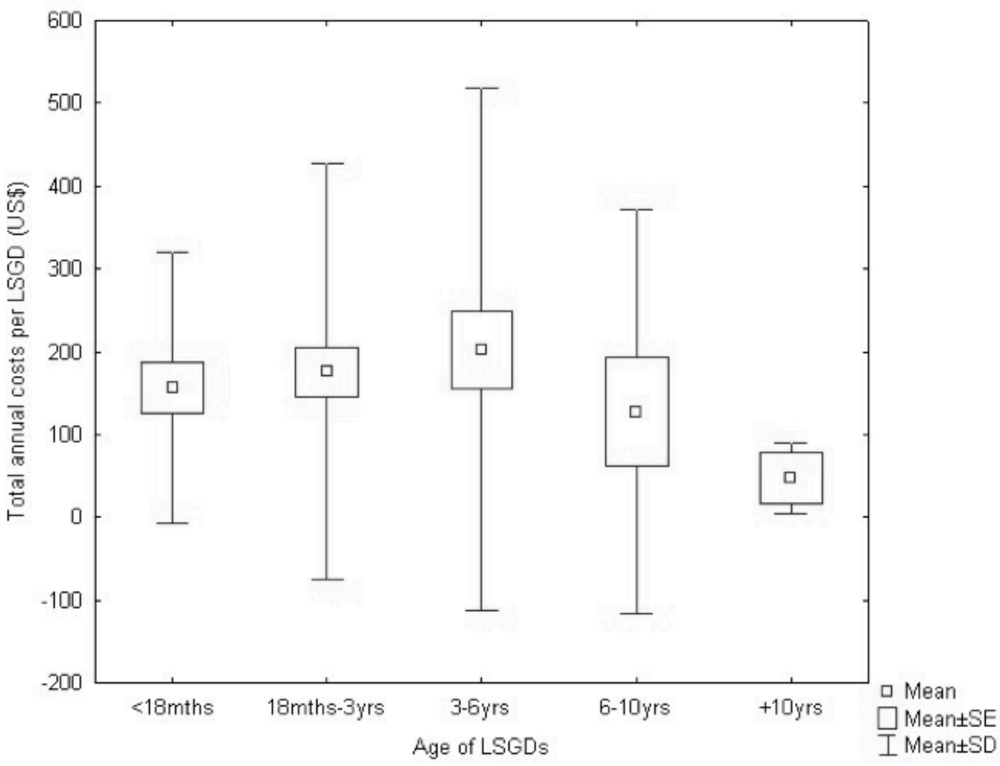

Figure 4.8 The total annual maintenance costs of a LSGD in Botswana in relation to its age.

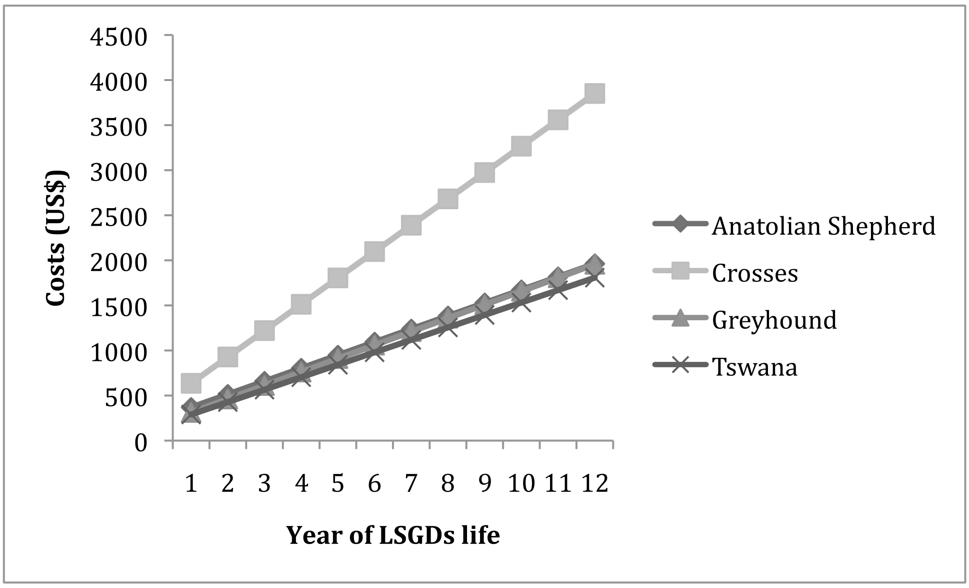

Figure 4.9 Cumulative costs for four different LSGD breeds over a maximum expected lifespan of 12 years (Lorenz *et al.,* 1986). Note that the average purchase price for each breed was included in the first years' total.

4.3.4 Benefits of owning a LSGD

a) Money saved on preventing livestock losses

Of the 108 farmers surveyed, 86 (79.6%) responded to questions regarding livestock losses before and after obtaining a LSGD. Eleven of these farmers (10.1%) did not lose livestock to predators before or after their LSGD began working and as such were awarded a "money saved" value of US$0. Of the remaining 75 farmers, 71 farmers reported reductions in depredation (94.6%), three farmers saw increases in depredation (4.0%) and one farmer had the same number of losses both before and after getting a LSGD (1.3%).

When these figures were broken down from the farm level and analysed per LSGD, a similar trend was observed. Of the 166 LSGDs that were owned by the 86 farmers who completed the livestock losses questions, 82.5% (n=137) of all LSGDs had saved their owners money by preventing livestock depredations and 12.0% broke even (n=20). Only 5.4% of LSGDs (n=9) lost money for their owners due to increases in livestock depredations on those farms.

The average cost of depredation on each farm annually before the presence of LSGDs was US$2,765 (±3,416, range: $0-16,480). The average amount of money saved annually on each farm after the implementation of LSGDs was US$2,017 (±2,879, range: -4,116–15,436) with an average annual saving of US$970 per LSGD (±1,625, range: -2,058–15,436). That is a potential saving of US$24,204 per farm over the course of 12 years and can be equated to US$11,640 saved by the average LSGD over its lifetime (if it lives for 12 years – Lorenz *et al.,* 1986).

The breed of LSGD had a significant effect on how much money it saved for its owner. Greyhounds and Crosses saved their owners more money than Tswana and Anatolian Shepherd LSGDs ($H_{(3, 165)} = 9.24$, $p = 0.03$)(Figure 4.10).

LSGDs that were accompanied by herders were found to save significantly less money than those that worked without human support ($Z = 2.83$, $df = 149$, $p = 0.005$). Diet was also a factor that contributed to a LSGD's ability to save money for its owner. LSGDs, which were fed a diet of only maize meal, saved their owner significantly less money than LSGDs that were fed a diet containing various foodstuffs ($Z = 0.42$, $df = 164$, $p = <0.001$).

The number of livestock that a LSGD guarded did not have a linear correlation with the amount of money saved ($r_{(164)} = -0.13$, $p = 0.11$). However, LSGDs that were guarding less than 100 head of livestock per LSGD saved significantly more money than LSGDs that were guarding larger herds ($Z = 2.71$, $df = 160$, $p = 0.007$)(Figure 4.11).

The LSGD's heritage also contributed to how much money it saved its owner, however, the results supported the null hypothesis that dogs without LSGD parentage saved more money than LSGDs that came from LSGD breeding stock ($Z = 1.96$, $df = 150$, $p = 0.049$).

The amount of herding behaviours displayed by the LSGD also showed relevance, as the more pronounced the herding behaviours (higher herding index score), the greater the amount of money saved by the LSGD ($r_{(165)} = 0.17$, $p = 0.03$).

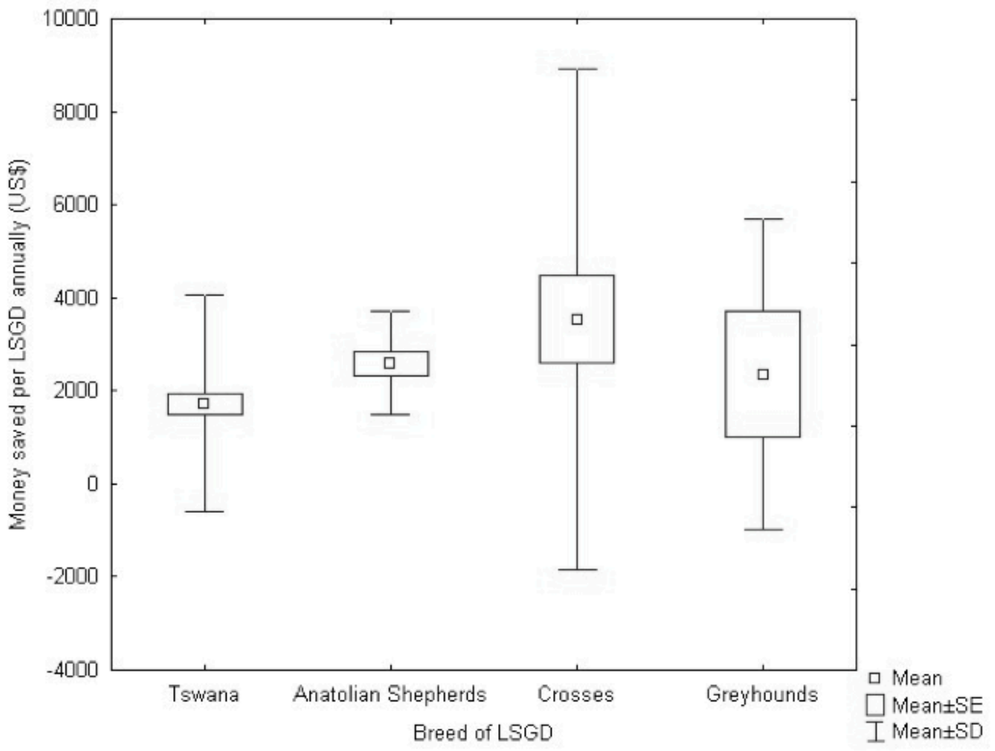

Figure 4.10 The differences in the amounts of money saved in depredation by the different breeds of LSGDs working on farms in Botswana.

