AFRICAN WILDCATS ON UNPROTECTED LAND IN THE NORTHERN CAPE, SOUTH AFRICA: POTENTIAL PREY AND CONFLICT STATUS

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By
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ABSTRACT

The African wildcat (*Felis lybica cafra*) is the most common and widely distributed of all wildcats. The southern Kalahari in South Africa offers favourable conditions for African wildcats and supports high wildcat densities on protected and unprotected land. African wildcats have been reported as livestock predators on South African farms, however wildcat-livestock predation is usually reported as infrequent and to have a low financial impact on the farmer. The aim of this study was, firstly, to determine what natural prey species were available for African wildcats on unprotected land and, secondly, to determine the extent of human-wildcat conflict on unprotected land in the southern Kalahari. The frequency of occurrence of potential African wildcat prey was determined through small mammal trapping, camera trap surveys and direct observations. The results indicated that a variety of the African wildcat's natural prey species occurred on unprotected land and that the dune and adjacent 'street' habitats most likely supported the majority of small mammals which are preferred prey for African wildcats. The African wildcat's human-predator conflict status was determined through interview questionnaires (n = 22) with participants who owned or managed farms in the southern Kalahari. African wildcats were perceived to occur on 100% of farms, to be common in the region, to be the top livestock predator on 68% of farms and to be responsible for 46% (n = 1542 newborn lambs) of all livestock deaths in 2020. African wildcats were, however, not viewed in the same negative light as black-backed jackals (*Canis mesomelas*) and caracals (*Caracal caracal*), who received more negativity from participants and who had the highest persecution rates in my study area. This result could potentially be explained by a combination of generationally taught hatred towards certain species and due to the perceived livestock loss (e.g. livestock size and species) caused by each predator species. It is important to research and monitor wildcats outside protected areas to obtain a deeper knowledge of wildcat behaviour, abundance, population dynamics and other aspects of their ecology. By doing this, specific conservation and management questions can be addressed and through the knowledge of the natural history of a species, conservation failures can be avoided.

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CHAPTER ONE

GENERAL INTRODUCTION

1.1 Taxonomy

The wildcat (*Felis silvestris*), ancestor of the domestic cat (*F.s. catus*), is thought to have originated from other subspecies of wildcat about 131 000 years ago (Driscoll *et al.*, 2007). It is believed that the first domestication of wildcats occurred in Egypt about 3600 to 4000 years ago (Nowell & Jackson, 1996; Randi *et al.*, 2001; Driscoll *et al.*, 2009). Others have more recently hypothesised that domestication happened in a number of different locations, spawning different breeds (Driscoll *et al.*, 2009). The domestication history and breeding development of domestic cats can be determined through archaeological discoveries, and by genetically accessing their genome sequence variations (Driscoll *et al.*, 2007, 2009). Genetic and archaeological findings suggest that the earliest domestication of wildcats happened together with the establishment of the first human settlements in the Fertile Crescent region of the Middle East (Driscoll *et al.*, 2007, 2009). The earliest domesticated wildcat remains were found in human burial sites, dating back as far as 9500 years ago (Vigne *et al.*, 2004; Wade, 2007; Driscoll *et al.*, 2009).

The deoxyribonucleic acid (DNA) of nearly 1000 domestic cats and wildcats from Africa, Asia and Europe were examined, and wildcats were grouped into five different clusters, or lineages (Driscoll *et al.*, 2009). The results established that the Middle Eastern wildcat (*F.s. lybica*) is the sole ancestor of all domestic cats and the only wildcat to be fully domesticated today (Driscoll *et al.*, 2009). Genetic and archaeological discoveries also suggest that all extant felids stemmed from one of several *Pseudaelurus* species, which inhabited Asia about 11 million years ago (Driscoll *et al.*, 2007; O'brien & Johnson, 2007). More than 38 felid species are grouped worldwide into eight lineages, one being the 'Domestic cat lineage', from which the African wildcat (*F.s. cafra*) stems (Driscoll *et al.*, 2011; Hunter, 2015). Other wild felids in this lineage are the jungle cat (*F. chaus*), black-footed cat (*F. nigripes*), desert cat (*F. margarita*), Chinese desert cat (*F.s. bieti*) and European wildcat (*F.s. silvestris*). *Felis silvestris* is divided into five clusters (Driscoll *et al.*, 2007, 2009); (i) the Middle Eastern wildcat and domestic cat, (ii) the Central Asian wildcat (*F.s. ornata*), (iii) the southern African wildcat (*F.s. cafra*), (iv) the European wildcat (*F.s. silvestris*) and (v) the Chinese mountain cat (*F.s. bieti*). In Africa, the wildcat is represented by two subspecies; *F.s. lybica*, in the north and *F.s. cafra*, in the south (Driscoll *et al.*, 2007). *Felis silvestris cafra* was first named in 1822, and renamed as *Felis lybica cafra* subspecies in 1944, on the basis of a description of a wildcat specimen captured in South Africa from whence sub-Saharan African wildcat samples were found (Driscoll *et al.*, 2007). The most recent phylogenetic work in 2017 resulted in the re-classification of the southern African wildcat subspecies as, *F. lybica cafra,* and those found in eastern and north-western parts of Africa as, *F. lybica lybica*, (see Figure 1.1) (Kitchener *et al.*, 2017).

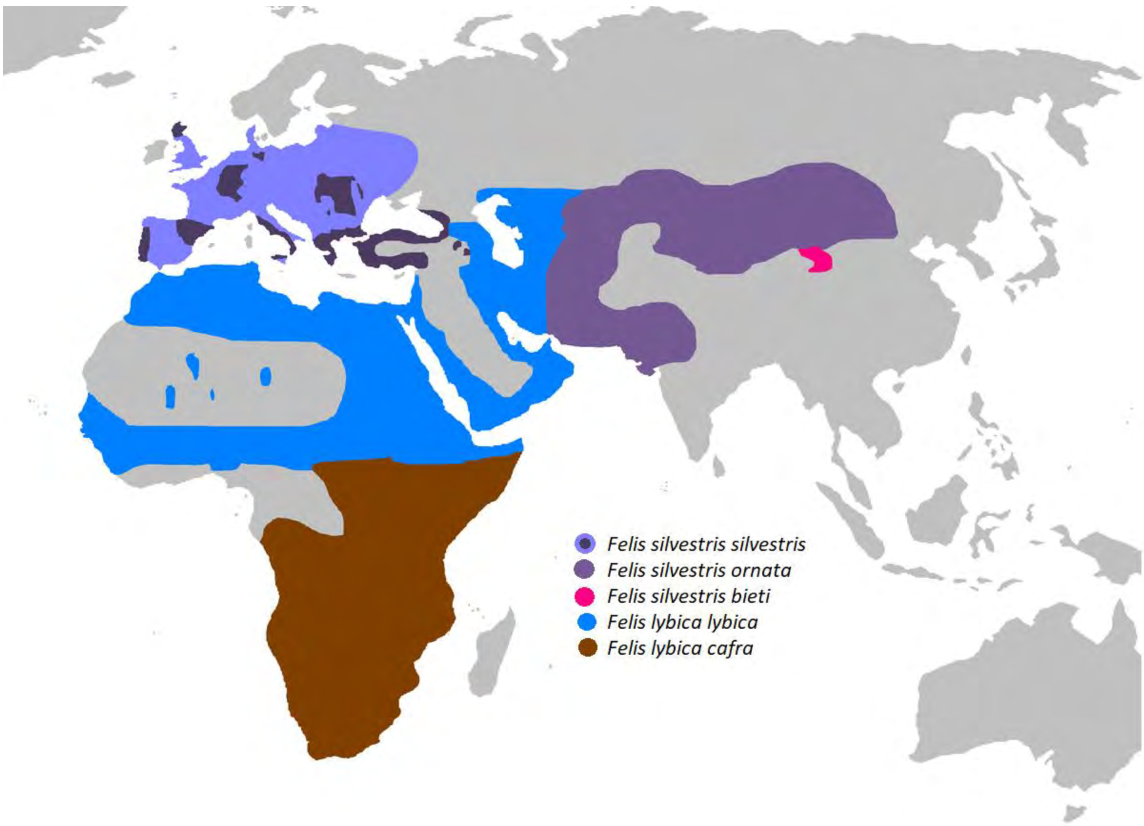

Figure 1.1: Map of world distribution of the five wildcat clans. Retrieved and modified from https://commons.wikimedia.org/wiki/File:Wiki-Felis_sylvestris.png. (The Zoologist. 2009. Wiki-Felis sylvestris.png).

1.2 Description, distribution and reproductions

The southern African wildcat (wildcat from hereon) is a nocturnal felid (Nowell & Jackson, 1996; Herbst, 2009; Stuart & Stuart, 2015; Van den Heever *et al*., 2017; Estes, 1992). It has a similar appearance and size to the common house cat and its ability to hybridize with domestic cats can cause confusion (see Figure 1.2) (Nowell & Jackson, 1996; Driscoll *et al.*, 2011; Le Roux *et al.*, 2015, Stuart & Suart, 2015; Van den Heever *et al*., 2017; Estes, 1992). The distinct reddish-brown colouration at the back of their ears, on their belly and at the back of their hind legs distinguishes them from domestic cats (Nowell & Jackson, 1996; Le Roux *et al.*, 2015). They have vertical stripes on their bodies, which vary from being very distinct to very faint (Nowell & Jackson, 1996; Herbst, 2009; Stuart & Suart, 2015; Van den Heever *et al*., 2017; Estes, 1992) and the undersides of their feet are black (see Figure 1.3) (Nowell & Jackson, 1996). Wildcats have a broad habitat tolerance (Nowell & Jackson, 1996; Yamaguchi *et al.*, 2015) and inhibit diverse habitats such as mountains, plains or grasslands, and brush lands (Nowell & Jackson, 1996; Sunquist & Sunquist, 2002; Yamaguchi *et al.*, 2015). Wildcats typically defend a territory for life (Driscoll *et al.*, 2009).

The various sub-species of African wildcats are distributed across northern Africa, extending around the Arabian Peninsula to the Caspian Sea (Nowell & Jackson, 1996; Driscoll *et al.*, 2007; Yamaguchi *et al.*, 2015). They are also distributed extensively across the west of Africa, eastwards and southwards, where they are present in all south-eastern African countries (Nowell & Jackson, 1996; Yamaguchi *et al.*, 2015). This wide distribution makes them the most common and widely distributed of all the wildcats (Yamaguchi *et al.*, 2015). Wildcat density and distribution is, however, expected to vary with prey availability (Nowell & Jackson, 1996; Herbst & Mills, 2010a), causing them to be absent from true deserts, such as the Namib Desert, coastal and tropical forests (Nowell & Jackson, 1996; Yamaguchi *et al.*, 2015).

Female wildcats have a gestation period of 65 days after which two to five kittens are born amongst dense cover (this includes vegetation, rocks and inside burrows dug by other species) (Herbst, 2009; Stuart & Stuart, 2015). Kittens are born between September and March, with occasional records outside this period (Smithers, 1983; Herbst, 2009). However, no clear seasonal breeding was evident during a study conducted in the Kgalagadi Transfrontier Park (KTP) between 2003 and 2006 (Herbst, 2009). During this period, 15 litters were born with no litters being born during periods when food availability was low

(Herbst, 2009). Climate change can have a dramatic influence on a species whose diet, breeding success and other ecological parameters are determined by small mammal abundance (Smithers, 1983; Avenant & Nel, 1997; Sunquist & Sunquist, 2002; Herbst, 2009; Santos *et al.*, 2017). Wildcats have a solitary nature, except in the mating season and when females rear kittens (Sunquist & Sunquist, 2002; Herbst, 2009; Stuart & Suart, 2015; Van den Heever *et al*., 2017; Estes, 1992).

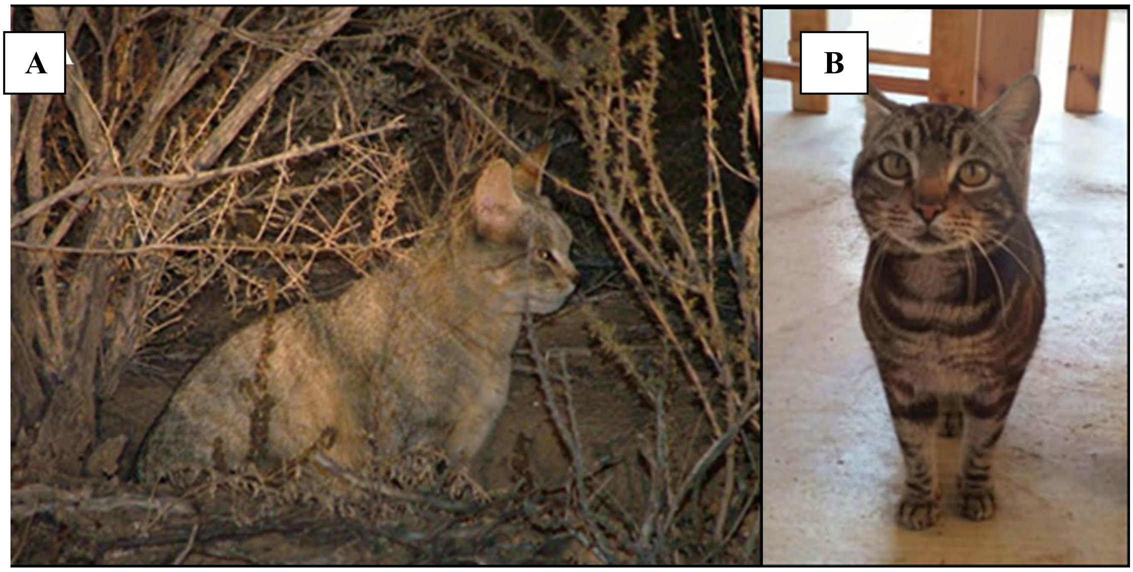

Figure 1.2: Wildcats (A) have a similar appearance to the domestic housecat (B) (Stadler, 2004).

Figure 1.3: Wildcats have a distinct reddish-brown colouration behind their ears and black under their feet (Stadler, 2016).

1.3 Feeding habits and foraging behaviour

Limited information is available on the feeding habits of the wildcat, however, murid rodents are reportedly the most commonly consumed prey (Smithers, 1971; Stuart, 1977; Smithers & Wilson, 1979; Palmer & Fairall, 1988; Herbst & Mills, 2010a; Stuart & Suart, 2015; Van den Heever *et al*., 2017; Estes, 1992). The wildcat is an opportunistic ambush hunter and depending on prey availability, may select species other than rodents (Smithers, 1971; Herbst, 2009; Estes, 1992). A two-year drought period in Botswana (1962 – 1965) caused murid populations to plummet to unprecedentedly low levels, which resulted in the contents of 16 wildcat stomachs to consist of invertebrates, fruit and birds (Smithers, 1971). A study conducted on the seasonal diet change of feral domestic cats on Juan de Nova Island, Mozambique Channel, showed a dramatic change in diet, shifting from insects, rats and mice, to primarily Sooty Terns (*Onychoprion fuscatus nubilosus*), when the birds' breeding season started (Peck *et al*., 2008). An average of 22% of surplus Sooty Terns were killed, but not eaten, each day, illustrating the cats' opportunistic nature (Peck *et al*., 2008). Similar to the caracal (*Caracal caracal*) and the black-backed jackal (*Canis mesomelas*), the wildcat predates predominantly on rodents (the largest being springhares (*Pedetes capensis*)), hares, small mammals, birds (up to the size of Guineafowl (*Numida meleagris*)), reptiles, amphibians, insects and other invertebrates (Stuart & Stuart, 2015; Van den Heever *et al*., 2017; Estes, 1992). Plant material also regularly occurs in wildcat diets with up to 42% frequency of occurrence of plant matter in wildcat scats in the KTP (Herbst & Mills, 2010a). Insects made up 40% of the wildcat's diet in the Karoo National Park (KNP), of which 50% were coleopterans (Palmer & Fairall, 1988). Another study in the KNP concluded that from 11 wildcat scats, all contained rodents and seven had coleoptera present (Palmer & Fairall, 1988). In Zimbabwe, red rock rabbit (*Pronolagus rupestris*), elephant shrew (*Elephantulus myurus*) (unusual prey for small carnivores) and either Sharpe's grysbok (*Raphicerus sharpei*) or steenbok (*R. campestris*) were found amongst wildcat prey items (Smithers & Wilson, 1979).

The Kalahari ecosystem experiences droughts which occur frequently in biennial and/or twenty-year patterns (Goodall, Evenari & Noy-Meir, 1986). This climate not only affects the rodent populations, but also overall prey availability for wildcats (Herbst & Mills, 2010a). As seasonal changes influence prey abundance and diversity, wildcats adapt their diet and foraging behaviour (Herbst & Mills, 2010a). A study on wildcats in the KTP concluded that the total biomass of the wildcats' diet was; 73% rodents, 10% birds, 9% large mammals (500

- 2000 g), 6% reptiles and 2% invertebrates (Herbst & Mills, 2010a). The highest capture success rates for both sexes however were with invertebrates and reptiles, but these contributed less to the total biomass (Herbst & Mills, 2010a). Invertebrates were primarily eaten when rodent numbers were low during the drought, and included; lace wings (*Neuroptera*), locusts (*Orthoptera*), moths (*Lepidoptera*) and scorpions (Scorpionidae) (Herbst & Mills, 2010a). Barking geckos (*Ptenopus garrulous*) were observed to be the most consumed reptile (Herbst & Mills, 2010a). Overall, rodents, reptiles and invertebrates had the highest percentage of occurrence in wildcat diets in the KTP (Herbst & Mills, 2010a).

Male wildcats are significantly larger than females (the average male weighing 4.9 kg and female, 3.7 kg) (Skinner & Smithers, 1990). Although both predominantly prey on small rodents, males tend to select larger mammals (e.g. scrub hares (*Lepus saxatilis*) (Estes, 1992), whereas females tend to favour reptiles and birds (Herbst & Mills, 2010a). Wildcat hunting expeditions observed by Herbst (2009) showed that males only managed a 33% large mammal (> 500 g) capture success rate, mostly due to hares outrunning them. Females pursued only one out of 16 observed hunting attempts on hares and did not catch anything larger than 500 – 2000 g (Herbst, 2009). It was estimated that a wildcat weighing 4 – 5 kg, needs a 1000 g food intake per day (Carbone *et al.*, 1999; Malo *et al.*, 2004). Therefore, one hare (ca. 1500 g) exceeds the cat's daily energetic requirements, by providing the equivalent amount of energy of nearly 20 rodents (Herbst, 2009).

Wildcats appear to have a higher tolerance for human-modified habitats and seem to benefit from the higher rodent numbers, often associated with farming practices (Nowell & Jackson, 1996; Estes, 1992). Accounts from farmers, claiming livestock losses due to wildcats consuming newborn lambs (*Ovis aries*) have been recorded for decades (Palmer & Fairall, 1988; Nowell & Jackson, 1996; Blaum, Tietjen & Rossmanith, 2009; Todd *et al.*, 2009). The resultant culling of wildcats and other problem predators is a common practice across South Africa (Balme, Slotow & Hunter, 2009; Blaum *et al.*, 2009; Herbst, 2009; Todd *et al.*, 2009; Chapman & Balme, 2010; Kerley, Wilson & Balfour, 2018). The absence of such predators on farmlands can sometimes cause an increase in wildcat numbers and could have a negative effect on certain prey species (Herbst, 2009).

1.4 The wildcat's conservation status, ecological role and role in human-wildlife conflict

The wildcat is listed as 'Least Concern' by the International Union for Conservation of Nature (IUCN) (Yamaguchi *et al.*, 2015). The ecological status and density estimations of wildcats are poorly known as these are frequently estimated from incomplete or unverified data (Nowell & Jackson, 1996; Estes, 1992). Previous research efforts have focused on the wildcat's diet, through scat analyses, small prey capture and opportunistic observations (Smithers, 1971; Smithers & Wilson, 1979; Palmer & Fairall, 1988; Herbst & Mills, 2010a) and on their genetics (Herbst, 2009; Le Roux *et al.*, 2015).

Small to medium sized predators play a key role in ecosystem dynamics and species diversity of both animals and plants (Gutiérrez *et al.*, 1997; Rogers & Caro, 1998; Crooks & Soulé, 1999; Karki, Gese & Klavetter, 2007). For example, wildcats prey on insects and rodents that may become pests on arid and semi-arid rangelands (Stenseth *et al.*, 2003). Recent studies found that although small and medium sized carnivores are often abundant in the arid savanna rangelands of the southern Kalahari, livestock grazing-induced changes in landscape structure are causing a local decline (Blaum *et al.*, 2009).

Currently, wildcats are threatened by habitat destruction, persecution and road kills (see Figure 1.4), but the biggest threat is their ability to interbreed with domestic cats and produce fertile offspring (Nowell & Jackson, 1996; Herbst, 2009; Driscoll *et al.*, 2011; Herbst *et al.*, 2016; Estes, 1992). Wildcats are also preyed upon by caracals (Grobler, 1981; Bothma & Le Riche, 1994; Melville, Bothma & Mills, 2004) and black-backed jackals (Nicoli *et al.*, 2017). The behaviour of one predator killing and eating a competitor species is a common occurrence in nature and is known as asymmetrical intraguild predation (Polis, Myers & Holt, 1989).

Figure 1.4: A wildcat killed by a tourist vehicle in the KTP in 2004 (Stadler, 2004).

Human-wildlife conflict is one of the biggest threats facing wildlife species today (Dickman, 2010). Predators, in particular, are a major problem for livestock farmers in South Africa (Beinart, 2004). Human-wildlife conflict affects over 75% of the world's felid species, with the severity increasing with felid body mass (Inskip & Zimmermann, 2009). Nevertheless, wildcats are often persecuted by farmers who maintain that they cause significant losses, mostly to sheep lambs (see Figure 1.5) (Palmer & Fairall, 1988; Nowell & Jackson, 1996; Blaum *et al.*, 2009; Todd *et al.*, 2009; Yamaguchi *et al.*, 2015). The Kalahari offers favourable conditions that hosts high wildcat densities and is known to have a high persecution rate (Herbst, 2009).

Human-carnivore conflict typically stems from competition between humans and carnivores over limited recourses (Treves & Karanth, 2003; Graham, Beckerman & Thirgood, 2005). Such resources include space and prey species valued by humans with economic, nutritional and recreational value (Treves & Karanth, 2003; Graham *et al.*, 2005; Woodroffe *et al.*, 2007; Inskip & Zimmermann, 2009). Due to their large home ranges, which increasingly overlap with human-occupied areas and the human depletion of carnivores' natural prey species (Graham *et al.*, 2005; Gusset *et al.*, 2009), carnivores often prey upon game and livestock

(Nowell & Jackson, 1996; Treves & Karanth, 2003; Blaum *et al.*, 2009; Todd *et al.*, 2009). The culling of problem predators, such as black-backed jackals and caracals to control numbers on livestock farms has been a common practice since the colonization of southern Africa, where along with jackals, wildcat skins were traded for rewards in 1814 (Beinart, 1998). Predator management on farms has since continued to remain a popular practice as the government, in cooperation with livestock farmers, continue to use lethal and non-lethal predator management programs to manage predation on mainly sheep and goat (*Capra hircus*) farms (Bergman *et al.*, 2013).

Figure 1.5: Dorper lambs, allegedly killed by wildcats on a farm in my study area (Stadler, 2016).

A mesopredator can be defined as any mid-ranking predator in the food web, regardless of its size or taxonomy (Prugh *et al.*, 2009). Thus, a mesopredator in one ecosystem may be an apex predator in another, and one ecosystem may have several mesopredators (Roemer, Gompper & Van Valkenburgh, 2009). Mesopredators are generally more successful than apex predators because they occur at higher densities and have greater resilience towards lethal control efforts (Prugh *et al.*, 2009). The removal of competing predators such as black-backed jackals and caracals on farmland, could benefit smaller predators, such as wildcats, as a high density of mesocarnivore competition results in harassment, pirating of kills and intraguild predation (Herbst, 2009). Examples of mesopredators worldwide are; coyotes

(*Canis latrans*) who function as the mesopredators in the Yellowstone ecosystem where wolves (*Canis lupus*) had been reintroduced (Berger & Conner, 2008), but have been promoted to the role of apex predator in other areas of the United States where larger predators have been exterminated (Crooks & Soulé, 1999; Roemer *et al.*, 2009). Similarly, feral cats' function as mesopredators in many continental ecosystems (Crooks & Soulé, 1999), but function as apex predators on many islands (Rayner *et al.*, 2007; Bergstrom *et al.*, 2009). Mesopredator release is caused when predators of intermediate body size are more prevalent in the absence of larger carnivores (Soule *et al.*, 1988; Brashares, Prugh & Epps, 1999). Although several studies found no evidence of apex predator decline resulting in mesopredator release (e.g., (Wright, Gompper & DeLeon, 1994; Gehrt & Prange, 2006), the negative effects of mesopredator release have been documented for birds, sea turtles, lizards, rodents, marsupials, rabbits, fish, scallops, insects, and ungulates throughout the world (Brashares *et al.*, 1999). Numerous studies have highlighted the consequences following 'problem mesopredator control', by unleashing a new problem, such as a new mesopredator (Prugh *et al.*, 2009). For example, the lethal control of raccoons (*Procyon lotor*) in Florida, USA (United States of America), to protect sea turtle eggs, resulted in an increase in one of its prey species, the ghost crab (*Ocypode quadrata*), which also consumes sea turtle eggs (Barton, 2005). Similarly, olive baboons (*Papio anubis*) increased in regions of sub-Saharan Africa, where lions (*Panthera leo*) and leopards (*Panthera pardus*) had been decimated (Brashares *et al.*, 1999). This increase in baboon numbers led to excessive predation and decline in ungulate populations and crop raiding by baboon troops (Brashares *et al.*, 1999).

The impact of lethal predator control on small carnivores in the southern Kalahari remains unclear (Blaum *et al.*, 2009). A recent study conducted on 12 species of small and medium sized predators in the southern Kalahari found that lethal predator control and high stocking rates were the main determinants of predator abundance and species richness (Blaum *et al.*, 2009). Wildcats and caracals were negatively affected by persecution, which in turn decreased intraguild predation, resulting in small spotted-genets (*Genetta genetta*), Cape foxes (*Vulpes chama*) and bat-eared foxes (*Otocyon megalotis*) to increase (Blaum *et al.*, 2009). This might result in the release of new mesopredators and may affect the abundance and diversity of their prey (Courchamp, Langlais & Sugihara, 1999; Crooks & Soulé, 1999; Schmidt, 2003), but see Gehrtand & Clark (2003) for conflicting results. Similarly, the removal of apex predators such as lions, leopards, cheetahs (*Acinonyx jubatus*) and spotted hyenas (*Crocuta crocuta*) on southern Kalahari farmlands (Herbst, 2009), could have a cascading effect on prey and smaller predator populations (Estes, 1996; Ripple & Beschta, 2004; Herbst, 2009; Prugh *et al.*, 2009; Chapman & Balme, 2010). For instance, the role of wildcats could change from being a subordinate predator to an apex predator (Herbst, 2009).

1.5 Purpose of this study

The motive for this study began in December 2012, when anecdotal conversations with farmers in the southern Kalahari indicated that the top, and most persecuted predator, of livestock on farms appeared to be wildcats, as they are believed to kill newborn lambs, causing financial distress (Du Toit, A., Rossauw, J. & Knoetze, H., pers. com., 23 December 2012). A questionnaire distributed by Blaum *et al*. (2009) amongst 22 farms in the southern Kalahari, concluded that most farm managers perceived small to medium sized carnivores, in particular wildcats, black-backed jackals and caracals as the most damage causing predators to livestock in the region. Although lethal predator control presumably reduced the numbers of the three species, the wildcat was still the most abundant carnivore across farms (including most commonly observed tracks found), and black-backed jackals and caracals were the least common species and were locally absent on farms which practiced lethal predator control (Blaum *et al.*, 2009). Wildcats are partially protected in the Northern Cape under PHASA (Professional Hunters' Association of South African) and are legally allowed to be hunted by registered permit holders (*Northern Cape Provincial Gazette Extraordinary, 19 December 2012.*, 2013).

Numerous studies have been conducted on caracals (Bothma & Le Riche, 1994; Avenant & Nel, 1998, 2002; Melville *et al.*, 2004; Blaum *et al.*, 2009; Braczkowski *et al.*, 2012) and black-backed jackals (Downs *et al.*, 1991; Beinart, 1998; Blaum *et al.*, 2009; Do Linh San *et al.*, 2009; Brassine, 2011; Bergman *et al.*, 2013; Nicoli *et al.*, 2017), which are widely recorded as top predators on livestock farms in South Africa (Brassine, 2011; Thorn *et al.*, 2012; Bergman *et al.*, 2013). Some studies have recorded wildcats as livestock predators on unprotected land (Palmer & Fairall, 1988; Nowell & Jackson, 1996; Blaum *et al.*, 2009; Todd *et al.*, 2009), however, the majority of wildcat studies have focused on the wildcat's natural diet on protected land (Bothma, 1966; Palmer & Fairall, 1988; Herbst & Mills, 2010a) and wildcat genetics (Herbst, 2009; Le Roux *et al.*, 2015). To my knowledge, no studies have been conducted on the diet and relative abundance of wildcats and their prey, on unprotected land (Herbst, 2009), or on the role that wildcats play as livestock predators. It is important to research wildcats' behavioural patterns and feeding ecology outside protected areas, as the majority of natural history studies have been conducted within protected areas (Herbst, 2009; Estes, 1992).

Due to the difficulty of studying the behaviour of small, nocturnal and elusive animals, there is a general lack of knowledge on the natural history of small felids (Nowell & Jackson, 1996). A study combining the findings of human-felid conflict worldwide concluded that the wildcat has low human conflict, but also noted that documentation on these cats is limited (Inskip & Zimmermann, 2009). The wildcat's solitary nature, nocturnal status and the fact that they give birth to multiple offspring (Herbst, 2009; Stuart & Stuart, 2015; Estes, 1992) have ensured their successful existence (Herbst, 2009). Its adaptability allows it to be a generalist and opportunistic hunter, changing diet according to prey availability (Herbst, 2009; Estes, 1992). Due to farmers reporting high wildcat persecution rates in my study area, assumptions could be made that wildcat densities are high on the unprotected land surrounding the KTP, although this needs to be investigated.

This study aimed to firstly, determine what natural prey are available for wildcats on unprotected land in the southern Kalahari and how this may differ to protected land (e.g. KTP). Secondly, this study aimed to determine farmer attitudes towards 'conflict predators', and in particular towards wildcats on their farms, by means of questionnaire interviews. The study area is made up of 22 participating farms (207124 ha) in the southern Kalahari, between KTP and Upington (with one farm near Groblershoop). The main study site represented a 44000 ha farm in the southern Kalahari, where the wildcat dietary data was collected through camera trap stations (i.e. identify water-dependant prey species and wildcat presence), small mammal trapping (i.e. identify rodents) and personal observations.

CHAPTER TWO
STUDY AREA

2.1 Location

The Kalahari ecosystem expands diagonally across southern to central Africa and consists of the largest continuous stretch of sand in the world (Van Rooyen, 2001). The south-western Kalahari remains relatively unspoilt (Van Rooyen & Van Rooyen, 1998) and hosts the largest conservation area within the Kalahari ecosystem, the Kgalagadi Transfrontier Park (KTP), which is united across South Africa and Botswana (Van Rooyen, 2001).

My study area consists of livestock farms, which are mostly situated along dry riverbeds, south of the KTP, on the South African side and along the Botswana border fence. Some farms stretch along the R360, towards Upington and along the predominantly dry Molopo and Kuruman Rivers (see Figure 2.1). A total of 22 livestock farms partook in this study by completing interview questionnaires. A game farm can be defined as adequately fenced land with a variety of game (wildlife), which can be used for hunting, meat production, photographic opportunities, environmental education, live game sales, and ecotourism (Van der Merwe & Saayman, 2005). Game are therefore kept for both, consumptive and non-consumptive purposes (Van der Merwe & Saayman, 2005). Only one participating farm falls outside the main study area on the N10, outside Groblershoop, which still falls under the Kalahari belt. The selected farms all raise sheep (*Ovis aries*) and/or goats (*Capra hircus*) and cattle (*Bos taurus*) and most generate a financial income from game hunting in the winter season. Large and medium sized antelope occur on the majority of the farms (i.e., springbok (*Antidorcas marsupialis*), gemsbok (*Oryx gazella*), steenbok (*Raphicerus campestris*) and common duiker (*Sylvicapra grimmia*)). The main study site (44000 ha), where personal observations, camera trapping and small mammal trapping were conducted, is situated along the Molopo River (GPS: S27°06’59.3” E20°29’52.7”) (see Chapter 3).

