Towards the development of a sustainable management strategy for *Canis mesomelas* and *Caracal caracal* on rangeland

by

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Declaration

I declare that this thesis, hereby handed in for the qualification Doctor of Philosophy in Environmental Management in the Faculty of Natural and Agricultural Sciences at the University of the Free State, is my own independent work and that I have not previously submitted the same work for a qualification at another university/faculty. I cede copyright of the thesis in favour of the University of the Free State.

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Jurie du Plessis Date

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Summary

South Africa has a long history of human-wildlife conflict with black-backed jackal *Canis mesomelas* and caracal *Caracal caracal*, especially in the small livestock industry. Recently, wildlife ranchers and cattle farmers have also started to report losses. Despite the excessive losses and widespread efforts to curb these conflicts there is no sustainable human predator conflict management (HPCM) strategy in place. Livestock owners still tackle the challenges individually or in small groups and concentrate mostly on elimination and precautionary techniques. Blanket-control and poisoning practices in many areas results in biodiversity being under constant threat, while stock losses do not decline.

Current knowledge on aspects relating to black-backed jackal and caracal in South Africa (including ecology, economics, management techniques, predation rates, sociology) was collated and evaluated. Such information is needed for the development of a sustainable HPCM strategy for damage-causing black-backed jackal and caracal on livestock farms and wildlife ranches, and to inform policy and decision-making related to these species.

There is a general lack of scientific information on virtually all the identified aspects, limiting the development of management strategies. Specific information gaps with regards to each aspect were identified and a conceptual model presented for the development of a sustainable HPCM plan for damage-causing black-backed jackal and caracal in South African rangeland.

Most of the available ecological research on black-backed jackal and caracal are from spatially and temporally isolated studies, limited in scope, confined to protected areas and not focused on the development of sustainable management strategies. This results in a limited understanding of the ecological role of both black-backed jackal and caracal in South African ecosystems. A prerequisite for sustainable HPCM programs is a sound ecological understanding of the animals that are to be managed, and the ecosystems in which they operate. Without such an understanding it is difficult to predict the contribution of different management

interventions to mitigate damage and the effects on the behaviour and ecology of target animals.

The study has also highlighted the overall lack of scientific estimations on the economics of black-backed jackal and caracal predation, and HPCM operations. Isolated pieces of evidence confirm that the current associated costs are high. A range of benefits and costs associated with these two species, which have not yet been quantified, are also emphasized. With reference to the human dimension there is insufficient information to understand the diversity of perceptions which various stakeholders may hold towards black-backed jackal, caracal and associated HPCM actions. Understanding these perceptions and its drivers are most important for the drafting of a sustainable HPCM strategy.

Further, scientific information on HPCM methods for black-backed jackal and caracal in South Africa is lacking. Most information on these methods is contained in popular literature and very few refer specifically to the management of damage-causing black-backed jackal or caracal. A number of information gaps have been identified regarding the effectiveness of available HPCM methods to curb black-backed jackal and caracal predation under different South African conditions.

Some major shortcomings have been identified in the availability of current predation information. The small number of available sources on livestock and wildlife predation is limiting an understanding of specifically black-backed jackal or caracal predation patterns. Better qualitative information on livestock and wildlife predation is needed to substantiate reported losses, and provide grounds for HPCM decisions. Moreover, it could also be used to better understand the dynamics of the predation which is necessary to develop sustainable HPCM strategies.

Future research should be directed, coordinated and conducted systematically to ensure that the understanding of these damage-causing species is complemented and priority knowledge gaps filled in a focused way. Setting short and long-term goals is important, as well as the continuous feedback between participating scientists, livestock farmers, wildlife ranchers, conservation managers, legislation officials, the coordinator(s) and the public.

Key words: *Canis mesomelas*; *Caracal caracal*; damage-causing; ecology; economics; human dimensions; human-predator conflict; management techniques; rangeland; sustainable human-predator conflict management plan

Opsomming

Suid-Afrika het ‘n lang geskiedenis van konflik tussen mense en die rooijakkals *Canis mesomelas* en rooikat *Caracal caracal*. Alhoewel die meeste konflik in die verlede in die kleinvee industrie paasgevind het, is daar meer onglangs ook bewerings van bees- en wildboere dat hulle verliese as gevolg van hierdie twee predatore ervaar. Nieteenstaande die bomatige verliese en weidverspreide pogings om hierdie konflik te stop is daar geen volhoubare bestuurs strategie in plek. Vee eienaars probeer tans die probleem op hulle eie of in klein groepe oplos en daarvoor maak hulle meestal gebruik van metodes wat predator getalle uitdun en predasie voorkom. Oorhoofse beheer en gif word in baie areas gebruik. Hierdie metodes is egter selde suksesvol om veeverliese te verminder en in baie gevalle plaas dit net ekstra druk op die biodiversiteit in hierdie areas.

Huidige kennis oor aspekte rakende die rooijakkals en die rooikat in Suid-Afrika (insluitende ekologie, ekonomie, bestuurs metodes, predasie getalle, sosiologie) is saamgevoeg en krities ondersoek. Hierdie inligting is nodig vir die opstel van ‘n volhoubare strategie vir die bestuur van die skade veroorsaakende rooijakkals en rooikat op vee- en wildsplase en om beleidvorming en besluitneming rakende hierdie twee spesies in te lig.

Daar is ‘n algemene tekortkoming van wetenskaplike inligting oor feitlik al die geïdentifiseerde aspekte wat die ontwikkeling van suksesvolle bestuurs strategieë belemmer. Spesifieke inligtings tekorte ten opsigte van elke aspek is geïdentifiseer en ‘n konsep model word hiervolgens voorgestel van wat nodig is vir die ontwikkeling van ‘n volhoubare bestuurs plan vir skade veroorsakende rooijakkals en rooikat op vee- en wildsplase in Suid Afrika.

Meeste van die ekologiese navorsing op beide die rooijakkals en rooikat is van geïsoleerde areas, is gedoen oor ‘n kort tydperk, het ‘n beperkte omvang, is meestal in natuurreservate uitgevoer en het nie gefokus op die ontwikkeling van volhoubare bestuurs strategieë nie. Die inligting dra ook net by tot ‘n beperkte kennis oor die ekologiese rol van rooijakkals en rooikat in Suid Afrikaanse ekosisteme. ‘n Volhoubare bestuurs strategieë is gegrond op ‘n ferm ekologiese kennis oor die

diere wat bestuur word, asook oor die ekosisteme waarin hulle voorkom. Sonder hierdie kennis is dit moeilik om te voorspel watter toevoeging verskillende bestuurs ingrypings kan maak om skade te verminder en watter effek dit kan hê op die gedrag en ekologie van die teiken diere.

Die studie het ook die algemene tekort van wetenskaplike skattings oor die ekonomiese waarde van rooijakkals en rooikat predasie, asook die bestuurs praktyke wat teen hulle gebruik word, uitgewys. Geïsoleerde studies dui daarop dat die huidige kostes geassosieer met rooijakkals en rooikat hoog kan wees. Verder word ander moontlike kostes en voordele wat ook met hierdie twee spesies geassosieer kan word, maar wat nog nie bepaal is nie, ook uitgewys. Met verwysing tot die menslike aspek is daar ook baie beperkte inligting om die verskillende persepsies wat belangehebbendes oor die rooijakkals en rooikat en die bestuur van hierdie spesies mag hê te kan verstaan. Dit is belangrik om hierdie persepsies asook die faktore wat hierdie persepsies beinvloed te verstaan voordat ‘n volhoubare bestuurs strategie opgestel kan word.

Daar is verder ook ‘n tekort van inligting oor bestuur metodes wat gebruik kan word teen die rooijakkals en rooikat. Meeste van die inligting wat beskikbaar is, is in populêre publikasies opgeskryf terwyl net ‘n paar van die bronne spesifiek verwys na die bestuur van die rooijakkals en rooikat. Verskeie inligtings tekorte is geïdentifiseer rakende die effektiwiteit van moontlike metodes wat gebruik kan word om rooijakkals en rooikat skade te beheer onder Suid Afrikaanse toestande.

Verskeie terkortkominge is uitgewys rakende die beskikbaarheid en aard van predasie inligting. Die klein bietjie inligting is onvoldoende om spesifiek rooijakkalse en rooikatte se predasiepatrone te verstaan. Beter kwalitatiewe inligting oor predasie op vee en wild word benodig om beweerde skade toegesryf aan predasie te bevestig en om bewys te lewer vir moontlike bestuurs besluite rakende hierdie predasies. Hierdie inligting kan verder ook gebruik word om die dinamika van predasie te verstaan. Laasgenoemde is belangrik vir die ontwikkeling van volhoubare bestuurs strategieë gemik op skade veroorsakende predatore.

Dit word voorgestel dat toekomstige navorsing op die rooijakkals en rooikat sistematies uitgevoer moet word op ‘n gekoördineerde wyse om te verseker dat ons kennis van hierdie spesies uitgebou word en prioritiet areas waar inligting kort aangespreek word. Dit is ook belangrik om kort- en langtermyn mikpunte daar te stel en dat daar volgehoue terugvoer plaasvind tussen deelnemende weteskaplikes, vee- en wildboere, bewarings beamptes, wetstoepassers, die koördineerders van predator bestuur en die publiek.

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Damage-causing animal: A wild animal that, when interacting with humans or interfering with human activities, there is substantial proof that it –

- causes losses to stock or to other wild specimens;
- causes damage to cultivated trees, crops, natural flora or other property;
- presents a threat to human life; or
- is present in such numbers that agricultural grazing is materially depleted (National Environmental Management Biodiversity Act, 2004: Act no. 10 of 2004).

Human-wildlife conflicts (*HWC*): Conflicts that develop when the behaviour of a wildlife species threatens the safety or livelihood of a person or community, and in response, persecution of that species pursues (Inskip & Zimmerman 2009).

Human-wildlife conflict management [*HWCM* – include Animal damage control (ADC), Problem wildlife management, and Wildlife damage management]: Any strategy or method which is applied to manage a situation of negative interaction between humans and wildlife (Messmer 2000).

Human-wildlife conflict management method: A form of procedure used to manage a situation of negative interaction between humans and wildlife (Brandford 1994).