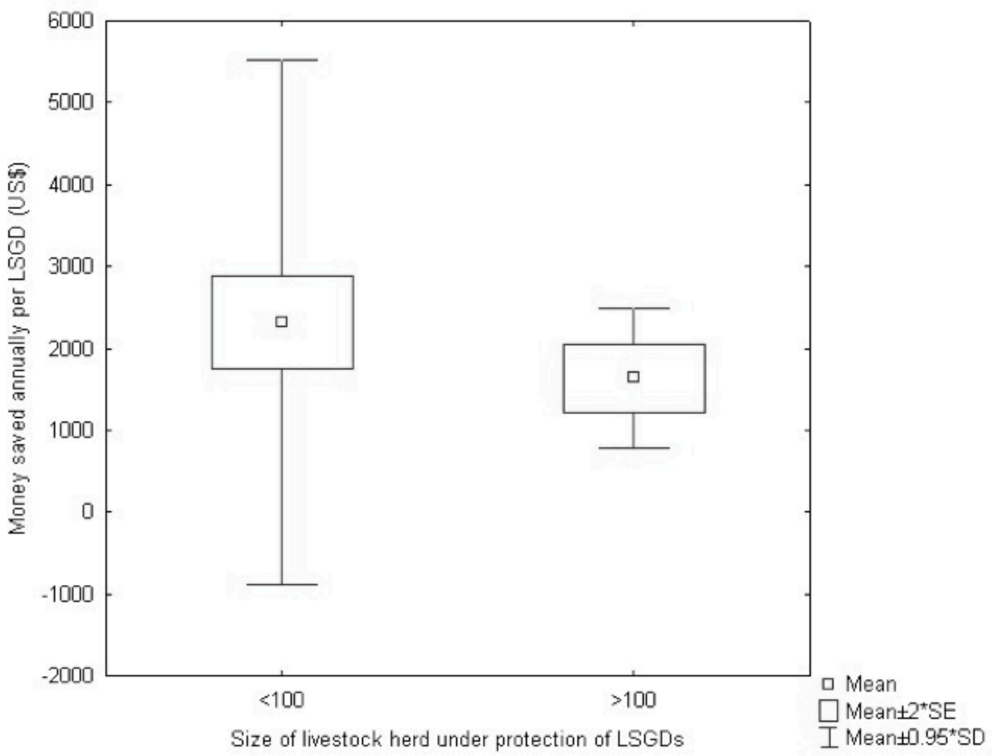

Figure 4.11 The differences in the amount of money saved in depredation between LSGDs who were guarding large or small herds of livestock.

b) Indirect Benefits

Of all the farmers surveyed, 92.6% (n=100) reported being more confident in the safety of their livestock since getting a LSGD, with 97.2% (n=105) saying that they would recommend LSGDs to other farmers. A high proportion of the respondents (n=45, 50.6%) also reported that they were less likely to use lethal control since getting a LSGD, however, these results represent only a reported intention rather than a precise measure and the results should be interpreted with caution, as some farmers may not have provided truthful accounts of their intentions of using lethal control. And 66.3% of farmers (n=61) said that the presence of a LSGD improved their tolerance towards predators. These figures were supported when statement-based questions were used (Figure 4.12 and 4.13). The degree to which the LSGD incited positive behavioural changes in their owners (improvement in the level of tolerance of predators and caused a reduction in the use of lethal control of predators – measured by the Conservation Index), was positively correlated with the LSGD's effectiveness ($r_{(197)} = 0.16$, $p = 0.02$) and even more significantly to how well behaved the LSGD was (the absence of behavioural problems, measured by the disciplinary problems score; $r_{(193)} = 0.19$, $p = 0.007$).

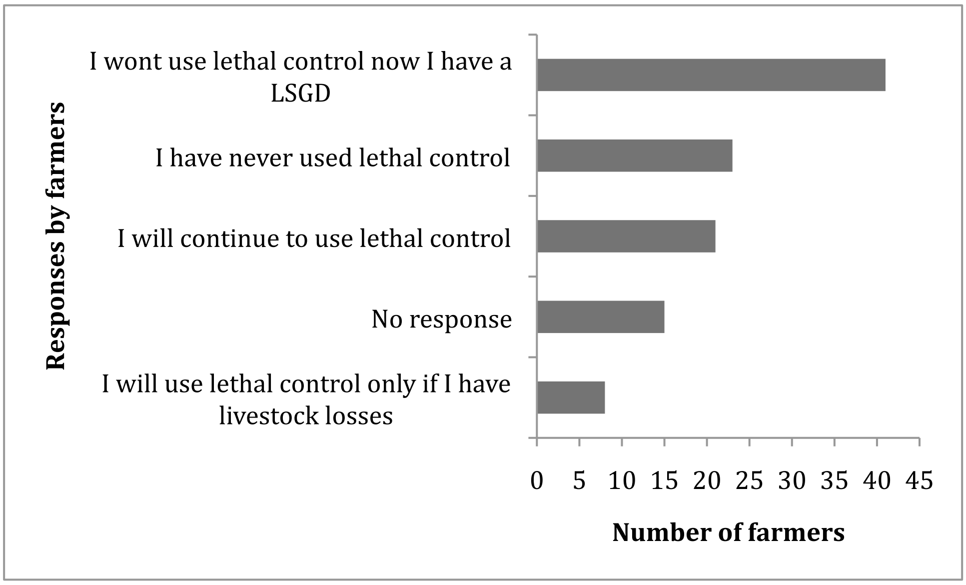

Figure 4.12 Farmers' responses to questions regarding whether they use lethal measures to control predators on their farms now that they own a LSGD.

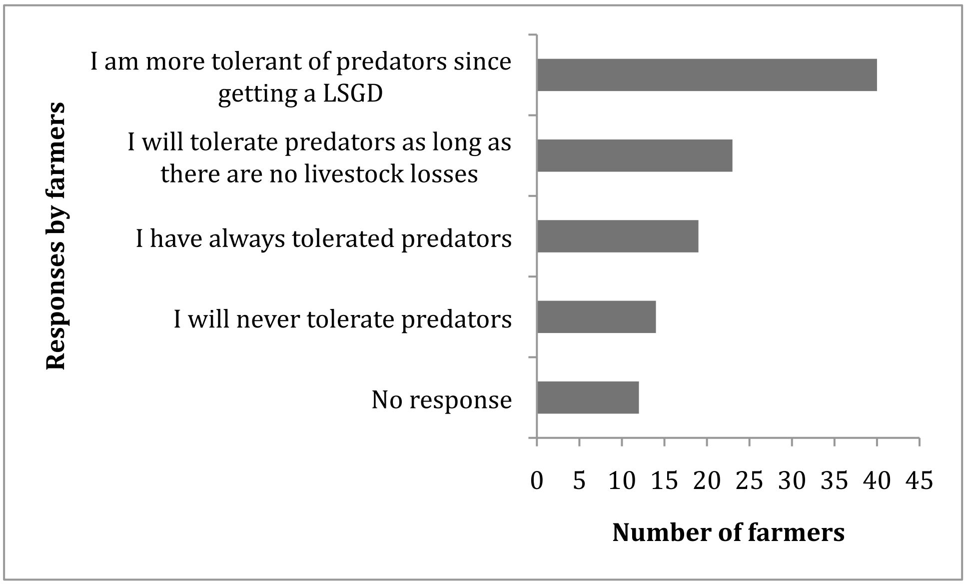

Figure 4.13 Farmers' responses to questions regarding whether they tolerate predators on their farms now that they own a LSGD.

c) Profits

Seventy-seven farmers (71.3%) reported both costs and livestock loss data, enabling an analysis of profits. Fifty-nine of these farmers (76.6% of those that responded) registered a profit from owning LSGDs and for 18 producers' (23.4%) LSGDs were not financially viable (costs outweighed the money saved on depredation). For the 77 responding farmers, the average annual profit per farm was US$1,497 (±2,798, range: -4,480–15,401) and the average annual profit per LSGD was US$789 (±1,646, range: -2,256–15,401). If a LSGD were to live the minimum expected lifespan of 4 years (Marker *et al.,* 2005a; Potgieter, 2011), its expected total profit would be US$3,156, with a total profit of US$9,468 if it lived to the maximum lifespan of 12 years (Lorenz *et al*., 1986).

The average profit per year, per farm was US$1,497, compounding annually to create significant benefits for producers in the long run (Figure 4.14). Although Crosses were the most expensive breed to maintain (i.e. total annual maintenance costs), they also saved enough livestock to make their profit margin the highest amongst all the breeds ($H_{(3, 148)} = 12.46$, $p = 0.006$; average profit per Cross LSGD of US$1,221 ±2,941, range: -2,256-15,401)(Figure 4.15).

No significant relationship was found between the age, size, sex or the number of LSGDs working together and the amount of profit that the LSGD yielded.

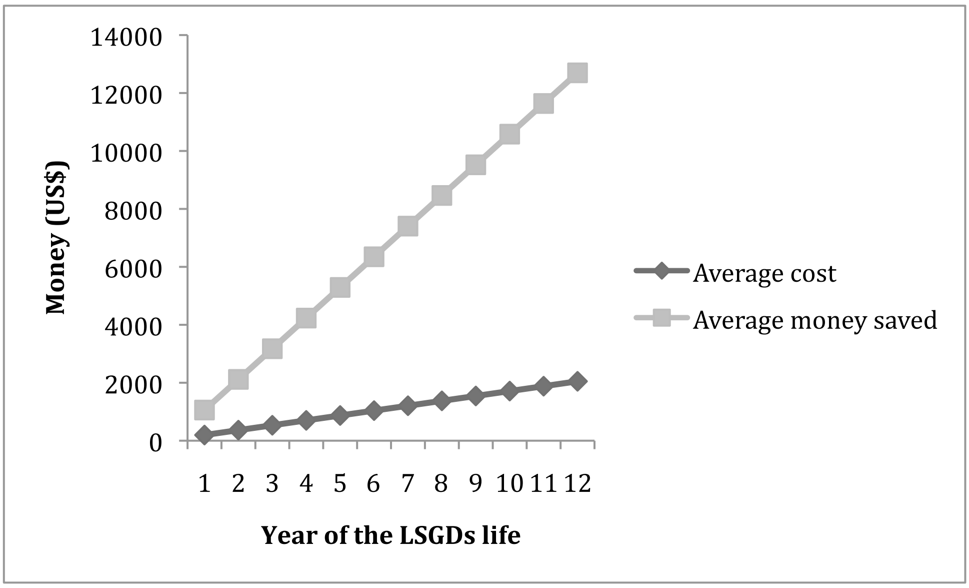

Figure 4.14 Cumulative costs and benefits of the average LSGD in Botswana over the expected maximum lifespan of 12 years.

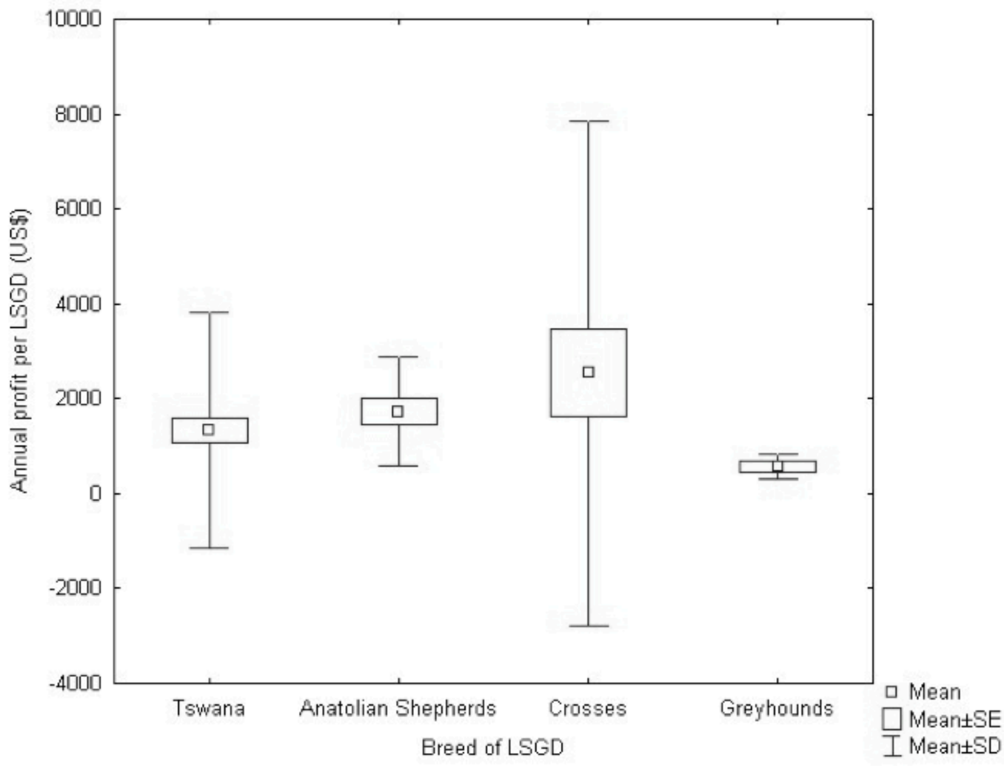

Figure 4.15 Annual profits (annual costs taken from the money saved on livestock depredation annually) made by different breeds of LSGDs working on farms in Botswana.