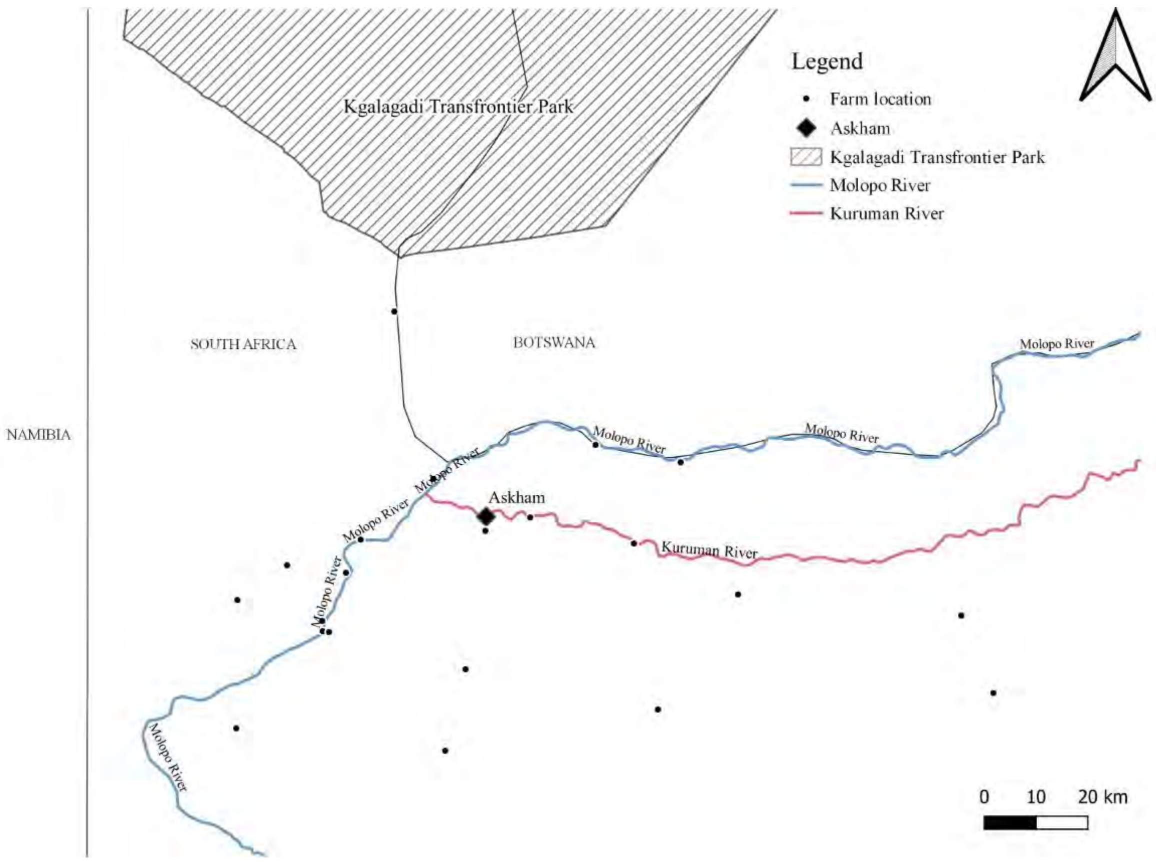

Figure 2.1: Map of the study area in the southern Kalahari, indicating the location of participating farms and the Kgalagadi Transfrontier Park (excluding the farm near Groblershoop).

2.2 Climate

2.2.1 Rainfall

The Kalahari-duneveld experiences summer rainfall (wettest months are generally between January and April) with the average annual rainfall varying from 150 mm in the south-west to 350 mm in the north-eastern region (Van Rooyen, 2001). The rainfall in this area is precarious and can vary from a mere 100 mm to as much as 700 mm per year (Van Rooyen, 2001). It is said that an area which receives less than 255 mm of rain per year should be considered desert (Mills & Haagner, 1989). During droughts little to no rain falls and that which does fall, evaporates rapidly (Goodall *et al.*, 1986). The rainfall recorded for the study site and study area between 2013 and 2020 was very low as a result of a continuous drought (see Figure 2.2 and 2.3 respectively). Rainfall and temperature data were obtained from the Molopo weather station (GPS: S28°16’31.909” E20°23’36.544”).

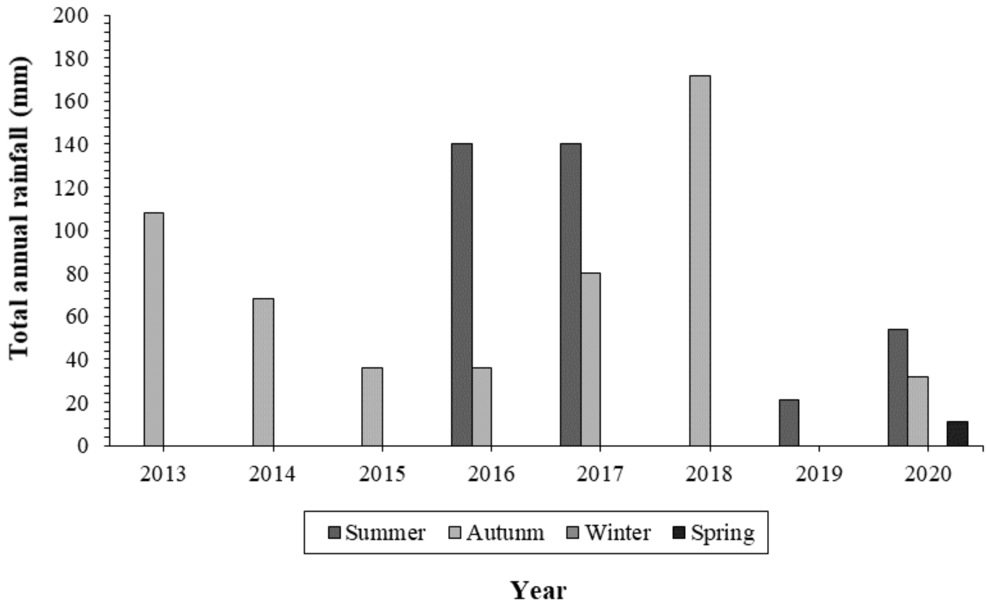

Figure 2.2: Total annual rainfall recorded on the study site between 2013 and 2020.

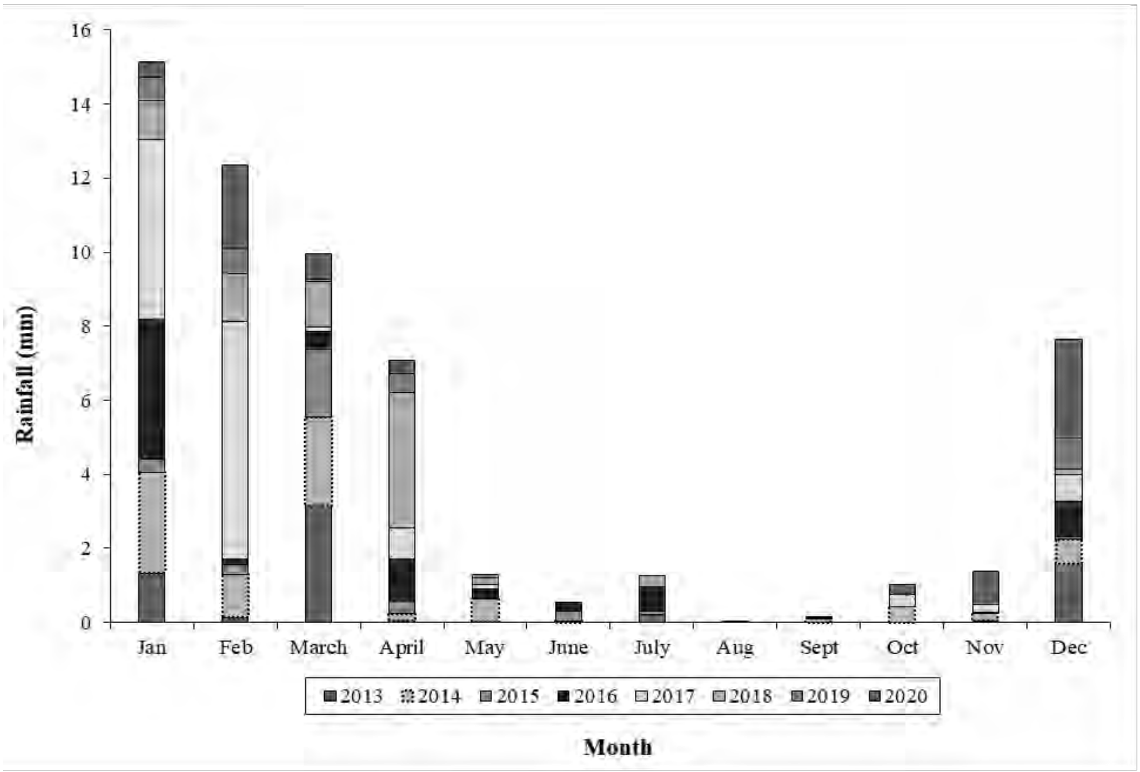

Figure 2.3: Mean annual rainfall for the study area between 2013 and 2020). Data supplied by: Johan van den Berg, MSc Agric (Agricultural Meteorology, University of the Free State). Data Source: Agricultural Research Council, Institute for Soil, Climate and Water, Pretoria.

2.2.2 Temperature

With maximum temperatures of 45 ºC or higher in the summer and winter minimums as low as -10.3 ºC (Van Rooyen, 2001), the Kalahari is a place of extremes. The highest temperature recorded on my study site between 2013 and 2018 (via camera traps) was 53 ºC and the lowest was -3 ºC (see Table 2.1). See Figure 2.4 for the average monthly temperature data obtained for my study area, between 2013 and 2020.

Table 2.1: The highest and lowest temperatures (ºC) recorded by camera traps on the study site (2013 and 2018).

		Season		
	June - Aug	**Sept - Nov**	**Dec - Feb**	**March - May**
Temperature (ºC)	Winter	Spring	Summer	Autumn
Highest	49	38	53	48
Lowest	-3	10	5	16

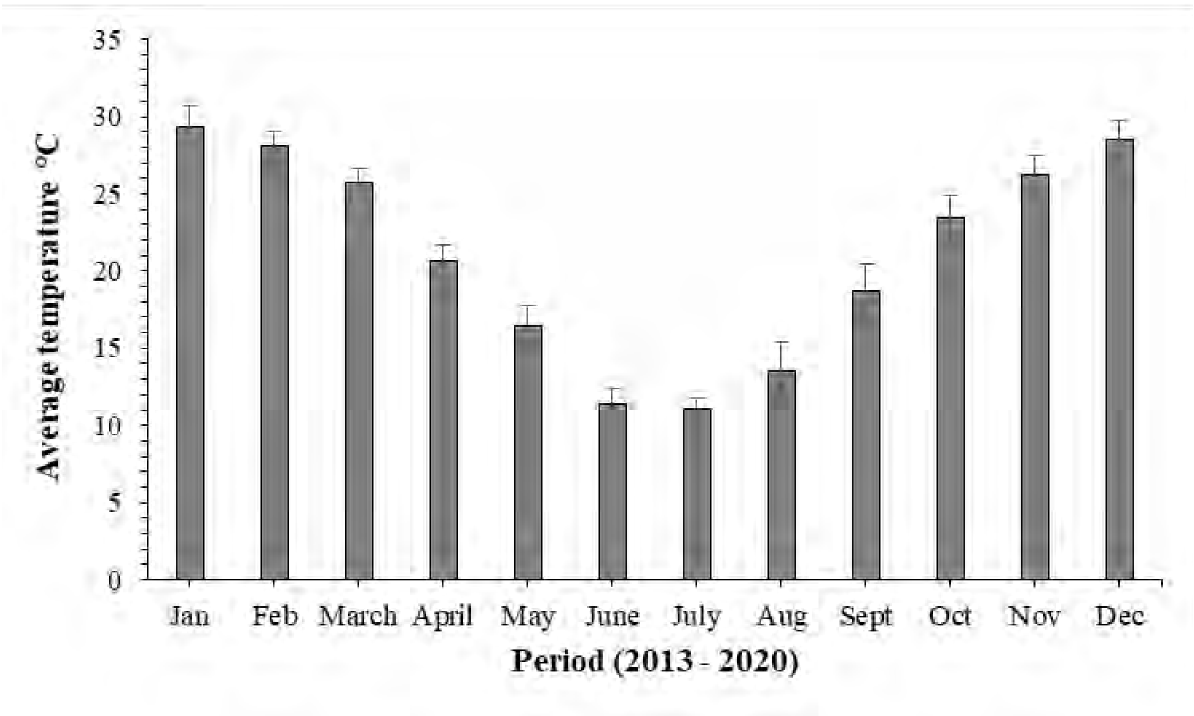

Figure 2.4: Average monthly temperatures recorded for the study area (2013 - 2020). Data supplied by: Johan van den Berg, MSc Agric (Agricultural Meteorology, University of the Free State). Data Source: Agricultural Research Council, Institute for Soil, Climate and Water, Pretoria.

2.3 Geology

The floor rocks of the Kalahari Group are only known through the drilling of boreholes, starting in the 1960's and consists of the Karoo Sequence with its associated intrusions of dolerite (Malherbe, 1984). The Kalahari consists of the following formations (Malherbe, 1984); Wessels Formation (clayey gravel), Budin Formation (clay), Eden Formation (sandstone, grit and conglomerate), Mokalanen Formation (calcrete), Gordonia Formation (sand), Lonely Formation (clayey diatomaceous limestone) and the Goeboe Goeboe Formation (consists of clay and sand in the pans and rivers) (Malherbe, 1984).

The south-western Kalahari sands display two distinct surfaces (Van Rooyen, 2001). In the extreme west and south-west of the Kalahari the sands pile up to form a belt of dunes 800 km long and 100 - 200 km wide, which is called the southern Kalahari (Van Rooyen, 2001). Eastwards, from the dry Nossob riverbed into Botswana, the dunes are less conspicuous and the country is rather flat (Van Rooyen, 2001). The entire area's altitude varies between 900 m and 1100 m (Van Rooyen, 2001). The north-western direction of the long parallel dunes indicates the strong winds from which they originated (Van der Walt & Le Riche, 1999).

2.4 Vegetation

Vegetation plays a vital role in the Kalahari ecosystem and is totally dependent on rainfall (Mills & Haagner, 1989). The southern Kalahari gets its semi-desert status due to the vegetation it supports, which is shrub savanna, or plains with widely scattered trees (Mills & Haagner, 1989). One of the seven Kalahari vegetation types described by Mills and Haagner (1989) is Shrubby Kalahari Dune Bushveld, which consists of gently undulating dunes with scattered pans and this covers most of the Kalahari Gemsbok National Park (old Botswana side) and the Gordonia area south of the KTP (study area). The southern Kalahari vegetation also consists of Gordonia Bushveld and Auob Duneveld, an open scrubland with a low scrub cover and a well-developed tree layer (Mucina & Rutherford, 2006).

African wildcats (*Felis lybica cafra*) on surrounding farmland, including the main study site (see Figure 2.5), typically occupy similar habitats as that found in the KTP, therefore, my study area was divided into the same four main habitats (Herbst, 2009); (1) dry riverbeds, (2) *Rhigozum trichotomum* scrub veld ("streets"), (3) adjacent dune areas, and (4) calcrete banks and limestone plains (see Figure 2.5 and 2.6).

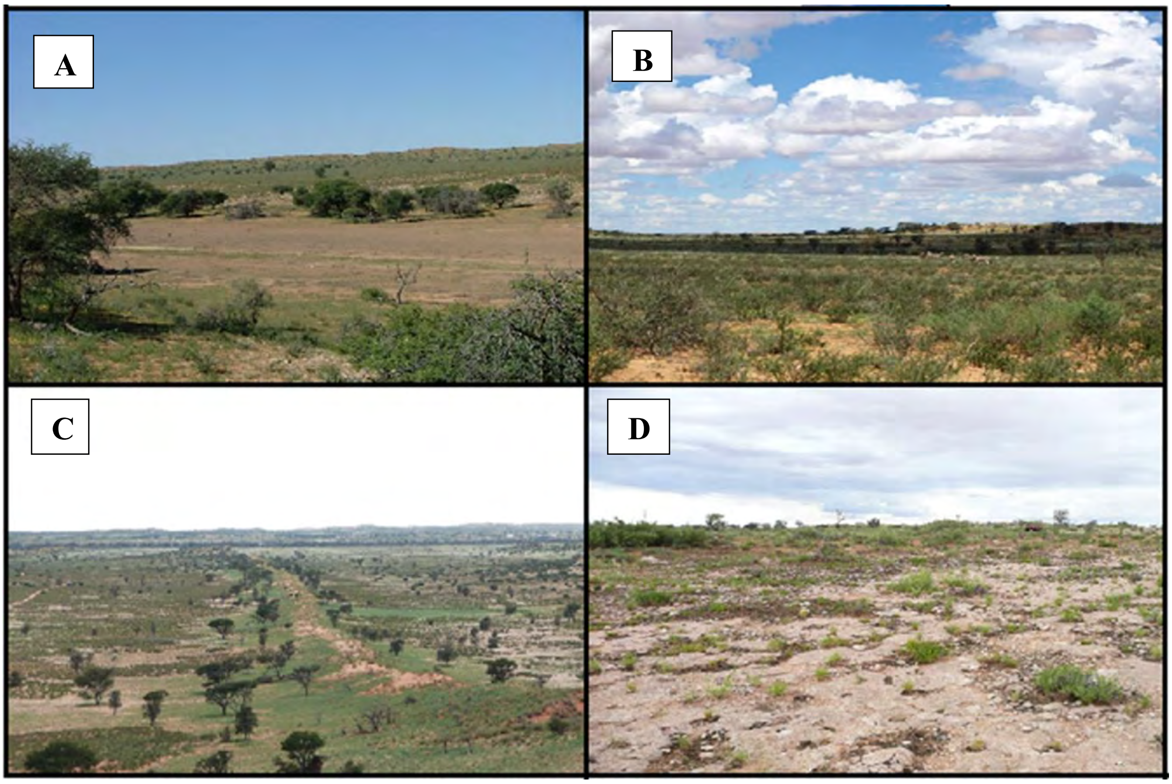

Figure 2.5: The four main habitats in the study area: (A) dry riverbeds, (B) *Rhigozum trichotomum* scrub veld (“streets”), (C) adjacent dune areas, (D) calcrete sides and limestone plains (Stadler, 2004).

There are two dry riverbeds within the study area, the Kuruman and the Molopo (Van Rooyen, 2001). These rivers are predominantly dry, with short lived seasonal pools forming with rain and play an important role in the ecosystem (Van Rooyen, 2001). Dry fossil riverbeds are characterized by large camel thorn trees (*Vachellia erioloba*), smaller gray camelthorn trees (*V. haematoxylon*), bushy blackthorn (*V. mellifera*), the scrub, *Galenia africana* and perennial grasses (Herbst, 2009). Alongside the dry riverbeds are limestone plains, characterized by scattered camel thorn trees and dominated by dense dwarf shrub, such as drie doring (*R. trichotomum*), blou ganna (*Monechma incanum*) and *Aptosimum albomarginatum*. Grasses such as short bushman grass (*Stipagrostis obtusa*), Kalahari sour grass (*Schmidtia kalahariensis*), tall bushman grass (*Stipagrostis ciliata*) and silky bushman grass (*S. uniplumis*) also occur in this habitat (Herbst, 2009). The long parallel sand dunes are set with fixed vegetation (Mucina & Rutherford, 2006). This loose sand dune habitat is dominated by tall perennial grasses, such as *S. amabilis*, *Eragrostis trichophora* and *E. lehmanniana*, whereas dune areas host dominant scrub species such as, dune bush (*Crotalaria spartioides*), lucern bush (*Hermannia tomentosa*) and gemsbok cucumber (*Acanthosicyos* *naudinianus*) (Herbst, 2009). Camelthorn, grey camelthorn and shepard's trees (*Boscia albitrunca*) are also present (Herbst, 2009).

Figure 2.6: The main study site represents the four main habitat types as described by Herbst (2009).

CHAPTER THREE
NATURAL PREY AVAILABILITY

3.1 Introduction

Southern African wildcats (*Felis lybica cafra;* hereafter wildcat) are not protected over most of it's range and very few density estimates are available (Nowell & Jackson, 1996). Small carnivores in South Africa remain poorly studied (Bergman *et al.*, 2013; Du Plessis, Avenant & De Waal, 2015; Kelly, 2018), resulting in their management being based on assumptions, individual experiences and word of mouth (Avenant & Du Plessis, 2008; Kelly, 2018). In addition, the majority of small mammal studies are short-term, only covering one or two generations of local small mammals, which could skew long-term estimates of ecosystem processes, such as the dispersal of seeds (Chapman *et al.*, 2018). Long-term studies are often not logistically or financially possible and the lack of proper research could result in unreliable data being used to make management decisions on natural species management (Karanth & Chellam, 2009). Studies have been conducted on wildcat ecology (Herbst & Mills, 2010a) and genetic interbreeding with domestic cats (*Felis silvestris catus*), in and around protected areas, such as the Kgalagadi Transfrontier Park (KTP) and the Kruger National Park (Herbst, 2009; Le Roux *et al.*, 2015). However, no field study has been published on the ecology and behaviour of wildcats on unprotected land (Herbst, 2009). From both a conservation and scientific viewpoint, it is important to understand the basic biology, ecological role and social system of wildcats in unprotected ecosystems (Caro & Durant, 1994; Komdeur & Deerenberg, 1997).

The wildcat is a common, small, nocturnal felid with an exceptional ability to adapt to most natural environments (Palmer & Fairall, 1988; Herbst & Mills, 2010a; Stuart & Suart, 2015; Van den Heever *et al*., 2017; Estes, 1992). The southern Kalahari offers favourable conditions for the species and supports high wildcat densities (Blaum *et al.*, 2009; Herbst, 2009). Given the extreme environmental conditions of the southern Kalahari, wildcats often find cover under isolated stands of *Vachellia* scrub, *Galenia africana* and dense vegetation, or in the branches of camelthorn trees (*V. erioloba*) (Herbst, 2009). If adequate cover is not available, wildcats will use holes dug by aardvarks (*Orycteropus afer*), under the roots of trees, in rocky areas or crevices (Herbst, 2009; Stuart & Suart, 2015; Van den Heever *et al*., 2017; Estes, 1992).

Wildcat densities and home ranges may vary widely between individuals and regions, and according to prey availability (Nowell & Jackson, 1996; Herbst & Mills, 2010a). Male wildcats in the KTP occupied significantly larger annual home ranges than females (Minimum Convex Polygon (MCP) 95%, male = 7.7 ± 3.5 km^2 and female = 3.5 ± 1.0 km^2) (Herbst, 2009; Estes, 1992). Females showed an extensive overlap of home ranges, however the core areas were mostly exclusive. By contrast, male-male overlap was limited and showed no overlap of core areas (Herbst, 2009; Estes, 1992). There appears to be no difference in seasonal ranges between male and female wildcats and thus seasonal ranges dependent on food availability (Herbst, 2009). Urine spray marking and aggression is prominent with the territorial behaviour of male wildcats, while females only spray mark to advertise their reproductive status (Herbst, 2009; Van den Heever *et al*., 2017; Estes, 1992). In all instances where females increased urine spray marking in the KTP, kittens were born within three months (Herbst, 2009).

Despite sexual dimorphism, male and female wildcats show little differences in activity budgets, and both sexes exhibit a two peak activity period with a clear seasonal shift, from being predominantly nocturnal during the hotter seasons, to more diurnal activity in the colder seasons (Herbst, 2009). The two main factors influencing wildcat activity patterns and habitat preference appear to be prey abundances and temperature extremes (Herbst & Mills, 2010a). Wildcats in the KTP spent most of their time foraging (68%) and resting (26%), with little time spent on social activities (3%) (Herbst, 2009). Wildcats are solitary hunters and their prey are primarily located visually, followed by the use of auditory and olfactory senses (Herbst, 2009; Van den Heever *et al*., 2017). Wildcats display very little social behaviour, except for the short periods (2 – 4 months) when females rear kittens, or during the brief mating periods, when males trail receptive females (1 – 2 days) (Herbst, 2009; Stuart & Suart, 2015; Van den Heever *et al*., 2017).

Limited information is available on the feeding habits of wildcats, however murid rodents are reportedly the most commonly consumed prey (Smithers, 1971; Stuart, 1977; Smithers & Wilson, 1979; Palmer & Fairall, 1988; Herbst & Mills, 2010a; Stuart & Suart, 2015; Van den Heever *et al*., 2017; Estes, 1992). Male wildcats hunt larger mammals (< 4500 g), whereas females will focus more on birds and reptiles, after rodents (Herbst & Mills, 2010a; Stuart & Suart, 2015; Van den Heever *et al.*, 2017; Estes, 1992). The five main food categories that were consumed by wildcats in the KTP, were murid rodents (small mammals (< 500 g)), larger mammals (e.g. scrub hare (*Lepus saxatilis*)), birds, reptiles and invertebrates (Herbst & Mills, 2010a). The most recent wildcat study found that nearly all aspects of the wildcat's behavioural ecology are affected by the southern Kalahari's extreme climate, causing longer lean seasons (hot and dry, with below average rainfall) and abundant periods (wet and dry), which influence rodent abundances and, in turn, wildcat prey availability (Herbst, 2009; Herbst & Mills, 2010a). Lean seasons in the KTP were characterized by a high wildcat food-niche breadth and a high species rich diet (Herbst, 2009). Wildcats switched their diet from rodents, in wet seasons, to birds and reptiles, in lean seasons, and back to rodents when their preferred prey species abundance increased with good rains (Herbst, 2009). This switching indicates the wildcat's adaptable nature as a generalist, opportunistic feeder (Herbst & Mills, 2010a).

Small mammal availability is typically measured using live trapping (Dieckmann, 1979; Nel *et al.*, 1984; Avenant & Nel, 1998; Bergström, 2004; Melville *et al.*, 2004; Nicolas & Colyn, 2006; Herbst & Mills, 2010b). Sherman traps are a widely used and successful method for live trapping and determining small mammal presence (Dieckmann, 1979; Nel *et al.*, 1984; Avenant & Nel, 1998; Nicolas & Colyn, 2006). They are more selective and humane than snap traps, non-lethal (if capture conditions are ideal), can capture small mammals with extra-long tails and allow for a wider variety of data to be collected (Barnett & Dutton, 1995). Small mammal abundance cannot be accurately estimated with Sherman traps, as the exact number of animals depends on the density of small mammals across the sampling site, food availability, capture season, how close the capture date is to the full moon period, the abundance of cover and weather conditions (Smithers, 1983; Nel *et al.*, 1984; Barnett & Dutton, 1995; Avenant & Nel, 1997; Sunquist & Sunquist, 2002; Herbst, 2009; Santos *et al.*, 2017; Stryjek, Kalinowski & Parsons, 2019). Nevertheless, live trapping of small mammals remains one of the more appropriate techniques for determining the species present and their approximate abundances in a given ecosystem.

One of the ways to determine the availability of other (larger) wildcat prey items is to use passive, infra-red camera traps (Keiter *et al.*, 2020; Smith *et al.*, 2020). Camera trapping surveys are a popular method for wildlife monitoring (see Balme, Slotow & Hunter, 2009;

Ancrenaz *et al.*, 2012; Mann, 2014; Keiter *et al.*, 2020; Smith *et al.*, 2020) and offer numerous advantages compared to traditional (live-capture) monitoring methods, as they are less labour-intensive and time consuming and less invasive (Ancrenaz *et al.*, 2012). Camera trap surveys also allow for the monitoring of rare, secretive and nocturnal species (Ancrenaz *et al.*, 2012).

An important, initial step in understanding the feeding ecology of any predator is determining the availability of potential prey species (Ghoddousi *et al.*, 2016; Santos *et al.*, 2019). In the case of wildcats, the prey items are small mammals and, to a lesser extent, birds, reptiles and invertebrates (Herbst & Mills, 2010a). The aim of this chapter was, therefore, to generate an inventory of the natural prey available to wildcats on unprotected land in the southern Kalahari. To my knowledge, this is the first time that such an assessment has been undertaken. It also represents an important initial step in understanding one of the potential drivers of human-wildcat conflict in the region.

3.2 Methods

I collected data on the natural prey availability at my study site (see Chapter 2) using three approaches; small mammal live trapping, camera trap surveys and direct observations of mammals and birds. Previous research has demonstrated that employing a combination of techniques to triangulate overall prey availability in a given area is more effective than using a single technique (Jansen, 2016; Lee & Turner, 2016; Spencer, Newsome & Dickman, 2017).

3.2.1 Small mammal trapping

I conducted small mammal trapping on the main study site (GPS: S27°06’59.3” E20°52.7”), in the same four habitat types used by Herbst (2009) (see Figure 3.2). For the sake of my data analysis, the four habitats (see description in Chapter 2) were referred to as dry riverbeds (riverbeds), *Rhigozum trichotomum* scrub veld (streets), adjacent dune areas (dunes) and calcrete banks and limestone plains (calcrete). The four habitat types are commonly found, transitioning from one habitat type into the next, which made the checking of the traps less time consuming (see Figure 3.1).

Figure 3.1: The main habitat types of my study site in the southern Kalahari are commonly found adjacent to one another e.g. (A) dry riverbeds with calcrete banks and (B) alternating dunes and streets (Stadler, 2019).

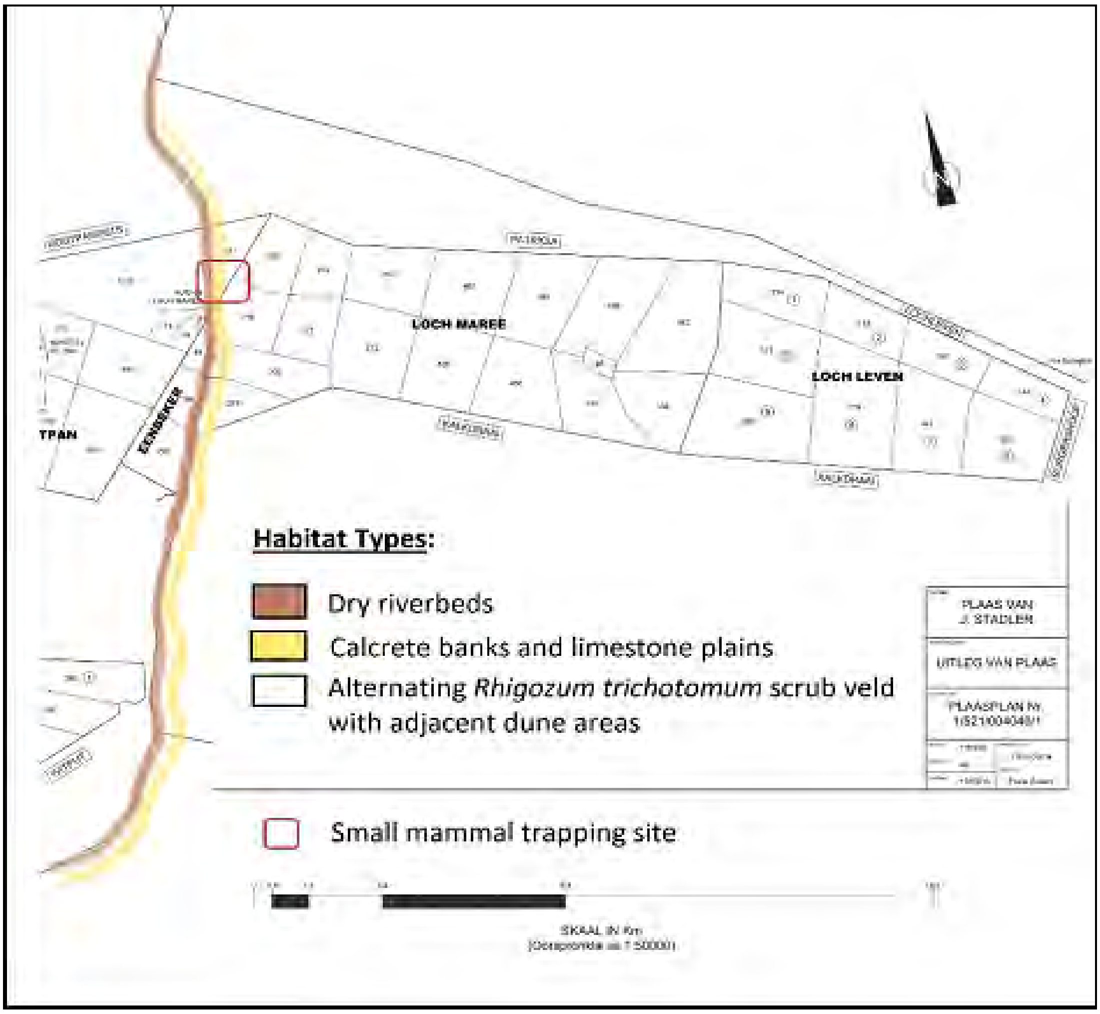

Figure 3.2: Map of my study site located in the southern Kalahari along with the small mammal trapping site.

Small mammal trapping was conducted in September 2020 (start of the hot-dry season), when the differential night and day temperatures were not as extreme as they are at other times of the year (see Chapter 2). The average temperatures recorded during the trapping period were between 11 ºC at night and 27 ºC during the day. This sampling period minimized the chances of specimens perishing in the traps from cold nights or hot mornings (Jennings & Gunther, 2015). I chose a 'once-off' sampling approach to trap small mammals ahead of a seasonal/repeat sampling regime for two reasons. Firstly, from an ethical perspective, I wanted to minimize the potential stress on any captured small mammals in such an extreme environment (Sikes, 2016). Secondly, sampling in the remote southern Kalahari is logistically challenging and I was only able to visit the study area once to undertake the sampling. A total of 144 Sherman traps (7.5 x 9 x 23 cm) were used over five days of sampling, resulting in a total of 720 trap nights. According to Barnett and Dutton (1995), 200 trap nights (no. traps x no. nights) is a good minimum sample size. Each habitat type consisted of three transects, 100 m apart (Gurnell & Flowerdew, 1990), each containing 12 Sherman traps, spaced 5 m apart (i.e. along 60 m transects) (see Figure 3.3). The traps were labeled and set up following the recommendations of Barnett and Dutton (1995). Sampling plots and transects were initially measured and plotted out, and closed traps placed two days before the first capture night. Traps were placed either under the natural cover of a shrub (within one meter from the transect line), or were covered with grass cuttings from the surrounding area to prevent exposure to the sun.