Human-wildlife conflict management strategy: A plan of action implemented to manage a situation of negative interaction between humans and wildlife (Brandford 1994).

Livestock farming (also *livestock ranching*): An operation where domesticated animals (mostly sheep, goats and cattle) are raised for animal production (Brandford 1994).

Rangeland: Livestock farms and wildlife ranches

Sustainable human-wildlife conflict management strategy: A management strategy that simultaneously and continuously ensures a decrease in human-wildlife conflicts, the conservation of associated ecosystems, and which is socially acceptable and economically viable (Brandford 1994).

Wildlife ranching (also known as game farming and game ranching): A managed (extensively or intensively) production of wild animals in fenced or unfenced areas for commercial utilization which include hunting for food, recreational hunting, production, or tourism (Bothma & Du Toit 2010).

1. Introduction

South Africa has a long history of human-wildlife conflict (HWC), and especially of predation on livestock (Stadler 2006; Gunter 2008; De Waal 2009; Strauss 2009; Van Niekerk 2010). However, more than ever before, many controversies and sentiments exist today about the management of specifically black-backed jackal *Canis mesomelas* and caracal *Caracal caracal* (Avenant 2012). This is fuelled by an increasing number of claims without scientific substitution that predation losses are high and on the increase. At the one extreme, livestock owners claim to lose large sums of income (and some small livestock owners have already sold out); on the other hand environmental activists accuse farmers of inflating the problem and being poor farm managers, and hunters of being opportunists and inhumane. In the process facts are distorted, comments taken out of context, and divergent and unconfirmed claims from scientists or conservation bodies increase the controversy (Avenant 2012). According to recent studies the direct cost of predation on small livestock by predominantly black-backed jackal and caracal exceeds ZAR 1.39 thousand million per annum (Van Niekerk 2010) and some farmers suffer high actual predation losses (e.g. 38.58 ± 15.96% of all lambs born in the open were predated/killed before they weaned; Strauss 2009). Nevertheless, there is no comprehensive system of co-ordinated predation management in South Africa (Avenant *et al*. 2006; De Waal 2009, 2012). While damage-causing carnivores are not unique to southern Africa, the fact that this region has two sympatric meso-carnivores (black-backed jackal and caracal) that both have a major impact on the livestock and wildlife ranching industries complicates the situation.

Human-wildlife conflict (HWC) typically arises when the behaviour of a wildlife species threatens the livelihood or the safety of a person or community (Inskip & Zimmerman 2009). In response, persecution of that species is then pursued. Such conflict is generally more frequent where wildlife and humans are forced into close proximity, often driven by a rapid increase in human population resulting in increases in resource use and subsequent habitat and natural prey losses. Instances of HWC generally originate where predators prey on livestock (Wang & Macdonald 2006; Gusset *et al*. 2008; Strauss 2009; Van Niekerk 2010; Chaminuka *et al*. 2012); crops are damaged by wild herbivores (De Boer & Baquete 1998; Wang *et al*. 2006) or compete for grazing (Prins 2000; Mishra *et al.* 2004; Gadd 2005); predators or wild ungulates utilize resources of recreational value (Pederson *et al*. 1999; Skonhoft 2006); wild animals pose a threat to the safety of humans (Choudhury 2004; Loe & Roskaft 2004; Thavarajah 2008), impact negatively on the environment (Pimentel *et al*. 2000; Engeman *et al*. 2007), or compete with other species of conservation value (Engeman *et al*. 2002). Without negating the reality and impact of other forms of HWC, the focus of this study is on predation by predators and the term human-predator conflicts (HPC) is used in this regard.

The carnivorous predators are often in conflict with humans because of their feeding behaviour and their large home-ranges (Treves & Karanth 2003). Consequently, in overlapping areas, predators may switch to alternative protein sources (possibly livestock or introduced herbivorous wildlife) in the absence of native prey (Meriggi & Lovari 1996) while some may change their ranging behaviour to include areas where more food, such as livestock, is available (Danner & Smith 1980; Althoff & Gipson 1981).

To counter HPC, a variety of strategies have been implemented worldwide. Broadly these can be defined as eradication, regulated harvests, and preservation strategies (Treves & Karanth 2003). The first strategy aims to eradicate predator populations in a specific area; the second strategy aims to harvest predators to sustainable levels, ensuring the survival of these predator populations while at the same time minimizing agricultural or environmental damage; and the third strategy tries to prevent or minimize the killing of predators.

Some strategies have been implemented successfully to decrease HPC (Linnell *et al*. 2001), but negative consequences have also been associated, namely: (1) many predators have been driven to near extinction because of eradication programs and today their survival is mostly confined to protected areas (Woodroffe & Ginsberg 1999; Bauer & Van der Merwe 2004), or they have to be protected by law (Treves & Karanth 2003); (2) efforts to exclude unwanted predator species have created unstable ecosystems with increasing numbers of primary consumers and meso-predators (Estes 1996; Johnson *et al*. 2007); (3) non-specific management techniques threaten the existence of a range of non-target species (Glen *et al*.

2007a); and (4) the use of certain management techniques have strained relationships between producers, different sectors of society, and policy makers (Madden 2004).

Despite the potential negative consequences of human-predator conflict management (HPCM) strategies, such interventions are very important. In the absence of HPCM predation may, for example, threaten the viability of small livestock farms with widespread consequences for regional economies (Jones 2004; Feldman 2007). With more than *ca.* 75% of South Africa's area under private ownership (DRDLR 2013), and with South Africa's global commitment to conserve biodiversity (e.g. Convention on Biological Diversity), it is important to develop practical HPCM strategies that also promote biodiversity and ecosystem conservation (Avenant & Du Plessis 2008).

1.1 The evolution of human-wildlife conflict management

Human-wildlife conflict management (HWCM) refer to any strategy or method which is applied to manage a situation of negative interaction between humans and wildlife (Messmer 2000). Earlier strategies aimed to eliminate conflicting wildlife completely from an area. It did not consider the ecological consequences of such strategies and was mainly focused on a maximum reduction in economic losses (Feldman 2007). However, the ecological importance of wildlife and ecosystems have since been realised (Beinart 1998), as well as the importance of the social and economical aspects of HWCM strategies (Messmer 2000). Consequently HWCM has shifted to consider the ecological aspects of HWC, as well as involving the view of relevant stakeholders and considering the economic impact of different strategies. For example HPCM in Australia changed when dingo *Canis lupus dingo* was found to play an important role to regulate lower predators; this triggered suggestions that the operations which managed these species through elimination strategies should be reconsidered (Glen & Dickman 2005). In the United States of America (USA) HPCM practices have been forced to change markedly due to pressure and input from different sectors of the American society (Feldman 2007).

1.2 Human-predator conflicts in ranching areas worldwide

Throughout the world the history of HPC in ranching areas spans many decades and involves a range of species. Some frequently cited examples are from the USA, Australia and Europe where predators are responsible for major losses on livestock farms and wildlife ranches. In these areas, predation management strategies have generally shifted from uncontrolled eradication to regulation and preservation with active government involvement and or support.

1.2.1 United States of America (USA)

Coyotes *C. latrans*, and to a lesser extent wolves *C. lupus*, are in conflict with livestock ranchers in the USA (Feldman 2007; NASS 2011). Species such as the bobcat *Lynx rufus* and bears *Ursus* spp. are also blamed, but in more specific areas (Schwartz *et al*. 2003; Shelton 2004; NASS 2011). As a result of earlier HPCM activities, several of these species have been exterminated from their former ranges in the USA.

The first federal HPCM program within the United States Department of Agriculture (USDA), Bureau of Biological Surveys (BBS), was initiated in 1915 (Hawthorne *et al*. 1999). The initial role of the program was to provide information and demonstrations on predator control tools and techniques. The National Animal Damage Control Act (U.S. Public Law No. 776) was passed on 2 March 1931 and expanded the government's involvement in HPCM to also conduct control operations. For a long period control of wildlife-conflict was the responsibility of the Department of Interior. Effective lobbying by livestock producers prevailed and consequently the predecessor of Wildlife Services (WS) was formed on 19 December 1985 in the Animal and Plant Health Inspection Services (APHIS) section of the USDA (Bodenchuck *et al*. 2013).

In its early days WS mainly used hunting, traps and poison (mostly strychnine baiting stations) in attempts to eradicate damage-causing predators (Hawthorne *et al*. 1999). Gradual pressure over the use of non-selective strategies, however, forced changes in predator management in the USA. The use of trapping and poisoning was decreased, aircrafts were introduced to aid quicker response, and predator control was confined to high density sheep areas and areas with serious depredation problems (Flippen 1997; Feldman 2007; Miller 2007). One of the main focuses of WS now is to reduce predation impacts on private or public resources to acceptable levels without negatively impacting the populations of native predators (Bodenchuck *et al*. 2013).

Currently, WS remains actively involved in HPCM in the USA (USDA 2010). An Integrated Wildlife Damage Management Program recommends three broad HPCM strategies, namely resource management, physical exclusion, and predator management. With these strategies WS recommend the use of appropriate and approved management methods to reduce specific HPC effectively, while concurrently considering the environmental impacts, social and legal factors, and management costs associated with the selected method. The WS is also actively involved in research and method development on aspects of HPCM (USDA 2010; Bodenchuck *et al*. 2013).

1.2.2 Australia

Wild dogs (dingo *C. lupus dingo*; feral dogs *C. lupus familiaris*) have been implicated with widespread livestock predation in Australia (Fleming & Korn 1989; Brook & Kutt 2011), while the introduced fox *Vulpes vulpes* also contributes markedly to lamb predation (Lugton 1993; Greentree *et al*. 2000; McLeod *et al*. 2011).

Previously HPCM in Australia have mainly focused on methods to eliminate damage-causing predators and prevent the risk of livestock predations altogether, with both the government and producers actively involved. To achieve this, poison (sodium fluroacetate) was used commonly, mainly at bait stations or with aerial drops (in baits) from aircraft. It is alleged that this method does not have a serious impact on the specific environment, because Australia only have a small number of native predators (Allen & Fleming 2004). Other methods that have also been used included trapping, shooting and the fencing of properties where livestock is produced. In addition, the Australian government have started in the 1880s to erect long so-called Dingo/Dog Barrier Fences to exclude damage-causing predators from major sheep producing areas of Australia (Downward & Bromell 1990; Allen & Fleming 2004; Thomson 2008). Management focus has since shifted to the sheep farming areas, where more selective management strategies for especially wild dogs are used (Downward & Bromell 1990; DOA 2005; Glen & Dickman 2005).