4.4 Discussion

Results from my study indicate that the majority of LSGDs in Botswana bring in a considerable profit for farmers for relatively minimal costs. This translated into real conservation benefits by increasing a farmers' tolerance of predators and reducing the likelihood that they would resort to lethal control to manage their predator problems.

Considering that over 75% of LSGDs in this study had been obtained for free or bred by their owners indicates that puppies are readily available for low costs, and that breeding is widespread. Only 24% of LSGD owners purchased their LSGDs, with an average purchase price of a mere US$27. This indicates that obtaining a LSGDs in Botswana is much cheaper than in other countries, in which the purchase prices for LSGDs ranges from US$88-1,821 (Andelt, 1984; Green *et al.,* 1984; Andelt & Hopper, 2000; Fox & Papouchis, 2005; Landry *et al.,* 2005; Marker *et al.,* 2005a; Rigg, 2005; Ostavel *et al.,* 2009; Gehring *et al.,* 2010b; Potgieter, 2011; Gonzalez, *et* *al.,* 2012; Rust & Marker, 2013). It must also be noted the Tswana LSGDs were the most likely breed to be given to their owners. This data supports several studies which state that local breeds of dog are easily sourced and often free (Berry *et al.,* 2011; Gonzalez *et al.,* 2012; Rust & Marker, 2013). Encouragingly, the purchase price or absence of a purchase price had no influence on whether the LSGD would become an effective guardian later in life, supporting Black's adage "Why buy a Seiko-Quartz if a Timex will do." (Black, 1981, p237).

Food was the largest costs associated with LSGD in my study (73% of annual maintenance costs), however, the average annual food costs of US$126 per LSGD was the lowest out of a variety of other studies from around the world (Andelt, 1984; Green *et al.,* 1984; Andelt & Hopper, 2000; Fox & Papouchis, 2005; Landry *et al.,* 2005; Ostavel *et al.,* 2009; Gehring *et al*., 2010b; Potgieter, 2011; Gonzalez *et al.,* 2012; Rust & Marker, 2013). This is likely because most LSGDs in my study were fed on inexpensive food such as maize meal or human's leftovers. The large number of Tswana LSGDs in the sample may also have contributed to this result, as local breeds tend to have lower food costs than larger, purebred dogs (Marker, 2002; Gonzalez *et al.,* 2012; Rust & Marker, 2013). Many farmers quoted that they fed their LSGDs opportunistically to save money, specifying that they fed their LSGDs meat from animals that had died on their farms (farm animals and wildlife). Similarly, many of the farmers were using cow or goats' milk from the farm to supplement their dogs' diet rather than buying milk. Despite the low food costs and the fact that only a third of LSGDs were being supplied with commercial dog food, the general health of the LSGDs was good, with few health problems being reported (see Chapter 3). Although there were some anecdotal accounts of behavioural problems in LSGDs brought about by malnutrition, the analysis showed no relationship between the LSGDs' diet and behavioural problems it exhibited, including leaving the livestock (see Chapter 3). One would assume that the higher food costs found for Crosses could be attributed to their larger size, however, I found no correlation between the size of the LSGD and food costs, contradicting previous studies (Speakman, *et al*., 2003; Potgieter, 2011; Rust & Marker, 2013). However, it should be noted that over a third of the total number of Anatolian Shepherds (a large breed of LSGD) were not accounted for in the costs questions, as their owners did not complete the relevant questions. This may have left a bias in the sample, especially if the reason for not responding was because their costs were elaborate and difficult to calculate.

The result showing that LSGDs older than 6 years of age had significantly lower food costs than younger LSGDs was unexpected. One possible explanation is that a decrease in metabolism brought about by old age could minimise food requirements (Speakman, *et al.,* 2003). Additionally, it is possible that older LSGDs have learnt to be more economical with their energy than younger dogs, especially with a reduced tendency for play behaviour. It is unlikely that the decrease in food costs with age is because older dogs may have become more adept at hunting for their own food, as my results do not indicate an increase in the amount of game hunted as the LSGD's ages progressed. Marker *et al.,* (2005a) saw a decline in the care given to LSGDs as they grew older, which might account for the lower food costs, however, my results indicated this was not the case in my sample (see Chapter 3).

Medical costs were found to only be a small proportion of the maintenance costs of LSGDs and over a third of LSGDs had no reported medical costs at all. Twenty-three of the 77 LSGDs that had no medical costs were also reported to have suffered from health problems, which indicates that the LSGD owners in the sample are either unwilling or unable to obtain medical care for their LSGDs. Veterinary professionals are rare in Botswana, with private and government veterinarians only available in the largest towns, which can be a considerable distance from some farming areas in Botswana. The low socio-economic standing of most subsistence farmers in the country also means that veterinary care for LSGDs may be unaffordable to many farmers. However, considering the low costs of veterinary care in the sample, and the fact that communal farmers owned 70% of the LSGDs that received veterinary care, indicates that communal farmers were utilising veterinary facilities for their LSGDs (contradicting suggestions of Rust & Marker, 2013).

Free veterinary care is provided to LSGDs by some organisations in Botswana such as Cheetah Conservation Botswana (CCB), the Maun Animal Welfare Society (MAWS), and the government's Department of Veterinary Services. Because of this, those LSGDs that had no reported medical costs did not necessarily go without medical care, however, definitive evidence cannot be ascertained with this data. Forty-seven

LSGDs were reported to have medical costs but no health problems, indicating that some owners are providing preventative medicine for their LSGDs.

LSGDs that receive less health care would theoretically be more likely to be unhealthy and prone to illness, leading to higher medical costs. This was confirmed by the result that Greyhounds and Tswana LSGDs were found to have received less health care than the other breeds (see Chapter 3) and as a result, they incurred higher medical costs than other breeds of LSGD. Coppinger *et al.* (1985) indicated that although local breeds would be cheaper to purchase, they might cost an owner more in regular maintenance costs such as medical bills. My data does corroborate this (with Tswana LSGDs having high medical costs), however, it is likely due to low levels of care provided by the owners (Tswana LSGDs were found to have low health care scores – see Chapter 3), rather than a low general health status of the Tswana LSGDs. On the contrary, the fact that Tswana LSGDs received significantly less health care from their owners than other breeds but still managed to be more effective than other breeds such as Anatolian Shepherds indicates that they may have superior general health (see Chapter 3).

The collective annual maintenance cost of a LSGD in Botswana (average US$169) is the lowest out of other studies from around the world (Andelt, 1984; Green *et al*., 1984; Andelt & Hopper, 2000; Fox & Papouchis, 2005; Landry *et al.,* 2005; Ostavel *et al.,* 2009; Gehring *et al.,* 2010b; Potgieter, 2011; Gonzalez *et al.,* 2012; Rust & Marker, 2013). Maintenance costs represented a mere 6% of the average farmer's annual financial losses caused by depredation (which equates to one sheep, 82% of the price of one goat or ¼ of the price of one head of cattle). This figure is low enough that it should encourage farmers to invest in incorporating LSGDs into their farm management practices.

Interestingly, the money saved on depredation and the profits gained for farmers using LSGDs was the lowest when compared to other studies (Green *et al.,* 1984; Andelt & Hopper, 2000; Fox & Papouchis, 2005), however, this is likely a consequence of the higher livestock prices found in the USA and Canada where these studies took place. When one compares the average annual profit gained by producers to the gross domestic product per capita for the respective nations, the opposite trend was realised, with my study ranking the highest out of these studies. Botswana's relatively low economic standing makes the annual profit for producers (US$1,479) even more noteworthy, and is just shy of the average annual income of one agricultural worker in Botswana (US$1,527)(Statistics Botswana, 2011).

The high percentage of farmers reporting a reduction of livestock depredations since using a LSGD (83% of farmers who completed the livestock loss questions) was encouraging. The fact that only 3% of farmers surveyed reported an increase in livestock losses to predators since getting a LSGD is similar to other studies (5% in Green *et al.,* 1984; 3% in Potgieter, 2011). Seventy-six percent of LSGDs were economically viable, bringing in a profit for their owners, while 23% did not. This is comparable to the 73% of farmers having profitable LSGDs in Green *et al.* (1984) and 59% in Potgieter (2011). The annual profit per LSGD of US$789 in my study was slightly lower than US$990 in Coppinger *et al.* (1988); however, this is likely because the livestock prices are lower in Botswana than in the USA.

My study is the first to identify that Greyhounds and Crosses yielded a much higher profit margin than the other breeds. It is possible that the hot climate of Botswana is well suited to Greyhounds, however, the small sample size does mean that this result should be interpreted with caution. In the case of Crosses, the combination of local breeds crossed with purebred dogs may have created a good balance of size, temperament and good health suited for guarding livestock. The reasons for this are unclear, and it is a topic that would benefit from further investigation.

Almost all of the literature suggests herders as a tool for improving LSGD effectiveness, behaviour and health (Landry, 1999; Marker, 1999; Ogada *et al.,* 2003; Espuno *et al.,* 2004; Bangs *et al.,* 2005; Woodroffe *et al.,* 2007; Potgieter, 2011). However, the results from my study indicate otherwise, with LSGDs accompanied by herders being less effective, saving less money in depredation and displaying higher levels of behavioural problems such as chasing game (see Chapter 3). One possible explanation for this is that the proximity of a human may have threatened the bond that the LSGD has with its livestock, compromising its ability to guard effectively (Lorenz *et al.,* 1986; Rigg, 2001; Śmietana, 2005). Alternatively, herders may be encouraging LSGDs to hunt wildlife for their own personal benefit (Potgieter *et al.,* 2013).

The importance of a good diet was also highlighted in this study, with LSGDs that were fed a balanced diet saving more money than those fed on a diet of only maize meal. The fact that a malnourished LSGD is not able to work effectively is also evident in the fact that a number of farmers reported that behavioural problems were due to the LSGDs being underfed (see Chapter 3). Many farmers were able to provide a balance diet for LSGDs for minimal costs, by sourcing cheap food and using food sources from the farms (e.g. leftovers, milk from livestock and discarded animal carcasses). Some farmers noted that they only fed their LSGDs cooked meat as they were concerned that feeding them uncooked meat might encourage the LSGDs to attack their livestock, however, this was outside the scope of my study and may be a topic for further investigation.