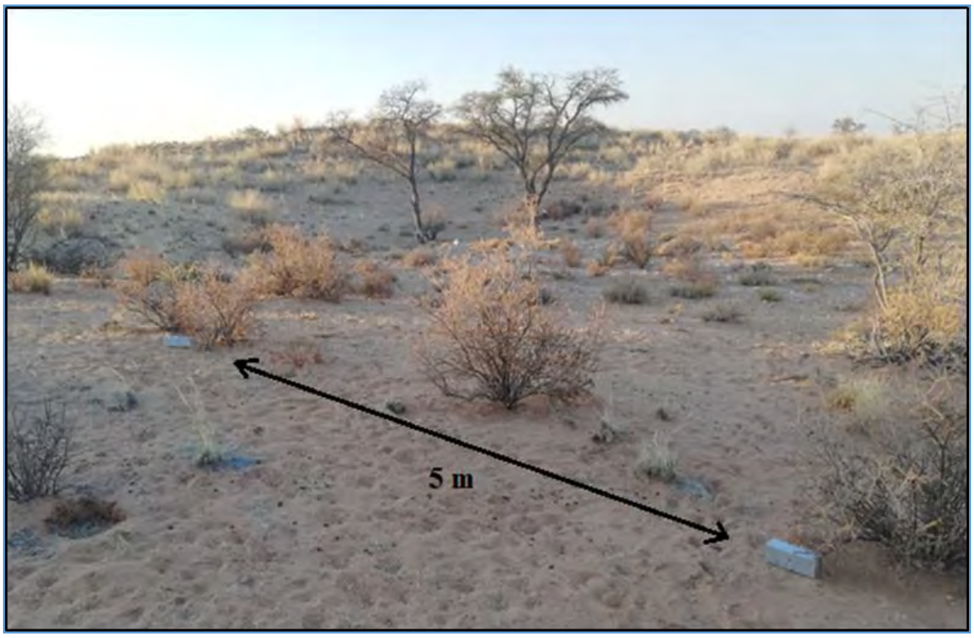

Figure 3.3: Sherman traps were placed 5 m apart and under natural cover, where possible (Stadler, 2020).

On the afternoon of the first capture night, traps were baited with peanut butter and oat balls (Barnett & Dutton, 1995; Shonfield *et al.*, 2013). Pure sheep (*Ovis aries*) wool was placed at the back of each trap to prevent hypothermia of captured small mammals (see Figure 3.4). Traps were set two hours before sunset (5 PM) and checked at sunrise (6 AM). Traps were closed during the heat of the day to prevent any trap mortalities (Nicolas & Colyn, 2006; Whittington-Jones, 2006; Herbst & Mills, 2010a). Ethical clearance for the small mammal trapping was obtained through the Rhodes University Animal Research Ethics Committee (RU-AREC) (Approval number: 2020-1577-4648).

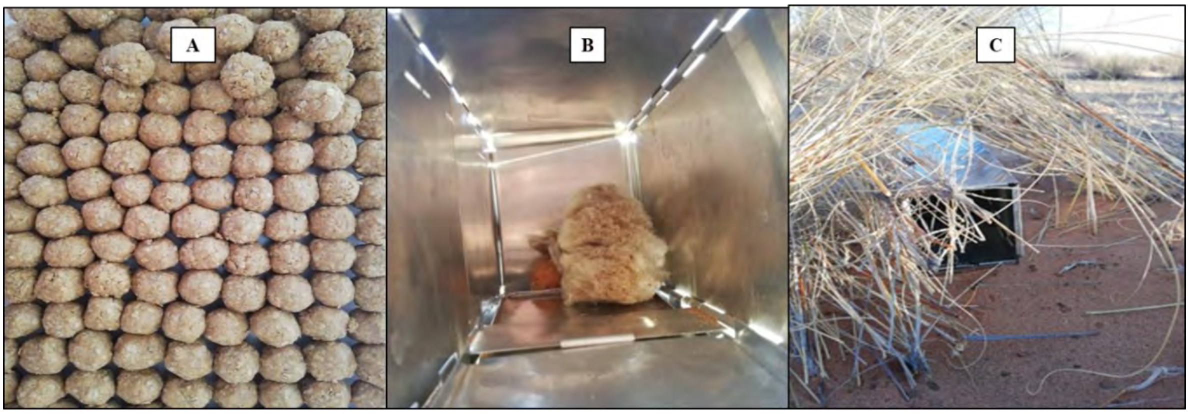

Figure 3.4: Peanut butter and oats balls (A) and (B) natural wool bedding was placed at the back of a Sherman trap, and (C) natural grass cover was provided for traps which were placed in the open (Stadler, 2020).

Traps were initially checked by myself and three field assistants (one per transect line), to make sure that the process was conducted quickly and efficiently. After the third day, there was only need for one field assistant, as the capture success rate for the previous days was low. Captured specimens were placed in a pre-weighed glass jar with holes in the lid, to assist in field identification and weighing. After weighing, each specimen was sexed, body measurements were taken and the specimen marked for reidentification purposes (hair clippings). A datasheet was completed for each of the captured specimens, recording the following information; date, trap number, habitat type, species identification (to species level), sex, basic standard body measurements (weight (g)), length of tail and total length (tip of nose to tip of tail (cm)) (Barnett & Dutton, 1995). The animals were released next to the nearest bush or burrow at their capture sites (see Figure 3.5).

Figure 3.5: After data were collected from the captured specimens, they were released at their capture site (Stadler, 2020).

3.2.2 Statistical analysis

Statistical analyses were conducted using RStudio (RStudio Team, 2020) and guided by the methods of Magige (2016) and Nyirenda *et al*. (2020). To determine trap success (number of animals caught per 100 trap nights), the index of relative abundance was used (Stanley, Goodman & Hutterer, 1996; Barnett *et al.*, 2002; Magige, 2016). This was calculated using the formula; *Trap success (TS%) = Tc / Tn * 100*, where *Tc* = Total catch = the total number of animals of species *i* caught, and *Tn* = Trap nights = a product of the number of traps used and trapping effort (Magige, 2016). Trapping effort = number of trapping nights, where a trap that was activated for a 24-hour period, from sunset to sunrise was referred to as a trap night (Magige, 2016).

The Sørensen Coefficient (CCs) was used to determine the similarity of small mammal species between the four habitats (Magige, 2016), using the formula, *CCs = 2c/ (S1+S2)*, where *S1* and *S2* are the number of species in habitat 1 and habitat 2, respectively and where

C is the number of species shared by the two sites (Magige, 2016). The similarity index (CCs) ranges from 0 (when no species are found in both sites) to 1 (when all species are found in both sites) (Magige, 2016).

Lastly, I used single factor ANOVA with multiple comparisons to determine the differences between the means of the small mammal abundance obtained between paired habitats (Nyirenda *et al.*, 2020). The "TurkeyHSD" package was used in RStudio with a confidence level set at 0.99.

3.2.3 Camera trap surveys and direct observations

Camera trap surveys were conducted during routine farm management practices by the farm managers on the study site. The farm managers were briefed on the preferred set-up and management of the camera traps and trap stations, however farm managers had full control of the placement of the camera traps during the data collection. Camera trapping was conducted at 25 stations on the main study site between August 2015 and July 2018 (see Figure 3.6). Two Sniper SN1012 camera traps were rotated between the trap stations on the study site at the same time of day during the data collection period. The cameras were active for an average of 13.2 days per trapping station for a total of 370 trap nights. In 2015, nine camera stations, totaling 59 trap nights was sampled. In 2016, 11 camera stations, totaling 100 trap nights were sampled. In 2017, seven camera stations, totaling 107 trap nights were sampled. In 2018, one camera station, totaling 104 trap nights were sampled. The cameras were placed at artificial waterholes in various sheep camps and covered three of the four main habitat types (excluding riverbeds, where no livestock are kept). I aimed to capture water dependent wildlife that could be identified as potential wildcat prey and to get a general idea of the medium to large mammal species richness of the study site. I also aimed to see if there were any wildcats present. Due to the nature of the farm operations, systematic data collection was not possible and this precluded any robust statistical analyses of the camera trapping data. Any mammal (see Figure 3.12 and Appendix 1) or avian species (see Appendix 2) that was not introduced to the study site for the purpose of farming or hunting, was identified and recorded as being "present" during the time that the trap station was active. Therefore, irrespective of how long a camera station was active, if a species was captured on camera, it was recorded as being "present", no matter how many times it was captured on that camera during that trapping period. The frequency of occurrence for each species was then calculated by summing the number of camera trap stations where a species had been captured, divided by the total number of camera trap stations (25), multiplied by 100. For example, if a species was recorded at 11 out of the 25 camera trap stations, it would have a frequency of occurrence of 44%. The frequency of occurrence for each bird species was not calculated, but added to a bird list for the study site.

General bird and wildlife species lists were also compiled through direct observations during field work on the study site (2013 – 2020) and I aimed to supplement the data collected via camera traps. The observed species or positive identification of species, by means of e.g. dung, tracks or burrows on the study site, were recorded and marked as ‘present’ on the study site. I aimed to compare the bird and other species that occur the study site with those found in the KTP. I further aimed to get an indication of the study site’s wildlife diversity and to identify potential wildcat prey species on the study site.

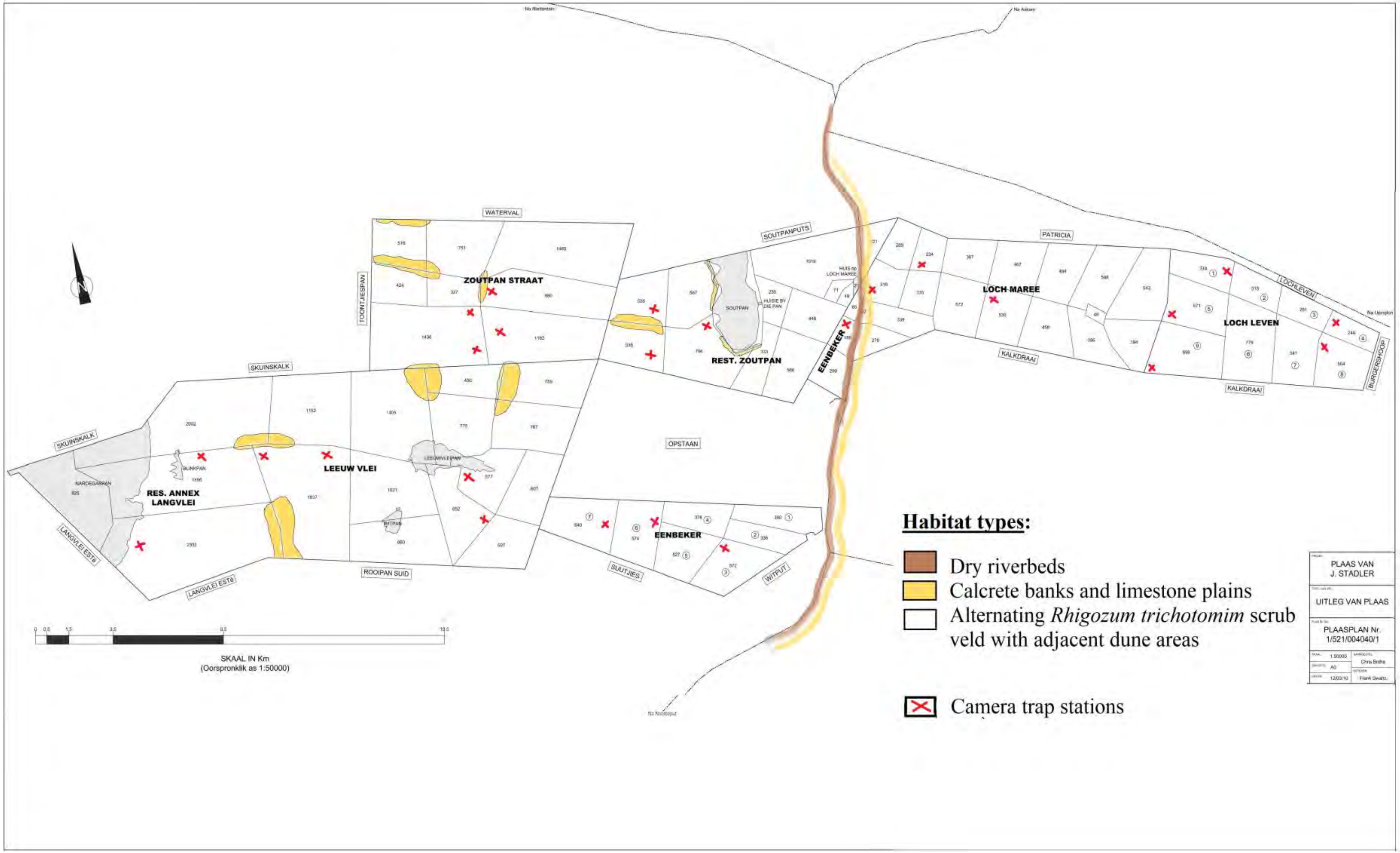

Figure 3.6: Map of camera trap stations (n = 25) on the study site (August 2015 – June 2018).

3.3 Results

3.3.1 Small mammal trapping

A total of 20 individual small mammals were trapped on the study site, comprising four species, namely, pygmy hairy-footed gerbil (*Gerbillurus paeba*) (n = 9), Namaqua rock mouse (*Micaelamys namaquensis*) (n = 3), four-striped grass mouse (*Rhabdomys pumilio*) (n = 7) and a bushveld sengi (*Elephantulus intufi*) (see Figure 3.7). Basic ecological data for the four species is presented in Table 3.1.

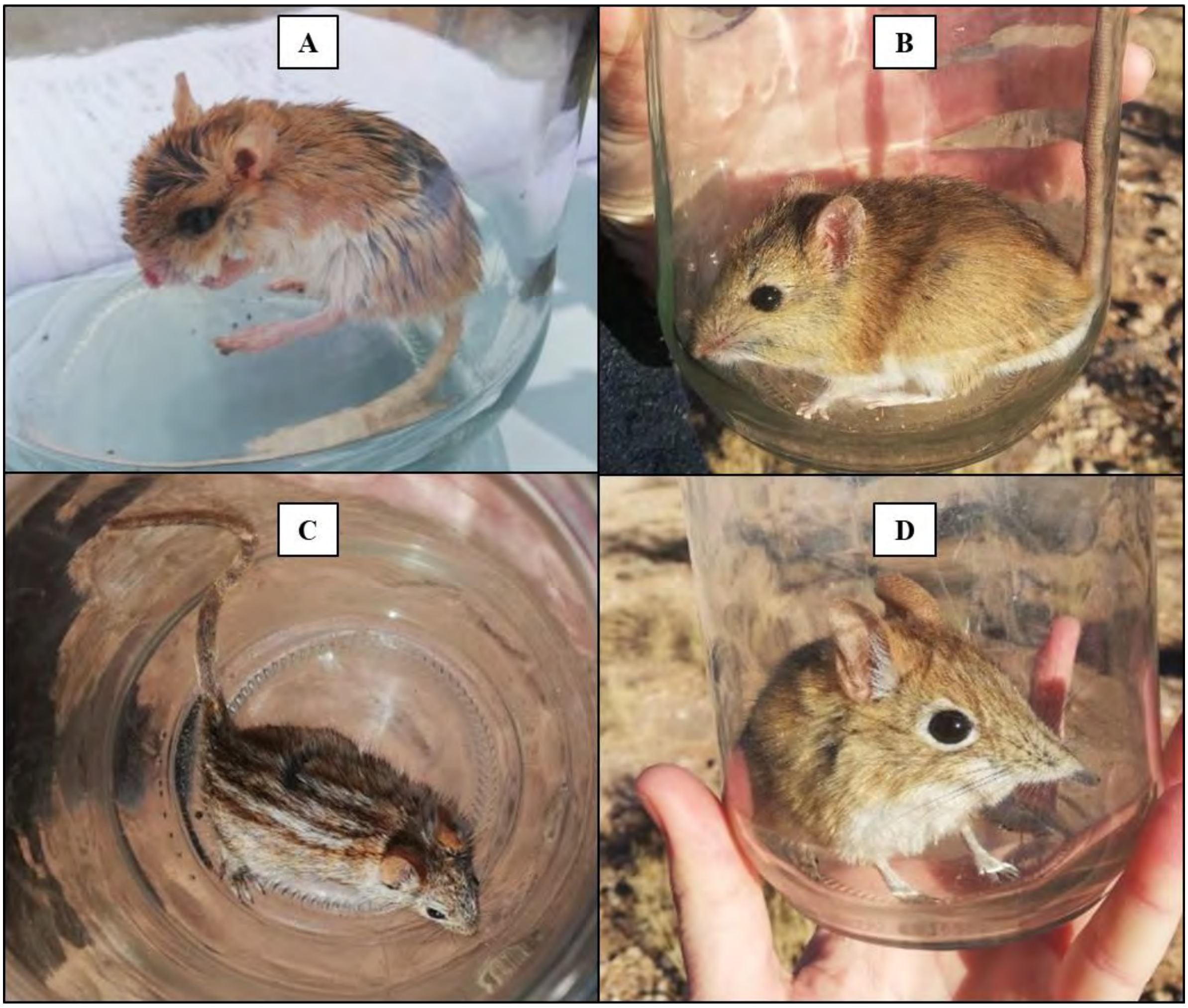

Figure 3.7: The four small mammal species captured were, (A) pygmy hairy-footed gerbil, (B) Namaqua rock mouse, (C) four-striped grass mouse and (D) a bushveld sengi (Stadler, 2020).

Table 3.1: A summary of the four species of small mammals that were captured on the study site, indicating their preferred habitat type, number of young, activity period and whether they are solitary or social (Stuart & Stuart, 2015).

	Pygmy hairy-footed gerbil	Namaqua rock mouse	Four-striped field mouse	Bushveld sengi
Preferred habitat	Sandy soil	Rocky	Sandy soil	Rocky
Number of young	2 – 5	3 – 5	2 - 9	1 - 3
Activity period	Nocturnal	Nocturnal	Diurnal and crepuscular	Diurnal
Social status	Social	Social	Social	Solitary

Pygmy hairy-footed gerbils were more abundant in the streets (n = 6), a third of the total number captured were on the sides of dunes (n = 3). A similar, and opposite apparent habitat preference was found for four-striped grass mice, where five of the seven individuals were captured on dunes and the remaining in adjacent streets. Three Namaqua rock mice and a single bushveld sengi were captured on the calcrete banks (see Figure 3.8). Overall, most small mammals were captured in the dunes (n = 8) and streets (n = 8), followed by the calcrete banks (n = 4). No small mammals were captured in the dry riverbeds, even though rodent tracks were observed, and the three transects in the riverbed varied substantially in ground cover (ranging from, densely populated grassy areas, to very bare soil with little vegetation) (see Figure 3.9).

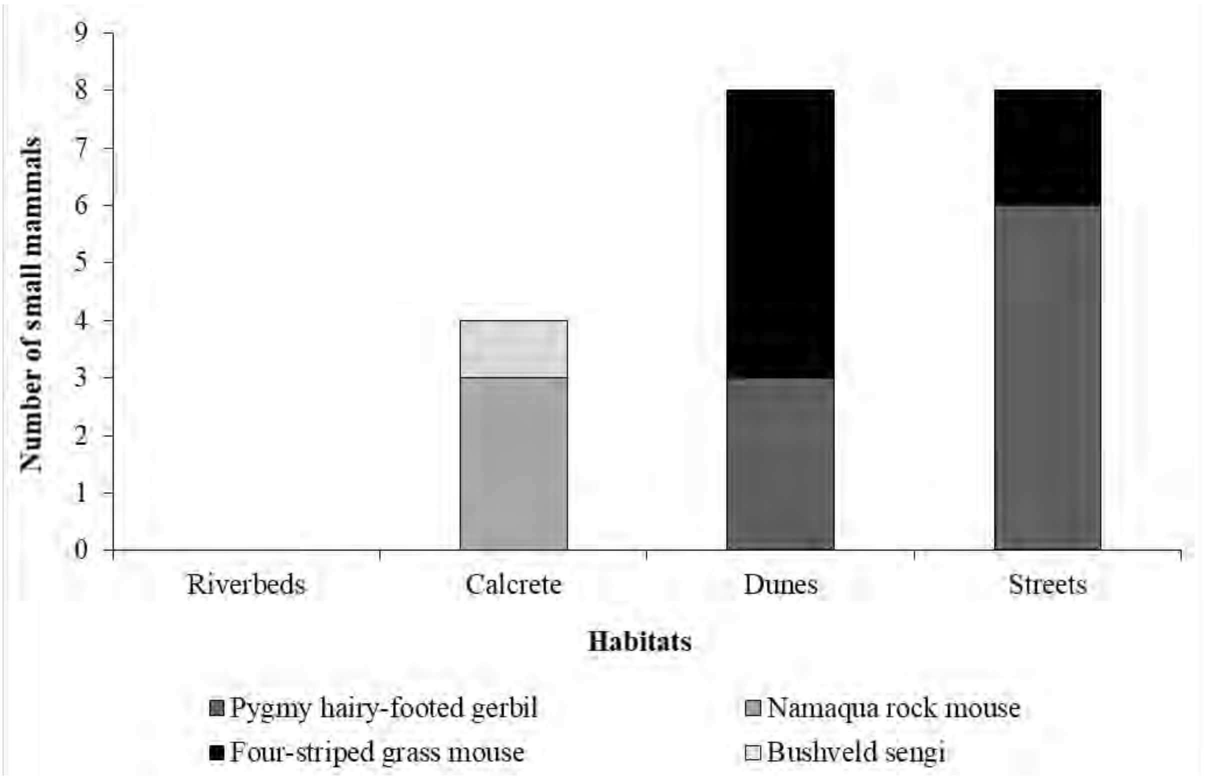

Figure 3.8: Graph depicting the number of small mammals caught in the four habitat types of my study site in the southern Kalahari.

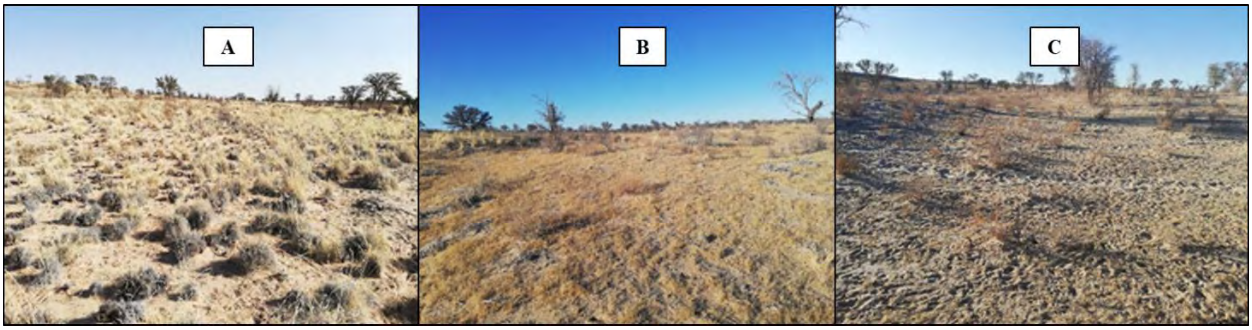

Figure 3.9: The transects in dry riverbeds differed from, (A) sandy with tall grass, close to the calcrete banks, (B) to medium height grass with a few *Rhigozum* shrubs lower down the riverbed, (C) and mostly bare ground with a mixture of clay and sandy soil, hosting hardly any grass and more three-thorn shrubs (Stadler, 2020).

3.3.2 Statistical analysis

The results from statistical analysis indicated a 25% relative abundance for bushveld sengi and 75%, for Namaqua rock mice on the calcrete banks. Four-striped grass mice had a relative abundance of 62.5% on the dunes and 25% in adjacent streets. Pygmy hairy-footed gerbils showed the opposite, with 37.5% on dunes and 75% in streets. No significant difference was found between the means of the small mammal capture data, when the four habitats were tested using an ANOVA ($F_{(3, 11)} = 0.91$; $P > 0.05$). The results did, however indicate that calcrete, dunes and streets had high within-group variance and high among-group variance (see Figure 3.10).

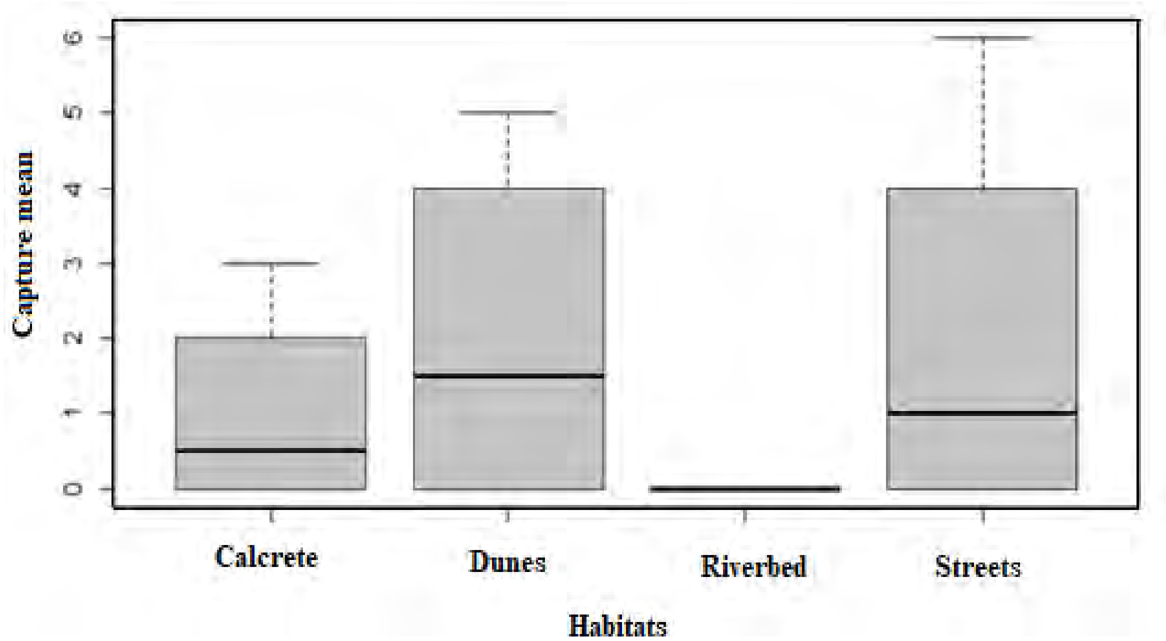

Figure 3.10: Box plot with standard top error bars, representing the standard errors, based on the means of the number of small mammals captured in each habitat. The box plots indicate the maximum, median line and minimum values of the data set, with the first quartile below and the third quartile above the median line, and a top error bar.

When the small mammal capture data were paired between habitats and tested with the Tukey multiple comparisons of means test ($P > 0.99$), the results indicated further insignificant relationships between the capture values (see Table 3.2).

Table 3.2: Table indicating the difference in means (diff), lower (lwr) and upper (upr) error values and adjusted P-values (p adj) for the small mammal capture data between paired habitats.

Paired habitats	diff	lwr	upr	p adj
Dunes-Streets	1	-4.5	6.5	0.89
Riverbed-Calcrete	-1	-6.5	4.5	0.89
Streets-Calcrete	1	-4.5	6.5	0.89
Riverbed-Dunes	-2	-7.5	3.5	0.51
Streets-Dunes	4.44×10^{-16}	-5.5	5.5	1
Streets-Riverbed	2	-3.5	7.5	0.51

The results from the similarity index (CCs) yielded the following results; dunes and streets (CCs = 1), followed by dunes and calcrete, dunes and riverbeds, and streets and calcrete, which all scored CCs = 0. The results therefore indicate that dune and adjacent street habitats had the closest similarity scores. Thus, the dunes and streets had the strongest relationship with respect to small mammal species similarity.

3.3.3 Camera trap surveys and direct observations

The wildlife species identified on camera traps varied across the survey stations. Most waterholes recorded one or more nocturnal species frequenting the station. The frequency of occurrence (%) for each of the species identified on cameras is listed in Figure 3.11. Small antelope, such as common duikers (*Sylvicapra grimmia*) and steenbok (*Raphicerus campestris*) were observed at the waterholes. Cape foxes (*Vulpes chamai*) were more common than bat-eared foxes (*Otocyon megalotis*), but both were frequent visitors to the camera stations. Wildcats were only observed at two sites, of which only one station showed the repeated appearance of what appeared to be the same wildcat (young adult), but this cannot be confirmed. Caracals (*Caracal caracal*) and black-backed jackals (*Canis mesomelas*) were not photographed, however, according to the farm owner they were present, but numbers kept low, due to culling practices on the property. No aardwolf (*Proteles cristata*) were observed during the capture period, but they do reportedly occur on the study site and in the study area (Chapter 4). Both porcupines (*Hystrix africaeaustralis*) and aardvarks were common (see Figure 3.12). A striped polecat (*Ictonyx striatus*) and a small-spotted genet (*Genetta genetta*) were only observed once. Although honey badgers (*Mellivora capensis*) were not observed on the cameras, they were reported as livestock predators in my study area (see Chapter 4) and tracks were found on the study site.

Species that would fall under wildcat prey size according to Herbst's (2009) records, were also observed at waterholes and included Cape ground squirrels (*Xerus inauris*), yellow mongoose (*Cynictis penicillata*), slender mongoose (*Galerella sanguinea*) and scrub hares. Meercats (*Suricata suricatta*) were also commonly observed, but not captured on camera. Evidence that springhares (*Pedetes capensis*) were abundant could be found across all four habitat types, in the form of dung pellets, feeding sites, tracks and burrows.

The larger game species observed at the waterholes, such as scimitar oryx (*Oryx dammah*), gemsbok (*Oryx gazella*), springbok (*Antidorcas marsupialis*), red hartebeest (*Alcelaphus buselaphus caama*), blue wildebeest (*Connochaetes taurinus*) and Ostrich (*Struthio camelus*) are for the purposes of this study, viewed as domestic wildlife, which are kept for hunting or recreational purposes and have not been included in Figure 3.11. A comparison of wildcat diet, between the KTP and what was found on the study site by way of small mammal trapping, camera trapping and direct observations, can be viewed in Appendix 4.

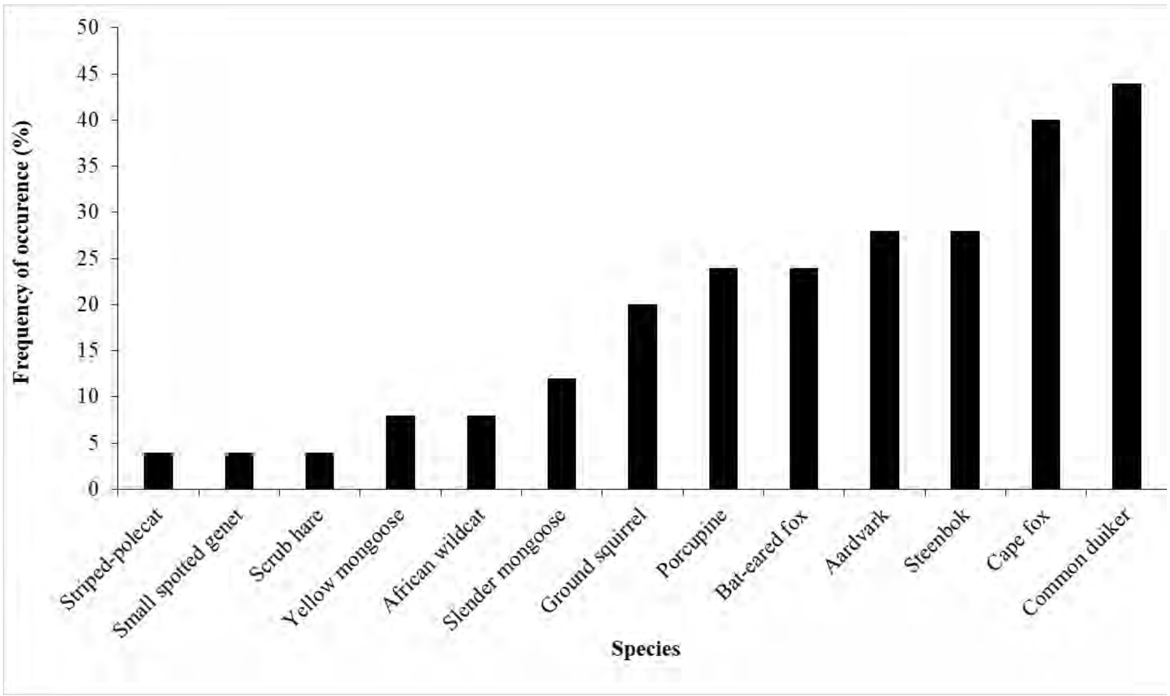

Figure 3.11: The wildlife species identified on cameras on the study site and their frequency of occurrence (%) in terms of their abundance across 25 trap stations.

Figure 3.12: (A) Porcupines and (B) an aardvark visiting a waterhole at night (2015).

An ongoing bird list was kept for the study site (2013 – 2020) and compared with a list from the KTP (see Appendix 3).

During camera trapping sessions, there was clear evidence that the waterholes attracted numerous smaller bird species. Some of the species identified were, Cape Turtle Doves (*Streptopelia capicola*), Namaqua Doves (*Oena capensis*), Masked Weavers (*Ploceus velatus*), Ant-eating Chats (*Myrmecocichla formicivora*), White Browed Sparrow-weavers (*Plocepasser mahali*), Cape Glossy Starlings (*Lamprotornis nitens*), Fork-tailed Drongos (*Dicrurus adsimilis*), Lilac-breasted Rollers (*Coracias caudatus*), Crowned Lapwings (*Vanellus coronatus*) and Yellow Canaries (*Crithagra flaviventris*). Sociable Weavers (*Philetairus socius*), in particular, were abundant and gathered in large flocks. Besides smaller avian species, Tawny Eagles (*Aquila rapax*), Martial Eagles (*Polemaetus bellicosus*), Gabar Goshawks (*Micronisus gabar*), Pale Chanting Goshawks (*Melierax canorus*), Cape vultures (*Gyps coprotheres*), Lappet-faced Vultures (*Torgos tracheliotos*), White-backed Vultures (*Gyps africanus*), Kori Bustards (*Ardeotis kori*), Secretary Birds (*Sagittarius serpentarius*) and Spotted Eagle Owls (*Bubo africanus*), were some of the larger species identified at the waterholes (see Appendix 2).