1.2.3 Europe

Brown bears *U. arctos*, wolves, Eurasian lynx *L. lynx* and Iberian lynx *L. pardinus* are the predators most in conflict with livestock and game ranchers in Europe (Breitenmoser 1998, Linnell *et al*. 2009; Molinari-Jobin *et al*. 2010; Rigg *et al*. 2011). Similar to the USA and Australia, earlier HPCM activities in Europe have focused on ways to eradicate these species from human dominated landscapes. Bounties were paid for predators killed and unselective trapping, shooting and poison were commonly used (Schwartz *et al*. 2003).

Recently, many European countries have started to give large predators protection status to stimulate their recovery (Breitenmoser 1998; Zimmerman *et al.* 2001). They have also endorsed conventions [e.g. the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention)] committed to the protection of large predators, forcing governments to get actively involved with the management of these predators (Andersen *et al*. 2003). As a result non-lethal and selective methods are now considered more widely for HPCM in Europe, such as selective removal of problem individuals (Stahl *et al*. 2001a), livestock guarding animals (Hansen & Bakken 1999) and compensation for losses (Cuicci & Boitani 1998).

1.3 Human-predator conflict in South Africa

The documented history of HPC in South Africa started in the 1600s when the first European settlers clashed with lions *Panthera leo*, brown hyaenas *Parahyaena brunnea* and spotted hyaenas *Crocuta crocuta* in the Cape Province (Stadler 2006). Other predators that were also in conflict at a lesser scale, included leopard *Panthera pardus*, African wild dog *Lycaon pictus*, black-backed jackal and caracal (Beinart 1998; Stadler 2006).

Over the years HPCM operations have decreased the population numbers of most large predators in South Africa, with drastic changes in relative population densities.

Some larger predators, such as lions and spotted hyaenas, are today confined to nature reserves and national parks, as well as some private wildlife ranches (Skinner & Chimimba 2005). In the absence of the larger carnivorous competitors, smaller species such as black-backed jackal and caracal have increased their population numbers and ranges markedly (Stadler 2006). Despite many comprehensive HPCM efforts spanning decades, black-backed jackal and caracal are currently believed to be responsible for most of the damage in the livestock farming areas of South Africa (Avenant & Du Plessis 2008; Strauss 2009; De Waal 2009; Van Niekerk 2010). Some individual small livestock enterprises suffer unsustainable losses from these two species (Strauss 2009), and it is estimated that the direct cost of predation in the small livestock industry exceeds ZAR 1.39 thousand million per annum (Van Niekerk 2010). Black-backed jackal and caracal are also increasingly implicated in predation on wildlife ranches (De Waal 2009, 2012), while their potential detrimental impact on natural biodiversity is increasingly realized (Du Plessis 1972; Avenant & Du Plessis 2008; Anon 2010).

1.3.1 Human-predator conflict management in South Africa

The first HPCM activities or strategies in South Africa focused on ways to locally exterminate problem species (Stadler 2006). Bounties were paid by administrators for every unwanted predator (called vermin) killed and the methods used included shooting, trapping, poisoning and hunting with dogs. Formal poisoning clubs, partially supported by the Department of Agriculture, were formed during 1887 to aid in HPCM. Additionally, farmers used a kraaling system to protect their livestock from predators during times of highest risk. During these early periods livestock farms were not fenced and predators could still move freely across the land (Beinart 1998; Nattrass & Conradie 2013).

Over time livestock farmers and administrators started realizing the impact of certain HPCM methods (Beinart 1998). For example, kraaling was believed to contribute to increased incidences of diseases in livestock and increased erosion through trampling, and thus decreased grazing quality. It was also recognized that the bounty system was open to many abuses. As a result, a large part of government subsidies was shifted towards the fencing of properties (jackal-proof fences) in declared problem areas (specifically in the Free State Province, South Africa), while formal hunting clubs were formed to facilitate the control of "declared problem predators" on a regional level (Ferreira 1988; Nattrass & Conradie 2013). These hunting clubs were financed by government subsidies and membership fees from livestock farmers, and were specifically active in the erstwhile Orange Free State (Ferreira 1988) and Cape of Good Hope (Gunter 2008). Until 1965, hunting was conducted by more than 34 small private hunting associations in the Free State Province (Ferreira 1988). These hunting associations were dissolved by Provincial Proclamation on 24 December 1965 and a single hunting organization (Oranjejag) was created. It operated with government subsidies and compulsory membership by livestock farmers. At its peak, Oranjejag employed 20 full time hunters with about 1 000 hounds (Ferreira 1988). Membership was at first compulsory for all farmers, but from 1971 this was changed and membership was voluntary. Consequently, membership numbers dropped sharply (from 15 904 in 1970 to 5 200 in 1973) because farmers believed that predation problems were not controlled effectively (Ferreira 1988).

These hunting associations or clubs were mainly involved with the control of black-backed jackal, caracal and vagrant dogs *C. familiaris* (Ferreira 1988; Gunter 2008). At the same time the provincial government in the Cape Province was also involved in HPCM in some areas through research and method development at the Vrolijkheid Problem Animal Control Station near McGregor (currently in the Western Cape Province) and two satellite facilities at Adelaide (currently in the Eastern Cape Province) and Hartswater (currently in the Northern Cape Province). Farmers were also trained on different aspects of HPCM (Stadler 2006; Gunter 2008). At Vrolijkheid hunting hounds were bred and trained by government officials before being provided to the hunting clubs; the hounds men, mounted on horseback, were also trained at Vrolijkheid (Gunter 2008). The close co-operation between government officials and farmers was demonstrated by the fact that hunting clubs were inspected regularly to ensure compliance with its obligations to the state and being eligible for subsidies (Gunter 2008).

From the mid 1990's the responsibility of HPCM in South Africa has shifted towards private landowners. Subsidized hunting clubs were phased out, dedicated research facilities have been closed down, and management today is conducted mainly by landowners, private hunting clubs and professional problem-animal hunters (Beinart

1998; Stadler 2006; Avenant & Du Plessis 2008). In an attempt by livestock farmers and wildlife ranchers to seek unified solutions for predator management in South Africa, these parties launched the Forum for Damage Causing Animals on 2 July 2009 in Port Elizabeth; the name was later changed to the Predation Management Forum of South Africa (PMF; De Waal 2009). The PMF comprises the Red Meat Producers Organisation (RPO), the National Wool Growers' Association (NWGA), the South African Mohair Growers' Association (SAMGA) and Wildlife Ranching South Africa (WRSA) as the key role players at national and provincial level (De Waal 2009; 2012). However, interested parties, such as officials from the provincial and national environmental conservation authorities (DEA) and departments of agriculture (DAFF), scientists and academics are invited to attend PMF meetings. Although considerable progress has been made from 2009 to 2012 by the PMF towards achieving their primary goals, the initial momentum is waning (De Waal 2009, 2012). The main reason for this situation may be found in the absence of a unifying system of co-ordinated predation management in South Africa; without such an entity the activities related to predation remain fragmented, uncoordinated and ineffective (Avenant 2012; De Waal 2009, 2012).

Currently, government involvement is mostly restricted to the role of formulating and administrating the regulations of HPCM (Environmental Management Biodiversity Act, 2004: Act no. 10 of 2004). Some of the prominent recent initiatives by government to regulate black-backed jackal and caracal management include the unsuccessful attempt in 2006 to add these two species to the list of threatened or protected species (National Environmental Management Biodiversity Act: Act no. 10 of 2004). If this effort had been successful, control of these two species would have been subjected to the issuing of relevant permits by all nine provinces; it was suggested that, in addition to being logistically near to impossible to administer, such measures would have severely impacted the livestock farming and wildlife ranching industries in South Africa (H.O. de Waal, 2012, University of the Free State, *pers. comm.*). The development of National Norms and Standards for the Management of Damage Causing Animals, and the development of formal agreements with relevant stakeholders on the management of damage-causing animals is still underway in drawn out processes (National Environmental Management Biodiversity Act: Act no. 10 of 2004; CapeNature 2012).

A variety of HPCM methods are employed in South Africa (see **Chapter 5**). This includes both non-lethal and lethal methods (De Wet 2006; Snow 2006). Non-lethal methods include bells, livestock protection collars, fencing and livestock guarding dogs; the lethal methods used are non selective (e.g. random shooting, traps, poison), species-selective (e.g. calling and shooting), and individual-selective (e.g. poison collars). However, management is conducted in a fragmented way by individual producers and on isolated properties with very few efforts implemented over extended areas (Avenant & Du Plessis 2008; De Waal 2012). Many efforts are applied without recording of successes or failures, while its potential impact on ecosystems is ignored (Avenant & Du Plessis 2008; De Waal 2009, 2012). Furthermore, there is growing pressure from sections of South African society against the use of some of these methods (Landmark Foundation 2008; Animal Rights Africa 2010; Natrass & Conradie 2013).

1.3.2 Regulations for human-predator conflict management in South Africa

In South Africa HPCM is currently primarily regulated provincially, although some national and international regulations also apply (Appendix 1). In a recent summary of these regulations, Greyling (2006) pointed out that most are dated and that they contain various inconsistencies, gaps, and loopholes. As a result, Greyling (2006) recommended that new national norms and standards should be drafted to address the control of damage-causing animals in South Africa. Such norms and standards have since been drafted (National Environmental Management Biodiversity Act: Act no. 10 of 2004) but to this date it has not yet been finalized or made official. It is envisaged that the current study will provide some valuable information which could enhance the viability of any newly developed guidelines on the management of damage-causing animals.