The data from my study indicates that LSGD effectiveness decreased as the size of a herd (livestock numbers per LSGD) increased (see Chapter 3). There did not seem to be a critical herd size at which effectiveness significantly decreased, however, having more than 100 head of livestock per LSGD was found to significantly decrease the amount of money saved in livestock depredation. This is likely due to large herds scattering widely over the grazing pastures (veldt) making it difficult for a LSGD to adequately protect all the members of the herd at the same time (Lorenz & Coppinger, 1996; Fox & Papouchis, 2005; Hansen, 2005). Herds that are large enough to begin scattering over distances that are large enough to compromise the effectiveness of the current LSGDs, should therefore be reinforced with an additional LSGD (Green & Woodruff, 1988; Lorenz & Coppinger, 1996; Urbigkit & Urbigkit, 2010), and as a rule, there should be a livestock to dog ratio of no more than 100:1 (van Bommel & Johnson, 2012). In instances where herds are large or scattering widely, a human herder could be utilized to encourage the herd to stay in one group, however, this should be implemented with caution in light of our results regarding herders.

The success of the LSGDs in my study was evident in the high number of farmers that were more confident of the safety of their livestock since getting a LSGD (93%) and the number of farmers who were eager to recommend LSGDs to other farmers (97%).

These figures were above and beyond the number of farmers who profited financially from their LSGDs, indicating that even in cases where LSGDs had not been financially viable, they still facilitated psychological change in their owners (Green *et al.,* 1984; Smith *et al.,* 2000; Rigg, 2001; Gehring *et al.,* 2010a) - an important element in mitigating human wildlife conflict (HWC)(Shivik, 2004; Shivik, 2006; Potgieter, 2011; Winterbach *et al.,* 2012).

It was encouraging to find that 18% of the farmers surveyed said that they have always tolerated predators and 21% would never use lethal control on their farms, whether they had a LSGD or not. It is even more encouraging to note that getting a LSGD had influenced an additional 37% of farmers to tolerate predators and 38% of farmers to stop using lethal control on predators altogether. Considering the considerable finances farmers sometimes invest in using lethal control against predators (McManus *et al.,* 2014), eliminating this need is a significant indirect financial benefit of using LSGDs. Because the farmers of Botswana have been known to kill predators on farmland in response to HWC (Selebatso, 2006; Klein, 2007; Muir, 2009), LSGDs are an important tool in the conservation of those predator species that cohabitate the farmlands of Botswana. It is important to note that the more effective the LSGD was, the more positive the behavioural change they incited in their owners in regards to the conservation of predators. Similarly, the more behavioural problems the LSGD exhibited, the less likely a farmer was to tolerate predators or to cease using lethal control of predators on their farms. This is yet another reason why improving the effectiveness of LSGDs and controlling behavioural problems is important, not only for the productivity of the farms, but also for the conservation of predators.

It must be noted that farmers can be reluctant to honestly answer questions about sensitive topics for fear of retribution from authorities (Siemiatycki, 1979; White *et al.,* 2005). Although respondents were given an option of “no response”, the results regarding the use of lethal control should still be interpreted with caution. Although useful in gauging changes in perceptions, these results represent an intention only and are not a direct measure of how many predators are being killed on farms. Furthermore, predator abundance and activity on different farms would directly affect a farmers’ tolerance of predators and their use of lethal control and may have affected the answers provided. Furthermore, past lethal control measures on farms may have affected predator abundances and as a result, farmers who had eliminated predators from their farms in the past may have reported that they were less likely to use lethal control, contradicting the results. Future investigations into these topics would benefit from direct measures of predators killed both in the past and present with confidentiality measures taken to improve the reliability of the data (Siemiatycki, 1979).

The medical costs associated with keeping a LSGD were the only section of the data that indicated there was a non-response bias in this sample. This phenomenon is likely due to the fact that the organizations with which this questionnaire was carried out (CCB), provided free veterinary care for LSGDs. It is possible that producers who were having health issues with their LSGDs (and thus had higher medical costs) were more eager to fill out the questionnaire with the hope that they may be eligible to receive free medical treatments for their LSGDs. The other possibility is that the early respondents may be more diligent owners, who are more likely to spend money on their LSGD's health than more lackadaisical farmers. Whatever the cause, the even distribution of early and late respondents (55% and 45% respectively) and similarly respondents and non-respondents (52% and 48% respectively) renders any non-response bias in this study negligible.

LSGDs were found to be financially profitable for most farmers that were using them in Botswana, with minimal costs and considerable benefits that included money saved from a reduction and prevention of depredations of livestock. It must also be noted that although the actual reduction of livestock losses is an obvious benefit of owning a LSGD, there is still a possibility that a LSGD may be preventing further higher losses than previously experienced such as surplus killings, or deaths in light of a new influx of predators on the farms (Rigg, 2001; Potgieter, 2011). Additional benefits for farmers included an increase in the confidence of the safety of their herds and minimizing the need for other predator control measures. These factors combined to improve farmers' tolerance of predators on their farms and a reduction in their likelihood of using lethal control to manage their predator problems. Because other tools used to mitigate the conflict between predators and livestock farmers can be exceedingly expensive, these findings demonstrate that LSGDs are an important, cost-effective predator management tool in Botswana. Furthermore, the low purchase and maintenance costs associated with LSGDs in Botswana make them affordable for low-income subsistence farmers who may not be able to afford more expensive mitigation methods. This indicates that LSGDs may be the key tool in improving conservation in areas where poor farmers are coming into considerable conflict with predator species. In Botswana, where key populations of vulnerable species such as cheetahs (*Acinonyx jubatus*) and African wild dogs (*Lycaon pictus*) are present, LSGDs should be promoted as an effective and cost-efficient mitigation method in the quest to save these species.

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CHAPTER 5 – General discussion of the use of livestock guarding dogs on Botswana farms

5.1 Human wildlife conflict and predator control methods

Human wildlife conflicts (HWC) are a threat to wildlife worldwide, with conflicts heightening when wildlife threaten human life or livelihoods (Ogada *et al.,* 2003; Graham *et al.,* 2005; Woodroffe *et al.,* 2007). Pre-emptive and retaliation killings of predators by livestock farmers in the wake of real or perceived threats to livestock, are a serious threat to the survival of cheetahs (*Acinonyx jubatus*), African wild dogs (*Lycaon pictus*) and other predators on farmlands in Africa (Lindsey *et al*., 2005; Selebatso, 2006; Klein, 2013). Lethal methods of controlling predator species can be ecologically damaging, indiscriminate and cruel, as well as having questionable effects on reducing livestock depredation (Macdonald & Baker, 2004; McManus *et al*., 2014). However, any technique of controlling predation, whether it is a lethal or non-lethal method, should ideally fulfill eight criteria to be successful and acceptable. Predator control methods should be effective at reducing predation over a period of time, cost-effective relating to the losses being experienced, will target the problem animals selectively and not cause damage to other species or individuals, be obtainable and simple to implement for farmers, have limited negative environmental impacts and be legal and socially acceptable (Macdonald & Baker, 2004; Mitchell *et al.,* 2004; Woodroffe, 2004; Woodroffe & Frank, 2005; Shivik, 2006; Thorn *et al.,* 2012). No one method is a panacea for all predator-farmer conflicts, however, livestock guarding dogs (LSGDs) have been found to be one of the best tools in fighting farmer-predator conflicts, fulfilling most of the aforementioned criteria as a suitable predator control technique (Potgieter *et al*., 2013; Rust *et al.,* 2013; McManus *et al*., 2014).

LSGDs have been used for millennia to help protect livestock herds from depredation; however, their use dwindled over the previous century in response to a decline in predator species in farming areas across the globe (Landry, 1999; Rigg, 2001; Andelt, 2004). Over the last 50 years, however, LSGDs have undergone a revival at the hands of conservationists who have utilized LSGDs as a tool to promote coexistence between livestock farmers and persecuted carnivore species such as coyotes (*Canis latrans)*, wolves (*Canis lupus)* and cheetahs (Coppinger *et al.,* 1988; Landry, 1999; Marker *et al*., 2005a; Gehring *et al.,* 2010a). Conservation organizations in southern Africa, such as the Endangered Wildlife Trust and Cheetah Outreach in South Africa and the Cheetah Conservation Fund in Namibia have primarily promoted Anatolian Shepherds in their LSGD programs (Marker *et al*., 2005a; Cheetah Outreach, 2013; Potgieter *et al*., 2013). These LSGDs have had mixed success, with some LSGDs displaying behavioural problems, health problems and having low life expectancies (Marker *et al*., 2005a; Potgieter, 2011; Cheetah Outreach, 2013). However, successes have been seen when regular supervision is provided by these organizations (Cheetah Outreach, 2013; Rust *et al.*, 2013). Despite all three of these non-government organizations (NGOs) providing either the LSGDs, health care and/or the dog food for free, as well as providing site visits and training for the farmers and the LSGDs free of charge, the costs of maintaining these dogs can still be financially prohibitive for some farmers (Potgieter, 2011; Potgieter *et al*., 2013).

The promotion of Anatolian Shepherds by NGOs and in the media created a belief within farming communities in southern Africa that Anatolian Shepherds were the only breed of dog that could be used to protect livestock. In light of the problems associated with Anatolian Shepherds in southern Africa, on top of their unavailability in Botswana and their high purchase costs, a cheaper and more practical option was needed. Some farmers in Botswana and Namibia have therefore sourced other breeds of dogs to use as LSGDs (Klein, 2013; Rust & Marker, 2013) with many of the farmers in Botswana adopting the use of the local, mixed breed “Tswana” dogs for this purpose (CCB, 2013). Although Tswana dogs are considered to be the cheaper alternative (CCB, 2006), their ability to effectively guard livestock was previous unknown and undocumented.

5.2 Methodology and study design

My study was designed to take an in-depth look at how livestock farmers were using LSGDs in Botswana, including whether or not they were economically viable and whether their use positively impacted predator conservation efforts. This research was conducted using postal, telephonic and face-to-face interview questionnaires of 108 known LSGDs owners around Botswana (Andelt & Hopper, 2000; Potgieter *et al.,* 2013; Rust & Marker, 2013). Some studies looking at the effectiveness of LSGDs do not account for confounding variables such as other protective management techniques used on the farm, ground cover and predator populations in the area (Gehring *et al.,* 2010a). My study accounts for many of these factors by looking at livestock depredations on individual farms before and after LSGDs were implemented (Green *et al*., 1984; Ostavel *et al*., 2009; Potgieter, 2011; Gonzalez *et al*., 2012) and by asking questions about the farm, including predators present in the area. By measuring livestock losses in this way, yearly fluctuations in depredations may have influence the results, however, the large sample size, wide geographic range of respondents and the fact that data was collected over a period of 22 months should reduce this bias.