Some of the most commonly observed reptiles on the study site were, Kalahari tree skinks (*Trachylepis spilogaster*) and blue headed ground agamas (*Agama aculeate*), and nocturnal species, such as barking geckos (*Ptenopus garrulous*) and common giant ground geckos (*Chondrodactylus angulifer*) were also recorded.

During a 36 day period (1 August and 5 September 2017) a waterhole was frequented by a young adult wildcat (or possibly different wildcats) 14 times (seven times in the morning and seven times in the afternoon). This allowed for a crude assessment of wildcat activity at the study site. The waterhole, which was situated in one of the streets, was only visited at dusk and dawn, twice, on one day, and for the remainder of the recorded period, wildcats were only captured on camera once per day. Sunrise occurred around 7:06 AM and sunset, around 18:16 PM, however, the footage indicated that wildcats frequented the waterhole at set times (3:49 – 5:58 AM and 16:52 – 17:59 PM), indicating wildcat activity before sunrise and sunset. Camera trap thermometers also indicated that the wildcat(s) visited the waterhole during temperatures ranging between 0 °C in the early mornings and 31 °C in the afternoons. The longest that the wildcat(s) stayed away from this waterhole was six days (see Figure 3.13 and 3.14).

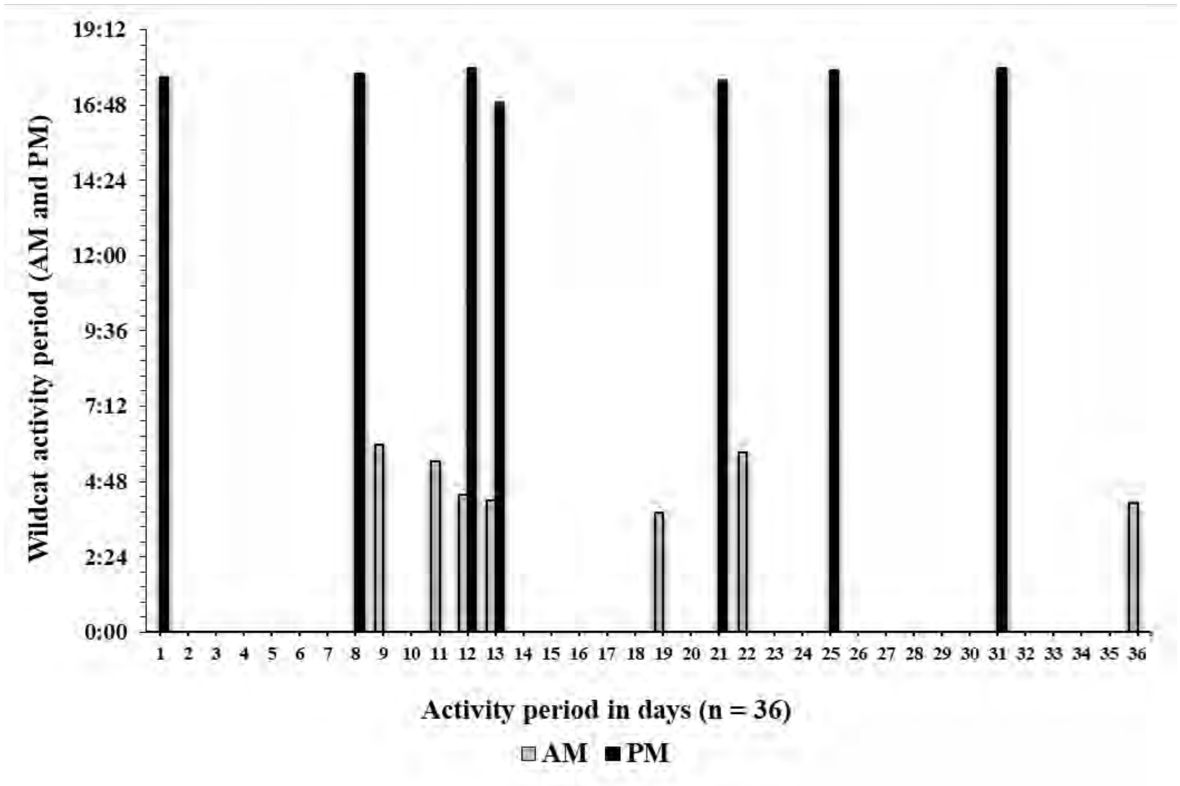

Figure 3.13: The activity period of a wildcat(s) visiting a waterhole over 36 days between, 1 August and 5 September 2017.

Figure 3.14: A wildcat on the study site visiting the waterhole at dawn (A) and dusk (B) between 1 August and 5 September 2017 (date on camera was set incorrectly).

3.4 Discussion

Since there has only been one comprehensive field study conducted on wildcats in the southern Kalahari (90 km from my study site), which shares the same environmental conditions (climate and habitat), the research of Herbst (2009) was used as a benchmark to compare data collected from my study site (unprotected land), with that of the KTP (protected land). The following topics will be compared and discussed; wildcat prey availability (see Appendix 4), habitat selection of small mammal prey and wildcat activity patterns according to prey availability.

Small mammals have long been acknowledged as indicator species for environmental change and ecosystem health (Rowe & Terry, 2014; Santos *et al.*, 2017). A greater understanding is needed to comprehend how communities and their constituent species have responded to environmental change over time (Dawson *et al.*, 2011). Long-term monitoring can highlight both patterns and processes to explain how past forces structure modern communities, by identifying principal ecological drivers, relevant for conservation and management (Rowe & Terry, 2014; Santoro *et al.*, 2016; Spencer *et al.*, 2017). Long-term studies are also encouraged at individual sites (Rowe & Terry, 2014; Santos *et al.*, 2017), as biotic and abiotic factors vary regionally and it is therefore not viable to compare studies from different geological areas (Kelt, 2011).

It is hard to find information regarding the feeding habits of wildcats, however, murid rodents are reportedly the most commonly consumed prey (Smithers, 1971; Stuart, 1977; Smithers &

Wilson, 1979; Palmer & Fairall, 1988; Herbst & Mills, 2010a). A meat diet is often replaced with another food category when the wildcat's preferred prey species are low in numbers (Smithers, 1971; Herbst & Mills, 2010a), such as the case in the Karoo National Park (KNP), where insects made up 40% of the wildcat's diet (Palmer & Fairall, 1988). Another study in the KNP concluded that from 11 wildcat scats, all contained rodents and seven had coleoptera present (Palmer & Fairall, 1988). Murid rodents formed the bulk of the biomass in wildcat diet in the KTP, followed by birds, large mammals (<4500 g), reptiles and invertebrates (Herbst & Mills, 2010a).

There are 17 known rodent species in the KTP, 13 of which weigh < 100 g (Nel *et al.*, 1984). Eight species of small rodents (< 500 g) were identified by Herbst (2009) to be consumed by wildcats in the KTP, namely, Brant's gerbil (*Tatera brantsii*), Brant's whistling rat (*Parotomys brantsii*), four-striped grass mouse, Damaraland mole-rat (*Fukomys damarensis*), pygmy hairy-footed gerbil, short-tailed gerbil (*Desmodillus auricularis*), pygmy mouse *(Mus indictus*) and bushveld sengi (Herbst, 2009). Hunting attempts on rodents, by both sexes of wildcats, had a 72% success rate (Herbst, 2009). Female wildcats seldom hunted larger mammals (500 – 2000 g), and only one successful attempt on a hare (*Lepus* sp.) was observed, compared to the 15 hunting attempts (33% success rate) by male wildcats (Herbst, 2009; Herbst & Mills, 2010a). The largest known prey species consumed by wildcats are hares and springhares. I captured three of the eight small mammal species found to be consumed by wildcats in the KTP on my study site, namely pygmy hairy-footed gerbil, four-striped grass mouse and bushveld sengi (see Figure 3.8). Even though I increased the minimum recommend trap nights of 200 (Barnett & Dutton, 1995), to 720 trap nights, the trap success and overall species diversity amongst the habitat types were low. This could most likely be explained by the ongoing extreme drought conditions experienced during the capture period (see Chapter 2 for climatic conditions at the time). A two-year drought period in Botswana in the 1960s caused murid populations to plummet to an unprecedentedly low level, which resulted in the contents of 16 wildcat stomachs to consist of invertebrates, fruit and birds only (Smithers, 1971). Food availability, capture season, the abundance of natural cover and weather conditions, all play a role in the density of small mammals across sampling sites (Smithers, 1983; Nel *et al.*, 1984; Barnett & Dutton, 1995; Avenant & Nel, 1997; Sunquist & Sunquist, 2002; Herbst & Mills, 2010a; Santos *et al.*, 2017; Stryjek *et al.*, 2019). Furthermore, I only sampled small mammals in one season (beginning of spring 2020). Small mammal abundance and diversity might differ between habitats and change according to their food availability and season (Addisu & Bekele, 2013). As such, future research should incorporate additional temporal replication.

In the KTP, 43% of all rodents were trapped in the sand dunes, 34% in the *Rhigozum* veld, 17% in the riverbed and 6% on the calcrete ridges (Herbst, 2009). Wildcats caught most of the rodents in the sand dunes (51%) or the *Rhigozum* veld (42%) and significantly less rodents were caught in the riverbeds (Herbst, 2009). The capture success of small mammals on my study site was lower than expected across all four habitat types with the total number being 20 individuals (see Figure 3.8). My small mammal capture success was higher in dunes and streets (4.44% each) and lower on calcrete banks (2.22%) and riverbeds (0%). It is important to note that, due to the extended drought at the time, no livestock was kept in camps within riverbeds for years and therefore, the food availability for small mammals would not have been affected by grazing pressure from livestock. Dunes and streets hosted different small mammal species (four-striped grass mice (n = 7) and pygmy hairy-footed gerbils (n = 9)), to that of calcrete banks (Namaqua rock mice (n = 3) and bushveld sengi (n = 1)) (see Figure 3.8). The two species associated with dunes and streets both occur in higher densities and are either nocturnal or crepuscular (see Table 3.1) (Stuart & Stuart, 2015). The two species associated with calcrete banks either live in small communal nests and are nocturnal (Namaqua rock mouse) or are solitary and diurnal (bushveld sengi) (Stuart & Stuart, 2015). Besides the climatic conditions at the time affecting food availability, the low capture success of small mammals could also be explained by the ecology and social status of the captured species (see Table 3.1). The higher trap success in dunes and streets could therefore be explained by a higher number of individuals living in these two habitats, with a greater possibility to be captured before the traps were closed in the morning (Stuart & Stuart, 2015). The bushveld sengi's diurnal and solitary status might explain why its trap success was low as they occur in lower numbers and the fact that the traps were closed in the day (Stuart & Stuart, 2015). The low trap success of Namaqua rock mice can however, not be explained and therefore one could speculate that they may occur in lower numbers or the drought could be the reason.

The statistical analysis indicated that although dunes, streets and calcrete banks yielded the same species diversity, dunes and streets had an overall higher relative abundance (%) of small mammal species, which occupied these habitats (see Figure 3.10). Dunes and streets also shared more similar small mammal species (CCs) than the other. This is most likely due to these two habitats sharing similar vegetation growth (Mucina & Rutherford, 2006) and geology (Malherbe, 1984b). It is, however, important to note that no small mammals were captured in the riverbeds, even though the riverbed was surveyed. These rivers are predominantly dry, with short lived seasonal pools forming with rain (Van Rooyen, 2001). The small mammal capture size for my study site's four habitats were extremely small, which could have affected the results. Extensive research has found that a decreased sample size, results in decreased accuracy and increased variability across species and between models (n < 30) (Wisz *et al.*, 2008). My small capture size, therefore, prevented a statistical comparison of my study site with that of the KTP.

Three species of larger mammals (500 g – 2000 g) were consumed by wildcats in the KTP (springhares, unidentified hare species and a ground squirrel) (see Appendix 4). My camera trap census confirmed that scrub hares and ground squirrels were present on my study site and my direct observations indicate that springhares were plentiful across all four habitat types (burrows, tracks, dung pellets and feeding sights). Other potential wildcat prey species, such as meerkats and mongooses were also either captured by the camera traps or observed (see Appendix 1 and 4). The majority of the diurnal and nocturnal camera footage consisted of livestock, a varieaty of mammal wildlife and bird species, which were present in every livestock camp with a trap station. The results from the camera trap surveys therefore indicated that my study site hosted a healthy natural species richness, including a variety of the wildcat's potential natural prey species.

Female wildcats in the KTP had a 63% success rate when catching birds, while male cats had a 30% success rate (Herbst, 2009). Namaqua Sandgrouse (*Pterocles namaqua*) and doves (Namaqua and Cape Turtle Doves) were commonly consumed around waterholes (Herbst, 2009). Wildcats caught 66% of birds in the riverbeds, but the findings were noted to possibly be a biased result due to a female wildcat specializing in catching birds at a waterhole and reservoir (Herbst, 2009). This particular female changed her foraging behaviour from, diurnal hunting for birds around waterholes, to being active at night, when rodent numbers increased (Herbst, 2009). Birds were also captured on calcrete ridges (17%) and in sand dunes (17%) (Herbst, 2009). Like in the KTP, the camera traps on my study site indicated that the species of doves and many other species of small birds were attracted to waterholes (see Appendix 2), which could potentially attract wildcats who opportunistically prey on birds around waterholes on unprotected land. The waterholes on my study site, which were situated in riverbeds, were not sampled as no livestock were kept in the riverbed habitats during the sampling period, due to drought (see Figure 3.6). Future studies should therefore conduct camera trap surveys at waterholes in riverbeds, outside the drought period, to determine if waterholes in riverbed habitats play as important a role on unprotected land as it does in the KTP, regarding the attraction of bird prey species.

It could be hypothesized that a major reason why wildcats preyed on birds at waterholes in the dry riverbeds of the KTP was due to the placement of the majority of the artificial waterholes in this habitat type. Therefore, the opportunistic nature of wildcats could influence their habitat selection due to prey availability, and this could change if the waterholes were placed in different habitat types. A study on neotropical forest felids (jaguar (*Panthera onca*), puma (*Puma concolor*), ocelot (*Leopardus pardalis)*, jaguarundi (*Herpailurus yagouaroundi*) and margay (*Leopardus wiedii*)) indicated that their patterns of habitat use were best explained by prey availability, rather than habitat structure (Santos *et al.*, 2019).

Wildcats in the KTP had a 95% success rate in catching reptiles, which included barking geckos, common giant ground geckos, blue headed ground agamas and sand snakes (*Psammophis* sp.) (Herbst, 2009). Wildcats captured 57% of reptiles in the *Rhigozum* veld and 42% in the sand dunes (Herbst, 2009). Since no specific data were collected on bird, reptilian or invertebrate diet abundance on my study site, no statistical comparisons could be made, making this an important future research priority. However, view Appendix 3 for comparative bird and Appendix 4 for comparative mammalian and reptilian species collected via camera traps and personal observations. Due to the environmental similarity between my study site and the KTP, it is likely that both habitats host similar avian, reptilian and invertebrate prey species.

Wildcats in the KTP showed the same two peak activity patterns, during early mornings and evenings, as common with many carnivores (Aschoff, 1966) for example, the Cape fox (Smithers, 1983), spotted hyaena (*Crocuta crocuta*) (Kruuk, 1972), honey badger (Begg, 2001) and leopard, (*Panthera pardus*) (Jenny & Zuberbühler, 2005). Wildcats in the KTP emerged from resting sites at the time of sunset during hot seasons, however, the time an activity ended was not correlated with the time of sunrise (Herbst, 2009). In addition, there was virtually no activity during daylight hours for both sexes (Herbst, 2009). In cold-dry seasons wildcats were active for longer periods in the mornings, as well as earlier in the afternoons (Herbst, 2009). It is probable that the wildcat's energy dependence and climate are important variables in determining its activity (Herbst & Mills, 2010a). Predators have been known to synchronize their foraging behaviour with that of their main prey (Schuh, Tietze & Schmidt, 1971; Curio, 1976; Armitage *et al.*, 1996) and therefore wildcat prey availability and activity patterns might also play a role in determining their activity patterns (Herbst, 2009; Herbst & Mills, 2010a). Although wildcats are predominantly nocturnal, they may display crepuscular characteristics, by shifting from predominantly nocturnal in hot seasons, to increased diurnal activity patterns, in cold seasons (Herbst, 2009; Herbst & Mills, 2010a).

The wildcat(s) recorded at a waterhole on the study site only visited the waterhole 14 times and at times spent up to six days away, before returning. The wildcat(s) visited the waterhole at first light and/or around sundown and therefore, displayed similar activity patterns as what was found in the KTP.

Even though my sample size for small mammals was small, the results indicated that similar species of small mammals occur on the study site, which were also found to be consumed by wildcats in a protected area (see Appendix 4). Furthermore, small mammals occurred in higher densities on dunes and in streets, indicating that the small mammal prey available for wildcats on unprotected land, occupies the same preferred habitats, which was found for wildcats in the KTP. Dunes and streets also proved the most important habitats for both invertebrates and reptiles in the KTP (Herbst, 2009). Therefore, these two habitat types could be considered to be just as important for wildcats on unprotected land, as they are in the KTP, because they support higher densities of the wildcat's favoured prey species. My small mammal trapping results on calcrete and riverbed habitats showed the opposite of that found in the KTP (see Figure 3.8). In the KTP, riverbeds were favoured over calcrete habitats (Herbst, 2009). The calcrete habitat on my study site produced the same number of small mammal species as was found in dunes and streets, but yielded a smaller species abundance and different species occupancy. Riverbeds, surprisingly produced no small mammal captures, even though there was rodent activity (tracks) at the capture sites. This low capture rate is difficult to explain, as the two capture sites with high and medium grass and shrub cover, yielded the same result as the capture site with very sparse vegetation cover. Future research could however yield a higher capture success if small mammal capture is conducted outside the drought period and across all four seasons.

The wildlife censuses which I conducted through small mammal trapping, camera trapping, direct observations and information provided by farmers via questionnaires (Chapter 4), indicates that the study area potentially hosts a healthy variety of small to medium sized mammalian and avian species. Future research does however, need to be conducted on farmland to determine detailed and reliable species lists of the various wildlife categories available to wildcats. Although the results from my study suggest that wildcats on unprotected land rely on the same natural prey species as found on protected land, there is an urgent need to determine the diet of wildcats on unprotected land. Future research could determine the diet of wildcats through scat analysis, stomach content analysis and radio-telemetry tracking, combined with observational recordings (Herbst, 2009; Herbst & Mills, 2010a, 2010b). Such research would assist in future management decisions of the species as a whole and could aid in more genuine facts being made available when addressing topics on human-wildlife conflict.

CHAPTER 4

FARM MANAGER ATTITUDES TOWARDS PREDATORS

4.1 Introduction

The southern African wildcat (*Felis lybica cafra*; hereafter wildcat) is a common small predator (Stuart, 1981; Driscoll *et al.*, 2011; Yamaguchi *et al.*, 2015) that is classified as 'least concern', by the International Union for Conservation of Nature (IUCN) (Yamaguchi *et al.*, 2015). Wildcats are currently threatened by habitat destruction, persecution, road kill and their ability to produce fertile offspring with domestic cats (*F. catus*) (Nowell & Jackson, 1996; Herbst, 2009; Driscoll *et al.*, 2011, Herbst, *et alI.*, 2016). Wildcats favour murid rodents (Smithers, 1971; Stuart, 1977; Smithers & Wilson, 1979; Palmer & Fairall, 1988; Herbst, 2009, Herbst *et al*., 2016), however, wildcats are opportunistic ambush hunters and, depending on seasonal prey availability, may select species other than rodents (Smithers, 1971; Herbst, 2009). On South African farmland, wildcats have been reported to prey on newborn lambs (*Ovis aries*), resulting in conflict with farmers (Palmer & Fairall, 1988; Nowell & Jackson, 1996; Blaum *et al.*, 2009; Todd *et al.*, 2009; Yamaguchi *et al.*, 2015).

Human-wildlife conflict can be defined as any case in which the resource demands of humans overlap with that of wildlife, resulting in competition for food, space and water (Gilbert & Dodds, 2001; Woodroffe, Thirgood & Rabinowitz, 2005; Seoraj-Pillai, 2016; Nieman, Wilkinson & Leslie, 2020). One of the main driving forces behind the dramatic global decline of wildlife populations stems from habitat destruction where natural habitats become increasingly fragmented with the expansion of the human population (Woodroffe *et al.*, 2005; Treves *et al.*, 2006; Hazzah, Borgerhoff Mulder & Frank, 2009; Thornton *et al.*, 2011; Seoraj-Pillai, 2016). Habitat fragmentation is a global issue which often causes wild animals to threaten human safety and damage crops, poultry, livestock, farmed game and fisheries, resulting in human-wildlife conflict (Peterson *et al.*, 2010; Seoraj-Pillai, 2016). The effects of human-wildlife conflict have negatively impacted the home ranges and population sizes of naturally occurring wildlife species on unprotected land (Nieman *et al.*, 2020). The consequent removal of the perceived conflict species, especially apex predators, can have unpredictable negative ecological ramifications (Treves & Naughton-Treves, 2005; Seoraj-Pillai, 2016). In some cases, lethal control can cause an increase in predator populations, by releasing sub-dominant animals from the hormonal suppression of breeding (Blaum *et al.*, 2009). For example, it was found that sub-dominant black-backed jackals (*Canis mesomelas*) do not breed in areas with stable black-backed jackal populations (Todd *et al.*, 2009; Minnie, 2016; Kerley *et al.*, 2018). Black-backed jackals are monogamous and aggressively defend their territory, but when the dominant pair is removed, a gap is created, which could be filled with numerous new black-backed jackals (Todd *et al.*, 2009). The same result was found for caracals (*Caracal caracal*), where farms that culled caracals had more livestock losses than farms which did not cull caracals (Bailey & Conradie, 2013).

Human-wildlife conflict has been documented in South Africa, from as early as 1652, where large scale unselective lethal control methods, such as poison, traps and snares (Daly *et al.*, 2006; Du Plessis *et al.*, 2018) were used to exterminate perceived damage-causing wildlife (Fabricius, Kock & Magome, 2004; Daly *et al.*, 2006; Seoraj-Pillai, 2016). Methods such as baited explosive cyanide cartridges and the gassing of dens have been shown to be ecologically damaging, as these methods are unselective and affect non-target species (Treves & Naughton-Treves, 2005; Bergstrom *et al.*, 2014; Seoraj-Pillai, 2016).

In recent decades, the illegal poisoning of wild predators has increased exponentially in many parts of the world, with the knock on effect of negatively affecting non-target species such as scavenging birds of prey (Virani *et al.*, 2011). Cape Vultures (*Gyps coprotheres*) (Margalida, Campión & Donázar, 2014; Seoraj-Pillai, 2016), for example, have in the past experienced poisoning episodes, either directly or indirectly, in areas where they are perceived to have a negative impact on game species or livestock (Mateo-Tomás *et al.*, 2012). In parts of South Africa's Drakensburg region and Lesotho, Cape Vultures are blamed for taking "live" sheep (*Ovis aries*) and newborn lambs, resulting in farmers lacing carcasses with poison to kill the vultures (Wolter, 2011). Intentional vulture poisoning events are also the number one cause of the Cape Vulture species' decline in Namibia (Wolter, 2011). Indirect vulture poisoning events occur when vultures consume poison laced carcasses, that farmers put out to target mammalian problem predators (Wolter, 2011). Indirect poisoning can also occur when vultures consume livestock carcasses which have been treated with agricultural chemicals to prevent ticks and blow flies (*Calliphoridae* spp.) on livestock (Wolter, 2011). Non-target species, such as the endangered Yellow-billed Oxpecker (*Buphagus africanus*), experienced widespread declines and even local extinctions, due to secondary poisoning, where arsenic-based cattle (*Bos taurus*) dips poisoned the birds who consumed ecto-parasites on treated cattle (Stutterheim & Brooke, 1981).

The lethal control of wildlife, carnivores in particular, has a far bigger reach than solely on the target animal and could have ramifications for the target species' population density, reproduction and genetic variability (Woodroffe *et al.*, 2005; Swanepoel *et al.*, 2014). Today, active predator control management includes the use of both lethal and non-lethal methods, with the latter being perceived to be more selective, ethical and environmentally acceptable (Treves & Naughton-Treves, 2005; Todd *et al.*, 2009; Du Plessis *et al.*, 2018). Lethal control should be used as a last resort as lethal control methods are viewed as less environmentally friendly and less humane for both target and non-targeted species (Todd *et al.*, 2009). Non-lethal predator control methods include the use of deterrents (e.g. bells and collars), well-constructed fences, cage traps, shepherds and guard animals such as dogs (e.g. *Canis lupus familiaris*), donkeys (*Equus africanus asinus*), Ostriches (*Struthio camelus*) and alpacas (*Vicugna pacos*) (Treves & Naughton-Treves, 2005; Todd *et al.*, 2009). Guard animals are naturally protective towards livestock herds and aggressive towards wild predators (Todd *et al.*, 2009). Nevertheless, lethal control methods, such as poison, gin traps or leg-holding devices, hunting, poison collars and hunting dogs are still actively used to control problem predators on South African livestock farms today (Treves & Naughton-Treves, 2005; Todd *et al.*, 2009).

South African examples of wildlife species, which have been classified as problem animals on livestock farms, are; African wild dogs (*Lycaon pictus*), wildcats, cheetahs (*Acinonyx jubatus*), civets (*Civettictis civetta*), genets (*Genetta genetta* and *G. tigrina*), spotted hyenas (*Crocuta crocuta*), black-backed jackals, lions (*Panthera leo*), leopards (*Panthera pardus*), yellow mongoose (*Cynictis penicillata*), slender mongoose (*Galerella sanguinea*) (Foster, McIntyre & Haussmann, 2019), baboons (*Papio ursinus*) and honey badgers (*Mellivora capensis*) (Seoraj-Pillai, 2016). Cape porcupines (*Hystrix africaeaustralis*) are also on the list, as they have a reputation for damaging crops, fences and polyvinyl chloride water pipes (Nieman *et al.*, 2020). Bush pigs (*Potamochoerus larvatus*) are considered pests on maize, sugar cane and tree nut farms (Venter, Seydack & Ehlers Smith, 2016). Similarly, warthogs (*Phacochoerus africanus*) are viewed as extralimital agricultural pests on farms in parts of the Northern Cape and Free State Provinces (Swanepoel, Leslie & Hoffman, 2016).

Human-wildlife conflict is common on South African livestock farms (Avenant & Du Plessis, 2008; Gusset *et al.*, 2009; Van Niekerk, 2010; Thorn *et al.*, 2012; Swanepoel *et al.*, 2014; Thorn *et al.*, 2015) and farmers' negative attitudes towards problem carnivores are mostly driven by financial threats (Thorn *et al.*, 2015). Human-wildlife conflict also has indirect economic costs, which includes the extra finances spent on predator deterrents, such as, electrified fencing or labour to guard livestock and crops (Woodroffe *et al.*, 2005; Van Niekerk, 2010). Some state-funded compensation programs offer reparations or reimbursements for wildlife-predation losses (Hemson *et al.*, 2009; Seoraj-Pillai, 2016). These compensation programs aim to mitigate human-wildlife conflict and prevent depredation of crops and livestock (Dickman, 2010; Kerley *et al.*, 2018). Compensation programs encourage participant tolerance towards losses, by buffering the economics of such losses (Naughton-Treves, 1999; Seoraj-Pillai, 2016). The governments and problem animal authorities, especially from developing countries, however, do not have the financial or administrative capacity to give fair compensation for stock damage or loss, caused by wild animals (Naughton-Treves, 1999; Seoraj-Pillai, 2016). Compensation schemes are often criticised for being ineffective, drawn-out (Hemson *et al.*, 2009) and to have unrealistic expectations for fair compensation for wildlife-related damage, which could lead to further negativity towards wildlife (Boonzaier, 1996).

The majority of human-wildlife conflict mitigation studies investigate only the technical aspects of conflict reduction, however, social aspects (human-human), such as religious affiliation, ethnicity, age, cultural beliefs and relationships with conservation authorities could play a part in conflict intensity (Dickman, 2010). A study by Hill (2004) recognized that people showed different levels of vulnerability towards human-wildlife conflict, based on demographic factors (age, sex, ethnicity and culture), farm location in relation to protected areas, livestock kept, game and crop assemblages, as well as the problem species concerned (Seoraj-Pillai, 2016). A clearer understanding of the underlying environmental and human-wildlife conflict drivers is therefore needed to better manage wildlife conflict issues (Inskip & Zimmermann, 2009; Dickman, 2010; Thorn *et al.*, 2012; Abram *et al.*, 2015). Moreover, depredation management requires an in-depth understanding on the workings of how predators select domestic prey relative to wild prey (Sacks & Neale, 2002).

The aim of this chapter was to firstly, determine the attitudes of southern Kalahari farmers towards predators on their farms and in their area by way of questionnaire interviews.

Secondly, to determine farmer attitudes towards wildcats in particular and thirdly, to determine if social factors play a role in the attitudes of farmers towards these predators (e.g. farmer age, generation, farm size, amount of livestock species farmed with, level of education and the distance of the farm to the nearest wildlife conservancy). I hypothesized that farmers would present negative attitudes towards all predator species, which are perceived to cause financial distress through the killing of livestock. I further hypothesized that black-backed jackals, caracals and wildcats would be perceived to be the most damage-causing predators on farms in my study area.

4.2 Methods

4.2.1 Questionnaire interviews

Questionnaire interviews (see Appendix 5) were conducted with farm owners and farm managers (n = 24) in the southern Kalahari (Chapter 2) between September and December 2020. I decided to remove two of the questionnaires from my overall dataset, as one of the participants managed a hunting farm and the other owned a game reserve and their answers were not relevant to the overall goal of this chapter. Therefore, a total of 22 questionnaires were used in my study.

Information was collected on farm size, species of livestock farmed, predators present on farms and predator control measures in place on farms. Information was also collected on the participants' perceptions of predators on their farms and in the region. For the purpose of this study, wildcats, bat-eared foxes (*Otocyon megalotis*) and Cape foxes (*Vulpes chama*) were considered as small carnivores (1 – 10 kg) (Gittleman, 1985; Kelly, 2018), black-backed jackals and caracals were considered as medium-sized carnivores (10 – 20 kg) (Van Niekerk, 2010; Kelly, 2018) and brown hyenas (*Parahyaena brunnea*) and leopards, as medium to large carnivores (> 20 kg) (Owens & Owens, 1978; Skinner & Chimimba, 2005). The final section of the questionnaires focused on participant attitudes towards wildcats in particular. The results will be presented in three categories; (1) participant attitudes towards predators in general, (2) participant attitudes towards wildcats and (3) other results (which includes other causes of livestock loss).

To protect sensitive data, such as the names of participants, farm size, level of education and predator management practices, no personal information is presented (Blaum *et al.*, 2009).

4.2.2 Statistical analysis

Statistical analyses were conducted using RStudio (RStudio Team, 2020). Linear models were used to determine the relationships between participant attitudes and the predators that occurred on the study site (Horgan *et al.*, 2020). Data collected from the questionnaires were used to create farmer attitude scores from selected dependent variables, which were tested against predictor variables, to determine any relationships.

An attitude score for each participant, towards each predator concerned was derived from a select set of questions from the questionnaires. Positive, neutral and negative answers were given values of 1, 0 and -1, respectively and summed for each predator concerned (Thorn *et al.*, 2015). The following questions were used to determine the attitude scores; (1) whether the participant felt positive, negative or neutral towards the predator being on their farm and area (all participants indicated the same answer for both questions and therefore, it was decided to combine the two questions, as one), (2) whether participants knew of any of their neighbours who cull predators on the list, (3) whether the participant knew of neighbours who used one of the listed illegal predator culling methods on the predators on the list, (4) whether participants would be more tolerant of predators if they were compensated for their loss and (5) whether participants thought that predators play an important role in the environment.

The predictor variables used were; (1) generation ("Gen"), (2) education ("EduO" = participants who have qualifications unrelated to farming, "EduH" = participants whose highest level of education was high school and "EduA" = participants with agriculture Degrees/ Diplomas/ Masters of Science), (3) the number of livestock species (sheep, goats (*Capra hircus*) and cattle) on the farm (scored, 1 – 3 ("LS")), (4) the direct distance of the main farm house to the entrance gate of KTP ("Dist") (determined by Google Earth's distance calculator), (5) participant age ("Age"), (6) farm size (ha) ("Ha") and (7) whether the predator occurred on the farm ("Pres" = "Yes" or "No").

A linear model, containing all predictor variables, was run through a multicollinearity test, to determine each predictor variable's Variance Inflation Factors (VIF) score (RStudio packages; "car", "caret" and "faraway) (Mc Guinness, 2014). Multicollinearity is when two or more predictor variables are correlated, in which case the standard errors are over-inflated, making some variables statistically insignificant (Daoud, 2017). The predictor variables with VIF scores < 5 (moderate correlation) and tolerance levels > .02, were used to create and run the linear models, containing all possible combinations of predictor variables.

The "AICcmodavg" package was used to conduct Akaike Information Criterion (AIC) model selection to determine the top performing linear models (Blackburn *et al.*, 2016; Horgan *et al.*, 2020). The top performing models were indicated by a Delta AICc score (< 2) and an AICc weight score (> 0.1). The top performing model for each predator, with its relative confidence intervals (95%) was summarized for discussion (see Table 4.2) and prediction plots were created for the qualifying models.