1.4 Problem statement

The apparent ineffectiveness of current fragmented and uncoordinated approaches to decrease the impact of predation by black-backed jackal and caracal in South Africa, as well as the non-selectiveness, potential negative environmental impact and social non-acceptance of some of the methods used, calls for a review of the situation. A new approach which is scientifically based, biologically sound, environmentally safe and socially responsible is needed. A comprehensive HPCM strategy must ensure that organs of state, as represented among others by the Departments of Environmental Affairs (DEA; as custodian of biodiversity) and Agriculture, Forestry and Fisheries (DAFF; responsible for food security), are active partners in HPCM, engage in research and implementation, and not merely involve themselves with regulation and administration (Avenant & Du Plessis 2008; De Waal 2009, 2012).

Currently there is insufficient information to formulate a meaningful and practical HPCM strategy for black-backed jackal and caracal in South Africa (Avenant & Du Plessis 2008). According to Avenant *et al*. (2006) specific information for these two species is required on *inter alia*:

- their ecology in different South African habitats;
- the impact (extent and magnitude of predation) of these species in different areas in South Africa;
- the effectiveness of different HPCM methods;
- their contribution to ecosystem functioning in different habitats, including rangelands; and
- the social and economic aspects of HPC where they are involved.

As a result, the Canis-Caracal Program (CCP) was initiated in 2004 under the auspices of the African Large Predator Research Unit (ALPRU), University of the Free State (Avenant *et al*. 2004; ALPRU 2012). The main aim of the CCP is to find sustainable solutions by developing meaningful and practical HPCM strategies for black-backed jackal and caracal in South Africa (De Waal *et al*. 2006; ALPRU 2012).

1.5 Aim of this study

The aim of this study is to collate and review available information on black-backed jackal and caracal in South Africa with a view to develop a practical and sustainable HPCM strategy for these two species and reduce the impact of predation on the livestock and wildlife industries.

1.6 Study objectives

In line with the aim of the study specific objectives were identified, namely to collate and review all available information on:

- the ecology of black-backed jackal and caracal;
- the damage caused by predation on livestock farms and wildlife ranches;
- the different methods available to manage HPC involving black-backed jackal and caracal on livestock farms and wildlife ranches; and
- the social and economic aspects related to HPC involving black-backed jackal and caracal.

The goal of the study is to provide guidance on taking the process of developing a coordinated system of predation management in South Africa forward in a meaningful, practical and sustainable way.

2. Interactions involving sympatric black-backed jackal and caracal: implications for human-predator conflict management

2.1 Introduction

Predators form an integral part of ecosystems (Estes 1996), and through their interactions with other predators (Tannerfeldt *et al*. 2002; Glen & Dickman 2005; Trewby *et al*. 2008) or with prey (Glen *et al*. 2007b; Johnson *et al*. 2007) play a very important role in ecosystem functioning. These roles include the structuring of communities and the maintenance of biodiversity via their suppressing effect on competing predators and prey populations (Fedriani *et al*. 2000; Glen *et al*. 2007b; Johnson *et al*. 2007; Vanak & Gompper 2010).

Predator-predator interactions commonly include competition between a top-predator and lower-predators for available resources (Ritchie & Johnson 2009), with the outcome being that lower-predator numbers are either maintained at low densities or they are excluded (Estes 1996; Henke & Bryant 1999; Caro & Stoner 2003; Allen *et al*. 2012). Predator-prey interactions commonly occur in two major ways: firstly, predators directly consume prey species, thereby keeping their numbers and densities low; secondly, top-predators control lower-predators which indirectly result in less exploitation of prey species by these lower predators (Henke 1995; Estes 1996; Palomares & Caro 1999; Sinclair *et al*. 2003; Glen *et al*. 2007b; Allen *et al*. 2012).

In southern Africa, black-backed jackal *Canis mesomelas* and caracal *Caracal caracal* are two widespread, medium-sized predators sharing the largest part of their distribution ranges (Skinner & Chimimba 2005). However, both species are presently the largest predators in most areas (because human intervention has removed their larger competitors; Stadler 2006). They are also notorious for their contribution towards livestock and wildlife predation (De Waal 2009) and as a result are often managed unselectively (Avenant & Du Plessis 2008). Not much has been published on the ecology of these two sympatric species (see **Chapter 3**), with virtually no dedicated studies on their ecological importance. The impact of various ranch management practices on the ecology of these species and on the associated ecosystems are also not understood (Avenant & Du Plessis 2008; see **Chapter 3**). It is important to obtain more such information. As an example, Johnson *et al*. (2007) noted that the extensive removal of dingo *C. lupus dingo* from Australian ecosystems positively correlated with the collapse of several Australian marsupial species. This was attributed to a combination of lower-predator release and overexploitation. Consequently they (Johnson *et al*. 2007) identified the important ecological role of dingo in Australian ecosystems and highlighted the importance of developing management options that maintain them in these ecosystems.

Given the important role which predators generally play in ecosystem functioning, the current status of black-backed jackal and caracal as the largest predators in many southern African ecosystems and their current (mostly unselective) removal on rangeland, the potential ecological role of caracal and black-backed jackal in southern African ecosystems were investigated. The findings are related to an important aspect of rangeland management, namely human-predator conflict management (HPCM).

2.2 Materials and methods

Data were obtained through a comprehensive literature search (including Academic Search Complete, EBSCOHost, ISI Web of Knowledge, Reference lists) for published examples of direct observations on ecological interactions pertaining to black-backed jackal and caracal (Keywords included in the search: black-backed jackal; *Canis mesomelas*; caracal; *Caracal caracal*; ecology; *Felis caracal*; interactions). The subject material was divided according to predator-predator (between predators) and predator-prey (between predators and prey) interactions. The nature of each described interaction (e.g. competition; predation) was noted, while for competition it was also noted whether the specific interaction occurred within the species (intra-specific) or between different species (inter-specific).

2.3 Results and Discussion

A limited number of published examples were obtained on ecological interactions pertaining to black-backed jackal and caracal (Table 2.1). Most of these are on predator-predator interactions (n = 12), while only four (4) described predator-prey interactions.

Table 2.1: Published observations on direct predator-predator and predator-prey interactions involving black-backed jackal *Canis mesomelas* and caracal *Caracal caracal*

Species[1]	Type of interaction	Summary of observation/s	Study	Study Area
		<u>Predator-predator interactions</u>		
BBJ; BF; CAR; CF; SSG	Inter-specific competition	When black-backed jackal and caracal numbers decreased, cape fox, bat-eared fox and small-spotted genet numbers increased	Blaum *et al*. 2009	Livestock ranches, Kalahari, South Africa
BBJ	Intra-specific competition	Evidence of black-backed jackal remains in scats – potential predation	Rowe-Rowe 1982a	Giants Castle Game Reserve, Kwazulu-Natal, South Africa
BBJ; BH	Inter-and intra-specific competition	Discuss potential inter- or intraspecific competition at seal colonies	Hiscocks & Perrin 1987	Cape-Cross Seal Reserve, Namibia
BBJ; CAR	Inter-specific competition	When caracal numbers decreased in an area black-backed jackal numbers increased, and *vice versa*	Ferreira 1988	Free State, South Africa
BBJ; GJ	Inter- and intra-specific competition	Black-backed jackal tolerated golden jackal individuals, but chased other black-backed jackal	Fuller *et al*. 1989	Rift Valley, Kenya
CAR	Intra-specific competition	Caracal cubs were consumed by caracal males (on three occasions)	Stuart & Hickman 1991	Cape Province, South Africa
BBJ; BF ; CF	Inter-specific competition	Black-backed jackal killed cape fox and bat-eared fox individuals – interference competition	Kamler *et al*. 2012a	Benfontein Game Ranch, Northern Cape, South Africa
BBJ; CAR	Inter-specific competition	Mentioned the role of black-backed jackal in suppressing caracal	Kaunda 2001	Mokolodi Nature Reserve, Botswana
BBJ	Intra-specific competition	Evidence of black-backed jackal remains in scats – potential predation	Kaunda & Skinner 2003	Mokolodi Nature Reserve, Botswana
BBJ; CAR	Inter-specific competition	Black-backed jackal and caracal food sharing – discuss the potential for competition	Kok & Nel 2004	Free State, South Africa
BBJ, SSJ	Inter-specific competition	Black-backed jackal aggressively displaced side-striped jackals from grasslands	Loveridge & Macdonald 2002	Hwange National Park, Zimbabwe
BBJ; CAR	Inter-specific competition	One incidence where caracal preyed on black-backed jackal	Melville *et al*. 2004	Kgalagadi Transfrontier Park, Northern Cape, South Africa

[1] BF = Bat-eared fox *Otocyon megalotis*; BH = Brown hyaena *Parahyaena brunnea*; BBJ = Black-backed jackal *Canis mesomelas*; CAR = Caracal *Caracal caracal*; CF = Cape fox *Vulpes chama*; GJ = Golden jackal *Canis aureus*; SSG = Small-spotted genet *Genetta genetta*; SSJ = Side-striped jackal *Canis adustus*

Table 2.1 (cont.): Published observations on direct predator-predator and predator-prey interactions involving black-backed jackal *Canis mesomelas* and caracal *Caracal caracal*

Species[1]	Type of interaction	Summary of observation/s	Study	Study Area
		<u>Predator-prey interactions</u>		
CAR	Predation	High predation on rock hyrax could potentially impact on hyrax numbers	Moolman 1986	Mountain Zebra National Park, Eastern Cape, South Africa
BBJ	Predation	Black-backed jackal kept several of it's prey species at acceptable, low numbers	McKenzie 1990	Northern Tuli Game Reserve, Botswana
CAR	Predation	Caracal predate opportunistically on small mammal and bird species, thereby keeping their numbers low	Avenant & Nel 2002	West Coast National Park, Western Cape, South Africa
BBJ	Predation	Black-backed jackal consumed large numbers of ungulates – potential control of ungulate numbers	Klare *et al*. 2010	Rooipoort and Benfontein Game Ranches, Northern Cape, South Africa

[1] BF = Bat-eared fox *Otocyon megalotis*; BH = Brown hyaena *Parahyaena brunnea*; BBJ = Black-backed jackal *Canis mesomelas*; CAR = Caracal *Caracal caracal*; CF = Cape fox *Vulpes chama*; GJ = Golden jackal *Canis aureus*; SSG = Small-spotted genet *Genetta genetta*; SSJ = Side-striped jackal *Canis adustus*

2.3.1 Predator-predator interactions

For both black-backed jackal and caracal direct evidence of predator-predator interactions (competition) were found (Table 2.1). Most of the examples (n = 9) describe inter-specific interactions, including interactions between black-backed jackal and caracal (n = 5) and black-backed jackal and other predator species (n = 5). One (1) example of interactions between caracal and other predator species, excluding black-backed jackal, was found. Five (5) examples described intra-specific interactions, the majority (n = 4) referring to black-backed jackal interactions.