Assessing livestock losses via retrospective respondent reports is not the most accurate way to discern how many livestock were depredated on a farm (Baker *et al.,* 2008), especially considering that predators are often blamed for livestock lost from other causes, such as disease, stillbirths and snakebite (Cozza *et al.,* 1996; Rasmussen, 1999). However, because my study focuses on HWC, it is the perceived losses that dictate the level of conflict taking place and as such, this method of reporting is sufficient for the scope of the project.

I identified that questions about sensitive topics (e.g. about a farmers likelihood of using lethal control on predators) were significantly different depending on the method of data collection used. Methods such as interviews and phone calls can be regarded as more confrontational and subsequently gained significantly more “predator-friendly” responses than surveys obtained from postal and take home methods. This indicates that the respondents may have felt pressured into giving answers that they thought would please the interviewer, and may not have been completely reliable (Siemiatycki, 1979; White *et al.,* 2005). This should be an important consideration when planning future studies using questionnaires to identify the use of the lethal control of predators, with postal or take-home surveys perhaps being a more appropriate method of data collection. Furthermore, the questions regarding lethal control represented the farmers’ intentions only and future studies would benefit from a more robust measure of predators killed on the farms.

Additionally, directly measuring the abundance of predator species on each farm over time would allow for an analysis of how predator presence or absence affects the use of lethal control measures on farms.

No matter what the style of data collection, the farmers surveyed were found to be less likely to answer questions about costs associated with LSGDs and their perceptions about predators, than other questions in the questionnaire. When the questions regarding costs and perceptions of predators were investigated more thoroughly, it was found that respondents were especially reluctant to answer these questions when they were being interviewed. This is likely a cultural effect as matters of money are not always discussed openly and farmers sometimes avoid honest answers regarding predators for fear of retribution from wildlife authorities (Berg, 2005).

The effectiveness of LSGDs in my study was measured in a variety of ways in order to gauge LSGD success from the viewpoint of a farmer and from a conservation standpoint. The effectiveness index (which used a variety of possible contributing factors, see Appendix C) is likely to be the best indicator of overall effectiveness in terms of the LSGDs' performances for the benefit of the farmer. Because most farmers value productivity and monetary gain, the amount of money saved in livestock depredations and profits were also used as indicators of LSGD success. Analyzing money saved and profits for each farm also allowed comparisons with similar studies (Andelt, 1984; Green *et al.,* 1984; Coppinger *et al*., 1988; Andelt & Hopper, 2000; Fox & Papouchis, 2005; Potgieter, 2011). Breaking down these values so that there were values for each LSGD (money saved and profits) also allowed comparisons between different breeds of LSGDs. The exact number of livestock that a LSGD saved was also calculated (Green *et al*., 1984; Ostavel *et al*., 2009; Potgieter, 2011; Gonzalez *et al*., 2012). However, the money saved and profit values were a slightly more precise measure of success in my study, as the values for different livestock species (cattle (*Bos taurus*), sheep (*Ovis aries*) and goats (*Capra hircus*)) varied so dramatically. This was especially important for farmers who were using LSGDs to guard cattle, as cattle values are much higher than those for goats and sheep. Although allowing farmers to record the estimated values of the specific livestock on their farms may have been a more accurate way to measure money saved (and would have taken into account the variations in the quality of livestock on specific farms i.e. stud animals), it was believed that farmers would not have reported these values accurately, especially considering that livestock in Botswana is often traded for goods or services and does not yield a monetary sum (Statistics Botswana, 2013a).

In terms of using LSGDs to facilitate predator conservation, the success of LSGDs was measured by assessing farmer satisfaction (Green & Woodruff, 1990; Ribeiro, 2004; Gonzalez *et al*., 2012; Potgieter *et al.,* 2013), farmer tolerance towards predators and whether their presence of LSGDs caused their owners to discontinue killing predators (Potgieter, 2011). These indicators, as well as identifying whether the LSGDs were killing wildlife, allowed a good examination into whether or not LSGDs were beneficial to conserving predators and the environment.

5.3 Breed Comparisons

The presence of Tswana dogs and other non-traditional LSGD breeds of dog in this sample allowed a unique investigation into a variety of dog breeds. Although previous studies have focused on comparing specialist LSGD breeds at work in the USA (e.g. Anatolian Shepherds, Great Pyrenees and Akbash dogs - Green & Woodruff, 1988; Green & Woodruff, 1990; Andelt, 1999), my study is the first to investigate the use of non-traditional dog breeds against each other and the first to compare different breeds of LSGDs in southern Africa.

Of the 40 acknowledged specialized breeds of LSGDs (Landry, 1999), Anatolian Shepherds were the only one represented in my sample. Although it was interesting to gain information regarding the use of non-traditional LSGD breeds such as Greyhounds and Pitbulls, the results regarding these breeds must be treated with caution due to the small sample sizes. The results showing that Crosses and Tswana LSGDs had higher effectiveness scores and better health than Anatolian Shepherds, indicates that these crossbreeds were performing well on farms in Botswana. This indicates that hybrid vigour and localized natural selection has resulted in crossbreeds being better suited physically to working in the extreme conditions of Botswana's farmlands (Coppinger & Coppinger, 2001; Berry *et al*., 2011), compared to Anatolian

Shepherds, which were bred to endure the very different environments of the highlands of Turkey (Rigg, 2001). The bushy scrublands that dominate farmlands in southern Africa also play host to parasites such as ticks and local diseases, and the fact that the crossbreeds (Crosses and Tswana LSGDs) were less likely to suffer from parasite problems and disease than Anatolian Shepherds further corroborates this theory.

The performance of the Cross LSGDs was the most impressive out of all of the breeds, with high effectiveness scores, low levels of disciplinary problems, the highest amounts of money saved in livestock losses, and the highest profits. However, Crosses also displayed the highest maintenance costs in the entire sample, costing their owners double that of the sample's average. This indicates that Crossed LSGDs would be the best type of LSGD to recommend to farmers, but only if they can afford the costs associated with these dogs.

Anatolian Shepherds in my sample had mixed results, with this breed causing the highest percentage reduction in livestock losses, resulting in high amounts of money saved, while displaying no injuries. However, they displayed poor performance in terms of their overall effectiveness, the highest incidences of disciplinary problems, highest proportions of parasites problems, high incidences of disease and high purchase costs. The high levels of disciplinary problems with Anatolian Shepherds confirms other reports of over-aggression and untrustworthiness in this breed (Coppinger *et al.,* 1988; Green & Woodruff, 1988; Green & Woodruff, 1990). Anatolian Shepherds should therefore be used on Botswana farms with caution, and should only be recommended to farmers who can afford their high costs, who can provide intensive training and monitoring to minimize behavioural problems, and who can provide thorough health care including preventative medicine to prevent problems with disease and parasites.

Tswana LSGDs performed admirably across the board with low purchase and maintenance costs, minimal disease and parasite problems, few disciplinary problems and high profits. Although they reduced the owners livestock losses by one of the lowest percentages (64% reduction as opposed to 96% for Anatolian Shepherds and 67% for Crosses), their low costs meant that profits obtained by the owners of Tswana

LSGDs was still impressive, at an average of US$1203 per LSGD/year - second only to Crosses. Thanks to their low costs and infrequent behavioural and health problems, Tswana LSGDs would be the most appropriate breed to recommend to farmers in Botswana, as most farmers in the region have limited funds, limited access to veterinary health professionals and most are unable or unwilling to invest a lot of time in monitoring and providing corrective training for behavioural problems in their LSGDs.

5.4 Minimising problems and improving the longevity of LSGDs

Health and behavioural problems in LSGDs should be avoided at all times as they can be financially devastating and time consuming for farmers and can reduce a LSGDs' effectiveness. In extreme cases, such as when LSGDs excessively wander, are physically unable to work due to disease or injury or die, it leaves the livestock without protection at all, making its livestock vulnerable to predation.

Health problems such as injuries and diseases can be more prevalent in LSGDs than in domestic dogs due to the harsh conditions in which they work (Green *et al.,* 1994). The usual medical care for dogs such as vaccinations, deworming for internal parasites and dipping for external parasites are recommended for all LSGDs and should be implemented throughout a LSGD's life to increase productivity, to avoid transmission of disease to humans and wildlife and to avoid premature death of the LSGD (Cheetah Outreach & De Wildt, 2005; Marker *et al.,* 2005a; Woodroffe *et al.,* 2007).

Proper health care and a suitable diet will not only improve the health and longevity of the LSGD but my study has shown that it will also improve the cost-effectiveness of the LSGD and its effectiveness at guarding livestock. A diet of only maize meal (pap) coincided with poorer performance from the LSGDs in my study, which is likely due to the fact that maize meal is not meeting the higher energy requirements of these working dogs (Marker, 2002). Providing more education about the proper health care, including dietary requirements of dogs is an important element to improve the performance of LSGDs in Botswana. The continuation and expansion of free and mobile veterinary health services for LSGDs (such as those already provided by Cheetah Conservation Botswana (CCB) and the Maun Animal Welfare Society (MAWS)), will further improve the health of LSGDs in Botswana by making veterinary services accessible to rural farmers who are normally unable to access veterinary care for their LSGDs.

Behavioural training is also an important tool in improving the effectiveness and longevity of a LSGD. The LSGDs in my study were exhibiting similar behavioural problems to other studies around the world: chasing and injuring game and livestock, and abandoning the livestock to wander. Chasing and injuring the livestock was the most common behavioural problem exhibited by the LSGDs in my study (24% of LSGDs did so regularly, 11% did so only rarely), which can be financially devastating and particularly demoralizing for farm owners, especially if the livestock is killed. Abandoning the livestock also occurred (14% regularly, 21% rarely), which leaves the herd unguarded and vulnerable to predation. Having LSGDs that chase or injure wildlife was also reported (in 13% of LSGDs regularly and 7% rarely) and although this may leave the herd temporarily unguarded, it is not as problematic for the LSGD owners as it is for the environment (see below). It is unclear how much corrective training was incorporated into the lives of the LSGDs in this sample, and although information booklets that include training recommendations are provided to farmers in Botswana by CCB, these dogs did not undergo any formal training such as that which is provided by other programs (Marker *et al*., 2005b; Cheetah Outreach, 2013). The frequency of behavioural problems exhibited by the LSGDs in my sample were similar to those where LSGDs underwent formal training (Coppinger *et al*., 1988; Potgieter, 2011), indicating that farmer training in Botswana can be as productive as formal training. Constant and thorough training, whether it is formal or informal, should help minimize behavioural problems in LSGDs (Coppinger *et al.,* 1988; Lorenz & Coppinger, 1996; Rigg, 2001).

In some cases, despite thorough and regular corrective training, behavioural problems may be uncorrectable and LSGDs need to be removed from working conditions (Rust *et al*., 2013). Highly valued LSGDs can be relocated as pets, however this can be problematic depending on the behavioural problem in question. For example, LSGDs that have been injuring or killing livestock require their new home to be isolated from domestic livestock to avoid reoccurring problems, and LSGDs that have shown aggression towards people can be dangerous to re-home. Non-lethal removals due to insurmountable behavioural problems occurred in 11% of LSGDs that were removed from Cheetah Outreach's study in South Africa between 2005-2011, despite regular corrective training by LSGD experts (Cheetah Outreach, 2011). In comparison, only four LSGDs in my study (4% of removals) were relocated because of disciplinary problems, with 11 LSGDs (10% of removals) being killed for the same reason. Culling due to disciplinary problems was the third leading cause of death in my dataset and the dispensability of the cheap and easily obtainable local dogs may have increased their chances of being culled rather than re-homed.