4.3 Results

The farms in my study area (n = 22) ranged from 1089 ha to 44000 ha in size. The majority of farms reared sheep (n = 20), cattle (n = 18) and goats (n = 5). Three farms reared sheep, cattle and goats, two farms reared only sheep and two farms reared only goats. Thirteen farms reared sheep and cattle and two farms reared sheep and goats. The average stocking rates for livestock, on the only seven farms who provided the information, was one livestock unit (LSU)/ 19.29 ha for cattle, one adult sheep/ 5 ha and one adult goat/ 3.3 ha. Wildlife tourism was present on some of the farms (n = 6), of which two farms answered, 'yes', to being part of a conservancy. Nearly all farms (95%) stated that their main form of income was derived from livestock farming and only one farm derived most of its income from salt mining. However, livestock and a variety of game species were farmed on the property. All the farms in the study area were fenced with either cattle fencing (1.2 m – 1.5 m high / 6 – 8 wire strands) (n = 19) or game fencing (2.25 m – 2.4 m high / 18-22 wire strands) (n = 6), of which four had jackal-proof fencing (a fence which is extended under the ground to prevent black-backed jackals from digging underneath). None of the farms had electric fencing.

The participants were all Afrikaans-speaking and ranged between 28 and 71 years of age. The majority of participants were white males (n = 20), with one coloured and one of Khoi San descent. Eight of the participants were first generation farmers, six second generation farmers, five third generation farmers, two fourth generation farmers and one was a fifth generation farmer. Four participants completed either a Degree/ Diploma/ Masters of Science qualification in agriculture. The majority of participants completed Grade 12 (n = 13), one participant completed Grade 7 and the remaining four participants had qualifications in other fields, such as, economics, financial marketing, health inspector and a vehicle mechanic.

The questionnaires originally included the following predators; black-backed jackals, caracals, brown hyenas, leopards, lions, cheetahs, wildcats, Cape foxes, bat-eared foxes and aardwolves (*Proteles cristata*). The latter two species are mainly insectivorous species (Stuart & Stuart, 2015) and were included to acquire information on how they were viewed by participants in the study area. Due to the majority of participants indicating that lions and cheetahs do not occur on their farm, it was decided to remove these two species from the results.

Participants were not able to provide the estimated numbers of game species that they perceived to be killed by predators on their farms, but they were able to confirm the following wildlife prey species to be available to predators, that naturally occur across the study area; springbok (*Antidorcas marsupialis*), common duiker (*Sylvicapra grimmia*), steenbok (*Raphicerus campestris*), aardvark (*Orycteropus afer*), porcupine, meerkats (*Suricata suricatta*), Cape ground squirrels (*Xerus inauris*), a few species of mongoose (*Herpestidae* spp.*),* springhare (*Pedetes capensis*) and many species of reptiles, snakes, invertebrates and birds. Larger species of game, such as gemsbok (*Oryx gazella*), blue wildebeest (*Connochaetes taurinus*), red hartebeest (*Alcelaphus buselaphus caama*) and Ostriches and species, such as, rock hyrax (*Procavia capensis*) and pangolins (*Smutsia temminckii*), also occurred across the majority of farms in the study area, however, varied from farm to farm.

4.3.1 Attitudes of participants towards predators in general

When participants (n = 22) were asked to indicate which predators on the questionnaire list occur on their farms, 100% of participants indicated that wildcats, Cape foxes and bat-eared foxes were common on their properties (see Figure 4.1). Aardwolves were also perceived to be relatively common on farms (95%), followed by caracals (91%) and black-backed jackals (82%). Brown hyenas were scarcer (55%), followed by leopards (23%), with some participants indicating that leopards were only observed on farms every three or more years. Only one participant did not know the difference between a brown hyena and an aardwolf, even after images were presented to him.

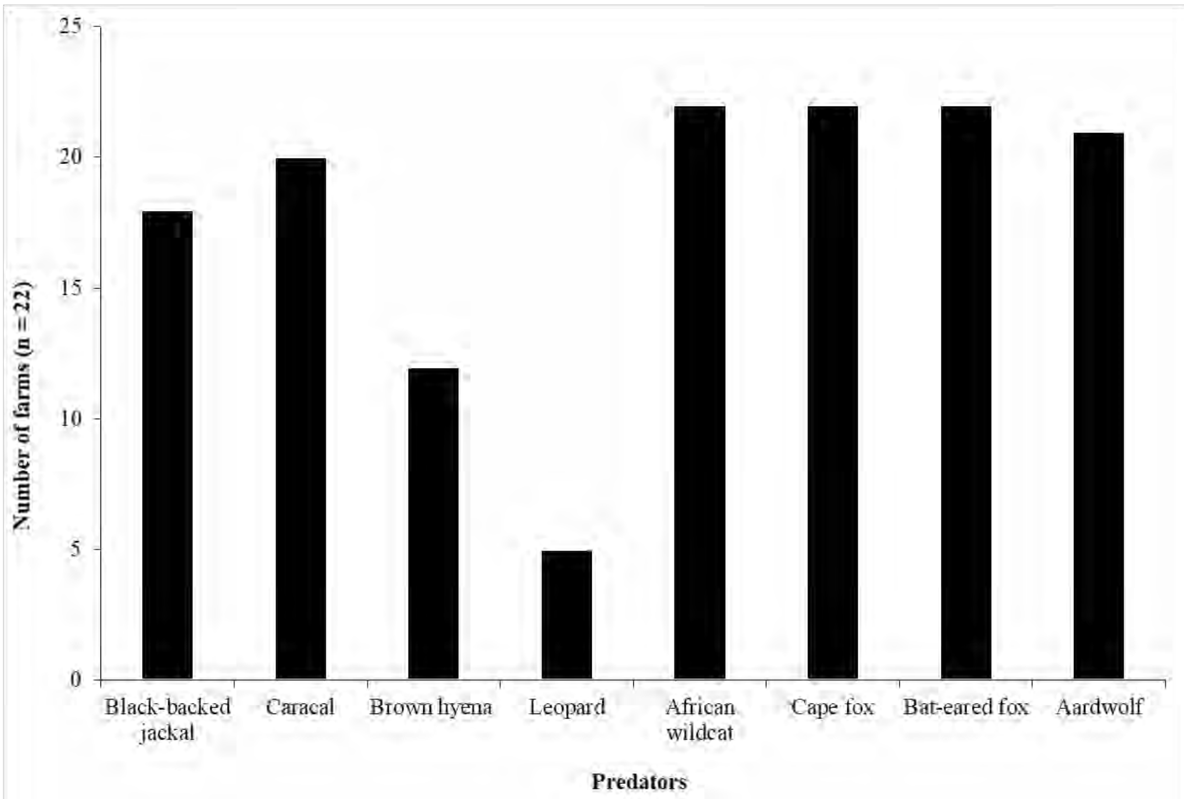

Figure 4.1: The number of participants indicating the presence of predator species on their farms in the southern Kalahari.

When asked to indicate how common the listed predators were on farms, 100% of participants indicated that they perceived the most common species to be bat-eared foxes, followed by wildcats (95%) and Cape foxes (95%). Caracals (59%), black-backed jackals (50%) and aardwolves (45%) were not perceived to be as common (see Figure 4.2). Fourteen percent of participants indicated that black-backed jackals were completely absent from their farms. Only 5% of participants indicated that brown hyenas were common on their farm. Leopards were believed to be absent from 77% of farms, with 23% of participants indicating that they have encountered leopards on their farms over the years, however the timeline varies between farms.

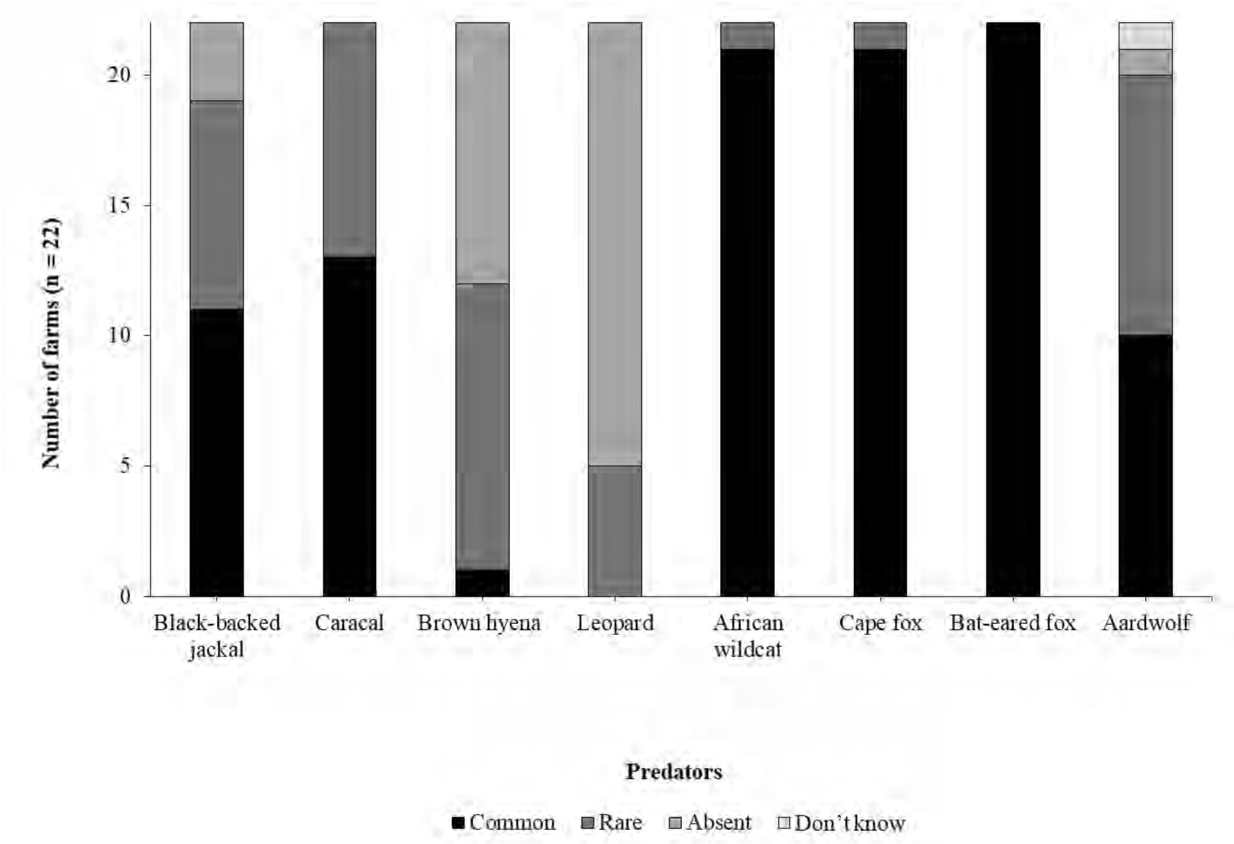

Figure 4.2: An indication of how common participants perceive predators to be on their farms in the southern Kalahari.

When asked if participants had lost any livestock or game to any of the predators on the list in the last 12 months, 100% of participants answered in the affirmative.

When asked to rank the listed predators in terms of their effect upon livestock and game on their farms, the majority of participants were not able to provide answers for leopards and none were able to estimate predator impact on game. Therefore, for the purpose of statistical analyses, only the top four damage causing predators were considered (see Figure 4.3). All participants agreed that bat-eared foxes and aardwolves did not predate on livestock. More than half of participants (68%) indicated that wildcats caused the highest negative impact on their livestock. Twenty six percent of participants indicated that caracals and black-backed jackals had an equal impact on their livestock. Cape foxes were ranked the lowest (9%) of the high impact predator species on farms. Brown hyenas were perceived to have low impacts on livestock by 18% of participants and participants observed brown hyenas to only occasionally prey on livestock, putting them in the least concern category, along with leopards (5%).

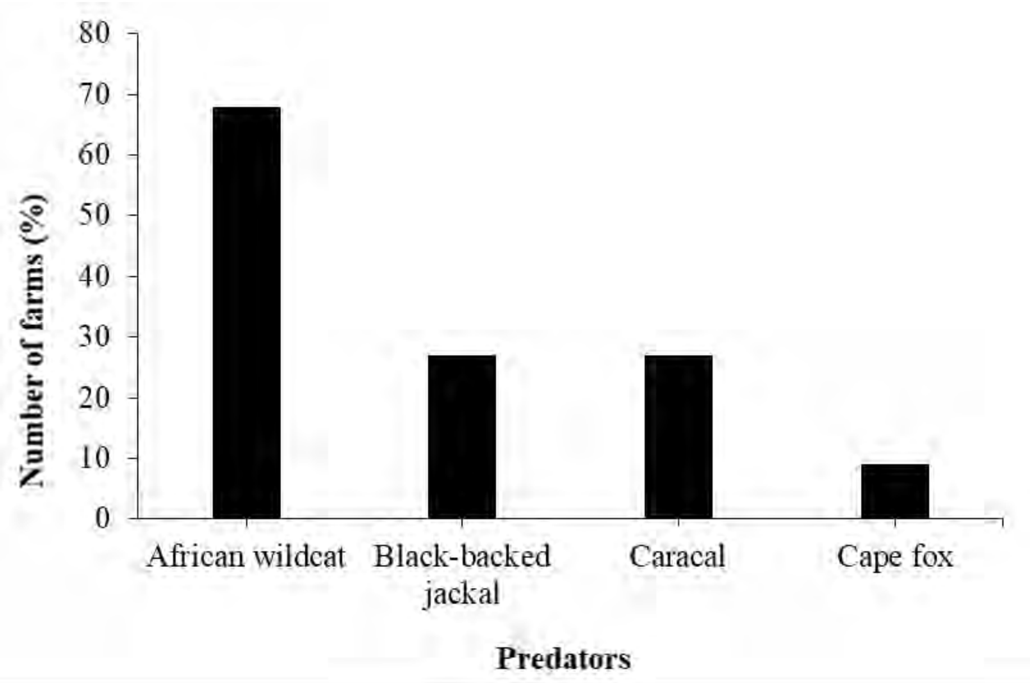

Figure 4.3: The four predators perceived to have the highest impact on livestock farms in the southern Kalahari.

When participants were asked to quantify the approximate number of livestock lost to predators over the preceding 12 months, the total amounted to 3323 animals (sheep (n = 3102), goats (n = 206) and cattle (n = 15)) (see Figure 4.4). The results indicated that participants estimated wildcats to be responsible for the death of 1542 (46% of total livestock loss) newborn lambs and kids, comprising of 1436 sheep and 106 goats. Black-backed jackals were estimated to have killed 1003 sheep and 100 goats (combined 30% of total livestock loss), and caracals 491 sheep (15%). The predator perceived to have the lowest impact on livestock was the Cape fox (7%), which was estimated to have killed 223 sheep (lambs). Brown hyenas (4%) were the only predator reported to prey on newborn calves.

Overall, predators were responsible for 10.86% of total livestock loss on the study area in 2020, equating to R 4,249,600 financial loss. Predators were responsible for 10.94% of the total sheep loss (R 3,722,400) in 2020. Participants who farmed with goats experienced the highest livestock loss (85.5% of total livestock) due to predation, totalling R 347,200 and cattle farmers only experienced a 0.76% loss of cattle due to predators in 2020, equating to R 180,000 financial loss.

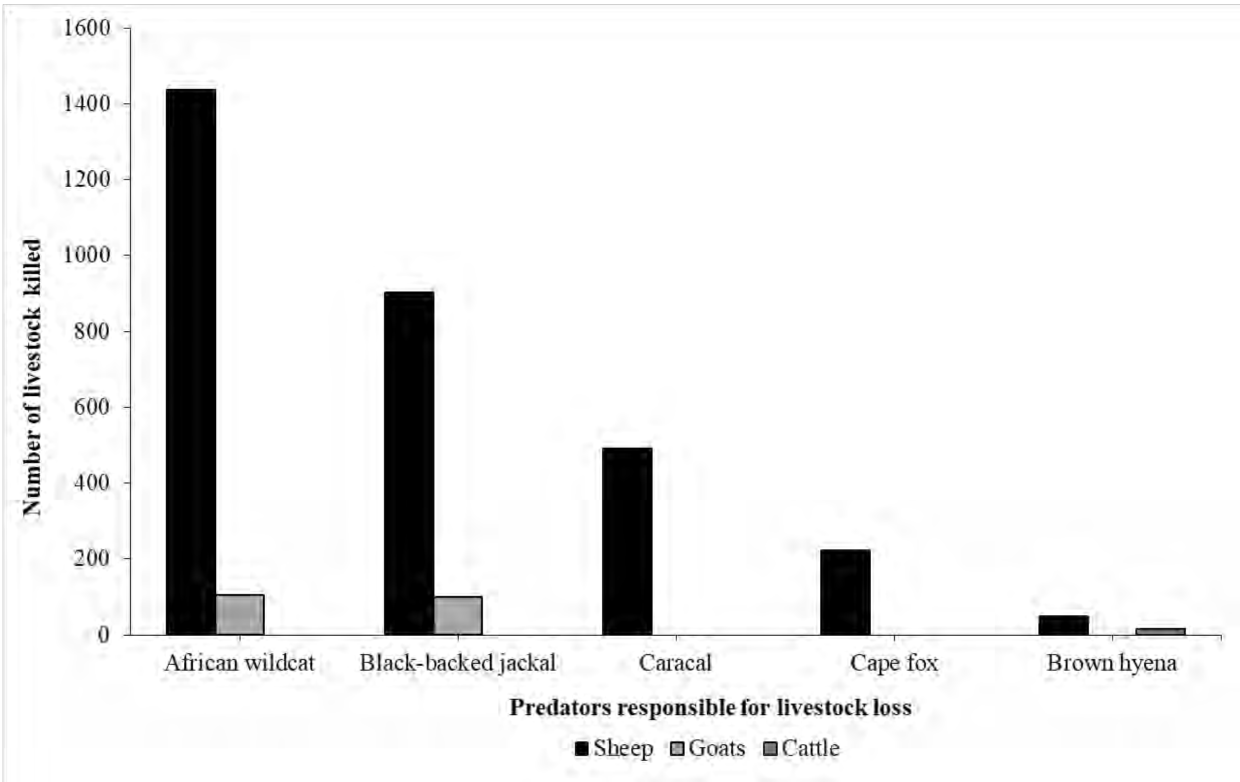

Figure 4.4: The number of livestock (sheep, goats and cattle) perceived to have been killed by predators on farms in the study area over the last 12 months (2019-2020).

Participants were asked to state whether the predators on the list have increased, decreased or remained the same over the past three years (see Figure 4.5) and provide a reason for their answer (see Figure 4.6). Fifty percent of participants indicated that black-backed jackals, wildcats and Cape foxes have increased over the past three years. Caracals were indicated to have increased by 45% of participants. Participants (45%) perceived bat-eared fox numbers to have decreased or stayed the same (31%). Thirty six percent of participants viewed aardwolf numbers to have stayed the same over the past three years, whereas 27% of participants indicated that aardwolf numbers have increased and 31% of participants were unsure of the aardwolf's status on their farms and on the study area. The majority of participants were not able to provide answers for the abundance of brown hyenas (68%) and leopards (90%) on their farms or in the study area.

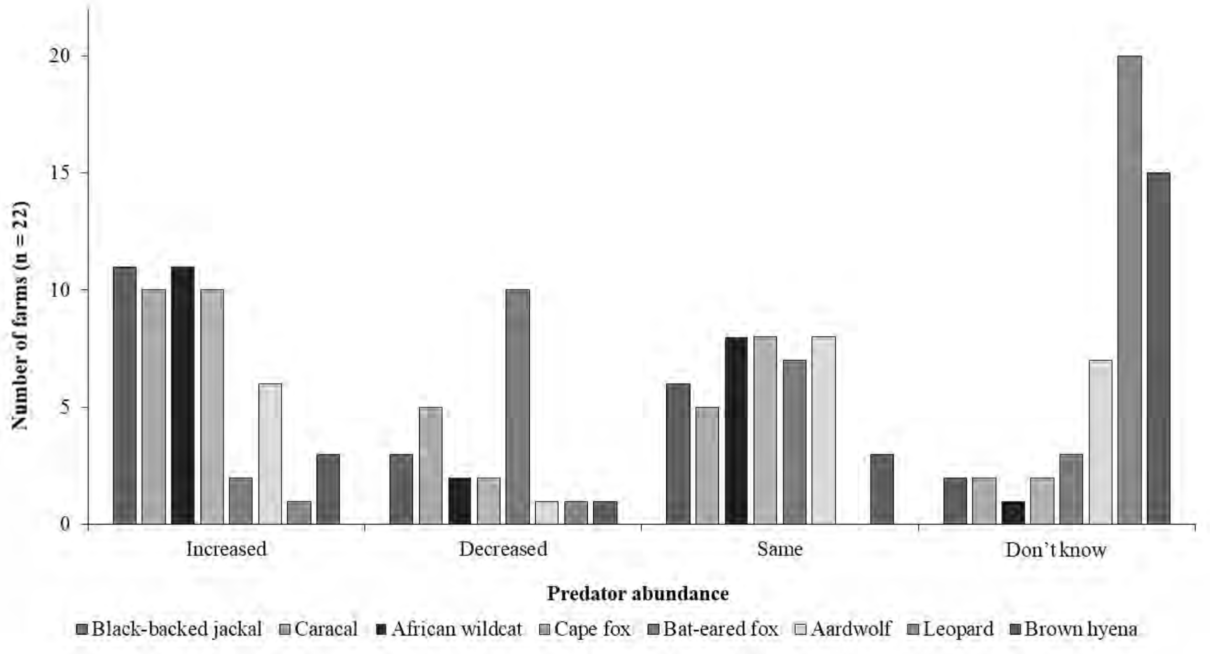

Figure 4.5: The number of farms indicating whether they perceived predators to have increased, decreased or stayed the same over the last three years.

The most common answer provided by participants to explain their perceptions about changes in the abundance of black-backed jackals, caracals, wildcats, Cape foxes, bat-eared foxes and aardwolves, was due to seeing more sightings and spoor in the veld (see Figure 4.6). The majority of participants (73%) indicated that they were not able to provide a reason for their perception of brown hyena abundance, whereas 27% supported their answer by indicating that they see more animals and spoor on their farms. Nine percent of participants stated that brown hyena numbers had increased, while 9% also stated that brown hyena numbers have remained the same, due to an increase in livestock loss. Similarly, participants (91%) were not able to provide an answer for their perception on leopard abundance. From the 5% of participants who indicated that leopard numbers had increased over the last three years, and the 5% who indicated that leopard numbers have decreased, 9% of participants indicated that their perception is derived from seeing more spoor and leopards (indicating leopard presence) and less spoor and leopards (indicating no leopard presence). The participants who stated, ‘other reasons’ as an answer as to how they know a predator’s abundance status, could not provide another reason and was therefore treated as, ‘do not know’ (see Figure 4.6).

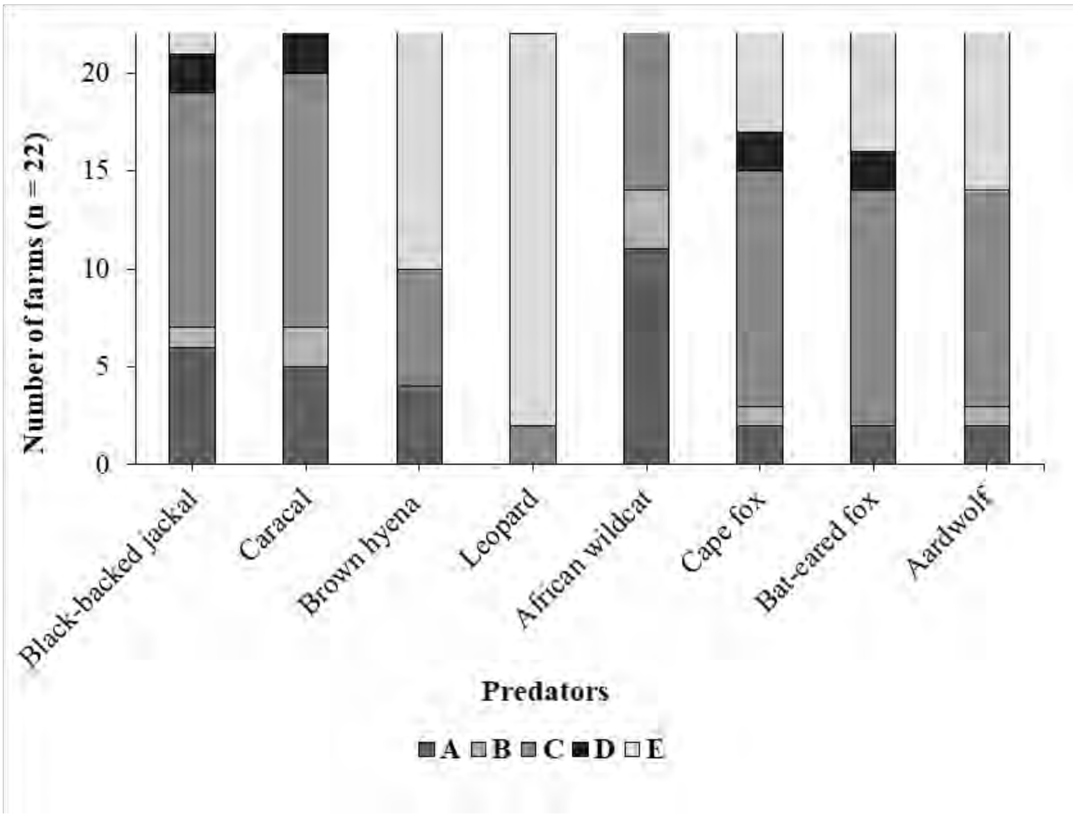

Figure 4.6: Answers given when participants were asked to give the reasons for changes in their perception on predator abundance over the last three years; (A) an increase in stock loss, (B) a decrease in stock loss, (C) more sightings or spoor, (D) less sightings or spoor and (E) other reasons/ do not know.

Participants were asked whether they feel positive, negative or neutral about the listed predators occurring in their district and on their farms (see Figure 4.7). The most negative responses were towards leopards, where 100% of participants indicated that they felt negative towards leopards roaming freely. Back-backed jackals and caracals ranked second, with 95% of participants feeling negativity towards both species being on their farm and in their area. Participants also indicated to have negative feelings towards wildcats (82%) and brown hyenas (73%), but presented mixed feelings towards Cape foxes, with 36% of participants feeling positive, 32% feeling negative and 32% feeling neutral about them occurring on their farm or in the surrounding areas. Participants mostly harboured positive feelings towards bat-eared foxes (91%) and aardwolves (86%).

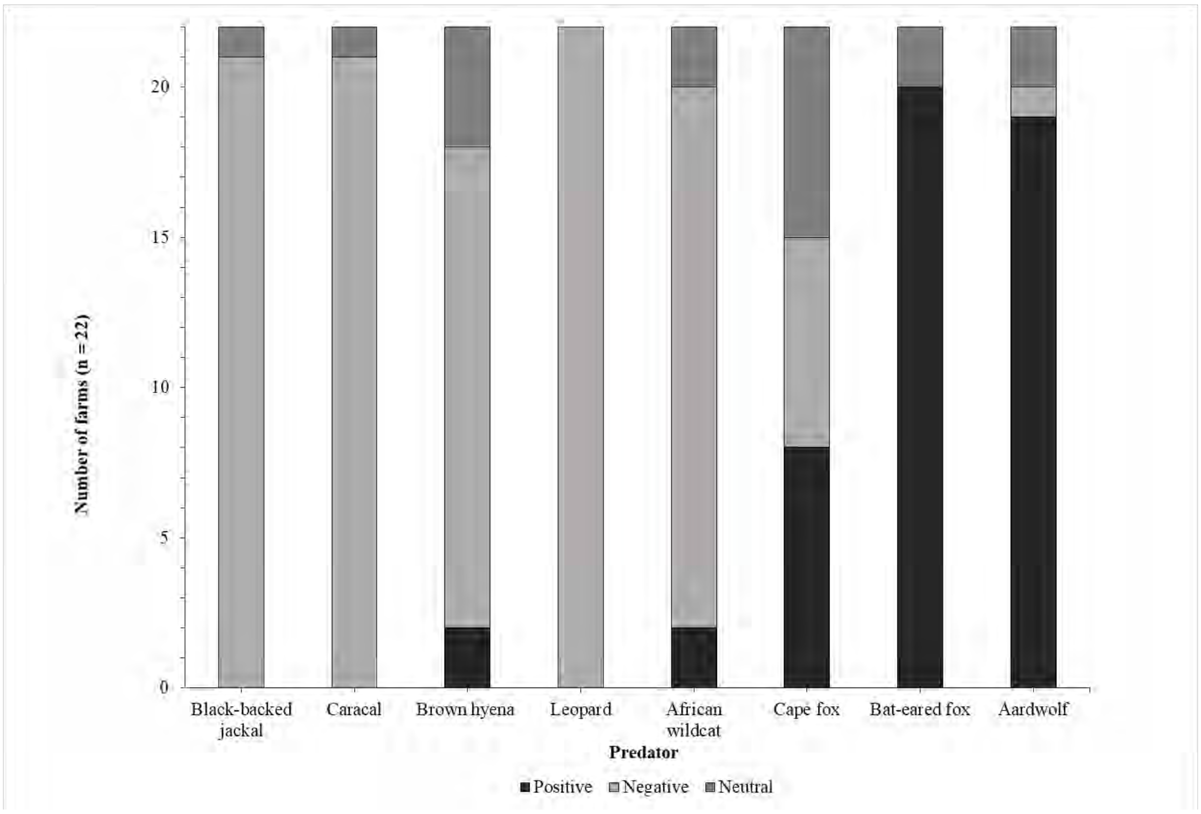

Figure 4.7: The number of farms indicating whether they feel positive, negative or neutral towards the listed predators on their farms and in their district.

When participants were asked if they were aware of any of their neighbours who may have killed or allowed predators to be killed on their properties, 100% of participants answered 'yes' to black-backed jackals and caracals (see Figure 4.8). This was followed by wildcats (91%) and Cape foxes (55%) and lastly brown hyenas (27%) and leopards (14%). No participants were aware of anyone who killed aardwolves or bat-eared foxes.

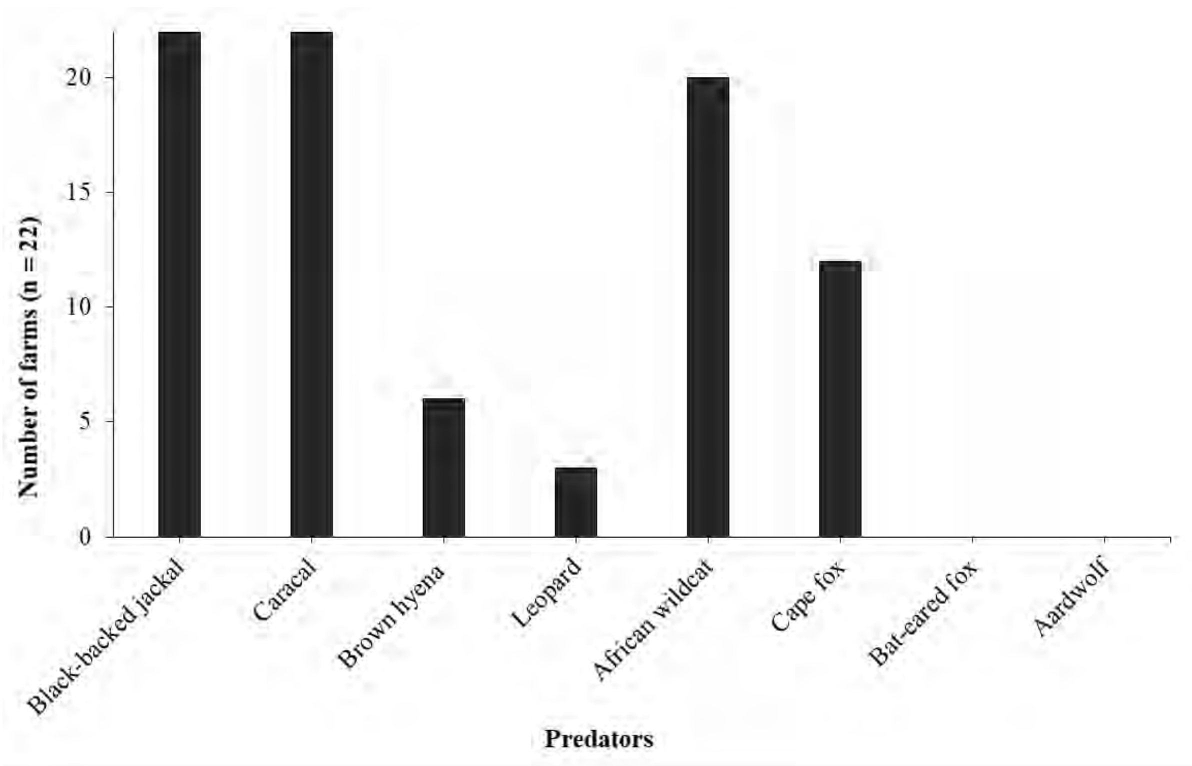

Figure 4.8: The number of farmers who indicated that they were aware of neighbours who kill predators.

Black-backed jackal, caracal, brown hyena, leopard and Cape fox numbers in the study area, were mostly controlled by tracking and shooting, or by spotlight shooting at night, as these predators are all nocturnal and easier to find at night (see Figure 4.9). The second preferred method for controlling black-backed jackal and caracal numbers was by making use of local culling teams, which usually includes tracking dogs (*Canis familiaris*) and horses (*Equus caballus*). The only predator that participants would not kill by using horses and dogs, were leopards. Gin traps were indicated to have medium to low use by participants, regarding the capture of all predator species. Cage traps were the preferred method for capturing wildcats (41%) in the study area, closely followed by tracking and shooting (36%) and the use of culling teams with horses and dogs (36%) (see Figure 4.9).