In general, competition between predators results in the regulation of competitor numbers (Palomares & Caro 1999; Caro & Stoner 2003; Donadio & Buskirk 2006; May *et al*. 2008). For example, Berger & Gese (2007) noted that gray wolf *C. lupus* harass and kill competing coyote *C. latrans*, which results in a lower density of coyotes in areas where wolves occur. Fedriani *et al*. (2000) found that coyotes, likewise, restrict the distribution of grey fox *Urocyon cinereoargenteus* in overlapping areas. Predator-predator interactions involving black-backed jackal and caracal could have similar inhibiting effects. In the case of black-backed jackal, it has been observed that territorial individuals aggressively chase, kill and even predate on conspecifics (Rowe-Rowe 1982a; Fuller *et al*. 1989; Kaunda & Skinner 2003). They also chase (Loveridge & Macdonald 2002), kill (Kamler *et al*. 2012a) and predate on (Kaunda & Skinner 2003; Melville *et al*. 2004) other predators. For caracal, Stuart & Hickman (1991) observed predation on conspecifics. Ferreira (1988) suggested that black-backed jackal and caracal numbers inversely fluctuate where they co-occur, and attributed it to the exclusion effect.

Dominant black-backed jackal (pairs) and caracal (individuals) are naturally territorial and will exclude conspecifics and presumably, also limit the numbers of other predators in their territories. However, it is possible that territorial individuals may be more tolerant as food availability increase (Ferguson *et al.* 1983; McKenzie 1990; Oosthuizen *et al.* 1997; Loveridge & Macdonald 2001, 2003; Berger *et al*. 2008). Therefore, under conditions where food availability is higher (e.g. in ranching areas where more food is available in the form of livestock or introduced wildlife) it is possible that the exclusion effect by especially black-backed jackal may be less. Habitat complexity may also influence territoriality and competitive interactions (both intra- and inter-specific) between predators (Creel 2001; Ritchie & Johnson 2009). Accordingly, in a complex habitat where more refuge areas are available for competing predators, encounters may decrease and their co-existence increase.

2.3.2 Predator-prey interactions

There is limited published evidence for direct predator-prey interaction in black-backed jackal (n = 2 studies) and caracal (n = 2 studies) populations. Black-backed jackal has been suggested to control the numbers of various prey species (including springhare *Pedetes capensis* and springbok *Antidorcas marsupialis* – McKenzie 1990; Klare *et al*. 2010), while caracal controlled rock hyrax *Procavia capensis* (Moolman 1986) and a diversity of small mammal and bird species (Avenant & Nel 2002).

Predators may often play an important role in controlling common prey species, reducing their potential impact on surrounding ecosystems. Henke (1992), Glen *et al.* (2007b) and Johnson *et al.* (2007) for instance found that other, similar-sized carnivores play an important role in controlling common prey species elsewhere, thereby preventing overexploitation of associated plant communities. Black-backed jackal and caracal may, therefore, also contribute indirectly to the preservation of associated plant communities and ecosystems.

2.3.3 Relevance to human-predator conflict management

Many of the current management techniques used for problem-causing black-backed jackal and caracal are unselective and in many instances focus on ways to eliminate or exclude these species (De Wet 2006; Snow 2006; Avenant & Du Plessis 2008). Such approaches could have profound effects on the ecosystems where these species occur (also see Trout *et al*. 2000; Glen & Dickman 2005; Baker *et al*. 2008). In general, it may eliminate competition between specific species, enabling other predators to move into the area (increase their densities), and result in an increase of certain prey species, leading to changes in community composition and, ultimately, a decrease in biodiversity.

Top-predators occupy the top trophic position in an ecosystem (Ritchie & Johnson 2009) and when these predators are removed it often results in lower-predator release and hyperpredation (Estes 1996; Johnson *et al*. 2007). In Australia for example, the removal of dingo's from some areas resulted in the invasion of exotic foxes *Vulpes vulpes*. Consequently, the foxes were responsible for the extermination of a local population of rufus hare-wallaby *Lagorchestes hirsutus* (Glen *et al*. 2007b). This phenomenon of lower-predator release and or hyperpredation remains to be tested in the southern African ecosystems where black-backed jackal or caracal is removed. The occurrence of lower-predator release could possibly explain to some extent the observation by many South African farmers that black-backed jackal and caracal have expanded their ranges to areas where they were not present before (De Waal 2009). It could also mean that the current management practices, by which these problem-causing predators are removed or excluded unselectively, are possibly disrupting competitive interactions, consequently contributing to the observed range expansion and overlap. The observed patterns could, however, also be attributed to food availability. For predators that do take livestock or introduced and re-introduced wildlife, food availability in rangelands is potentially higher, presumably resulting in decreased competition (Ferguson *et al.* 1983; McKenzie

1990; Oosthuizen *et al.* 1997; Loveridge & Macdonald 2001, 2003; Berger *et al*. 2008).

Black-backed jackal and caracal may further also play an important role in interactions with smaller predators (Avenant & Nel 1997; Blaum *et al*. 2009). They may have an important top-down effect on these smaller predators (Estes 1996; Johnson *et al*. 2007) with major consequences for overall ecosystem functioning. Further, an increase in the numbers of these smaller predators in the absence of black-backed jackal or caracal could have significant implications for disease outbreaks and management (Loveridge & Macdonald 2001; Butler *et al*. 2004; Marino *et al*. 2005).

Apart from disrupting competitive interactions when unselectively removing or excluding black-backed jackal or caracal, it could also impact prey abundance and ecosystem diversity. Glen *et al*. (2007b) noted that rabbit numbers in Australian ecosystems increased after dingo were removed, and the rabbits then had a negative impact on associated plant communities. It is not impossible that extensive and unselective removal of black-backed jackal or caracal could have the same effects. For example, springhare, rock hyrax, gerbils *Tatera spp.* and molerats *Cryptomys hottentotus* have the ability to consume large amounts of plant material and are known to damage natural vegetation and crops where they occur in high numbers (Korn & Korn 1989; Zwolinski *et al*. 1998; Skinner & Chimimba 2005). These small herbivores are all important prey items of both black-backed jackal and caracal (Avenant & Nel 1997, 2002; Loveridge & Macdonald 2003; Melville 2004). Therefore, the unselective and extensive removal of black-backed jackal or caracal in areas where they are important predators of the abovementioned species could create an unnatural explosion of the prey populations, with potential negative implications for plant species. In rangelands, increased competition with livestock and wildlife may, therefore, follow (Henke & Bryant 1999). Furthermore, the subterranean nesting behaviour of many of the abovementioned species may increase the risk of damage to farming equipment (e.g. vehicles) when their populations, and resultantly their burrows, increase (N.L. Avenant, 2012, National Museum, Bloemfontein, *pers. comm.*).

It has also been suggested, although not proven, that unselective control methods might have indirectly increased the numbers of black-backed jackal and caracal through compensatory breeding and migration (Avenant & Du Plessis 2008). If true, this may have a pronounced effect on both prey and sympatric predator population density and structure, with cascading effects on the ecosystem. It is also not impossible that a decrease in natural prey density and diversity might “force” an increasingly number of caracal and black-backed jackal to prey on “unnatural” livestock or introduced wildlife, and this behaviour be passed on to their offspring (Avenant & Du Plessis 2008).

2.4 Conclusions

In this chapter important direct evidence was reviewed which demonstrates how black-backed jackal and caracal may interact with other species in ways important for overall ecosystem functioning and biodiversity conservation. It also shows that black-backed jackal and caracal may, through competitive interactions, inhibit or exclude conspecifics and other predator species, and regulate prey numbers. Most of the limited published evidence found is, however, not very conclusive because the majority are based on single observations or inferences from other results. Also, the studies were in general not designed specifically for the purpose of studying ecological interactions. The conclusions that can be drawn from these examples are therefore limited, highlighting important gaps in the knowledge base and thus warranting more research. Dedicated experimental studies should be conducted to test these hypotheses.

The impact which different HPCM strategies may have on the potential ecological function of black-backed jackal or caracal in rangeland areas (≈ to suppress conspecifics, other predators and prey species) is also unclear due to a lack of information on the ecological roles of these two predators. Furthermore, it is also not known how this may impact biodiversity (e.g. loss of species due to mesopredator release or hyperpredation), rangeland dynamics (e.g. decreasing grazing potential due to increased densities of indigenous grazers) and livestock or wildlife losses (≈ increased predator numbers may cause increased predation rates).

The importance of understanding the ecological interactions pertaining to black-backed jackals, caracals, other predators and their prey species was highlighted. Understanding these interactions will enhance a better perspective on the ecological role these predators play. Because these species are currently mostly managed in isolation, this information should also provide important insight into how these approaches may impact on overall ecosystem functioning (Glen & Dickman, 2005; Allen *et al*., 2012).

3. Ecological information on the black-backed jackal and caracal: identifying information needs for southern Africa

3.1 Introduction

Black-backed jackal *Canis mesomelas* and caracal *Caracal caracal* are considered the major contributors to livestock losses in South Africa (Stadler 2006; Strauss 2009; Van Niekerk 2010). These losses are reported to be on the increase (Avenant & Du Plessis 2008; De Waal 2009) and have a considerable negative impact on individual small livestock enterprises (Strauss 2009) and the South African small stock industry (Van Niekerk 2010). Some claims also suggest that they are increasingly responsible for substantial losses in the cattle and wildlife ranching industries (De Waal 2009).