The more behavioural problems exhibited by the LSGDs in this study, the less likely their owners were to tolerate predators and the more likely they were to continue using lethal means to control predators. It is therefore imperative that behavioural problems be minimized in LSGDs, not only to improve productivity on the farms, but also to facilitate the conservation of predators.

The longer the lifespan of a LSGD, the more cost-effective it becomes (Green *et al.,* 1984; Lorenz *et al.,* 1986), especially considering that expenses in the first year of their lives are higher than in the rest of its life (Lorenz *et al.,* 1986; Green *et al.,* 1994; Gehring *et al.,* 2010a). A LSGD that dies or is removed prematurely (due to health, behavioural or other problems) will minimize profits for the owner while also leaving the herd at risk from depredation while a new LSGD is sourced and trained (Lorenz *et al.,* 1986). A farmer can minimize his chances of having to replace LSGDs by the selection of puppies from healthy breeding stock and through thorough and appropriate training, monitoring and health care (Coppinger *et al.,* 1985).

Across other studies, an average of 53% of LSGDs that started working on farms survived to work a long life (>4 years; Green *et al.,* 1984; Lorenz *et al.,* 1986; Green & Woodruff, 1990; Landry *et al.,* 2005; Marker *et al.,* 2005b; Rigg *et al.,* 2011; Cheetah Outreach, 2013). Considering that the chance of having to replace a LSGD prematurely is so high, it is even more imperative that LSGDs are cheap and easy to source. The average purchase price of LSGDs in this dataset (US$27) was considerably cheaper than other studies, and this means that LSGDs in Botswana are affordable and easily replaced, even for poor farmers (the average purchase costs across other studies, in comparison, was US$562 – Andelt, 1984; Green *et al*., 1984; Andelt & Hopper, 2000; Andelt, 2001; Fox & Papouchis, 2005; Landry *et al*., 2005; Marker *et al*., 2005a; Rigg, 2005; Ostavel *et al*., 2009; Gehring *et al*., 2010b; Potgieter, 2011; Gonzalez *et al*., 2012; Rust & Marker, 2013). The fact that a large number of farmers were breeding LSGDs themselves also indicates that puppies were easily sourced even in remote areas. Tswana dogs were the most likely breed in my study to be sourced for free, and this is an important benefit of using local dogs, especially considering that obtaining purebred dogs in rural villages is often impossible.

The fact that the most common cause of death amongst my sample was old age suggests that a large number of LSGDs in Botswana survive until an age comparable to non-working dogs (10-12 years; Green *et al.,* 1984; Lorenz *et al.,* 1986; Rigg, 2001; Potgieter, 2011). Poisoning was a common cause of death, however, this could be minimised by informing neighbouring farmers that a working dog is moving around the area and ensuring that all poisons should be removed while the dog is working.

It is possible that local dogs carry a natural immunity to parasites and disease as they undergo strong selection to survive the environments in which they have been bred, including the climate, terrain and local dangers such as predators, snakes or poisonous plants. This localized natural selection contributes to the sturdiness of local breeds and may explain why imported, purebred animals have shorter life spans (Andelt, 2004). This theory was unable to be tested in my study due to the small sample sizes of breeds within the mortalities segment of the dataset, however, low life expectancies have been found previously with purebreeds in southern Africa (Anatolian Shepherds had a life expectancy of only 4 years in Namibia - Marker *et al.,* 2005a).

5.5 Conservation and environmental considerations

When targeting HWC, mitigation measures that benefit both the human and the wildlife sides of the conflict will tend to be the most successful and sustainable (Macdonald & Sillero-Zubiri, 2004; Balme *et al.,* 2009). LSGDs achieve this by increasing productivity for farmers, as well as inciting positive attitude and behaviour changes in LSGD owners towards predators (Shivik, 2004). Although the lethal control of predators by livestock farmers is believed to ease as livestock depredation on a farm decreases, this does not account for those farmers who kill predators indiscriminately (i.e. whether they are losing livestock to depredation or not). A fifth of farmers in my sample fell into this category, stating that they would continue to use lethal control of predators, whether they lost livestock or not. Farmers like this may require other measures such as education to improve their attitudes towards predators (Dickman, 2010; Madden & McQuinn, 2014).

Most farmers in my study were less likely to kill predators after getting a LSGD (51%). However, it must also be noted that predators are sometimes killed by the LSGDs themselves while they are protecting their herds (Black & Green, 1985; Potgieter, 2011). For example, Potgieter (2011) referred to LSGDs as a lethal predator control method after finding that the Anatolian Shepherds working in Namibia killed many more black-backed jackals (*Canis mesomelas*) than the farmers had previously killed in retaliation of depredation (Potgieter, 2011). Clearly, a LSGD that is killing predators is threatening rather than contributing to conservation efforts. Most studies, however, have reported that LSGD's bark to scare away attackers and are rarely involved in physical interactions, indicating that they rarely kill or injure predators (Lorenz *et al.,* 1986; Rigg, 2001; Ostavel *et al.,* 2009). Potgieter's (2011) results may be due to the overly aggressive nature of Anatolian Shepherds (Green & Woodruff, 1988; Green & Woodruff, 1990) and it is unclear whether this behaviour is common with other LSGD breeds. Additionally, because black-backed jackals are small predators they may be more susceptible to LSGD attacks than larger predators such as cheetahs or leopards (*Panthera pardus*). Although my study measured the incidences of LSGDs chasing or injuring game species, it did not directly specify the number of predators killed by LSGDs. Because predators killed only six LSGDs in this sample, it is likely that serious altercations between LSGDs and predators were rare. It is also possible that LSGDs in this sample would be more likely to avoid direct confrontations with predators due to their smaller size, (average 17kgs for LSGDs in this sample), as opposed to Anatolian Shepherds which have an average body mass of 70-75kgs (for males – Rigg, 2001).

It should be noted that even if LSGDs are not killing predators but merely excluding them from certain areas, there is still environmental ramifications in terms of segmenting populations, disturbing localized migration and movement patterns and possibly increasing conflicts on neighbouring farms, as has been found previously (Gehring *et al.,* 2010b). However, these factors were not measured in this study, and are topics for potential future investigations.

Killing non-target (i.e. game) species is a common behavioural problem associated with LSGDs and one that can have serious environmental impacts (Gehring *et al.,* 2010b; Potgieter, 2011; VerCauteren *et al.,* 2012). The frequency of this problem with LSGDs in my study (21% of all LSGDs displayed this behaviour) was similar to other studies (Hansen & Smith, 1999; Landry, 1999; Rigg, 2001; Marker *et al.,* 2005b; Gehring *et al.,* 2010b; Potgieter, 2011; VerCauteren *et al.,* 2012). Initially thought to be a behaviour brought on by hunger, Potgieter (2011) found that most game that was killed by LSGDs in Namibia was not eaten, indicating that the behaviour could be motivated by protective instincts rather than for consumption. A LSGD that kills wildlife would be particularly damaging in areas where threatened species are present or where the wildlife is an important resource for the community (Potgieter, 2011). Improved monitoring and training of LSGDs, especially when they are young, would likely reduce the probability of LSGDs killing wild game (Ribeiro, 2004). Also, my study identified that the presence of a herder increases the amount of game that a LSGD hunts (as was also mention in Potgieter *et al*., 2013). Therefore, to minimize hunting in LSGDs, it is the author's recommendation to restrict the use of herders to the initial training stage and only for intermittent monitoring during the rest of the LSGD's life.

The degree to which LSGDs aided conservation efforts was measured by assessing whether the farmers' tolerance of predators improved and whether their use of lethal control decreased since they began using LSGDs. There was a significant correlation between the effectiveness of the LSGDs and the amount of attitude and behaviour change they prompted in their owners. Similarly, LSGDs that behaved badly did not incite these change in their owners. These results suggest that, in general, a LSGD must be effective and well behaved in order to change the behaviour of its owner to benefit the conservation of predators. Because LSGD behaviour does influence behavioural change in their owners, it indicates that the majority of conflict that farmers face with predators is based on perceived livestock losses, and that lethal control is used mostly when farmers believe they are losing livestock to predators. The alternative to this is when farmers kill predators indiscriminately, which can be particularly damaging and can cause widespread predator population declines (Macdonald & Sillero-Zubiri, 2004). The high number of respondents reporting an improvement in their tolerance of predators (66% of respondents) and a decrease tendency to kill predators (51% of respondents) indicates that LSGDs in Botswana are contributing significantly to the conservation of predators.

5.6 Management Implications

Apart from dogs, farmers in this survey noted some other species they were using as livestock guarding animals including donkeys (*Equus africanus*)(n=10), horses (*Equus ferus*)(n=1) and in one instance a cat (*Felis catus*), which the farmer was using to deter pythons (*Python sebae*) from eating small goats. Livestock guarding donkeys are a technique that is being used sporadically in southern Africa and is, as yet, untested in the region, and would be a useful area of further research.

It is important to note that the majority of farmers in my sample were using LSGDs to guard their goats and/or sheep and only three farmers used LSGDs to guard cattle. Although LSGDs have been used successfully to guard cattle in South Africa (Cheetah Outreach, 2013), the over-aggressive nature of some breeds of cattle in their region and their tendency to scatter widely in the pastures makes them difficult for a LSGD to guard (Marker *et al.,* 2005b). My results indicated that the type of livestock guarded did not influence a LSGDs' effectiveness but the small sample made it difficult to identify LSGD success with cattle. Considering the extent of cattle farming in Botswana and elsewhere in southern Africa, and the degree in which these farmers come into conflict with predators (Selebatso, 2006), the experimentation and advancement of knowledge of the use of LSGDs with cattle could have significant positive ramifications for farming production and predator conservation in the region.

The LSGDs in my study were obtained and trained by the farm owners themselves, with little assistance from external organizations such as conservation NGOs.

Considering that the performance of the LSGDs in my study were comparable with projects that implemented specialized breeds of LSGDs and implemented ongoing training (Marker *et al.,* 2005a; Cheetah Outreach, 2013; Potgieter *et al.,* 2013), indicates that implemented LSGD programs may not be necessary in the promotion of LSGDs as a tool to mitigate HWC. However, this could not be definitively stated without a side-by-side case study. One obvious limitation to these implementation programs is the high costs that are footed solely by the conservation NGOs. For example, in South Africa, Cheetah Outreach spends US$2,780 to place a single LSGD for the first year of their life (Rust *et al.,* 2013). A more cost-effective way to promote LSGDs as a conservation tool may be to bolster farmer education on LSGD care and training and enabling accessible and affordable health care for LSGDs in rural areas. This approach could result in a much larger number of farmers utilising successful LSGDs rather than placement programs, which are limited to a small number of farmers thanks to their high costs.