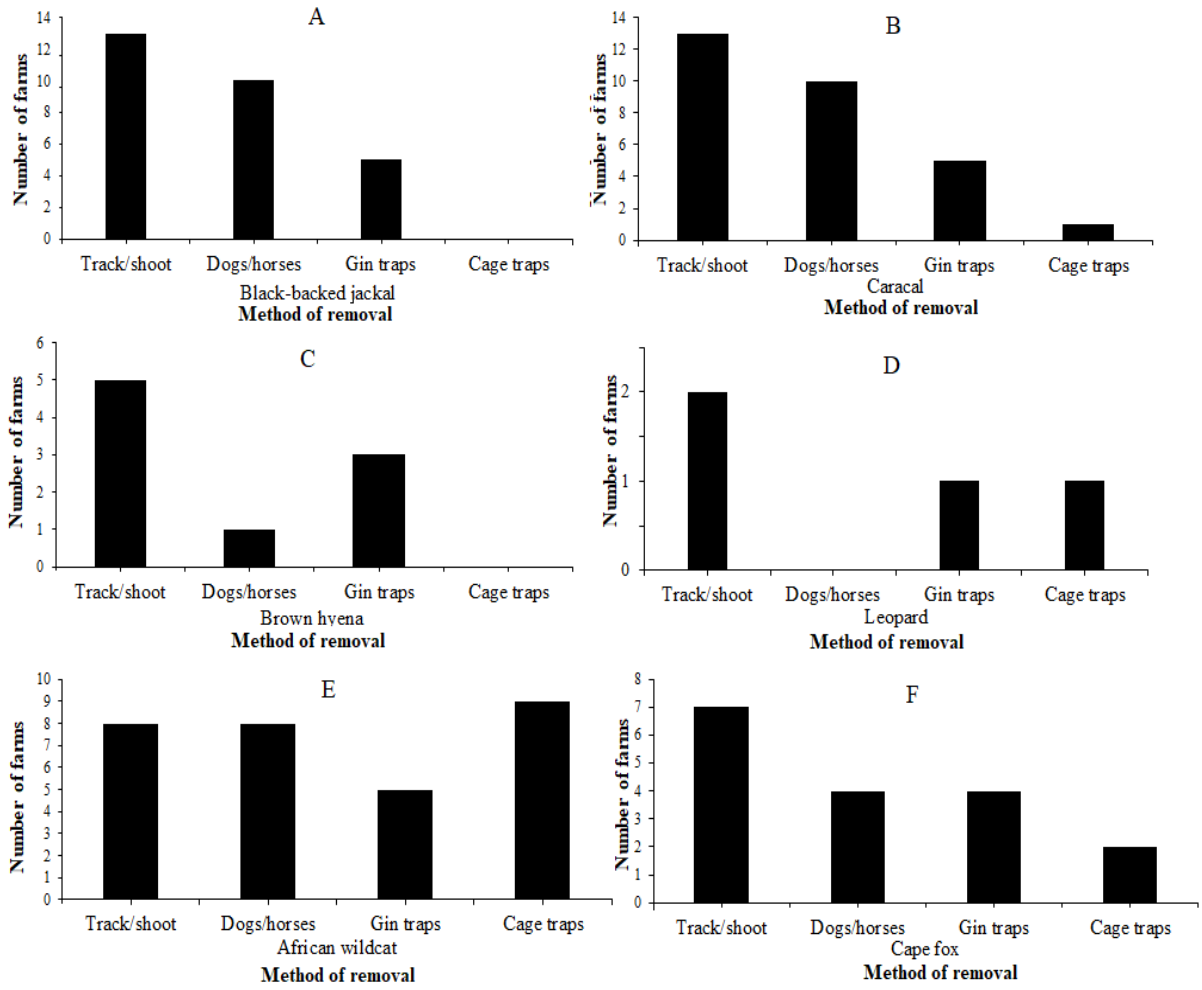

Figure 4.9: Number of farms who use lethal control methods on (A) black-backed jackals, (B) caracals, (C) brown hyenas, (D) leopards, (E) wildcats and (F) Cape foxes in the study area.

Participants were asked if they would be more tolerant towards problem predators if they were compensated for livestock damage and 64% answered, "yes". Fewer participants (27%) indicated that they would not be more tolerant of predators if they received compensation for livestock damage and 9% of participants were unsure if they would be more tolerant towards predators if they received compensation.

When participants were asked if they have, in the past, paid a monetary reward towards the culling of problem predators, 59% answered "yes" to offering rewards for black-backed jackals, caracals, wildcats, Cape foxes and honey badgers (see Figure 4.10). When asked to quantify the amount (South African Rand (R)) that participants were willing to pay per predator culled, the results varied hugely in price between predator species and participant (see Table 4.1). Participants were willing to pay local culling teams between R300 and R1200, per black-backed jackal culled, however, the majority of participants (77%) were willing to pay R1000. The reward for caracals was between R300 to R1000, with the majority of participants (86%), willing to pay R1000 per caracal to be culled. The going rate for wildcats, varied vastly and ranged from R30 to R1000, with the majority of participants (90%) paying R150 to R300 per wildcat culled. Cape foxes fetched between R100 to R1000, with the majority of participants (86%) paying between R250 and R300 per animal culled. Only one participant added another predator to the existing list and was willing to pay R1200 per honey badger culled, stating an apparent increase in sheep predation by honey badgers in recent years as the reason. The 41% of participants that answered "no", to offering a reward for the culling of problem predators, indicated that they do their own culling.

Table 4.1: The monetary reward (R) that participants (n = 22) were willing to pay to a culling team, per predator culled.

Farm	Black-backed jackal	Caracal	African wildcat	Cape fox	Honey badger
1	0	0	0	0	0
2	1200	1000	0	0	0
3	0	0	0	0	0
4	1000	1000	1000	1000	0
5	1000	1000	300	300	1200
6	1000	1000	0	0	0
7	1000	1000	0	0	0
8	0	1000	300	100	0
9	1000	1000	250	250	0
10	0	0	0	0	0
11	0	0	0	0	0
12	1000	1000	300	300	0
13	1000	1000	150	0	0
14	0	0	0	0	0
15	0	0	0	0	0
16	1000	1000	200	200	0
17	0	0	0	0	0
18	1000	1000	250	250	0
19	1000	1000	200	0	0
20	0	500	30	0	0
21	0	0	0	0	0
22	300	300	0	0	0

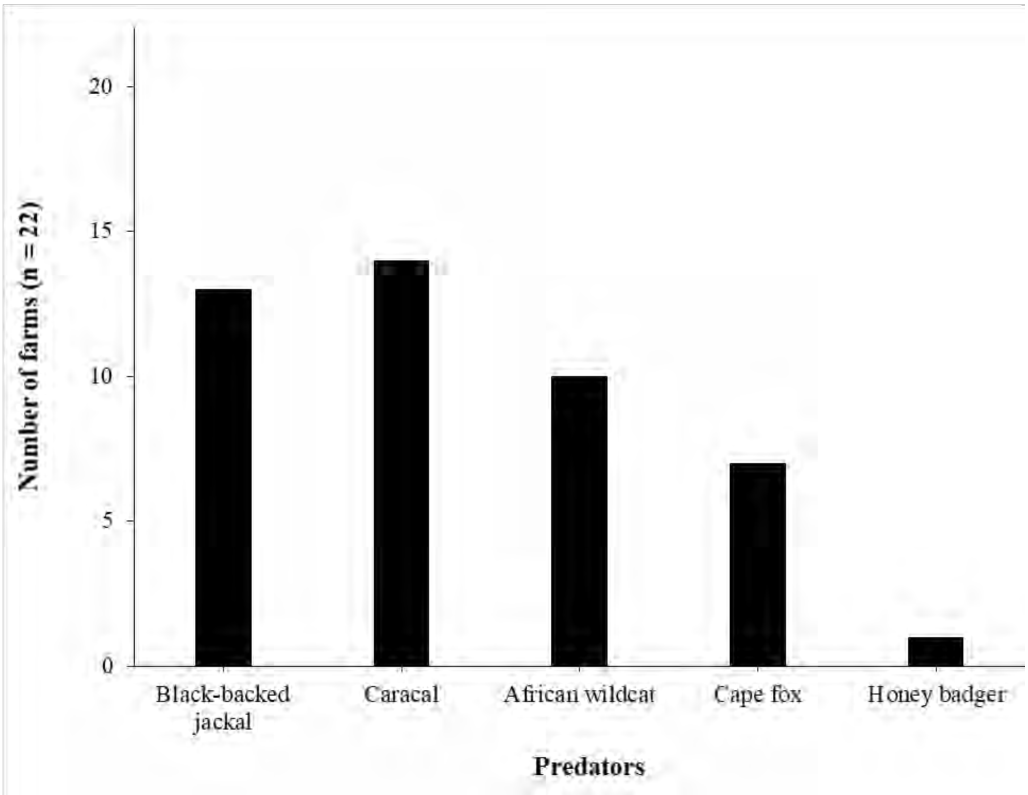

Figure 4.10: The number of farms that would offer a monetary reward towards the culling of problem predators.

4.3.2 Attitudes of participants towards wildcats

The majority of participants in my study area (82%) agreed that small predators, such as wildcats play an important role in the farming environment (e.g. pest control), however 73% admitted that wildcats were considered problem predators on their farms. Eighteen percent of participants commented that they did not think that wildcats play an important role in the farming environment and the other 9% of participants were unsure. Fourteen percent of participants acknowledged that wildcats were not considered problem predators on their farms and one participant (5%) was unsure if wildcats were a problem.

The majority of participants (77%) stated that wildcats have a negative financial impact on their farming business. A smaller portion of participants (18%) indicated that wildcats did not negatively impact their business and one participant (5%) was unsure.

When asked if participants viewed themselves to be more tolerant towards wildcats than their neighbours, 23% replied ‘yes’, 50% commented, ‘no’ and 27% of participants were unsure.

When participants were asked whether they would tolerate a resident wildcat on their farms, 50% indicated that they would and 50% indicated that they would not.

Thirty two percent of participants admitted that they would be happier if wildcats were completely absent from their farms, of which 57% stated that wildcats have a negative impact on their business. Forty seven percent of participants indicated that wildcats were good for maintaining a natural balance on farms in the form of pest control, but in lower numbers. Sixty eight percent of participants stated that they did not want wildcats to be completely absent from their property.

Only 14% of participants thought that wildcats should be protected, with the majority commenting that they should not (77%) and 9% who were uncertain. Nine percent of participants stated that wildcats could produce tourism benefits for their business, however, the majority (86%) of participants did not agree, or were unsure (5%). The majority of participants (77%) would like to see wildcats on protected land and a smaller portion of participants (18%) indicated that they would not like to see wildcats on protected land, with only 5% being unsure.

A smaller number of participants (27%) indicated that wildcats were currently important to them, compared to the number of participants who stated that wildcats were not (68%), with 5% commenting, 'maybe'. However, more than half (64%) of participants wanted to learn more about wildcats, compared to the 32% who were not interested. Only 5% of participants were not sure if they wanted to learn more about wildcats, however it is important to note that the 5% of participants who answered, 'unsure', to all the questions in this section (4.3.2) obtained his main income through salt mining.

4.3.3 Other results

Participants were asked to rank "other" causes of livestock loss on their farms from most to least problematic (see Figure 4.11). Participants remarked that it is not possible to quantify the amount of livestock lost due to other causes, however the degree of livestock losses were not as severe as with the predators that are the main focus of this study. Honey badgers, vultures, drought and poisonous plants were added to the list due to the amount of times they came up as a reason for livestock losses by participants. Disease made up 77% of participant responses, followed by, domestic dogs (73%), theft (68%), Martial Eagles (*Polemaetus bellicosus*) (50%), snake bites (45%), fire (41%), honey badgers (36%), vultures (27%), drought (14%) and poisonous plants (5%).

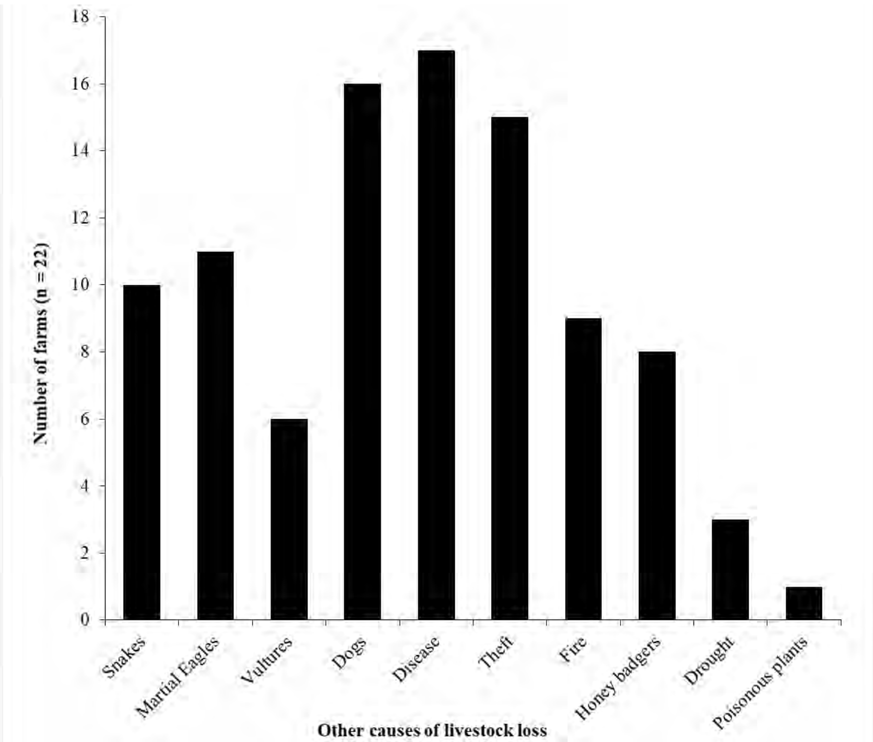

Figure 4.11: Number of farms indicating other causes of livestock loss in the study area, ranked according to severity.

Only one participant commented on disease, mentioning that he lost an estimated 100 sheep in 12 months due to the parasite, wireworm (*Haemonchus contortus*). From the 68% of participants who experienced livestock theft, only one participant experienced repeated large scale sheep theft, due to his farm bordering a public road. Snakes, such as Cape cobras (*Naja nivea)* and puff adders (*Bitis arietans*) are reported to be a minor reason for livestock deaths on 45% of farms, however one participant commented that it is not possible to quantify livestock loss due to snake bites that occur in the veld, other than that which occur when sheep or goats are bitten while in a kraal (pen). Participants reported that they identified snake bites, by finding sheep in the veld with very swollen eyes and tongues however, these were reported to be rare occurrences.

Fourteen percent of participants commented that the lack of rainfall is a major threat to farms in this semi-arid landscape. This is mainly due to the extra financial cost associated with drought, in relation to the purchase of animal feed to supplement the diet of livestock. One participant reported that drought killed 110 sheep on his farm in the last three years. Another participant, reported losing 120 sheep and 20 cattle to drought in the last three years. The majority of the interview group were, however, not able to quantify the total livestock mortality due to drought. Participants further noted that drought was a common cause of livestock loss across farms, however, larger farms are able to move livestock into empty camps and are not as affected by drought related expenses.

4.3.4 Results from statistical analysis

The results from the top performing AIC models for all predators can be found in Appendix 6. Significant relationships were found for participant attitudes and stipulated predictor variables for caracals, black-backed jackals and Cape foxes (see Table 4.2). As participant age increased, so the likelihood of having more negative attitudes towards caracals and black-backed jackals increased ($P < 0.05$) (see Figure 4.12). There was also a negative relationship between participant attitudes towards Cape foxes when participants perceived Cape foxes to kill more livestock on their farms ($P < 0.05$) (see Figure 4.14). No significant relationships were found for participant attitudes towards leopards ($P > 0.05$). In addition, none of the predictor variables considered explain participant attitudes towards brown hyenas or wildcats (see Table 4.2).

Table 4.2: Table indicating the results for the top performing participant attitude models for each predator. The table contains the indicator variables for each predator's top performing model and the related estimates, standard errors (SE), t-values and p-values (*P*).

Coefficients					
Predators	**Predictors**	**Estimates**	**SE**	**t-value**	***P***
Caracal	Age	-6.01×10^{-2}	2.61×10^{-2}	-2.31	0.03
	Ha	7.14×10^{-5}	3.86×10^{-5}	1.85	0.08
Leopard	Dist	0.01	0.01	1.92	0.07
Black-backed jackal	Age	-6.01×10^{-2}	2.61×10^{-2}	-2.31	0.03
	Ha	7.14×10^{-5}	3.86×10^{-5}	1.85	0.08
Cape fox	Loss	-0.11	0.03	-3.56	0.00
Brown hyena	Null	1.27	0.53	2.38	0.03
African wildcat	Null	0.05	0.60	0.18	0.94

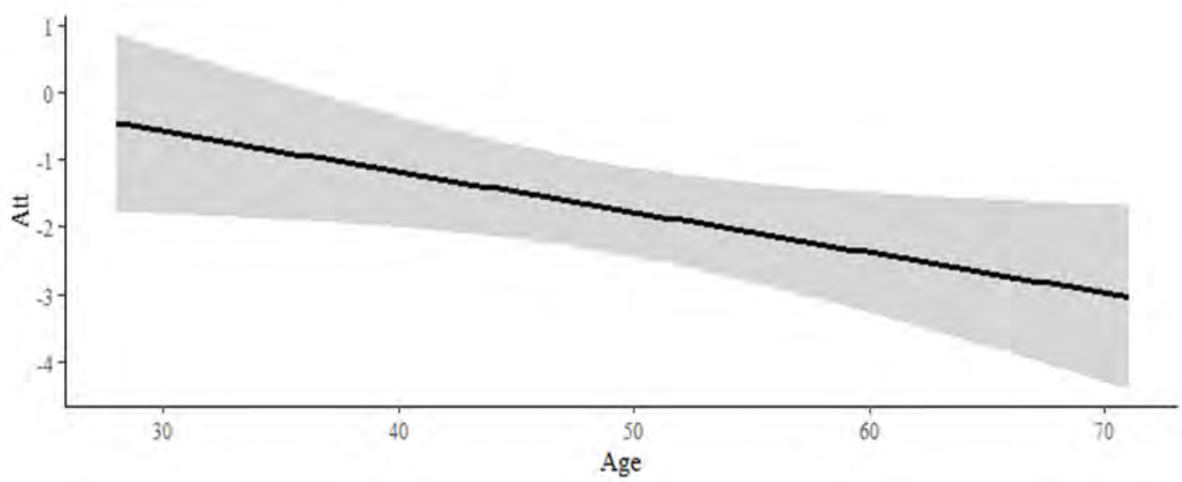

Figure 4.12: Prediction plot indicating the negative relationship between participant attitudes and age towards caracals.

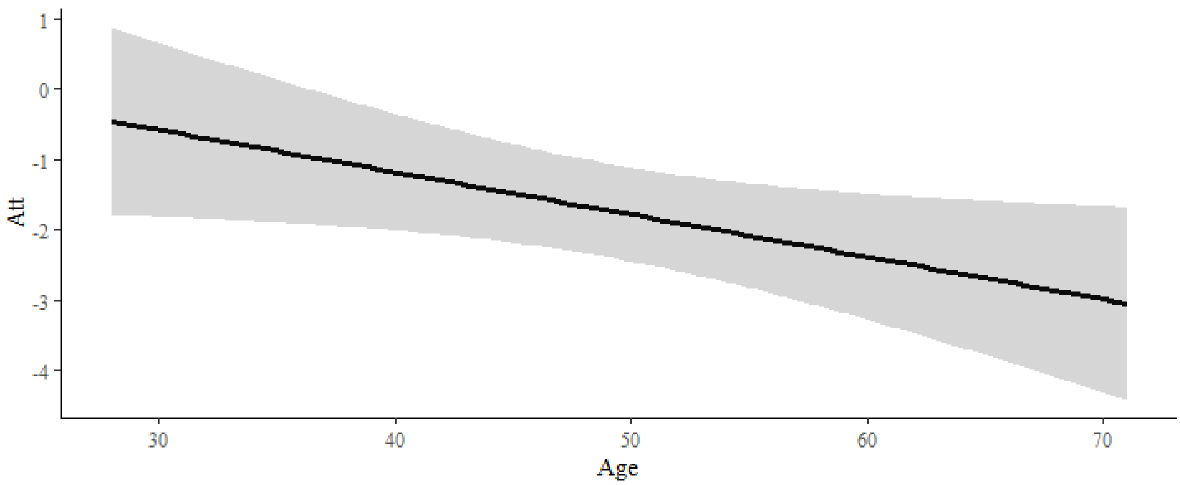

Figure 4.13: Prediction plot indicating the negative relationship between participant attitudes and age towards black-backed jackals.

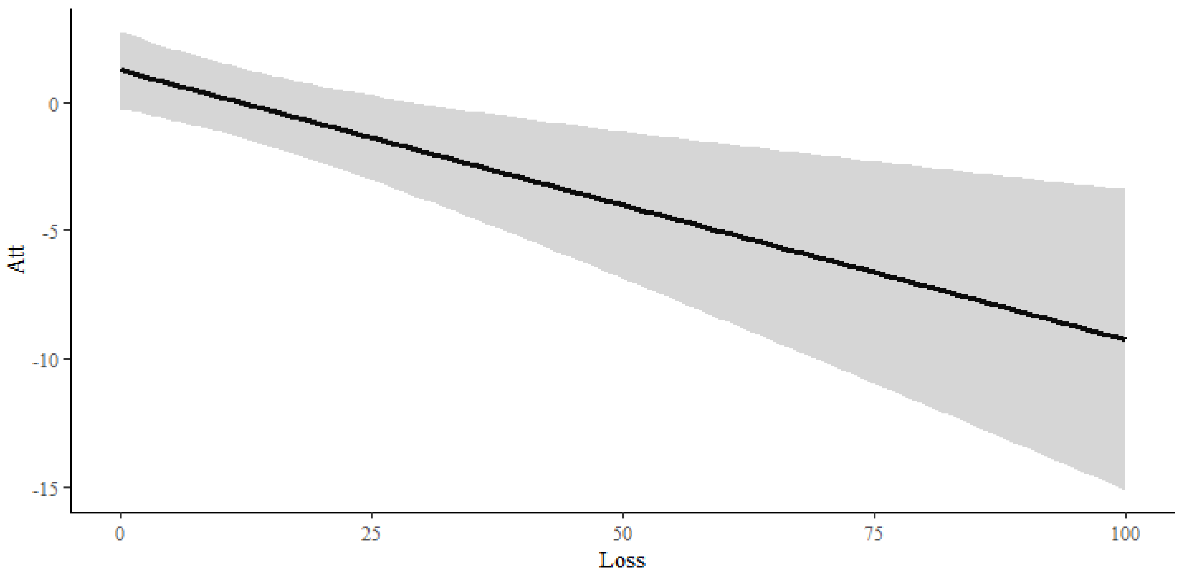

Figure 4.14: Prediction plot indicating the negative relationship between participant attitudes and livestock loss towards Cape foxes.

4.4 Discussion

The Northern Cape province is the largest province in South Africa with over 94% of its farmland utilized for extensive grazing (Van Niekerk, 2010). The Northern Cape also reports the highest livestock predation losses per year (R540,847,496), where an estimated 13% of livestock are lost to mainly black-backed jackals and caracals (Van Niekerk, 2010). Few studies have focused on determining the actual number of livestock lost to predation annually in South Africa, however, local producer organisations estimate an annual loss of 8% of small livestock (mainly sheep and goats) (Van Niekerk, 2010). A study from 2010 estimated a total financial loss of R1,390,453,062 between five of South Africa's provinces (Eastern Cape, Northern Cape, Western Cape, Mpumalanga province and the Free State province) (Van Niekerk, 2010). Direct livestock damage due to wild animals, especially in rural areas (Hill, 2000; Nieman *et al.*, 2020) can pose a serious threat to people and food security and often has a negative financial impact at the household level (Treves *et al.*, 2006; Seoraj-Pillai, 2016; Nieman *et al.*, 2020). Farmers that are financially affected by livestock predation and who do not receive support (e.g. Problem Animal Control) are unlikely to value either the predators on their farms or conservancies (Romanach, Lindsey & Woodroffe, 2007; Rust & Marker, 2013).

There are several factors which influence the extent of livestock predation on farms, such as, livestock type, the condition of livestock husbandry enclosures and the presence or absence of predator deterrents (Wang & Macdonald, 2006; Seoraj-Pillai, 2016). The frequency of livestock predation is also determined by the predator density on farms and natural prey availability (Mishra *et al.*, 2003; Woodroffe *et al.*, 2005). The farms in my study area raised their livestock on natural grazing and livestock pens were only used in the short term (e.g. a night or two before being transported). No predator deterrents were used on any of the farms in my study area as most methods were perceived to be impractical for large farms (e.g. herdsman, livestock protection dogs, lights and alarms). The farms in my study area apparently hosted high predator abundances and were rich in natural prey species (see Chapter 3) and livestock prey. Livestock predation and predator conflict were reported to be high throughout the study area. This finding highlights the importance of conducting studies in areas of South Africa where farms experience high human-wildlife conflict due to livestock predation.

Statistical analysis indicated that participant negativity towards caracals and black-backed jackals increased with participant age (see Figure 4.12 and 4.13, respectively). The participants in my study area were between 28 and 71 years of age and the majority of the interview group were generational farmers who all knew of a neighbour who had previously culled caracals and black-backed jackals. Human values towards wildlife develop from a young age and these learnt values have been found to be resistant to change and could affect a person's beliefs, attitudes and behaviours towards wildlife (Schwartz & Bilsky, 1987; Kretser *et al.*, 2009). Kretser *et al.*, (2009) found that people who grew up in urban areas were more likely to have more positive attitudes towards wildlife, compared to those with rural backgrounds, most likely due to generationally taught values. Farmers' negative attitudes towards damage causing species are often influenced by factors other than the damage caused to crops or livestock (Naughton-Treves, 1999; Abram *et al.*, 2015), but rather through generational hatred, as documented by Barnes *et al*. (1995), towards Central African forest elephants (*Loxodonta cyclotis*). The more negative attitudes towards black-backed jackals and caracals in my study area could therefore possibly be explained by learnt negative behaviour towards the two species from a young age, becoming normalized over time.

Cape foxes had an overall lower conflict status in my study area compared to black-backed jackals, caracals and wildcats (see Figure 4.8). Statistical analysis indicated that participants hosted strong negative attitudes towards Cape foxes when they were perceived to kill more livestock on their farms (see Figure 4.14). To my knowledge all of the farms in my study area were commercial farms, however, when visiting the smallest of the farms in my study area, poverty was evident. Livestock predation tends to be more problematic on commercial farms, than on communal and subsistence farms, as commercial farms tend to host a low human density, with few workers and dogs living close to livestock to deter predators (Kerley *et al.*, 2018). High levels of predation could have significant financial and welfare impacts in areas where farming is marginal and households are poor, however very few studies have been conducted on previously-disadvantaged, small-scale and subsistence farming communities (Kerley *et al.*, 2018). Small-scale farmers are more financially impacted with the loss of one sheep than large-scale farmers who have many sheep (Loveridge *et al.*, 2010). Overall, my study area experienced a total perceived financial loss of R 4,249,600 in 2020 due to livestock predation. Participants who farmed with goats experienced the highest livestock loss due to predation in 2020 (85.5% loss) but also owned the smallest farms. Even though I cannot comment on the financial statuses of the farms in my study area, my questionnaires clearly indicated that financial loss due perceived livestock predation was a key factor which promoted farmer negativity towards certain predator species.

No social factors were found to explain participant attitudes towards wildcats, brown hyenas and leopards. This result is difficult to explain and more research with larger participant groups would be needed to determine the reason for this outcome. It is, however, important to recognize that different groups of people cannot necessarily be considered or treated as homogenous units and that individual participants might experience livestock predation in different ways (Hill, 2004), resulting in different feelings towards different predator species. It is also important to consider that generational livestock predation experiences and learnt behaviour form a young age, could be the a major reason for negative participant attitudes towards wildcats, leopards and brown hyenas (Schwartz & Bilsky, 1987). This result could also have been due to my small participant group and therefore a larger participant group could have changed the outcome of my attitude results for wildcats, brown hyenas and leopards.

There is no doubt that mesopredators, such as wildcats, offer a natural ecosystem service in terms of pest control on farmlands (Gutierrez *et al.*, 1997; Crooks & Soulé, 1999; Prugh *et al.*, 2009), as rodents and invertebrates are amongst the highest percentage of occurrence prey items in their diet (Chapter 3) (Blaum *et al.*, 2009; Herbst & Mills, 2010a). It was, however, clear from this study that some predator species are perceived to have a higher human-wildlife conflict status than others (mostly, the larger the predator, the higher the level of conflict). Much of the negative participant attitudes in my study area could be linked to livestock lambing seasons. South African livestock lambing seasons occur from March to April and from August to September (Van Niekerk, 2010). Spikes in lamb predation have been documented during August and September, which coincides with the breeding seasons for specifically black-backed jackals, when pups are reared (Van Niekerk, 2010). Roughly, 90% of lambs in my study area are born between May and August, with around 10% of lambs being born throughout the summer months. This lambing period is mainly due to naturally run livestock production systems, where rams are left with the herds all year around (Stadler, L., pers. com., 16 August 2020). Participants perceived predator numbers to escalate after good rains and that predation spikes occur during the lambing season. The participants in my study area estimated a loss of 3323 livestock (10.86%) in the preceding year (2020), of which the majority were sheep (see Figure 4.4).

Overall, wildcats were believed to have the highest impact on livestock (68% of participants), followed by black-backed jackals (27%), caracals (27%) and Cape foxes (9%) (see Figure 4.3). To my knowledge, no field study has been conducted purely on wildcats as predators on livestock farms in South Africa. Wildcats have been documented as problem predators on farms (Palmer & Fairall, 1988; Nowell & Jackson, 1996; Blaum *et al.*, 2009; Herbst, 2009; Todd *et al.*, 2009; Yamaguchi *et al.*, 2015; Kerley *et al.*, 2018), however, not to the extent of black-backed jackals and caracals (Avenant & Du Plessis, 2008; Treves, Wallace & White, 2009; Van Niekerk, 2010; Brassine, 2011; Thorn *et al.*, 2012; Bergman *et al.*, 2013; Kelly, 2018; Kerley *et al.*, 2018). Wildcat predation on livestock is usually reported as infrequent and as having a low financial impact on the farmer (Bailey & Conradie, 2013; Kerley *et al.*, 2018), however this was not the case in my study area. It is important to study the wildcat's behaviour on unprotected areas as little is known about the role that wildcats play on livestock farms (Herbst, 2009).

Wildcats were considered to be problem predators on most of the farms in the study area due to the financial impact caused by the killing of livestock. Participants indicated that wildcats prey only on newborn lambs, by either killing them by suffocation or by breaking their necks. Herbst (2009) observed a male wildcat in the KTP, biting a hare (*Lepus* sp.) behind the neck and violently shaking it until it was dead. Wildcats were said by most participants to start feeding on the thigh and lower rib cage of newborn lambs, whereas caracals tended to start feeding at the throat (see Appendix 7 (A and B), respectively). Some participants indicated that they often find lambs on their farms with disfigured necks or swollen throats and blamed this on wildcats, attempting to kill too big or strong a lamb and the lamb ends up escaping (see Appendix 7 (C)).

One would expect that the reputation of the most damage causing predator species on farms (in this case, wildcats) to have the most negative attitudes directed towards them, however, although still high, fewer participants (82%) harboured negative feelings towards wildcats, than towards black-backed jackals and caracals (95% each) (see Figure 4.7). Wildcats were also less persecuted, as 91% of participants knew of neighbours who culled wildcats, compared to 100% of participants who knew of neighbours who culled black-backed jackals and caracals (see Figure 4.8). Participants also indicated a higher tolerance towards wildcats, compared to black-backed jackals and caracals. Twenty three percent of participants indicated that they were more tolerant of wildcats on their farms than their neighbours, with half of the interview group indicating that they would tolerate a resident wildcat on their farm. The majority of the participants (64%) also indicated that they would like to learn more about wildcats and that they enjoyed seeing wildcats on protected land (77%). Although 77% of participants did not feel that wildcats should be protected, the majority of participants (68%) however indicated that wildcats should not be absent on farms, of which 77% of participants indicated that wildcats play an important role on farms by maintaining natural ecosystem health, in the form of pest control.

To understand why wildcats are viewed in a slightly more positive light, compared to black-backed jackals, caracals and leopards in my study area, and to determine why they are so successful on unprotected land, we might need to understand why wildcats are so successful on protected land. Wildcats are solitary and elusive small predators (Sunquist & Sunquist, 2002; Herbst, 2009; Van den Heever *et al.*, 2017) that give birth to multiple offspring (Herbst, 2009; Stuart & Stuart, 2015). Kittens are born between September and March (Stuart & Stuart, 2015), however female wildcats in the KTP had up to four litters in a 12 month period and also gave birth outside this period (e.g. July) (Herbst, 2009). This birthing period coincides with my study area's lambing season, which could explain the high levels of newborn lamb predation. Wildcats are nocturnal (Nowell & Jackson, 1996; Herbst, 2009; Stuart & Stuart, 2015) and have the ability to change their diet according to prey availability, which makes them successful on protected land (Herbst, 2009) and, most likely, also on unprotected land. My study area shares a similar natural habitat to that of the KTP (see Chapter 2) and hosts a variety of the wildcat's natural prey species (see Chapter 3). Besides the natural prey species available on unprotected land, wildcats additionally prey on newborn lambs and kids.