The contributions made by the scientific community have not been sufficient to develop a meaningful human-predator conflict management (HPCM) strategy aimed at black-backed jackal and caracal (Avenant & Du Plessis 2008). As a result damage-causing predators are mostly controlled *ad hoc* based on assumptions, personal experience and by word of mouth (Avenant & Du Plessis 2008). Uncontrolled blanket-control and poisoning practices are employed over large areas (Jooste 2011), constantly threatening biodiversity in most ecosystems in small livestock farming areas in South Africa (Avenant & Du Plessis 2008). However, without a sound ecological understanding on the damage-causing predators, the long-term effectiveness of HPCM strategies is in jeopardy (Darrow & Shivik 2009). For example, it has been speculated that unselective HPCM methods may have contributed to increased black-backed jackal and caracal populations, and partly be responsible for the current high levels of livestock losses (Avenant & Du Plessis 2008).

The ecology of predators is influenced by changes in their immediate natural environment (Cypher & Schrivner 1992; Stoddart *et al.* 2001; Admasu *et al.* 2004) and, similarly, differences and changes in livestock farming and wildlife ranching areas should have an effect on damage-causing predators (Ferguson *et al.* 1983; Bradley & Fagre 1988; Lovallo & Anderson 1995; Stahl *et al*. 2001a; Bingham & Purchase 2002; Blejwas *et al.* 2002; Kok & Nel 2004; Marker & Dickman 2005;

Melville & Bothma 2006; Moa *et al*. 2006; Odden *et al*. 2008). For example, a change in prey availability may result in a change in predator diet (Windberg & Mitchell 1990; Stahl *et al*. 2001a; Avenant & Nel 2002; Kok & Nel 2004), a change in their social behaviour may enable them frequent access to livestock (Melville & Bothma 2006), and human persecution may change the predator's reproduction behaviour (Sterling *et al.* 1983; Cypher & Schrivner 1992; Sacks 2005), further affecting their diet. Many gaps, however, remain regarding the understanding of the ecology of damage-causing black-backed jackal and caracal under different conditions in southern Africa. It is especially important to know how these animals will react to changing conditions in farming areas, and how this may influence the effectiveness of different management interventions.

Available published scientific information on the ecology of black-backed jackal and caracal in southern Africa was collated and reviewed. The aim was to (1) review the nature of the information available; (2) assess the current understanding on black-backed jackal and caracal ecology in both natural and ranching areas; and (3) identify shortcomings that limit the desired progress to sustainably reduce the impact of black-backed jackal and caracal predation on livestock farms and wildlife ranches within the context of ecosystem and biodiversity conservation.

3.2 Materials and methods

Published scientific information on black-backed jackal and caracal ecology was obtained by means of a literature search; including Academic Search Complete, EBSCOHost, ISI Web of Knowledge and reference lists (Keywords included in search: activity, behaviour, black-backed jackal, *Canis mesomelas*, caracal, *Caracal caracal*, diet, dispersal, ecology, feeding, *Felis caracal*, habitat, home-range, ranging behaviour, reproduction, social structure, territoriality).

The locality of each study in southern Africa was plotted on a map to indicate the number of studies done in identifiable regions (biomes) within the current range of black-backed jackal and caracal in southern Africa. Within South Africa, Lesotho and Swaziland, biomes were delineated according to Mucina & Rutherford (2006), and in Namibia, Botswana, Zimbabwe and Mozambique according to Skinner & Chimimba (2005). Each study was also classified according to the anthropogenic land-use type in which it was conducted, namely in a protected area, a livestock farming or wildlife ranching area, or combinations of these areas.

The information from each study was then classified according to five main ecological aspects, namely:

- social structure and behaviour (social structure; dispersal; territoriality; home-range size and ranging behaviour; territorial overlap);
- activity patterns (timing of activity; activity types);
- feeding (feeding behaviour and strategy; diet composition; prey preferences)
- habitat utilization (habitat selectivity); and
- reproduction (timing of reproduction; litter size; fecundity; reproductive behaviour).

The presence and distribution of each ecological aspect within the different biomes were analysed according to a rating system adapted from Ray *et al.* (2005). This system considered the number of studies on each aspect as well as how large a part of each biome the specific studies covered. When more than one publication on a specific aspect stemmed from a single study (e.g. a number of publications from a single thesis), these were counted as a single study on that aspect for that locality. When a study was conducted at more than one isolated locality, each locality for which data were published was considered a separate study. The following ratings, with their classifications were used:

0 = No information available on the aspect in the region;
1 = Aspect studied in an isolated part or parts of the region;
2 = Aspect studied in a relatively large, but clustered, part of the region;
3 = Aspect studied in a large and more widely distributed part of the region, but gaps do exist; and
4 = Aspect studied in most of the region.

To indicate which studies linked different aspects, or related variables, it was noted when a study reported on more than one ecological variable. For example, when a study only reported on home-ranges (e.g. size and use) as an indication of black-backed jackal or caracal movements, but did not link this with prey availability and or distribution, the study was not included in this category. If the study linked the home-ranges with prey distribution, for example, it was considered as linking more than one ecological aspect or related variable.

3.3 Results

With a view to achieve more depth and greater detail, the information on the black-backed jackal and caracal are presented and discussed separately.

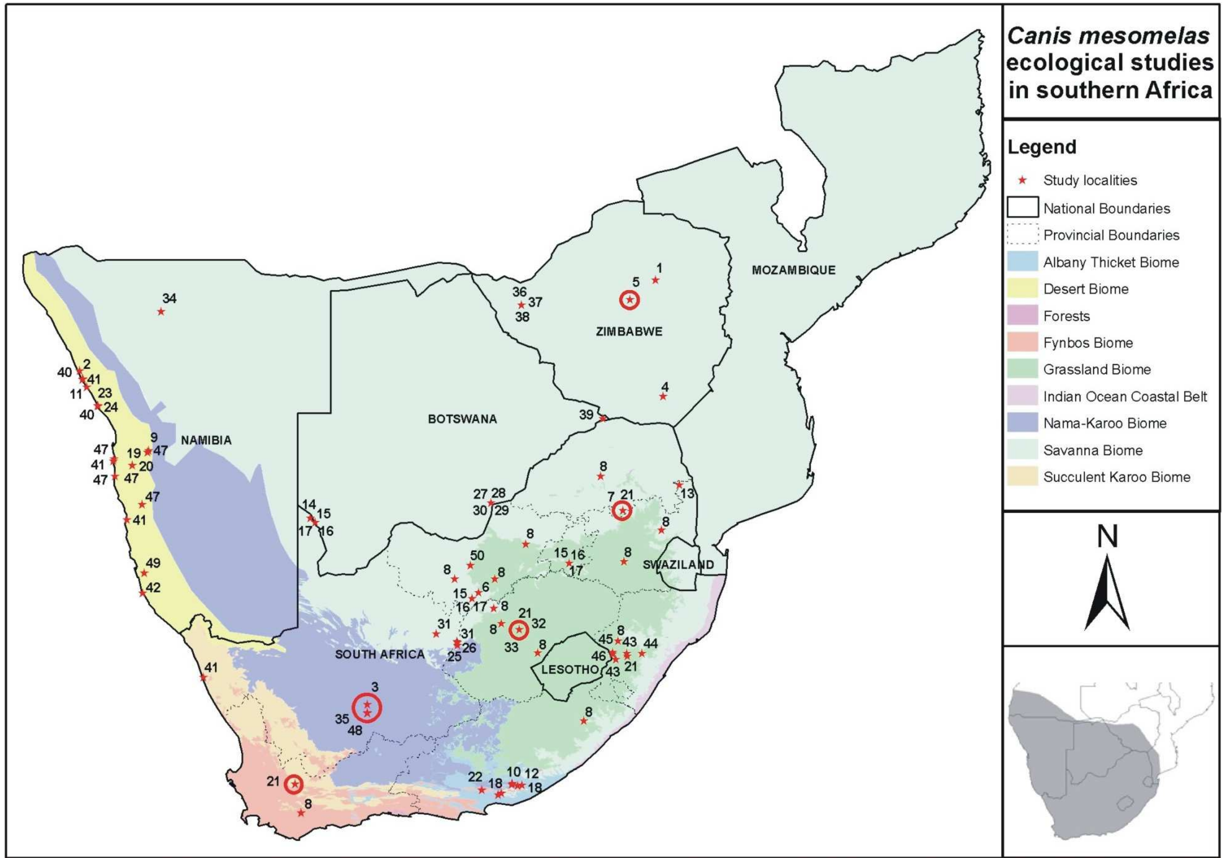
3.3.1 Black-backed jackal

Fifty (50) scientific publications on black-backed jackal ecology were obtained which emanated from 42 different studies. Most of these publications (n = 31) appeared prior to 2000; 14 were published since 2001, and ten (10) were published in the last seven years (2006 to 2012). The average publication date was *ca.* 24 years ago, the oldest paper appeared in 1965, and the most recent in 2012.

The 42 studies were conducted throughout the southern African distribution range of black-backed jackal (Fig. 3.1). Most publications stemmed from studies in Namibia (n = 13), but primarily from the Desert biome along the coast, from the Savannah (n = 14) and Grassland (n = 13) biomes within South Africa, and from the Savannah biome within the central parts of Zimbabwe (n = 6). Importantly, only 11 publications (22% of all) have been produced from the Succulent Karoo, Nama-Karoo and Albany Thicket biomes which are the predominant small livestock farming areas (Palmer & Ainslie 2006).

With regards to anthropogenic land-use type, the majority of the studies (74%; n = 31) were conducted in protected areas. Fourteen (14) studies were done in a combination of farming and protected areas, but most of these did not differentiate in their results between protected areas and rangelands. Only six (6) studies (14% of all) were done exclusively in rangelands.