Because the age of the initial placement of LSGDs with their herds did not influence effectiveness, bonding with the livestock does not need to be made at certain development stages in a dogs' life. This result changes possible placement options of LSGDs. Experimental trials carried out by CCB whereby LSGD puppies are placed on CCB's training farm between the ages of 4-10 weeks and undergo preliminary training at their facility before being placed on livestock farms at the age of 4 months, have shown encouraging success (CCB unpublished data). These LSGDs are displaying sufficient bonding and high levels of effectiveness despite being trained with different livestock than the ones they eventually protect, and not having been placed with their herds until a later stage of life. These LSGDs have even been found successful when trained with a herd of goats before being placed with herds of sheep – contradicting many previous reports (Lorenz & Coppinger, 1996; Rigg, 2001). Using locally sourced, crossbreed dogs, placement programs like CCB's can provide LSGDs to needy farmers for a fifth of the price of the Cheetah Outreach's Anatolian Shepherd placement program in South Africa, while still allowing initial veterinary care and training to take place (CCB purchases, vaccinates, treats for parasites and sterilizes each puppy for a cost of approximately US$550/LSGD – CCB unpublished data).

5.7 Conclusion

The performance of the LSGDs in my study was encouraging with the majority (79%) of LSGDs reducing or matching the livestock losses on farms with the average of 75% reduction in livestock depredation. In terms of cost-effectiveness, LSGDs saved their owners on average US$2,017 (annual saving per farm), at the average cost of only US$169/LSGD/year (the equivalent of only one sheep). The low costs and high savings associated with LSGDs in this sample are encouraging and this information is useful in promoting LSGDs as a conflict mitigation tool for farmers. Considering that the annual maintenance costs of one LSGD equates to the price of losing just one sheep, many farmers who are experiencing livestock losses to predators should be more willing to use LSGDs on their farms in light of these results. This figure is much more achievable than LSGDs in other programs, for example, Cheetah Conservation Fund's LSGD program, in which their Anatolian Shepherds needed to save between 4-11 sheep annually to remain economically viable (Potgieter, 2011). The profits gained from the use of the LSGDs in my study highlights that LSGDs are a cost-effective mitigation measure for use on farms in southern Africa (average annual profit per farm of US$1,497). Furthermore, the low costs associated with using LSGDs in Botswana make them considerably cheaper to implement than other predator conflict mitigation measures such as predator-proof fencing or lethal measures (McManus *et al*., 2014).

My study provides important information for farmers who wish to use LSGDs in Botswana and in similar environments. Most farming areas of Botswana are bushy scrublands with large temperature variations, low rainfall and rough terrain where there are problems with diseases and ticks and are farmed primarily by low-income subsistence farmers (Hemson, 2003; Statistics Botswana, 2013a). Tswana LSGDs are the most appropriate breed in these circumstances, as their low purchase and maintenance costs, few health problems and significant profits are ideal for low-income farmers on Botswana's farms. If a farmer can provide the elevated maintenance costs for Crosses or Anatolian Shepherds, they will perform very well at guarding livestock and will save sufficient livestock to cover their costs. However, Anatolian Shepherds are more likely than other breeds to display behavioural problems and may cause significant problems, especially if training and monitoring are insufficient. The results showing that Crosses and Tswana LSGDs had higher effectiveness scores than Anatolian Shepherds, and better health indicates that crossbreeds are better suited physically to working in the tough conditions on Botswana's farms. My results and the results from studies in North (Black, 1981) and South America (Gonzalez *et al*., 2012) indicate that using the local, mixed breed dogs that are native to a specific area are not only more cost-effective than imported purebred dogs, but result in healthier, more effective LSGDs that tend to live longer. These benefits should encourage more farmers around the world to use local dogs as LSGDs, which should result in healthier, more efficient LSGDs and in turn, help promote the use of LSGDs for low-income farmers.

Botswana has a vast array of threatened wildlife species with some of the world's largest populations of cheetahs, lions (*Panthera leo*) and African wild dogs (IUCN/SSC, 2007; KCS, 2009; IUCN, 2012). These carnivore species often come into conflict with Botswana's extensive rural farming communities whose dependence on livestock is high (MWTC, 2001; CSO, 2004; Selebatso *et al.,* 2008; Steyn & Funston, 2009; Statistics Botswana, 2013b). Livestock losses can be devastating, especially for subsistence farmers who rely on livestock to feed their families, and consequent retaliation and preventative killings of predators can be particularly damaging when threatened cheetahs and African wild dogs are concerned (Gusset *et al.,* 2009; Klein, 2013). Because of the preventative nature of LSGDs, their economic viability and high success rates, LSGDs are an effective way to mitigate the conflicts occurring between livestock farmers and predators in southern Africa. Preventative measures such as LSGDs, may serve better at reducing HWC than responsive methods such as compensation schemes (Muir, 2009). Botswana's Government is dedicated to preserving wildlife, and their compensation program aims to improve the tolerance of wildlife species that cause damage in Botswana (DWNP, 2009). Compensation schemes, however, have been known to be ineffective at reducing HWC (Rasmussen, 1999; Shivik, 2004; Woodroffe *et al*., 2005; Muir, 2009; Gusset *et al.,* 2009), and communities in Botswana often resent Botswana's compensation program due to low pay outs, slow delivery of payments and the restrictions on eligibility (Muir, 2009). Also, because it is a reactive measure, the compensation scheme does not inspire farmers to take preventative measure to minimize future damage (Swenson & Andren, 2002; Shivik, 2004; Gehring *et al*., 2010a). If the government were to channel monies used for the compensation program into subsidizing some of the costs of using LSGDs, more farmers may adopt this tool, creating more sustainable coexistence between farmers and predators, and bolstering the conservation of threatened carnivore species in this country. Furthermore, improving the effectiveness of LSGDs by utilizing the methods recommended in my thesis will increase the productivity of farms, therein assisting with poverty eradication, while causing positive changes in the perception of predators and reducing the numbers of predators killed by livestock farmers.

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Appendix A – The questionnaire distributed to LSGD owners in Botswana

CHEETAH CONSERVATION BOTSWANA

Livestock Guarding Dog (LSGD) Questionnaire

Method ________ Date: ___________

PERSONAL INFORMATION

Name: _________________ Contact no: ________________________________
Email: _________________ Postal address: _____________________________
Location: _______________ GPS location: S - ___________ E ______________

Would you like to receive newsletters from CCB?

1. **Farm type (please tick)**
   Communal farmland/subsistence farming ☐ Commercial farmland ☐

2. **Which of these farming techniques do you use?**
   Livestock guarding dogs ☐ Herders ☐ Guard donkeys ☐
   Lambing/calving season ☐ Maternity kraal ☐ Kraal (day) ☐
   Kraal (night) ☐
   Other (please specify) ____

3. **Do you use livestock guarding dogs with…?**
   Sheep ☐ Goats ☐ Cattle ☐

GENERAL INFORMATION ABOUT YOUR DOG/S

If you have more than one dog, you can answer for one dog, or if you want to answer for more than one dog, please make a note of which dog you are referring to by ticking multiple boxes or writing notes in the margin.

4. **How many LSGDs do you own?**
   Males _____________ Females_____________

5. **How many LSGDs do you have with your livestock**
   Number of dogs: Number of livestock
   Sheep :
   Goats :
   Cattle :

6. **How old is your LSGD/s?**
   <18 months ☐ 18mths-3yrs ☐ >3yrs-6yrs ☐ >6yrs-10yrs ☐ >10yrs ☐

7. **What size is your LSGD/s?**
   1-12kg (small) ☐ 13-25kg (medium) ☐ 26-40kg (large) ☐
   >40kg (very large) ☐

8. What breed is your LSGD/s?

Tswana ☐ Anatolian Shepherd ☐ Greyhound ☐
Crossbreed ☐ (please specify breeds) ________________________________
Other ☐ (please state) ____

9. Where did you get your LSGD/s?

Was given it ☐ Found it ☐ Owned its parents ☐
Bought it ☐ (how much was it?) __________________________________
Other ☐ ____

10. Were the dogs' parents livestock guarding dogs?

Yes (both) ☐ Mother was ☐ Father was ☐ No (pet) ☐ Unknown ☐

11. Do you breed the LSGD for any purpose?

Don't breed dogs ☐ Guarding stock for personal use ☐ For sale ☐
Other ☐ (please state) ____

12. How long have you been using LSGDs?

0-1yr ☐ >1-2yrs ☐ >2-3yrs ☐ >3-5yrs ☐ >5-10yrs ☐
>10yrs ☐

13. Do you have a herder accompanying the herds that you have LSGDs with?

Yes ☐ No ☐
If yes, how many hours of the day is the herder with the dog and the herd? ___
Do you feel that this improves the dog's effectiveness? Yes ☐ No ☐
How much do you pay your herder? _______P/day

14. Did you have a herder accompanying the dog while it was in training?

Yes ☐ No ☐
If yes, do you feel like it helped with the dogs' training? Yes ☐ No ☐

15. Was your dog trained alone or did it have other guarding dogs with it?

Alone ☐
With other guarding puppies ☐ how many? __________
With trained livestock guarding dogs ☐ how many? __________

16. Have you had livestock guarding dogs before? What happened to them?

Not applicable ☐
Breed of previous dog/s ______________________________________
Killed by an intruder ☐ Sold ☐
Killed by another farmer ☐ Given away ☐
Killed due to disciplinary prblms ☐ Given away due to disciplinary prblms ☐
Poisoned ☐ Lost ☐
Death from old age ☐ Stolen ☐
Killed by another animal ☐ (animal responsible) __________

CARE AND TRAINING OF THE DOG

17. What do you feed the dog/s?

Pap/porridge ☐ Leftovers ☐ Pelleted/tinned dog food ☐ Meat ☐
Other ☐ (please state) ____________________________________

18. Please estimate the cost for the upkeep of your dog/s (per dog per year).

Food costs P ______ per LSGD per year
Medical costs P ______ per LSGD per year
Other costs i.e. injuring livestock/killing game
(please specify what the problems are)________ P______ per LSGD per year

19. Veterinary care; do you….?

	Yes	**No**	**Unknown**
Spay/neuter you dog/s (stop it from having puppies	☐	☐	☐
Vaccinate your dog/s for diseases in addition to rabies	☐	☐	☐
Deworm your dog/s	☐	☐	☐
Dip your dog/s for ticks and fleas	☐	☐	☐

20. Would you be interested in free sterilization for your LSGD/s?

Yes ☐ No ☐ Unsure ☐

21. Please list any health problems that your dog/s has had or does have.

____

22. At what age was the dog/s placed in the kraal?

Born in the kraal ☐ <4wks ☐ 4-6 ☐ 7-9wks ☐ 10-12wks ☐
3-6mths ☐ >6-12mths ☐ >1yr ☐ Unsure ☐

23. Did your suckle from the livestock when it was young?

Yes ☐ No ☐ Unsure ☐

24. What age of livestock was the dog/s originally placed with

Young (kids/lambs) ☐ Sub Adults ☐ Adults ☐ All ages ☐
Unsure ☐

25. At what age did the dog/s go with the livestock into the veldt?

<8wks ☐ 8-12wks (>2-3mths) ☐ 13-24 wks (>3-6mths) ☐
25-52 wks (>6-12mths) ☐ >52wks (>1yr) ☐ Unsure ☐