Wildcats could further benefit from the culling of more suppressive and competitive mesopredators, such as black-backed jackals and caracals (Beinart, 1998; Balme *et al.*, 2009; Blaum *et al.*, 2009; Herbst, 2009; Todd *et al.*, 2009; Chapman & Balme, 2010; Kerley *et al.*, 2018). Black-backed jackals and caracals have been known to harass wildcats, compete with wildcats for food (Herbst, 2009) and have even been recorded to prey on wildcats in protected areas (Grobler, 1981; Bothma & Le Riche, 1994; Melville *et al.*, 2004). The relative absence of competing predators, such as black-backed jackals and caracals, could result in an increase in wildcat abundances on unprotected land as the role of wildcats for instance, could change from being a subordinate predator, to an apex predator (Herbst, 2009). A questionnaire conducted in 2004 by Blaum *et al.* (2009), amongst 22 southern Kalahari farms, concluded that most farm managers perceived wildcats, caracals and black-backed jackals, to predate on livestock. Predator control, resulted in reduced numbers of each species, however, wildcats were still the most abundant carnivore across farms, and black-backed jackals and caracals were the least common species and were locally absent on farms that practiced predator control (Blaum *et al.*, 2009). This finding was also found in my study area, where black-backed jackals and caracals were completely absent from some farms due to generational culling practices (see Figure 4.1).

Wildcats in my study area were reported to mainly cause financial loss during lambing seasons. Black-backed jackals and caracals were however reported to predate on anything from newborn lambs to larger livestock, such as adult sheep and goats and therefore have a larger financial impact throughout the year. Participants further reported that, although wildcats contribute largely to livestock predation, they are not as successful at catching livestock prey, as back-backed jackals and caracals are. Black-backed jackals have been known to opportunistically hunt in packs when the opportunity arises (Moehlman, 1987; McKenzie, 1990). It has even been speculated that they should be viewed as large predators due to their capacity to hunt medium-sized ungulates (e.g. springbok and impala (*Aepyceros melampus*)) (Klare *et al.*, 2010). Caracals are also known to prey on medium sized antelope, such as springbok (Bothma & Walker, 1999).

My study indicated that livestock loss was not the only driver of participant negativity towards a certain predator, but potentially also due to predator body mass and the predator's ability to kill larger livestock. Participants in my study area felt the most negative towards leopards, followed by black-backed jackals and caracals, wildcats, brown hyenas and Cape foxes, respectively. Human-wildlife conflict is one of the biggest threats facing wildlife species today (Dickman, 2010), with increased severity, with felid body mass (Inskip & Zimmermann, 2009). Participant attitudes indicated less tolerance towards the larger predator species (leopards, black-backed jackals and caracals) and somewhat higher tolerance towards the smaller predator species (wildcats and Cape foxes) (see Figure 4.7). The only exception was the brown hyena, which was ranked between wildcats and Cape foxes in terms of participant negativity. Brown hyenas were perceived to kill less livestock on farms than Cape foxes (see Figure 4.4), however were viewed more negatively by participants than Cape foxes (see Figure 4.7).

Many farmers feel that carnivores are overabundant and cause financial losses and that the lethal control of problem predators is the most cost-effective method of limiting the problem (Romanach *et al.*, 2007). The culling of problem predators is a common practice across South Africa (Balme *et al.*, 2009; Blaum *et al.*, 2009; Herbst, 2009; Todd *et al.*, 2009; Chapman & Balme, 2010; Kerley *et al.*, 2018). Sixty four percent of participants in the study area indicated that they would be more tolerant towards problem predators on their farms if they were compensated for their losses. Overall, 64% of participants in my study area indicated that they were more tolerant towards problem predators on their farms, than their neighbours, however all participants reported knowing of neighbours who practiced lethal predator control. Tracking and shooting, the use of dogs and horses (culling teams), gin traps and cage traps, were the most commonly used lethal predator control methods (see Figure 4.9). The method of tracking and shooting was the most popular method of lethal control for all predator species in my study area, except for wildcats, where cage traps were favoured. Cage traps are specific to solitary felids that cache and return to their kills (e.g. leopards and caracals) (Kerley *et al.*, 2018). In the KTP, the capture success of wildcats resulted in 70% wildcats spotted prior to placing the cage traps, being caught (Herbst & Mills, 2010b). Canids are not successfully caught in cage traps (Kerley *et al.*, 2018) and the participants in my study area confirmed this. Cage traps were common across the farms in the study area, as cage traps can activated and maintained on routine water runs throughout the year. This method of capture also require minimum effort to maintain, is more selective and non-target species can be released (Boitani & Powell, 2012; Kerley *et al.*, 2018). Wildcats are territorial and tend to stay in the same area (Driscoll *et al.*, 2009) and therefore the chance of trapping a wildcat in its territory and its replacement, is likely. One participant in my study area indicated that he was convinced that wildcats are attracted by sheep. He indicated to test this theory by placing cage traps in camps containing only sheep and in camps containing only cattle (12 month period). The result was, only capturing wildcats in camps containing sheep, which highlights the importance to conduct future studies to test this theory.

The use of lethal predator control methods, such as specialist culling teams are effective at reducing problem predator numbers as these individuals are usually well-skilled in the art of shooting at night and have a good knowledge of predator behaviour. The effectiveness of culling has however been disputed, for example, the culling of red foxes (*Vulpes vulpes*) resulted in an increase in their abundance and the same for feral cats, who's numbers increased by 211% at the two culling sites, by the end of the designated culling period. (Newsome *et al.*, 2017). It is therefore possible for the culling of wildcats over the years to have benefitted wildcat abundances in the study area, initiating an increase in wildcat breeding, in response to the culling.

Fifty nine percent of participants indicated that they would pay local culling teams a monetary reward towards the culling of problem predators on their farms. The highest amount (R) that participants were willing to pay as a reward, was for the culling of black-backed jackals, caracals and honey badgers (see Table 4.10). The 49% of participants who indicated to not offer rewards for culling, claimed to do the culling themselves. Whether participants offered rewards for the culling of predators or did the culling themselves, it is clear that culling signifies negative participant attitudes in my study area and higher levels of human-wildlife conflict towards black-backed jackals, caracals and wildcats, in particular. Regardless of the sustained predator culling pressure by participants, wildcat numbers have remained the highest of the predators on farms in my study area since at least 2004 (Blaum *et al.*, 2009), which to my knowledge was the last time that farmers were interviewed in the same farming area as my study area.

Non-lethal methods of predator control are more humanely acceptable (Todd *et al.*, 2009) and have widely been adopted in the Northern Cape, with 87% of farmers reportedly using at least one non-lethal method of control (more than any other major small livestock producing province) (Van Niekerk, 2010). None of the participants in my study area indicated that they made use of non-lethal predator deterrents, mainly due to the impractical nature of the available deterrents for this particular farming environment. In some cases, participants are also not able to afford better livestock husbandry practices (Rust & Marker, 2013).

The lack of quantitative scientific data concerning human-wildlife conflict retards the process of constructing effective mitigation strategies (Thorn *et al.*, 2012). My recommendations are that more studies be conducted on human-wildlife conflict issues in areas where such studies have not been conducted, especially on southern Kalahari farms, were human-wildlife conflict levels are high. Studies should also be conducted to determine the status of wildcats as problem predators on southern Kalahari farms and to determine the actual diet of wildcats on unprotected land. The methods used to study wildcat diet in the KTP was through direct observations, radio telemetry tracking, small prey trapping and scat analysis, which resulted in comprehensive wildcat dietary findings on protected land (Herbst & Mills, 2010b). The option of radio collaring and tracking of wildcats on farms in my study area was not welcomed by the participants and therefore the best opportunity to observe the true diet of wildcats on unprotected land would be through stomach content analysis or scat analysis.

By using the stomachs of culled wildcats from my study area, great insight could be obtained into the seasonal prey preferences of wildcats on unprotected land. The data acquired from such stomach content analysis could also give a good indication on the degree of livestock consumed by wildcats. Stomach content analysis allows for a more accurate assessment of the relative volume of each food item consumed (e.g. Feldhamer *et al.*, 2007; Balestrieri, Remonti & Prigioni, 2010) and makes it possible to identify partially digested food remains to species-level (Cavallini & Volpi, 1995). Stomach content analysis is also beneficial as it prevents the risk of predator misidentification, which could happen when working with scats (Pezzo, Parigi & Fico, 2003).

Wildcats are listed as 'least concern' by the IUCN (Yamaguchi *et al.*, 2015), however, they only remain partially protected in the Northern Cape, under PHASA (Professional Hunters' Association of South African), since 2013 and are listed under the category, 'EXTRAORDINARY' (*Northern Cape Provincial Gazette Extraordinary, 19 December 2012.*, 2013). This allows farms in possession of hunting permits to legally hunt three wildcats per year on their property (*Northern Cape Provincial Gazette Extraordinary, 19 December 2012.*, 2013). Obtaining the use of legally hunted wildcat by-products (e.g. stomach contents) could be beneficial for wildcat diet studies on unprotected land, however the process to get research permits approved and accepted by animal ethics committees are drawn out and difficult. To my knowledge no farmers in the southern Kalahari hunt wildcats for recreational or financial benefit and therefore, this legal method of wildcat stomach collection is not a viable option.

Scat analysis is another common method used to identify and quantify the individual components of the diets of elusive predators (Ciucci *et al.*, 1996; Kaunda & Skinner, 2003). The ethical collection of wildcat scats would be difficult to conduct on the farms in my study area as wildcats typically burry their scats (Stuart & Stuart, 2015; Van den Heever *et al.*, 2017) and they would have to be habituated and followed to collect these scats, as was done by Herbst, 2009, in the KTP. Farmers would also have to give their consent and as stated before, this was not an option in my study area.

Farmers are less likely to support carnivore conservation approaches which ignore the negative effects that predation has on farming environments, which in turn hampers the enforcement of such programs in remote areas (Lindsey *et al.*, 2009) and even provokes hostility towards conservation initiatives in general (Dar *et al.*, 2009). If local wildlife authorities are unable to allocate a local wildlife officer for southern Kalahari farmers to communicate with when they have wildlife problems, farmers will most likely continue to take care of the predation problems themselves. It is important to document the experiences of farmers who deal with various problem wildlife species on their farms. It is also important to not only conduct scientific studies on human-wildlife issues with quantitative data, but to also document and take the experiences of farmers more seriously, allowing the affected parties (farmers) to have a platform to be heard, without fear of persecution (St John *et al.*, 2011). It is often forgotten that farmers are experts in their own field and by ignoring their experiences regarding human-wildlife conflict issues, the full aspect of human-wildlife conflict cannot be understood or resolved. By including farmers in management decisions, better relationships can be established between conservation and farming communities and better human-wildlife mitigation decisions can be made through open conversation (Lindsey *et al.*, 2009; Treves *et al.*, 2009; Dickman, 2010). It is furthermore important to study and monitor wildcats outside protected areas to obtain a deeper knowledge of wildcat behaviour, abundance, population dynamics and other aspects of its ecology (Herbst, 2009). By studying wildcats on unprotected land, specific conservation and management questions can be addressed and through the knowledge of the natural history of a species, conservation failures can be avoided (Herbst, 2009).

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

There are two sub-species of wildcat in Africa, which are, those found in the eastern and north-western parts of Africa (*Felis lybica lybica*) and those found in southern Africa (*F.l. cafra*) (wildcat, hereafter) (Kitchener *et al.*, 2017). Wildcats have an exceptional ability to adapt to their environment (Nowell & Jackson, 1996; Driscoll *et al.*, 2007; Yamaguchi *et al.*, 2015), making them the most common and widely distributed of all the wildcats (Yamaguchi *et al.*, 2015; Estes, 1992). Wildcat density and distribution is however expected to vary with prey availability (Nowell & Jackson, 1996; Herbst & Mills, 2010a), causing them to be absent from true deserts (Nowell & Jackson, 1996; Yamaguchi *et al.*, 2015). Despite the extreme climate of the southern Kalahari in South Africa, this region offers favourable conditions for wildcats and supports high wildcat densities on both protected and unprotected land (Blaum *et al.*, 2009; Herbst, 2009). In fact, the participants in my study area indicated that wildcats were the most abundant predator on their farms.

My study area consisted of 22 farms on unprotected land, south of the Kgalagadi Transfrontier Park (KTP) (protected land). These farms share the same geology, climate and have a similar natural species richness to that of the KTP. The KTP is also the closest protected area, which offers safe breading grounds for wildcats (Herbst, 2009). The historic removal of apex predators (e.g. lions (*Panthera leo*), leopards (*Panthera pardus*), cheetahs (*Acinonyx jubatus*) and spotted hyenas (*Crocuta crocuta*)) (Herbst, 2009) could be the cause of the perceived high mesopredator densities (Estes, 1996; Ripple & Beschta, 2004; Herbst, 2009; Prugh *et al.*, 2009; Chapman & Balme, 2010) on unprotected land in the southern Kalahari. The southern Kalahari has a high human-predator conflict status due to perceived livestock predation (Blaum *et al.*, 2009; Herbst, 2009). The farms in my study area kept livestock (mainly sheep (*Ovis aries*) and cattle (*Bos taurus*) and to a smaller degree goats (*Capra hircus*)) on natural grazing and all indicated their frustration to losing livestock to predators, especially during lambing season.

My interest in human-wildlife conflict started at a young age, when it became clear that predators such as black-backed jackals (*Canis mesomelas*), caracals (*Caracal caracal*) and wildcats, were being accused of livestock predation on southern Kalahari farms. I later completed my practical experience as a conservation student in the KTP where I assisted Marna Herbst (then, Doctor of Philosophy student) with her data collection on wildcat diet on protected land. I decided to conduct this study when I realized that wildcats were not considered to be a big threat to livestock in other parts of South Africa. The aim of my study was firstly to determine the potential natural prey available for wildcats on unprotected land in the southern Kalahari and secondly, to determine the human-predator conflict status of mesopredators and in particular of wildcats, on unprotected land in the southern Kalahari.

5.2 Natural prey availably for wildcats on unprotected land

I predicted that similar natural prey species would occur on unprotected land as was found to be consumed by wildcats on protected land in the KTP (see Herbst & Mills, 2010a). The natural prey available for wildcats on unprotected land was determined through small mammal trapping (2020), personal observations (2013 – 2020) and camera trapping (2013 - 2015) on the main study site (see Chapter 3). Even though my small mammal trap success was low, the study site presented an overall healthy abundance of wildlife, which form part of the wildcat's natural prey on protected land (Smithers, 1971; Stuart, 1977; Smithers & Wilson, 1979; Palmer & Fairall, 1988; Herbst & Mills, 2010a; Stuart & Stuart, 2015). Dune and adjacent street habitats hosted the highest small mammal abundance on unprotected land, as was also found in the KTP (see Herbst & Mills, 2010a). This finding highlights the importance of these two habitats as hunting grounds for wildcats on both, protected and unprotected land, in the southern Kalahari.

There were a few limiting factors which prevented me from collecting the data which I originally intended to collect. Firstly, the extreme drought at the time of my small mammal trapping resulted in a disappointingly low small mammal capture success across the four habitat types, with no small mammals being captured in the riverbed habitat. A two-year drought period in Botswana (1960's) caused murid populations to plummet to an unprecedentedly low level, which resulted in no rodent content to be found in the 16 wildcat stomachs that were analysed (Smithers, 1971). Secondly, due to time constraints, small mammal capture was only possible during one season (spring of 2020). Thirdly, no camera trap surveys were conducted in the riverbed habitat, which again, was due to the drought, as no livestock were kept in riverbed habitats during the survey period and therefore the farm managers did not place cameras at waterholes in this habitat. Fourthly, I was not able to conduct the camera trap surveys myself and therefore the moving and activation of camera traps at the 25 trap stations were managed by the farm managers, which resulted in statistically unusable data to be collected. It is therefore important for future studies of this kind to focus on long-term research, surveying all four habitat types extensively, across all four seasons and during wet and dry years. It is also important for the research to be conducted by a full-time researcher in order for more statistically robust data to be collected. Wildcat dietary research should also survey all possible natural prey categories (e.g. invertebrate and reptilian diet) on unprotected land to allow for more comprehensive research on wildcat diet, which I was not able to do due to time constraints.

5.3 Human-predator conflict in the southern Kalahari with focus on wildcats

The wildcat's human conflict status in the southern Kalahari was determined through 22 questionnaire interviews. I predicted that wildcats, black-backed jackals and caracals would be perceived as the most common livestock predators and that they would also experience the highest human-predator conflict in my study area. Wildcats occurred on 100% of the farms and were perceived to have the highest impact on livestock in my study area (68%), followed by black-backed jackals (26%), caracals (26%) and Cape Foxes (9%). A similar, but opposite result was found in 2004, where the most perceived livestock damage causing predators were black-backed jackals, followed by wildcats and then caracals (Blaum *et al.*, 2009). Black-backed jackals and caracals were indicated to be the most persecuted predator species in my study area, followed by wildcats. The more negative perception of participants towards black-backed jackals and caracals was also clear when participants indicated that their neighbours were willing to put more effort and money into the control of both species, which most likely resulted in the higher wildcat numbers on southern Kalahari farms over the years (Beinart, 1998; Balme *et al.*, 2009; Blaum *et al.*, 2009; Herbst, 2009; Todd *et al.*, 2009; Chapman & Balme, 2010; Kerley *et al.*, 2018).

The method of tracking and shooting was the most popular method of lethal control for all predator species in my study area, except for wildcats, where cage traps were favoured (see Figure 4.9). Cage traps are commonly used to capture solitary felids that cache and return to their kills (Kerley *et al.*, 2018). The majority of participants offered rewards for the culling of predators and the remainder of participants indicated doing the culling themselves, which indicated high levels of human-predator conflict towards black-backed jackals, caracals and wildcats, in particular. The culling of wildcats and other problem predators is a common practice across South Africa (Balme *et al.*, 2009; Blaum *et al.*, 2009; Herbst, 2009; Todd *et al.*, 2009; Chapman & Balme, 2010; Kerley *et al.*, 2018).

Older participants felt more negative towards caracals and black-backed jackals, which could most likely be explained by generational learnt values instilled from a young age towards these two proclaimed damage causing predators (Schwartz & Bilsky, 1987; Barnes, Azika & Asamoah-Boateng, 1995; Kretser *et al.*, 2009). Farmers' negative attitudes towards wildlife are often influenced by factors other than the damage caused to livestock (Naughton-Treves, 1999; Abram *et al.*, 2015). In other cases, the most significant determinant of human-predator conflict, is often the real and/or perceived predation of livestock and game species (Todd *et al.*, 2009; Dickman, 2010; Van Niekerk, 2010; Rust & Marker, 2013; Kerley *et al.*, 2018). Participants felt more negative towards Cape foxes when they were perceived to be responsible for more livestock deaths on their farms, which is often linked to the related financial implications (Romanach *et al.*, 2007; Van Niekerk, 2010; Thorn *et al.*, 2012; Rust & Marker, 2013).

No social factors explained the participants' negative attitudes towards wildcats, leopards and brown hyenas in my study area. Additional studies, including a larger interview group could likeky change this result. The majority of participants' negativity towards certain predator species could however be hypothesized to be as a result of a combination of generationally taught hatred towards certain predator species and the fear that larger predators could potentially kill young livestock (e.g. lambs and kids), older livestock and larger livestock species (e.g. adult sheep, or calves), resulting in financial implications all year around. Human wildlife conflict threatens larger predator species more, with the severity of the threat decreasing, the smaller the predator (Inskip & Zimmermann, 2009). Large predators in many ecosystems occupy the top position of the food web, giving them the ability to alter the structure and function of entire ecosystems via predation and interspecific competition (Treves & Karanth, 2003; Ripple *et al.*, 2014). The participants in my study area harboured more negativity towards larger predators (e.g. leopards, black-backed jackals and caracals) on their farms than towards smaller predators (e.g. wildcats and Cape foxes), regardless of the degree of reported livestock predation linked to each predator species. Wildcats and Cape foxes were indicated to only be capable of causing financial distress during the lambing seasons, which most likely is the cause for the more positive participant view on the two species, on southern Kalahari farms.

5.4 Wildcats on unprotected land

Wildcats are reportedly common and very successful livestock predators on unprotected land and currently carry a high human-predator conflict status in the southern Kalahari (Blaum et al., 2009). Even though wildcats were reported to be the top livestock (newborn lambs) predators on unprotected land in the southern Kalahari, participants ironically viewed wildcats in a slightly more positive light, compared to black-backed jackals and caracals. The wildcat's solitary, nocturnal and elusive nature (Sunquist & Sunquist, 2002; Herbst, 2009; Stuart & Suart, 2015; Van den Heever *et al*., 2017; Estes, 1992) and their ability to give birth to multiple offspring (Herbst, 2009; Stuart & Stuart, 2015; Stuart & Suart, 2015; Estes, 1992) has made them successful on protected land. Wildcats are opportunistic small felids and can adapt their diet according to prey availability (Smithers, 1971; Herbst & Mills, 2010a). The same traits that make wildcats so successful on protected land can therefore explain the wildcat's successful existence on unprotected land. The wildcats in my study area share a very similar habitat (see Malherbe (1984) for geology and Van Rooyen (2001) for vegetation) and similar natural prey species, to that of wildcats on protected land (e.g. KTP) in the southern Kalahari and further have additional livestock prey to survive on. The wildcat's breeding season coincides with that of the southern Kalahari lambing season (between September and March) (Herbst, 2009; Stuart & Stuart, 2015) which supplements their natural diet and could further benefit the species' survival success on unprotected land. Predators tend to become more specialized when their prey abundance increases (Pyke, Pulliam & Charnov, 1977; Herbst, 2009) and therefore wildcats could switch their diet from natural prey to newborn lambs during lambing seasons.

In protected areas, several larger predators play the role of apex predator, however the role of wildcats can change to that of apex predator in the absence of larger predators (Herbst, 2009). The same is true on unprotected land, where the generational culling of caracal and black-backed jackal as apex predators on southern Kalahari farms could have likely benefited wildcat abundances over time (Beinart, 1998; Balme *et al.*, 2009; Blaum *et al.*, 2009; Herbst, 2009; Todd *et al.*, 2009; Chapman & Balme, 2010; Kerley *et al.*, 2018). The culling of more dominant mesopredators could also promote the wildcat's success on unprotected land as black-backed jackals and caracals on protected land have been known to harass wildcats, steal their kills and are responsible for intraguild predation (Herbst & Mills, 2010a). In some cases black-backed jackals and caracals have also been known to benefit from their own persecution, by either reproducing quicker or by immigrating to areas where the species' numbers have been reduced (Kerley *et al.*, 2018). It could therefore also be possible for wildcats to have benefited form their own persecution on farms, where black-backed jackals and caracals are absent.

Overall, wildcats were apparently less persecuted in my study area than black-backed jackals and caracals, which explains their high reported abundances on unprotected land, however, there could be a reason for the lower wildcat persecution rates in my study area. Firstly, due to their small size, wildcats were not perceived to be able to kill adult livestock. Secondly, wildcats were not perceived to be 100% successful at killing livestock lambs as stronger newborn lambs or older lambs were said to sometimes escape. Thirdly, wildcats were viewed by the majority of the participant group to play an important role on farms in terms of maintaining natural ecosystem health, in the form of pest control (Stenseth *et al.*, 2003), however, lower wildcat abundances were preferred.

Many farmers feel that livestock predators are overabundant which results in financial losses and that lethal predator control is the most cost-effective solution (Romanach *et al.*, 2007). Lennox *et al*. (2018) evaluated the effectiveness of predator removal from various studies and found it to only be effective in the short-term and to fail in the absence of sustained predator suppression. Predator removal is typically an ineffective and costly solution for problem predator control (Lennox *et al.*, 2018). The eradication of apex predators could have profound cascading impacts on the behaviour and abundance of other predator and prey species and drastically change ecosystem processes (Berger & Conner, 2008; Herbst, 2009; Glen & Dickman, 2014). Some of the farms in my study area claimed that black-backed jackals and caracals were completely absent from their properties. If for instance, wildcats were also to be completely eradicated, the result could have catastrophic cascading effects on small mammal populations and in turn, on the vegetation (Glen & Dickman, 2014). The complete extermination of predators such as wildcats would not only take away an effective form of rodent control in a semi-arid desert region, where vegetation would take a long time to recover from a rodent boom, but could also negatively impact rodent species richness and diversity. For example, the extermination of coyotes (*Canis latrans*) in Texas caused a decline in rodent species richness and diversity, resulting in only dominant rodent species to remain after 12 months (Henke & Bryant, 1999). It is therefore important to educate farmers so that they fully comprehend what the absence of predators could mean for their farms (Glen & Dickman, 2014).

5.5 Conclusion and recommendations

Human-predator conflict is widespread and common in South Africa, especially in the Northern Cape, where high predator densities exist (Van Niekerk, 2010; Thorn *et al.*, 2012). Farmers that are financially affected by livestock predation and who do not receive support from wildlife authorities are unlikely to value either the predators on their farms or conservancies (Romanach *et al.*, 2007; Rust & Marker, 2013). It is important to determine the extent to which predation effects livestock on farms, specifically wildcats, black-backed jackals and caracals on unprotected land in the southern Kalahari. An important step of human-predator conflict management would be to take advantage of farmer knowledge and experiences, which could assist in creating more effective, practical and sustainable predation mitigation strategies which are specific to an area (e.g. the southern Kalahari). If farmers feel included in the processes they might be more open to allowing for predator research to occur on their properties.

Livestock predation resulted in high levels of predator culling in my study area, with none of the farms making use of non-lethal predator deterrents. Non-lethal anti-livestock-predation solutions are available and offer more ecological benefits, by allowing the predator to remain in the ecosystem (Treves & Naughton-Treves, 2005; Todd *et al.*, 2009; Talbert, Leslie & Black, 2020). Non-lethal methods such as visual and audible alarms, secure covered pens or fences, livestock guard dogs, herdsmen or patrols, trapping and non-lethal removal of predators, and specialist fast response teams (Talbert *et al.*, 2020) are not practical options for the southern Kalahari farms, mainly due to farm sizes. For example, herdsmen might be effective on a small subsistence farm in my study area (e.g. hosting 130 sheep on my smallest participating farm (1089 ha)) (Hawkins & Muller, 2017), however may be less effective on large commercial farms, where livestock flocks are large and spread out (e.g. 4000 sheep on my largest participating farm (44 000 ha)) (Shivik, 2004). The number of herdsman needed to guard the livestock on a large commercial southern Kalahari farm would also not be cost-effective (Viljoen, 2015). Livestock guard dogs were successfully used in Namibia (Marker, Dickman & MacDonald, 2005), but due to extreme temperatures and farm size in my study area, I would suggest that alternative livestock guard animals be more effective, such as donkeys, which have successfully been used on large Namibian farms (5000 - 8000 ha) (Weise, Vidu & Fernandez-Armesto, in Press). It is important to educate farmers on the alternative methods that are available to minimize livestock predation, however it might be more important for new, non-lethal predator deterrents to be developed which are ecologically friendly, cost effective for large farms and are practical and successful on large farms with extreme temperature ranges.

The majority of the research available on wildcats mainly focuses on wildcat ecology (Herbst, 2009; Herbst & Mills, 2010a) and genetics in and around protected areas, such as the KTP and the Kruger National Park (Randi *et al.*, 2001; Herbst, 2009; Le Roux *et al.*, 2015). No field study has been published on the ecology and behaviour of wildcats on unprotected land (Herbst, 2009) and to my knowledge, no research has been conducted purely on wildcats as livestock predators on unprotected land in South Africa. Although wildcats have to some extent been documented as problem predators (Palmer & Fairall, 1988; Nowell & Jackson, 1996; Blaum *et al.*, 2009; Herbst, 2009; Todd *et al.*, 2009; Yamaguchi *et al.*, 2015; Kerley *et al.*, 2018), livestock predation by wildcats is usually reported as infrequent and to have little financial impact to the farmer (Bailey & Conradie, 2013; Kerley *et al.*, 2018). The lack of information available on a species such as wildcats, which experiences high human-predator conflict in the southern Kalahari (Blaum *et al.*, 2009), stresses the urgent need for more research, so that better management decisions can be made regarding their conservation (Herbst, 2009).

An important, initial step in understanding the feeding ecology of any predator is to determine its potential prey availability (Ghoddousi *et al.*, 2016; Santos *et al.*, 2019). Although the use of camera traps and small mammal trapping has provided some insight into the natural prey available to wildcats on southern Kalahari farms, there is an urgent need to determine the diet of wildcats on unprotected land, through long-term studies and across all four seasons. Long-term studies are crucial at individual sites (Rowe & Terry, 2014; Santos *et al.*, 2017) as biotic and abiotic factors vary regionally and it is therefore not viable to compare studies from different geological areas (Kelt, 2011). The diet of wildcats on unprotected land would therefore best be determined through scat analysis, stomach content analysis and radio-telemetry tracking, combined with observational recordings, as was done in the KTP (see Herbst & Mills, 2010a, 2010b). Studies on wildcat diet on unprotected land also rely heavily on a good relationship with the southern Kalahari farming community, whose access to their land and support with data collection is key to a comprehensive ecological study on wildcats on unprotected land.

From both a conservation and scientific viewpoint, it is important to understand the basic biology, ecological role and social systems of wildcats in unprotected ecosystems (Caro & Durant, 1994; Komdeur & Deerenberg, 1997; Herbst, 2009). It is important for farmers to be educated on the ecological importance of predators on their farms, such as rodent control and the cascading effects that the absence of predators might have on natural species and the vegetation (Glen & Dickman, 2014). The southern Kalahari is known to have a high human-wildcat conflict status (Blaum *et al.*, 2009; Herbst, 2009) and the impact of lethal predator control on small predators, such as wildcats remains unclear (Blaum *et al.*, 2009). Predator management is usually based on assumptions, individual experience, or word of mouth (Avenant & Du Plessis, 2008). Wildcats outside protected areas remain largely understudied, and it is therefore recommended to conduct more studies on wildcats on unprotected land in the southern Kalahari. By studying the difference in available wildcat prey species between protected and unprotected land, the extent of perceived versus real livestock predation (Todd *et al.*, 2009; Dickman, 2010; Van Niekerk, 2010; Rust & Marker, 2013; Kerley *et al.*, 2018) and wildcat activity patterns (Herbst & Mills, 2010a), one could begin to understand the conservation options available for the management of the future survival of wildcats (Herbst, 2009). It is also important to compare existing wildcat data with that of other felids (Herbst, 2009). By researching all aspects of wildcat ecology on unprotected land, specific conservation and management questions can be addressed and through the knowledge of the natural history of a species, conservation failures can be avoided (Herbst, 2009).

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APPENDIX 1

Mammalian wildlife identified from camera trap stations on the main study site.

Mammal	Scientific name
Porcupine	*Hystrix africaeaustralis*
Aardvark	*Orycteropus afer*
Bat-eared fox	*Otocyon megalotis*
Striped polecat	*Ictonyx striatus*
Small spotted genet	*Genetta genetta*
Cape ground squirrel	*Xerus inauris*
Yellow mongoose	*Cynictis penicillata*
Slender mongoose	*Galerella sanguinea*
Scrub hare	*Lepus saxatilis*
African wildcat	*Felis lybica cafra*
Cape fox	*Vulpes chama*
Scimitar oryx	*Oryx dammah*
Steenbok	*Raphicerus campestris*
Common duiker	*Sylvicapra grimmia*
Gemsbok	*Oryx gazella*
Springbok	*Antidorcas marsupialis*
Blue wildebeest	*Connochaetes taurinus*
Red hartebeest	*Alcelaphus buselaphus caama*

APPENDIX 2

Avian species identified from camera trap stations on the study site.

Bird	Scientific name
Cape Turtle Dove	*Streptopelia capicola*
Namaqua Dove	*Oena capensis*
Sociable Weaver	*Philetairus socius*
Masked Weaver	*Ploceus velatus*
Ant-eating Chat	*Myrmecocichla formicivora*
White Browed Sparrow-weaver	*Plocepasser mahali*
Cape Glossy Starling	*Lamprotornis nitens*
Fork-tailed Drongo	*Dicrurus adsimilis*
Lilac-breasted Roller	*Coracias caudatus*
Crowned Lapwing	*Vanellus coronatus*
Yellow Canary	*Crithagra flaviventris*
Ostrich	*Struthio camelus*
Kori Bustard	*Ardeotis kori*
Secretary Bird	*Sagittarius serpentarius*
Cape Vulture	*Gyps coprotheres*
Lapped-faced Vulture	*Torgos tracheliotos*
White-backed Vulture	*Gyps africanus*
Pale Chanting Goshawk	*Melierax canorus*
Gabar Goshawk	*Micronisus gabar*
Martial Eagle	*Polemaetus bellicosus*
Tawny Eagle	*Aquila rapax*
Spotted Eagle-owl	*Bubo africanus*

APPENDIX 3

A bird list comparison between the study site and Kgalagadi Transfrontier Park (KTP). Birds were identified through observations and from the camera trap stations. The bird list names and identification number were retrieved from Roberts Birds of South Africa (7th Edition) with each where 'x' = present.