The publications obtained addressed all of the main aspects of black-backed jackal ecology. Of these, feeding (n = 30), reproduction (n = 12) and social structure and behaviour (n = 12) were reported on most. Only seven (7) and six (6) papers



1 - Atkinson *et al*. 2002; 2 - Avery & Avery 1987; 3 - Bernard & Stuart 1992; 4 - Bingham & Purchase 2002; 5 - Bingham & Purchase 2003; 6 - Bothma 1971a; 7 - Bothma 1971b; 8 - Bothma 1971c; 9 - Bothma *et a*l. 1984; 10 - Brassine 2011; 11 - Dreyer & Nel 1990; 12 - Do Linh San *et al.* 2009; 13 - Fairall 1968; 14 - Ferguson 1978; 15 - Ferguson 1980; 16 - Ferguson *et al*. 1983; 17 - Ferguson *et al*. 1988; 18 - Forbes 2011; 19 - Goldenberg *et al*. 2008; 20 - Goldenberg *et al*. 2010; 21 - Grafton 1965; 22 - Hall-Martin & Botha 1980; 23 - Hiscocks & Perrin 1987; 24 - Hiscocks & Perrin 1988; 25 - Kamler *et al*. 2012a; 26 - Kamler *et al*. 2012b; 27 - Kaunda 1998; 28 - Kaunda 2000; 29 - Kaunda 2001; 30 - Kaunda & Skinner 2003; 31 - Klare *et al*. 2010; 32 - Kok 1996; 33 - Kok & Nel 2004; 34 - Krofel 2007; 35 - Lloyd & Millar 1982; 36 - Loveridge & Macdonald 2001; 37 - Loveridge & Macdonald 2002; 38 - Loveridge & Macdonald 2003; 39 - McKenzie 1990; 40 - Nel & Loutit 1986; 41 - Nel *et al.* 1997; 42 - Oosthuizen *et al.* 1997; 43 - Rowe-Rowe 1976; 44 - Rowe-Rowe 1978; 45 - Rowe-Rowe 1982; 46 - Rowe-Rowe 1984; 47 - Stuart 1976; 48 - Stuart 1981; 49 - Stuart & Shaugnessy 1984; 50 - Van der Merwe *et al*. 2009

Fig. 3.1: The distribution of studies on the ecology of black-backed jackal *Canis mesomelas* in the southern African subregion. Biomes according to Skinner & Chimimba (2005) and Mucina & Rutherford (2006); encircled studies were conducted throughout a country or province; grey area in insert indicates current distribution range of *C. mesomelas* according to Loveridge & Nel (2004) and Skinner & Chimimba (2005).

respectively reported on black-backed jackal habitat utilization and activity patterns. Most of the ecological aspects have, however, only been studied in isolated areas (Table 3.1). Furthermore, the publications were generally also isolated by not linking different ecological aspects, with only six (6) publications (12% of all) actually linking more than one aspect or related variable. These included linking prey availability with reproduction timing (Bernard & Stuart 1992), activity timing (Kaunda 2000), diet (Rowe-Rowe 1982a; Klare *et al.* 2010; Kamler *et al*. 2012a), and feeding strategy (McKenzie 1990).

Table 3.1: Ratings indicating the spread of scientific studies on aspects of black-backed jackal *Canis mesomelas* ecology in different biomes of southern Africa (Biomes according to Skinner & Chimimba 2005; Mucina & Rutherford 2006)

Biome	Rating per ecological aspect[1]					Average rating per biome
	Reproduction	Social structure and behaviour	Activity patterns	Feeding	Habitat utilization	
Albany Thicket	1	0	0	3	1	1
Desert	0	0	0	3	1	0.8
Forest	0	0	0	0	0	0
Fynbos	0	0	0	0	0	0
Grassland	3	1	1	3	1	1.8
Indian Ocean Coastal Belt	0	0	0	0	0	0
Nama-Karoo	1	0	0	1	1	0.6
Savanna	1	1	1	1	1	1
Succulent Karoo	1	0	0	1	1	0.6

[1] Rating classification: 0 = no information available on the aspect in the region; 1 = aspect studied in an isolated part or parts of the region; 2 = aspect studied in a relatively large, but clustered, part of the region; 3 = aspect studied in a large and more widely distributed part of the region, but gaps do exist; 4 = aspect studied in most of the region

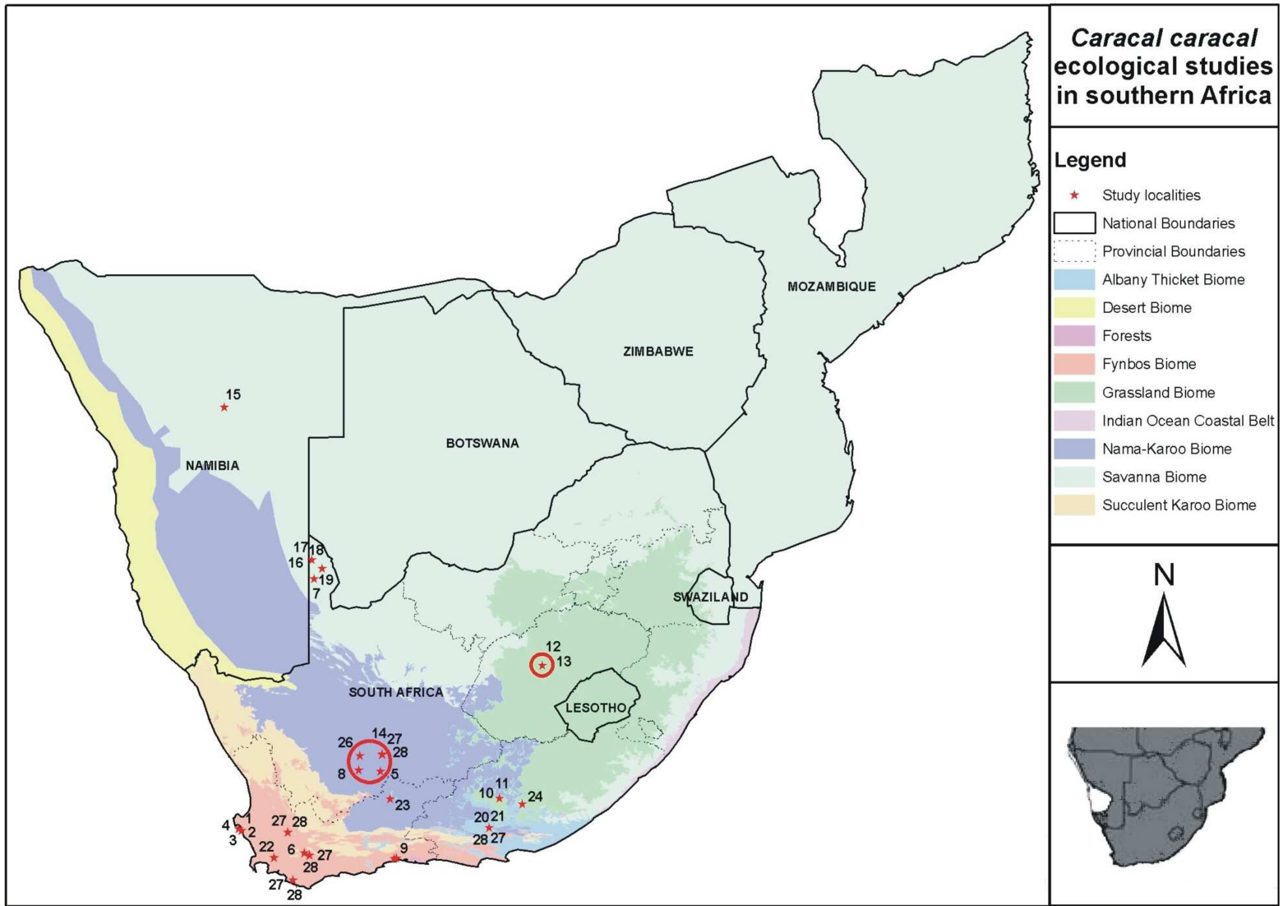
3.3.2 Caracal

Twenty eight (28) scientific publications, emanating from 22 different studies, were obtained. Fifteen (15) publications appeared in the period until 1990, six (6) were published since 2001, and only three (3) were published in the last seven years, from 2006 to 2012. The average publication date was *ca.* 21 years ago, with the oldest paper appearing in 1965 and the most recent in 2012.

Most of the publications (67%) emanated from the southern and western distribution range of caracal in southern Africa (Fig. 3.2). Only one (1) publication emanated from outside South Africa, namely in the Savannah biome of Namibia. Within South Africa most of the publications emanated from the Fynbos biome (n = 13), the Nama-Karoo biome (n = 7) and the Savanna biome (n = 6). In the relatively large Succulent Karoo biome, which is one of the major small livestock farming areas in South Africa (Palmer & Ainslie 2006), no dedicated study was conducted. The publications from the Savannah biome, an important area for livestock farming and wildlife ranching in South Africa (Palmer & Ainslie 2006), stemmed from only a small area in the north-western corner of this region. Also, no studies were conducted in the Forest, Desert, and Indian Coastal Belt biomes.

Most of the publications on caracal ecology emanated from studies conducted in protected areas (n = 10), and a combination of protected areas and rangelands (n = 10). Most of the latter did, however, not distinguish in their results between protected areas and rangelands. Eight (8) publications originated from studies conducted exclusively on rangelands.

All of the main aspects of caracal ecology, as identified for this study, have been addressed by the listed publications. Of these, feeding (n = 15), social structure and behaviour (n = 10), and habitat utilization (n = 9) were reported on the most. Only six (6) and three (3) publications, respectively, reported on reproduction and activity patterns. Most of the ecological aspects have, however, only been studied in isolated or clustered areas, in most of the biomes (Table 3.2). The publications were generally also isolated in linking different ecological aspects, with only seven (7; 25% of all) publications actually linking more than one aspect or a related variable. These included linking prey availability with reproduction timing (Bernard & Stuart 1987), diet composition (Avenant 1993; Avenant & Nel 1997, 2002), home-range size and use (Avenant 1993; Avenant & Nel 1997, 1998) and feeding strategy (Avenant 1993; Stuart 1982; Avenant & Nel 1998; Van Heezik & Seddon 1998).



1 - Avenant 1993; 2 - Avenant & Nel 1997; 3 - Avenant & Nel 1998; 4 - Avenant & Nel 2002; 5 - Bernard & Stuart 1987; 6 - Bothma 1965; 7 - Bothma & Le Riche 1994; 8 - Brand 1989; 9 - Braczkowski *et al.* 2012; 10 - Grobler 1981; 11 - Grobler 1982; 12 - Kok 1996; 13 - Kok & Nel 2004; 14 - Lloyd & Millar 1982; 15 - Marker & Dickman 2005; 16 - Melville 2004; 17 - Melville *et al.* 2004; 18 - Melville & Bothma 2006; 19 - Mills *et al.* 1984; 20 - Moolman 1984; 21 - Moolman 1986; 22 - Norton & Lawson 1985; 23 - Palmer & Fairrall 1988; 24 - Pringle & Pringle 1979; 25 - Skinner 1979; 26 - Stuart 1981; 27 - Stuart 1982; 28 - Stuart & Hickman 1991

Fig. 3.2: The distribution of studies on the ecology of caracal *Caracal caracal* in the southern African subregion. Biomes according to Skinner & Chimimba (2005) and Mucina & Rutherford (2006); studies encircled mean that they were conducted throughout a province; the grey area in the insert indicates current distribution range of *C. caracal* in southern Africa according to Skinner & Chimimba (2005).