26. Is the dog/s fed in the kraal?

Yes ☐ No ☐ Unsure ☐

DOG PERFORMANCE

27. Does your dog/s stay with the herd?

All of the time ☐ Most of the time ☐ Occasionally ☐ Never ☐
Unsure ☐

28. Please list any disciplinary problems you have or have had with your dog/s.

	Yes	No	Rarely	Unsure
Chasing/injuring game	☐	☐	☐	☐
Chasing/injuring livestock	☐	☐	☐	☐
Not staying with livestock (e.g. coming home in the heat of the day)	☐	☐	☐	☐
Other (please specify) ___________	☐	☐	☐	☐

____

If there were problems, please state how you corrected it

____

29. Can the dog be handled by people?

Yes ☐ No ☐ By herder/farmworker only ☐ Unsure ☐

30. Does your dog protect its livestock against predators and thieves?

Yes ☐ No ☐ Unsure ☐

31. How does the dog react to a predator?

Chase ☐ Bark ☐ Attack ☐ Herds the livestock ☐

Bluff attack (advances but keeps a distance) ☐ Ignores ☐ Unsure ☐

32. How does your dog/s react to human intruders?

Chase ☐ Bark ☐ Attack ☐ Herds the livestock ☐

Bluff attack (advances but keeps a distance) ☐ Ignores ☐ Unsure ☐

33. Does your dog keep the livestock together in a tight group?

Never ☐ All the time ☐ Only when threatened ☐ Unsure ☐

34. **Does your dog/s display herding tendencies more than guarding? Note:** herding means that the dog/s control the movements of the flock, directs them and keeps them together in a tight group; guarding dog/s will follow the lead of the flock whilst protecting them from predators.

Yes ☐ No ☐ Both equally ☐ Unsure ☐

35. How many livestock per year were you losing to predators prior to getting a dog (average)?

____________________ per year Unsure ☐

36. How many livestock per year were you losing to predators since getting a dog (average)?

____________________ per year Unsure ☐

PREDATOR ISSUES

37. List the predators you have the biggest problems with (from the biggest problem to the least).

____

____

38. **Are there any predators present on your farm that do not cause problems with your livestock?**

____

____

39. **If you had a problem with predators in the last 12 months, please state:**

Date	Animals killed or injured (species, number, sex)	Age or size of animals killed	Predator responsible (number, species, age) i.e. 2 x adult male cheetahs	How was it identified? (visual, spoor, carcass)	Time of day the event took place?	Location

FARMER SATISFACTION

40. **Do you feel more confident of the safety of your livestock because of having a LSGD?**
Yes ☐ No ☐ Unsure ☐

41. **Would you recommend LSGDs to other farmers?**
Yes ☐ No ☐ Unsure ☐

42. **Since getting a LSGD, are you more inclined to tolerate predators on your farm?**
Yes ☐ No ☐ Unsure ☐

43. **Which statement best matches your position on predators (please tick only one)**
☐ I have always tolerated predators on my farm
☐ I am more tolerant of predators on my farm since getting a dog
☐ I have never and will never tolerate predators on my farm
☐ I will tolerate predators on my farm so long as I have no livestock losses
☐ Unsure

44. **Since getting a LSGD, are you less likely to use lethal control for predators on your farm i.e. shooting, trapping, poisoning?**
Yes ☐ No ☐ Unsure ☐

45. Which statement best matches your opinion on lethal control (please tick only one)

☐ I will **not** use lethal control now I have a LSGD
☐ I will continue to use lethal control on predators
☐ I will use lethal control only if I have livestock losses and can confirm the problem animal whilst abiding by Department of Wildlife regulations.
☐ I have never and will never use lethal control of predators
☐ Unsure
Comments ____
____
____

46. Any additional information or interesting stories about your dog/s' performance?

____
____
____

47. Do you use other species as livestock guarding animals? i.e. donkeys, llamas?

Yes ☐ (please specify what type of animal ____________________________
No ☐ Unsure ☐

Thank you for taking the time to fill out our questionnaire. Your responses will help Cheetah Conservation Botswana establish predator-friendly techniques that can help farmers reduce their livestock losses to predators.

Appendix B – Response rates from the questionnaire

Method of administration	When	Number administered	Number completed	Response rate
Postal (pilot)	June 2010	252	49	19.4
Phone	March 2010	120	20	16.7
Postal	April 2011	57	31	54.4
Phone	June 2012	190	20	10.5
Postal	October 2012	173	21	12.1
In person interviews	2010-2013	72	67	93.1
Take home	August 2012	25	20	80.0
Total postal surveys		482	101	21.0
Total phone surveys		310	40	12.9
Take home/interviews		97	87	89.7
Grand total		889	228	25.6

Appendix C – How the various indices were created, including relevant questions and scores awarded to each possible answer

HEALTH CARE INDEX		
Q17. What do you feed the dog/s?	Pap/porridge, leftovers	+1
	Pelleted/tinned dog food	+2
	Others	Ad hoc, generally +1
Q19. Veterinary care; do you…?	Spay/neuter your dog, Vaccinate, Deworm, Dip – Yes	+1 for each
	Spay/neuter your dog, Vaccinate, Deworm, Dip – No	-1 for each
	Unsure	0 for each
Q21 Any health problems?	Each health problem that was due to neglect on the owners behalf (not accidental)	-1
	Accidental health issues	0
	No health issues	+1

TRAINING INDEX		
Q14. Did you have a herder accompanying the dog while it was in training?	Yes	+1
	No	-1
Q14 (b). Do you feel like it helped with the dogs' training?	Yes	+1
	No	-1
	N/A	0
Q15. Was your dog trained alone or did it have other guarding dogs with it?	With trained LSGDs	+1
	Alone	0
	Trained with other puppies	0
How many puppies or LSGDs was it trained with?	1 or 2	+1
	3 or more	-1
Q22. At what age was the dog/s placed in the kraal?	Born in the kraal, <4wks, 4-6wks, 7-9wks, 10-12wks	+1
	3-6mths	0
	>6-12mths, >1yr	-1
Q23. Did your dog/s suckle from the livestock when it was young?	Yes	+1
	No	-1
	Unsure	0
Q25. At what age did the dog/s go with the livestock into the veldt?	<8wks	-2
	8-12wks	-1
	13-24wks (3-6mths)	+2
	25-52wks (7-12mths)	-1
	>52wks (>1yr)	-1
	Unsure	0

EFFECTIVENESS INDEX		
Q23. Did your dog/s suckle from the livestock when it was young?	Yes	+1
	No	-1
	Unsure	0
Q27. Does your dog/s stay with the herd?	All of the time	+2
	Most of the time	+1
	Occasionally	0
	Never	-2
	Unsure	0
Q28. Please list any disciplinary problems your dog/s has had or is having?	Chasing/injuring game Yes	-2
	Chasing/injuring game No	+1
	Chasing/injuring game Rarely	-1
	Chasing/injuring livestock Yes	-3
	Chasing/injuring livestock No	+3
	Chasing/injuring livestock Rarely	-2
	Not staying with the livestock Yes	-2
	Not staying with the livestock No	+1
	Not staying with the livestock Rarely	-1
	Others	Done on an add hoc basis
	Unsure	0
Q29. Can your dog be handled by people?	Yes	+1
	By herder/farmworker only	+2
	No	-1
Q30. Does your dog/s protect its livestock from predators and thieves?	Yes	+1
	No	-1
	Unsure	0
Q31. How does your dog/s react to a predator?	Chase, Bark, Attack, Bluff attack, Herds the livestock	+1 each
	Ignores	-2
Q32. How does your dog/s react towards human intruders?	Chase, Bark, Attack, Bluff attack, Herds the livestock	+1 each
	Ignores	-1
Q33. Does your dog/s keep the livestock together in a tight group?	Never	-1
	All the time	+2
	Most of the time	+1
	Only when threatened	+1
	Unsure	0
Q34. Does your dog/s display herding tendencies more than guarding?	Yes (herding)	-1
	No (guarding)	+1
	Both equally	+2
	Unsure	0
Q35. How many livestock	Livestock losses have reduced (reduced by <10)	+1

per year were you losing to predators prior to getting a dog/s (average); Q36. How many livestock per year have you been losing to predators since getting a dog (average)?	Livestock losses have reduced (reduced by 10-99)	+2
	Livestock losses have reduced (reduced by 100 or more)	+3
	No change in livestock losses	0
	Livestock losses have increased (increased by <10)	-1
	Livestock losses have increased (increased by 10-99)	-2
	Livestock losses have increased (increased by more than 100)	-3
Q40. Do you feel more confident of the safety of your livestock because of having a LSGD?	Yes	+1
	No	-1
	Unsure	0
Q41. Would you recommend LSGDs to other farmers?	Yes	+1
	No	-1
	Unsure	0

MANAGEMENT INDEX		
Q2. Which of these farming techniques do you use?	Guard dogs, herders, donkeys, lambing/calving seasons, maternity kraals, day kraals, night kraals, other	+1
Q47. Do you use other species of livestock guarding animals?	Yes	+1
	No	-1
	Unsure	0
Q13. Do you have a herder accompanying the herds that have dogs?	Yes	+1
	No	-1
Q13b. How many hours of the day is the herder with the dog?	<2hrs	+1
	2-4hrs	+2
	>4-6yrs	+3
	>6yrs	+4
Q13e. How much do you pay your herder?	0P	-2
	<10P/day	-1
	11-20P/day	+1
	21-40P/day	+2
	>41P/day	+3

CONSERVATION INDEX		
Q42. Since getting a LSGD are you more inclined to tolerate predators on your farm?	Yes	+1
	No	-1
	Unsure	0
Q43. Which statement best describes your position on predators?	I have always tolerated predators on my farm	+2
	I am more tolerant of predators on my farm since getting a dog	+2
	I have never and will never tolerate predators on my farm	-2
	I will tolerate predators on my farm so long as I have no livestock losses	+1
	Unsure	0
Q44. Since getting a LSGD are you less likely to use lethal control for predators on your farm?	Yes	+1
	No	-1
	Unsure	0
Q45. Which statement best describes your opinion on lethal control?	I will not use lethal control now I have a LSGD	+2
	I will continue to use lethal control on predators	-2
	I will use lethal control only if I have livestock losses and can confirm the problem animal whilst abiding by DWNP regulations	-1
	I have never used lethal control of predators	+1
	Unsure	0

HERDING INDEX		
Q27. Does your dog/s stay with the herd?	All of the time	+2
	Most of the time	+1
	Occasionally	0
	Never	-2
	Unsure	0
Q31. How does your dog/s react to a predator?	Herds the livestock	+2
	Other answers	0
Q32. How does your dog/s react to a human intruder?	Herds the livestock	+2
	Other answers	0
Q33. Does your dog/s keep the livestock together in a tight group?	Never	-1
	All the time	+2
	Only when threatened	+1
	Unsure	0
Q34. Does your dog/s display herding tendencies	Yes (herding)	+2
	No (guarding)	-1

more than guarding?	Both equally	+1