Nr	Page number	Bird name	Scientific name	Study site
1	1	Common Ostrich	*Struthio camelus*	x
2	62	Grey Heron	*Ardea cinerea*	
3	63	Black-headed Heron	*Ardea melanocephala*	
4	71	Cattle Egret	*Bubulcus ibis*	
5	78	Little Bittern	*Ixobrychus minutus*	
6	79	Dwarf Bittern	*Ixobrychus sturmii*	
7	81	Hamerkop	*Scopus umbretta*	
8	83	White Stork	*Ciconia ciconia*	
9	84	Black Stork	*Ciconia nigra*	
10	85	Abdim's Stork	*Ciconia abdimii*	
11	89	Marabou Stork	*Leptoptilos crumenifer*	
12	90	Yellow-billed Stork	*Mycteria ibis*	
13	91	African Sacred Ibis	*Threskiornis aethiopicus*	
14	99	White-faced Duck	*Dendrocygna viduata*	
15	102	Egyptian Goose	*Alopochen aegyptiaca*	x
16	103	South African Shelduck	*Tadorna cana*	x
17	104	Yellow-billed Duck	*Anas undulata*	x
18	108	Red-billed Teal	*Anas erythrorhyncha*	
19	115	Comb Duck	*Sarkidiornis melanotos*	
20	118	Secretary Bird	*Sagittarius serpentarius*	x
21	123	White-backed Vulture	*Gyps africanus*	x
22	124	Lappet-faced Vulture	*Torgos tracheliotos*	x

23	125	White-headed Vulture	*Trigonoceps occipitalis*	
24	126	Black Kite	*Milvus migrans*	
25	126.1	Yellow-billed Kite	*Milvus aegyptius*	
26	127	Black-shouldered Kite	*Elanus axillaris*	x
27	132	Tawny Eagle	*Aquila rapax*	x
28	133	Steppe Eagle	*Aquila nipalensis*	
29	135	Wahlberg's Eagle	*Hieraaetus wahlbergi*	
30	136	Booted Eagle	*Hieraaetus pennatus*	
31	140	Martial Eagle	*Polemaetus bellicosus*	x
32	142	Brown Snake-Eagle	*Circaetus cinereus*	x
33	143	Black-breasted Snake-Eagle	*Circaetus pectoralis*	x
34	146	Bateleur	*Terathopius ecaudatus*	x
35	149	Steppe Buzzard	*Buteo buteo*	
36	152	Jackal Buzzard	*Buteo rufofuscus*	x
37	159	Shikra Little Banded Goshawk	*Accipiter badius*	
38	161	Gabar Goshawk	*Micronisus gabar*	x
39	162	Southern Pale Chanting	*Melierax canorus*	x
40	166	Montagu's Harrier	*Circus pygargus*	
41	167	Pallid Harrier	*Circus macrourus*	
42	168	Black Harrier	*Circus maurus*	x
43	169	African Harrier Hawk	*Polyboroides typus*	
44	171	Peregrine Falcon	*Falco peregrinus*	
45	172	Lanner Falcon	*Falco biarmicus*	x
46	173	Eurasian Hobby	*Falco subbuteo*	
47	178	Red-necked Falcon	*Falco chicquera*	
48	179	Red-footed Falcon	*Falco vespertinus*	
49	180	Amur Falcon	*Falco amurensis*	
50	181	Rock Kestrel	*Falco rupicolus*	x
51	182	Greater Kestrel	*Falco rupicoloides*	
52	183	Lesser Kestrel	*Falco naumanni*	
53	186	Pygmy Falcon	*Polihierax semitorquatus*	x
54	194	Red-billed Spurfowl	*Pternistis adspersus*	
55	200	Common Quail	*Coturnix coturnix*	x

56	201	Harlequin Quail	*Coturnix delegorguei*	
57	203	Helmeted Guineafowl	*Numida meleagris*	
58	205	Kurrichane Buttonquail	*Turnix sylvaticus*	
59	230	Kori Bustard	*Ardeotis kori*	x
60	232	Ludwig's Bustard	*Neotis ludwigii*	
61	237	Red-crested Korhaan	*Lophotis ruficrista*	
62	239.1	Northern Black Korhaan	*Afrotis afraoides*	x
63	246	White-fronted Plover	*Charadrius marginatus*	
64	249	Three-banded Plover	*Charadrius tricollaris*	x
65	254	Grey Plover	*Pluvialis squatarola*	
66	255	Crowned Lapwing	*Vanellus coronatus*	x
67	258	Blacksmith Lapwing	*Vanellus armatus*	x
68	264	Common Sandpiper	*Actitis hypoleucos*	x
69	266	Wood Sandpiper	*Tringa glareola*	
70	269	Marsh Sandpiper	*Tringa stagnatilis*	
71	270	Greenshank	*Tringa nebularia*	
72	272	Curlew Sandpiper	*Calidris ferruginea*	
73	284	Ruff (♂), Reeve (♀)	*Philomachus pugnax*	
74	294	Pied Avocet	*Recurvirostra avosetta*	
75	295	Black-winged Stilt	*Himantopus himantopus*	x
76	297	Spotted Thick-knee	*Burhinus capensis*	x
77	299	Burchell's Courser	*Cursorius rufus*	
78	300	Temminck's Courser	*Cursorius temminckii*	
79	301	Double-banded Courser	*Rhinoptilus africanus*	
80	303	Bronze-winged Courser	*Rhinoptilus chalcopterus*	
81	344	Namaqua Sandgrouse	*Pterocles namaqua*	x
82	345	Burchell's Sandgrouse	*Pterocles burchelli*	
83	348	Rock Dove	*Columba livia*	
84	349	Speckled Pigeon	*Columba guinea*	x
85	354	Cape Turtle Dove	*Streptopelia capicola*	x
86	355	Laughing Dove	*Spilopelia senegalensis*	x
87	356	Namaqua Dove	*Oena capensis*	x
88	367	Rosy-faced Lovebird	*Agapornis roseicollis*	

89	374	Common Cuckoo	*Cuculus canorus*	
90	375	African Cuckoo	*Cuculus gularis*	x
91	380	Great Spotted Cuckoo	*Clamator glandarius*	
92	382	Jacobin Cuckoo	*Clamator jacobinus*	
93	386	Diderick Cuckoo	*Chrysococcyx caprius*	
94	392	Barn Owl	*Tyto alba*	x
95	395	Marsh Owl	*Asio capensis*	
96	396	African Scops-Owl	*Otus senegalensis*	x
97	397	White-faced Scops-Owl	*Ptilopsis leucotis*	x
98	398	Pearl-spotted Owlet	*Glaucidium perlatum*	x
99	401	Spotted Eagle-Owl	*Bubo africanus*	x
100	402	Verreaux's Eagle-Owl	*Bubo lacteus*	x
101	404	European Nightjar	*Caprimulgus europaeus*	
102	406	Rufous-cheeked Nightjar	*Caprimulgus rufigena*	x
103	411	Common Swift	*Apus apus*	
104	413	Bradfield's Swift	*Apus bradfieldi*	
105	415	White-rumped Swift	*Apus caffer*	
106	425	White-backed Mousebird	*Colius colius*	x
107	426	Red-faced Mousebird	*Urocolius indicus*	x
108	437	Striped Kingfisher	*Halcyon chelicuti*	
109	438	Eurasian Bee-eater	*Merops apiaster*	
110	445	Swallow-tailed Bee-eater	*Merops hirundineus*	x
111	446	European Roller	*Coracias garrulus*	
112	447	Lilac-breasted Roller	*Coracias caudatus*	x
113	449	Purple Roller	*Coracias naevius*	
114	451	African Hoopoe	*Upupa africana*	x
115	452	Green Wood-hoopoe	*Phoeniculus purpureus*	x
116	454	Common Scimitarbill	*Rhinopomastus cyanomelas*	x
117	457	African Grey Hornbill	*Tockus nasutus*	x
118	459	Southern Yellow-billed Hornbill	*Tockus leucomelas*	x
119	465	Acacia Pied Barbet	*Tricholaema leucomelas*	x
120	481	Bennett's Woodpecker	*Campethera bennettii*	
121	483	Golden-tailed Woodpecker	*Campethera abingoni*	x

122	486	Cardinal Woodpecker	*Dendropicos fuscescens*	x
123	487	Bearded Woodpecker	*Dendropicos namaquus*	x
124	493	Monotonous Lark	*Mirafra passerina*	
125	495	Cape Clapper Lark	*Mirafra apiata*	x
126	497	Fawn-coloured Lark	*Calendulauda africanoides*	
127	498	Sabota Lark	*Mirafra sabota*	
128	506	Spike-heeled Lark	*Chersomanes albofasciata*	x
129	507	Red-capped Lark	*Calandrella cinerea*	x
130	508	Pink-billed Lark	*Spizocorys conirostris*	
131	511	Stark's Lark	*Spizocorys starki*	
132	516	Grey-backed Sparrow-lark	*Eremopterix verticalis*	x
133	518	Barn Swallow	*Hirundo rustica*	x
135	520	Pearl-breasted Swallow	*Hirundo dimidiata*	x
137	526	Greater Striped Swallow	*Cecropis cucullata*	x
138	528	South African Cliff Swallow	*Petrochelidon spilodera*	
139	529	Rock Martin	*Ptyonoprogne fuligula*	x
140	530	Common House Martin	*Delichon urbicum*	x
141	543	Eurasian Golden Oriole	*Oriolus oriolus*	
142	547	Cape Crow	*Corvus capensis*	
143	552	Ashy Tit	*Parus cinerascens*	x
144	557	Cape Penduline-Tit	*Anthoscopus minutus*	
145	563	Southern Pied Babbler	*Turdoides bicolor*	x
146	567	African Red-eyed Bulbul	*Pycnonotus nigricans*	x
147	580	Groundscraper Thrush	*Psophocichla litsitsirupa*	x
148	583	Short-toed Rockthrush	*Monticola brevipes*	
149	586	Mountain Wheatear	*Oenanthe monticola*	
150	587	Capped Wheatear	*Oenanthe pileata*	
151	589	Familiar Chat	*Cercomela familiaris*	x
152	595	Ant-eating Chat	*Myrmecocichla formicivora*	x
153	615	Kalahari Scrub-Robin	*Cercotrichas paena*	x
154	625	Icterine Warbler	*Hippolais icterina*	
155	631	African Reed-Warbler	*Acrocephalus baeticatus*	
156	643	Willow Warbler	*Phylloscopus trochilus*	

157	651	Long-billed Crombec	*Sylvietta rufescens*	x
158	653	Yellow-bellied Eremomela	*Eremomela icteropygialis*	
159	665	Desert Cisticola	*Cisticola aridulus*	
160	685	Black-chested Prinia	*Prinia flavicans*	
161	689	Spotted Flycatcher	*Muscicapa striata*	
163	695	Marico Flycatcher	*Bradornis mariquensis*	
164	697	Chat Flycatcher	*Bradornis infuscatus*	
165	703	Pririt Batis	*Batis pririt*	x
166	706	Fairy Flycatcher	*Stenostira scita*	
167	713	Cape Wagtail	*Motacilla capensis*	x
168	716	Grassveld (Richard's) Pipit	*Anthus cinnamomeus*	
169	717	Long-billed Pipit	*Anthus similis*	
170	719	Buffy Pipit	*Anthus vaalensis*	
171	731	Lesser Grey Shrike	*Lanius minor*	
172	732	Common Fiscal	*Lanius collaris*	x
173	733	Red-backed Shrike	*Lanius collurio*	
174	739	Crimson-breasted Shrike	*Laniarius atrococcineus*	x
175	741	Brubru	*Nilaus afer*	
176	743	Brown-crowned Tchagra	*Tchagra australis*	
177	760	Wattled Starling	*Creatophora cinerea*	x
179	762	Burchell's Starling	*Lamprotornis australis*	
180	764	Cape Glossy Starling	*Lamprotornis nitens*	x
181	779	Marico Sunbird	*Cinnyris mariquensis*	
182	788	Dusky Sunbird	*Cinnyris fuscus*	x
183	796	Cape White-eye	*Zosterops virens*	x
184	799	White Browed Sparrow-weaver	*Plocepasser mahali*	x
185	800	Sociable Weaver	*Philetairus socius*	x
186	801	House Sparrow	*Passer domesticus*	x
187	802	Great Sparrow	*Passer motitensis*	
188	803	Cape Sparrow	*Passer melanurus*	x
189	804	Southern Grey-headed Sparrow	*Passer diffusus*	x
190	806	Scaly-feathered Finch	*Sporopipes squamifrons*	x
191	814	Southern Masked-Weaver	*Ploceus velatus*	x

192	821	Red-billed Quelea	*Quelea quelea*	x
193	834	Green-winged Pytilia	*Pytilia melba*	
194	845	Violet-eared Waxbill	*Uraeginthus granatinus*	
195	847	Black-faced Waxbill	*Estrilda erythronotos*	
196	856	Redheaded Finch	*Amadina erythrocephala*	x
197	861	Shaft-tailed Whydah	*Vidua regia*	x
198	870	Black-throated Canary	*Serinus atrogularis*	
199	876	Black-headed Canary	*Serinus alario*	
200	878	Yellow Canary	*Serinus flaviventris*	x
201	884	Golden-breasted Bunting	*Emberiza flaviventris*	x
202	887	Lark-like Bunting	*Emberiza impetuani*	

Birds which have a few recordings in the KTP and are either migrant or appear with abnormal weather conditions:

203	8	Little Grebe	*Tachybaptus ruficollis*	
204	50	Pink-backed Pelican	*Pelecanus rufescens*	
205	55	White-breasted Cormorant	*Phalacrocorax carbo*	
206	58	Reed Cormorant	*Microcarbo africanus*	
207	65	Purple Heron	*Ardea purpurea*	
208	66	Great Egret	*Ardea alba*	
209	67	Little Egret	*Egretta garzetta*	
210	68	Yellow-billed Egret	*Egretta intermedia*	
211	72	Squacco Heron	*Ardeola ralloides*	
212	86	Woolly-necked Stork	*Ciconia episcopus*	
213	88	Saddle-billed Stork	*Ephippiorhynchus senegalensis*	
214	93	Glossy Ibis	*Plegadis falcinellus*	
215	95	African Spoonbill	*Platalea alba*	x
216	97	Lesser Flamingo	*Phoeniconaias minor*	x
217	106	Cape Teal	*Anas capensis*	
218	112	Cape Shoveller	*Anas smithii*	
219	113	Southern Pochard	*Netta erythrophthalma*	
220	116	Spur-winged Goose	*Plectropterus gambensis*	
221	121	Hooded Vulture	*Necrosyrtes monachus*	

222	122	Cape Vulture	*Gyps coprotheres*	x
223	147	Palm-nut Vulture	*Gypohierax angolensis*	
224	148	African Fish-Eagle	*Haliaeetus vocifer*	
225	156	Ovambo Sparrowhawk	*Accipiter ovampensis*	
226	157	Little Sparrowhawk	*Accipiter minullus*	
227	212	African Crake	*Crex egregia*	
228	216	Striped Crake	*Aenigmatolimnas marginalis*	
229	218	Buff-spotted Flufftail	*Sarothrura elegans*	
230	223	African Purple Swamphen	*Porphyrio porphyrio*	
231	227	Lesser Moorhen	*Gallinula angulata*	
232	228	Red-knobbed Coot	*Fulica cristata*	
233	240	African Jacana	*Actophilornis africanus*	
234	242	Greater Painted-Snipe	*Rostratula benghalensis*	
235	289	Eurasian Curlew	*Numenius arquata*	
236	290	Common Whimbrel	*Numenius phaeopus*	
237	305	Black-winged Pratincole	Glareola nordmanni	
238	308	Long-tailed Jaeger	*Stercorarius longicaudus*	
239	339	White-winged Tern	*Chlidonias leucopterus*	
240	354.1	European Turtle-Dove	*Streptopelia turtur*	
241	373	Grey Go-away-bird	*Corythaixoides concolor*	
242	391	Burchell's Coucal	*Centropus superciliosus*	
243	417	Little Swift	*Apus affinis*	
244	418	Alpine Swift	*Tachymarptis melba*	
245	436	Grey-headed Kingfisher	*Halcyon leucocephala*	
246	445.1	White-throated Bee-eater	*Merops albicollis*	
247	505	Dusky Lark	*Pinarocorys nigricans*	
248	510	Sclater's Lark	*Spizocorys sclateri*	
249	515	Chestnut-backed Sparrow-lark	*Eremopterix leucotis*	
250	527	Lesser Striped Swallow	*Cecropis abyssinica*	
251	533	Brown-throated Martin	*Riparia paludicola*	
252	548	Pied Crow	*Corvus albus*	
254	584.1	Common Redstart	*Phoenicurus phoenicurus*	
255	590	Tractrac Chat	*Cercomela tractrac*	

256	592	Karoo Chat	*Cercomela schlegelii*	
257	596	African Stonechat	*Saxicola torquatus*	x
258	634	Eurasian Sedge Warbler	*Acrocephalus scirpaceus*	
259	664	Zitting Cisticola	*Cisticola juncidis*	
260	681	Neddicky	*Cisticola fulvicapilla*	x
161	688	Rufous-eared Warbler	*Malcorus pectoralis*	
262	698	Fiscal Flycatcher	*Sigelus silens*	x
263	710	African Paradise-Flycatcher	*Terpsiphone viridis*	
264	715	Grey Wagtail	*Motacilla cinerea*	
265	756	Southern White-crowned Shrike	*Eurocephalus anguitimens*	
266	757	Common Starling	*Sturnus vulgaris*	x
267	798	Red-billed Buffalo-Weaver	*Bubalornis niger*	
268	824	Southern Red Bishop	*Euplectes orix*	
269	826	Yellow-crowned Bishop	*Euplectes afer*	
270	842	Red-billed Firefinch	*Lagonosticta senegala*	
271	846	Common Waxbill	*Estrilda astrild*	
272	852	African Quailfinch	*Ortygospiza atricollis*	
273	886	Cinnamon-breasted Bunting	*Emberiza tahapisi*	

Birds found on my study site but not recorded in the KTP:

274	224	Allen's Gallinule	*Allen's Gallinule*	x
245	473	Crested Barbet	*Trachyphonus vaillantii*	x
276	976	Orange River White-eye	*Zosterops pallidus*	x
253	577.1	Karoo Thrush	*Turdus smithi*	x

APPENDIX 4

A comparison of the African wildcat's natural prey between the KTP and their presense on my study site on unprotected land.

African wildcat diet in the KTP		Potential African wildcat diet on unprotected land		
Species identified	Scientific name	Observed	Camera traps	Small mammal capture
Larger mammals				
Spring hare	*Pedetes capensis*	x	x	
Hare sp. Lepus sp.	*Lepus sp.*	x	x	
Ground squirrel	*Xerus inauris*	x	x	
Small mammals				
Brant's gerbil	*Tatera brantsii*			
Brant's whistling rat	*Parotomys brantsii*			
Four-stripedgrass mice	*Rhabdomys pumilio*			x
Damaraland mole-rat	*Fukomys damarensis*			
Pygmy hairy-footed gerbil	*Gerbillurus paeba*			x
Short-tailed gerbil	*Desmodillus auricularis*			
Pygmy mouse	*Mus indictus*			
Bushveld sengi	*Elephantulus intufi*			x
Birds				
Lark sp.		x	x	
Namaqua Sand Grouse	*Pterocles namaqua*	x	x	
Cape Turtle Dove	*Streptopelia capicola*	x	x	
Spotted Thick-knee	*Burhinus capensis*	x		
Namaqua Dove	*Oena capensis*	x	x	

Reptiles

Common barking gecko	*Ptenopus garrulous*	x
Sand snake	*Psammophis sp.*	x
Giant ground gecko	*Chondrodactylus angulifer*	x
Ground agama	*Agama aculeate*	x
Kalahari tree skink	*Mabuya occidentalis*	x

APPENDIX 5

RHODES UNIVERSITY
Where leaders learn

Human/ Predator Conflict Questionnaire:

NR:

The following questionnaire has been compiled for the purpose of collecting data on human/predator conflict. The information gathered will remain confidential and will be used as a foundation for research done on the perceived degree of damage that small predators cause on livestock farms. Please assist the researcher by completing the following questionnaire as accurately as possible. Answer N/A to irrelevant questions. The interviewer will explain all questions throughout.

Please tick YES or NO bellow:

- **All the project information has been explained to me by the researcher:** (Yes □ / No □)
- **I have signed the Rhodes University Participation Consent Declaration:** (Yes □ / No □)
- **I would like to receive feedback from this study:** (Yes □ / No □)

Date:

Interviewer's name: CINDY STADLER

Interview language: AFRIKAANS

Please answer the following questions or tick the applicable box, where indicated:

1) GERERAL:

1.1) What do you farm with? ……………………………………………………………..

1.2) Is there currently any wildlife tourism on your property? (Yes □ / No □)

1.3) Is your property part of a conservancy? (Yes □ / No □)

1.4) Does most of your income come from: (livestock □ / tourism □ / other □)

If other, please state: ……………………………………………………………………….

1.5) Is your property perimeter fenced? **(**Yes □ / No □)

1.6) If yes, please specify (tick applicable):

a) □ Cattle fencing (1.2m – 1.5m / 6 – 8 strands of wire)

b) □ Game fencing (2.25m – 2.4m / 18-22 strands of wire)

c) □ Electrified with trip wire inside / outside / both / Bonnox Meshed with buried apron /

d) □ Other: ……………………………………………………………………...........

1.7) What are your current stocking rates for the following livestock?

 # Cattle: ……./…….. ha # Sheep: ……/…….ha # Goats: ……./…….. ha

2) PREDATORS:

2.1) Which of the following predators occur on your farm?

	On the farm			**Any Comments**
Black-backed jackal	□ yes	□ no	□ don't know	
Caracal	□ yes	□ no	□ don't know	
Brown Hyena	□ yes	□ no	□ don't know	
Lion	□ yes	□ no	□ don't know	
Cheetah	□ yes	□ no	□ don't know	
Leopard	□ yes	□ no	□ don't know	
African wildcat	□ yes	□ no	□ don't know	
Cape Fox	□ yes	□ no	□ don't know	
Bat-eared Fox	□ yes	□ no	□ don't know	
Aardwolf	□ yes	□ no	□ don't know	

2.2) How common do you think the following predators are on your farm?

	How common			
Black-backed jackal	□ absent	□ rare	□ common	□ don't know
Caracal	□ absent	□ rare	□ common	□ don't know
Brown Hyena	□ absent	□ rare	□ common	□ don't know
Lion	□ absent	□ rare	□ common	□ don't know
Cheetah	□ absent	□ rare	□ common	□ don't know
Leopard	□ absent	□ rare	□ common	□ don't know
African wildcat	□ absent	□ rare	□ common	□ don't know
Cape Fox	□ absent	□ rare	□ common	□ don't know
Bat Eared Fox	□ absent	□ rare	□ common	□ don't know
Aardwolf	□ absent	□ rare	□ common	□ don't know

2.3) Rank the following predators in terms of their effect upon livestock/game on your farm (1 = highest impact and 10 = lowest impact):

	Rank (1-10)
Black-backed jackal	
Caracal	
Brown Hyena	
Lion	
Cheetah	
Leopard	
African Wildcat	
Cape Fox	
Bat-eared Fox	
Aardwolf	

2.4) Have you lost any livestock/game to any of these predators in the last 12 months?
(Yes □ / No □ / Unsure? □)

2.5) If yes, please indicate the approximate number that were lost to each predator:

	Cattle	**Sheep**	**Goats**	**Donkeys**	**Game**
Black-backed jackal					
Caracal					
Brown Hyena					
Lion					
Cheetah					
Leopard					
African Wildcat					
Cape Fox					
Bat-eared Fox					
Aardwolf					

2.6) Would you say the following predators have increased, decreased or stayed the same over the last 3 years? Please support your answer with a reason (a, b, c or d). If you answer, 'don't know', please select 'e' and state your reason in the provided box.

a) Increase in stock loss? **/ b)** Decrease in stock loss? **/ c)** More sightings or spoor?**/ d)** Less sightings or spoor? **/ e)** Other reasons?

	Choose	**Reason (a-e)**
Black-backed jackal	□ increased □ decreased □ stable □ don't know	
Caracal	□ increased □ decreased □ stable □ don't know	
Brown Hyena	□ increased □ decreased □ stable □ don't know	
Lion	□ increased □ decreased □ stable □ don't know	

Cheetah	□ increased □ decreased □ stable □ don't know	
Leopard	□ increased □ decreased □ stable □ don't know	
African Wildcat	□ increased □ decreased □ stable □ don't know	
Cape Fox	□ increased □ decreased □ stable □ don't know	
Bat-eared Fox	□ increased □ decreased □ stable □ don't know	
Aardwolf	□ increased □ decreased □ stable □ don't know	

2.7) What do you think is the most important factor(s) causing stock losses on your farm? Please rank from 1 to 7, where 1 is the most problematic and 7 is the least problematic

Reason for stock loss	**Total livestock loss in last 3 yrs**	**Comment**
Snake bite		
Martial eagle		
Domestic dogs		
Disease		
Theft		
Fire		
Other		

2.8) What natural prey/game occurs on your farm?

2.9) Can you provide approximate numbers for each of these?

3) ATTITUDES TOWARDS PREDATORS:

3.1) How do you feel about the following predators occurring in your district?

	Positive	Neutral	Negative	N/A
Black-backed jackal				
Caracal				
Brown Hyena				
Lion				
Cheetah				
Leopard				
African Wildcat				
Cape Fox				
Bat-eared Fox				
Aardwolf				

3.2) How do you feel about the following predators occurring on your farm?

	Positive	Neutral	Negative	N/A
Black-backed jackal				
Caracal				
Brown Hyena				
Lion				
Cheetah				

Leopard				
African Wildcat				
Cape Fox				
Bat-eared Fox				
Aardwolf				

3.3) Do you know if any of your neighbours kill or allow predators to be killed on their properties? If yes, please specify the preferred method of removal.

	Tick where applicable			**Method**
Black-backed jackal	□ Yes	□ No	□ Maybe	
Caracal	□ Yes	□ No	□ Maybe	
Brown Hyena	□ Yes	□ No	□ Maybe	
Lion	□ Yes	□ No	□ Maybe	
Cheetah	□ Yes	□ No	□ Maybe	
Leopard	□ Yes	□ No	□ Maybe	
African Wildcat	□ Yes	□ No	□ Maybe	
Cape Fox	□ Yes	□ No	□ Maybe	
Bat-eared Fox	□ Yes	□ No	□ Maybe	
Aardwolf	□ Yes	□ No	□ Maybe	

3.4) Would you be more tolerant towards 'problem predators' if you were compensated for livestock losses? (Yes □/ No □/ Maybe □)

3.5) If you answered yes to having a conservancy on your farm, do you sometimes do small predator culling? (Yes □/ No □)

3.6) Do you/have you in the past made use of a monetary reward system for culling problem predators? If yes, please specify the amount(s) you would reward for each predator killed (R): (Yes □/ No □)

……………………………………………………………………………………………………

……………………………………………………………………………………………………
…………………………………………………………………………………………

4) <u>ATTITUDES TOWARDS AFRICAN WILDCATS</u>:

4.1) Do you think small predators such as the African Wildcat plays an important role on a farming environment? (Yes □/ No □/ Maybe □)

4.2) Is the African Wildcat a problem predator on your farm? (Yes □/ No □/ Maybe □)

4.3) Please indicate your disagreement/agreement with each of the following statements:

a) You are more tolerant of African wildcats than your neighbours. (Yes □/ No □/ Don't know □)

b) African wildcats negatively impact your business/livelihood/profit. (Yes □/ No □/Don't know □)

c) You would be happier if African wildcats were completely absent from your reserve/property. (Yes □/ No □/ Don't know □)

d) Please explain your responses to question 'c' above:

……………………………………………………………………………………………………
……………………………………………………………………………………………………
………………………………………………………………………………………

e) African wildcats should be protected. (Yes □/ No □/ Don't know □)

f) You would tolerate resident African wildcats on your property. (Yes □/ No □/ Don't know □)

g) African wildcats could produce tourism benefits for you/your business. (Yes □/ No □/ Don't know □)

h) You would like to see African wildcats in the wild. (Yes □/ No □/ Don't know □)

4.4) African wildcats are currently important to you. (Yes □/ No □/ Don't know □)

4.5) You would like to learn more about African wildcats. (Yes □/ No □/ Don't know □)

5) COMMENTS:

5.1) Are there any other comments you would like to make about predators or predator related experiences you would like to share?

PERSONAL / FARM DETAILS:

Farm Name: …………………………………………………………..

GPS coordinates at main house: ……………………………………………………

Farm size: ……………………………

How many livestock do you have on the farm?

Sheep	
Goats	
Cattle	

Is this a family farm? If yes, what generation farmer are you? …………………..

Interviewee name: ……………………………………………………………………

Position on the property: □ owner □ manager □ other (specify)................................

Age: ………

Gender: Male / Female

Ethnic group: ……………………………………..

Highest level of education: ….……………………………………………………...

Contact number: ………………………………….

Email address: ……………………………………..

Interviewer's Comments:

APPENDIX 6

Table indicating the top performing models' predictor variables based on AICc (Akaike Information Criterion) model selection for participant attitudes towards caracals, leopards, black-backed jackals, Cape foxes, brown hyenas and African wildcats. The table contains the values of the qualifying VIF models for each model (including the model which did not qualify, at the bottom). The following information is displayed; the predictor variables that made up the qualifying models (Predictors) (where, Age = participant age, Ha = size of farm, Null = the Null model, Dist = distance of farm from the closest protected land, Pres = if the predator is present on the farm, Loss = whether the participant has lost any livestock to the predator in the preceding 12 months), the number of parameters in the model (K), the AICc score (corrected for small sample size), the difference in AIC score between the best model and the model being compared (Delta_AICc), AICc weight (AICcWt), the sum of the AICc weights (Cum.Wt) and log-likelihood (LL).

Caracals

Predictors	K	AICc	Delta_AICc	AICcWt	Cum.Wt	LL
Age, Ha	4	87.17	0.00	0.29	0.29	-38.41
Age	3	87.78	0.62	0.21	0.51	-40.22
Null	2	88.53	1.36	0.15	0.66	-41.95
Age, Dist	4	88.78	1.62	0.13	0.79	-39.22
Age, Dist, Ha	5	89.11	1.94	0.11	0.90	-37.68
Dist	3	89.25	2.09	0.10	1.00	-40.96

Leopards

Models	K	AICc	Delta_AICc	AICcWt	Cum.Wt	LL
Dist	3	94.20	0.00	0.41	0.41	-43.43
Null	2	95.22	1.01	0.25	0.65	-45.29
Dist, Pres	4	95.56	1.35	0.21	0.86	-42.60
Dist, Ha	4	96.36	2.16	0.14	1.00	-43.01

Black-backed jackals

	K	AICc	Delta_AICc	AICcWt	Cum.Wt	LL
Age, Ha	4	87.17	0.00	0.29	0.29	-38.41
Age	3	87.78	0.62	0.21	0.51	-40.22
Null	2	88.53	1.36	0.15	0.66	-41.95
Age, Dist	4	88.78	1.62	0.13	0.79	-39.22
Age, Dist, Ha	5	89.11	1.94	0.11	0.90	-37.68
Dist	3	89.25	2.09	0.10	1.00	-40.96

Cape foxes

	K	AICc	Delta_AICc	AICcWt	Cum.Wt	LL
Loss	3	116.74	0.00	0.75	0.75	-54.70
Loss, Ha	4	118.90	2.16	0.25	1.00	-54.27

Brown hyenas

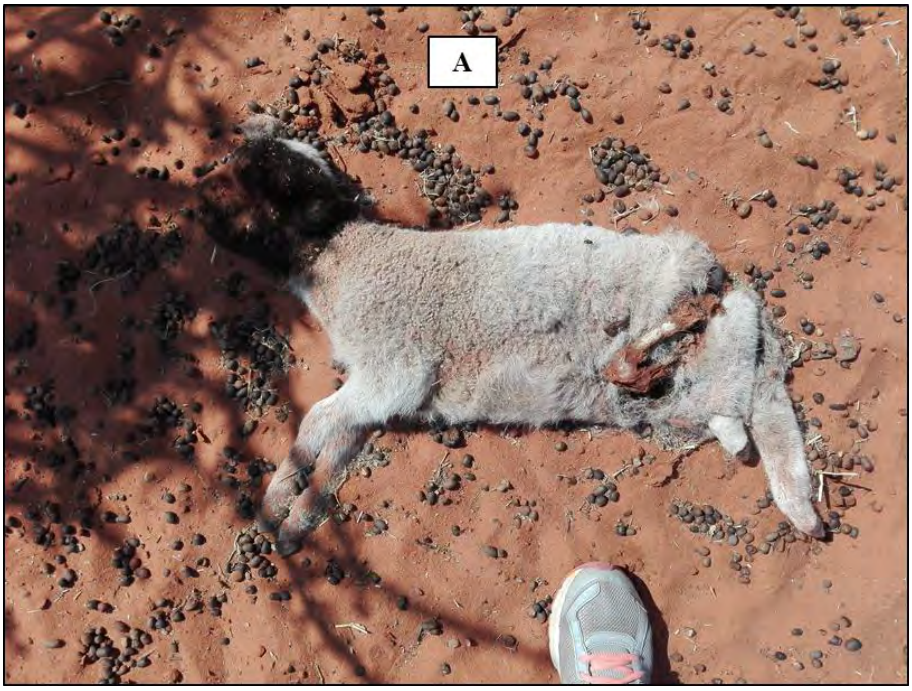
	K	AICc	Delta_AICc	AICcWt	Cum.Wt	LL
Null	2	106.54	0.00	0.59	0.59	-50.96
Age	3	108.49	1.95	0.22	0.81	-50.58
Dist	3	108.85	2.31	0.19	1.00	-50.76

African wildcats

Models	K	AICc	Delta_AICc	AICcWt	Cum.Wt	LL
Null	2	111.65	0.00	0.46	0.46	-53.51
Dist	3	111.95	0.30	0.40	0.86	-52.31
Age	3	114.09	2.44	0.14	1.00	-53.38

APPENDIX 7

The carcass of a newborn lamb, killed by a predator and eaten from the back left thigh, reportedly by a wildcat (A) (Stadler, 2016).



A larger lamb, eaten around the throat, reportedly by a caracal (B) (Stadler, 2016).

A Dorper lamb with a deformed neck, presumed by the owner to be from an injury it acquired when young. This type of injury is reportedly often found in the study area and presumed to be caused by wildcats, unsuccessfully attempting to kill larger of stronger lambs (C).