Table 3.2: Ratings indicating the spread of scientific studies on aspects of caracal *Caracal caracal* ecology in different biomes of southern Africa (Biomes according to Skinner & Chimimba 2005; Mucina & Rutherford 2006)

Biome	Rating per ecological aspect[1]					Average rating per biome or country
	Reproduction	Social structure and behaviour	Activity patterns	Feeding	Habitat utilization	
Albany Thicket	1	1	0	1	1	0.8
Desert	0	0	0	0	0	0
Forest	0	0	0	0	0	0
Fynbos	3	3	1	3	3	2.6
Grassland	1	1	1	3	1	1.4
Indian Ocean Coastal Belt	0	0	0	0	0	0
Nama-Karoo	1	1	0	3	1	1.2
Savanna	1	2	1	2	2	1.6
Succulent Karoo	1	1	0	1	1	0.8

[1] Rating classification: 0 = No information available on the aspect in the region; 1 = Aspect studied in an isolated part or parts of the region; 2 = Aspect studied in a relatively large, but clustered, part of the region; 3 = Aspect studied in a large and more widely distributed part of the region, but gaps do exist; 4 = Aspect studied in most of the region

3.4 Discussion

3.4.1 Nature of information

Most of the southern African studies on black-backed jackal and caracal are dated, with only a limited number of recent publications. This is noteworthy, considering the increasing importance of these two predators as damage-causing animals in South Africa, as well as the relatively recent geo-political and social changes in this area (De Waal 2009). Also, data from the southern African studies are mostly from localized and isolated areas and only address single aspects of black-backed jackal and caracal ecology; the latter is confirmed by the fact that most studies produced only a single publication. Findings from these studies may not apply to other regions or habitats, while very little can be learned on how different ecological aspects are interrelated. From an HPCM perspective, the ability to successfully manage damage-causing black-backed-jackal and caracal in southern Africa is limited by the temporal and spatial isolation of the available scientific information on the ecology of these species.

Most of the studies on black-backed jackal and caracal ecology were conducted in protected areas. It is suspected that faunal populations in such areas are generally not subjected to the same conditions and pressures as those in livestock farming or wildlife ranching areas. For example, these areas may differ vastly with regard to the level of disturbance, predator and prey composition, prey density and biomass, the level and timing of human activity, the presence of domestic dogs, the removal of sympatric predators, and the presence of fences and other management practices. Therefore, it can be expected that the ecology of black-backed jackal and caracal may vary accordingly; again limiting the assumptions, conclusions and predictions needed in formulating successful HPCM strategies.

Overall, there is a general lack of information on the ecology of black-backed jackal and caracal in southern Africa. This is also true for the remainder of their distribution ranges (Ray *et al.* 2005). This is in stark contrast to, for example, the damage-causing coyote *C. latrans* in North-America for which more than 300 publications (ISI Web of Knowledge, December 2011) are available on the various ecological aspects.

3.4.2 Current knowledge of black-backed jackal ecology

Some ecological patterns and underlying factors crucial for the development of sustainable livestock farming and wildlife ranching practices, and a HPCM strategy for the black-backed jackal in different southern African regions and habitats, were identified and are discussed below.

3.4.2.1 Social structure and behaviour

Black-backed jackal has a flexible social structure and their density may vary under different conditions. Family groups generally comprise a mated territorial pair and their offspring (Rowe-Rowe 1982b; Ferguson *et al.* 1983; Loveridge & Macdonald 2001). Some groups may also contain older juveniles or sub-adults, which delay their dispersal to act as helpers in raising sibling offspring (Moehlman 1979; Rowe-Rowe 1982b; Ferguson *et al.* 1983); the latter is expected to occur only under conditions where food availability is high (Ferguson *et al.* 1983). Further, when more vacant territories exist in neighbouring areas, it is expected that black-backed jackal dispersal will increase (Loveridge & Macdonald 2001). These dispersals can take place over long distances; exceeding 100 km (Bothma 1971b; Ferguson *et al.* 1983), highlighting the importance to manage black-backed jackals over large areas (Avenant *et al*. 2004; De Waal 2009).

Loveridge & Macdonald (2001) noted that black-backed jackal mated pairs form territories, which in some instances may overlap. Although territories are generally fixed, some cases have been noted where the boundaries shifted (Ferguson 1980; Kaunda 2000). The triggers that allow or necessitate these overlaps or shifts have not been ascertained. Despite their territoriality, cases have been observed where black-backed jackal allowed other mated pairs, sub-adults or juveniles into their territories (Macdonald 1979; Rowe-Rowe 1982b; Ferguson *et al.* 1983; Hiscocks & Perrin 1988; McKenzie 1990; Oosthuizen *et al.* 1997; Loveridge & Macdonald 2001, 2003). All of these territorial breakdown events were triggered by a higher availability of resources, mostly food. Consequently, Loveridge and Macdonald (2001) suggested that dispersing black-backed jackal may have one of four options depending on the conditions, namely (1) stay in their natal territory as a helper; (2) move into vacant territories; (3) move into nearby territories to be incorporated into that resident group; or (4) float between their natal territory and adjacent territories. Loveridge & Macdonald (2001) further observed that some individuals were even allowed to form their own smaller territory within their natal territory.

The home-range size of black-backed jackal is flexible and may have spatial (≈ between different areas), temporal (≈ over time), and local differences (≈ within a population). These differences are attributed to food availability and the social status of individuals. Ferguson *et al*. (1983) reported smaller home-ranges in areas where food availability were higher. Ferguson *et al*. (1983) also noted larger home-ranges in farming areas than in natural areas, and contributed it to lower natural food availability in the former areas. McKenzie (1990) and Loveridge & Macdonald (2003) also noted an increase in black-backed jackal home-range size during the colder, drier periods when food availability was low. On the social front, Rowe-Rowe (1982b) and Ferguson *et al*. (1983) noted that black-backed jackal juveniles generally have the smallest home-ranges (because they stay in their natal range), followed by the adults (which have to move around to protect their territories), and then the sub-adults (as this group encompass the dispersing, transient individuals). Further, territorial black-backed jackal adults may increase their home-ranges temporarily during the main dispersing period to maintain and defend their territories; lactating females generally decrease their home-ranges to stay closer to their young; and territorial males and helpers may increase their home-ranges in order to provide for the lactating females (Kaunda 2001).

3.4.2.2 Activity patterns

Although black-backed jackals are generally active at night, some studies have noted flexibility in their activity timing and or intensity. Firstly, Ferguson (1980) and Kaunda (2000) noted that territorial adults are more active because they have to protect their territories, while dispersing individuals increase their activity when in search of territories and mates. Secondly, black-backed jackal may peak their own activity when the activity of their most abundant prey peaks (Ferguson 1980; Ikeda *et al*. 1983; Ferguson *et al*. 1988; Kaunda 2000). Thirdly, when food availability decreases during winter, black-backed jackal may increase and or extend their activity to search for limited food resources (Oosthuizen *et al*. 1997). Fourthly, individuals that are heavily persecuted may shift their activity to periods when they are less vulnerable to these persecutions (McKenzie 1990; Kaunda 2000).

3.4.2.3 Feeding

Black-backed jackal is generally opportunistic in its diet, with individuals not selecting for any specific prey (Stuart 1976; Loveridge & Macdonald 2003; Kok & Nel 2004; Brassine 2011; Forbes 2011). Consequently, Kok & Nel (2004) concluded that black-backed jackal will consume livestock in addition to other prey items rather than as a substitute for these items. Some contradictions have, however, been noted where black-backed jackal selected for specific natural food items (Hiscocks & Perrin 1987; Nel *et al*. 1997; Kamler *et al*. 2012a). The perception that some black-backed jackal may specialize on livestock has not been substantiated yet.

The varying nature of black-backed jackal diet may be attributed to a number of factors. Nel *et al*. (1997), Kok & Nel (2004), Van der Merwe *et al*. (2009), Klare *et al*. (2010) and Forbes (2011) found that their diet reflected the relative abundance of food items in a specific area, with the most abundant food item also the most abundant in their diet. Temporal differences in prey abundance were also reflected in black-backed jackal diet (McKenzie 1990; Nel *et al*. 1997; Kaunda & Skinner 2003; Loveridge & Macdonald 2003). The relative accessibility and safety of food items also play a role: Hiscocks & Perrin (1987) noted that black-backed jackals consumed only less mobile prey; Rowe-Rowe (1976) and McKenzie (1990) noted that black-backed jackal only consumed the vulnerable individuals of larger prey species (e.g. the young and old); Nel *et al*. (1997) noted that black-backed jackal consumed specific prey items only in areas where they were less vulnerable to human persecution. Lastly, the social and or reproductive status of individuals may influence black-backed jackal diet. Kaunda & Skinner (2003) and Klare *et al*. (2010) noted that some black-backed jackal switched their diet to include more large species during the breeding season; it was not specified whether these were only reproductive individuals, which sexes were involved, and if this behaviour was only associated with the presence of offspring. Kaunda & Skinner (2003) recorded the diets of dispersing black-backed jackal as being the most diverse, which presumably happen because such individuals encounter a larger variety of food items as they pass through a number of different habitats.

Atkinson *et al*. (1998) noted that black-backed jackal move randomly within their entire range in search of food. According to Sacks & Neale (2002) this “time minimizer strategy” is typically used by coyotes when food resources are relatively abundant. When food abundance decrease, coyotes switch to a “time maximizing strategy” and, based on prior knowledge, move directly between core areas where food is most abundant (Sacks & Neale 2002). The latter feeding strategy has not yet been described for black-backed jackal. However, Dreyer & Nel (1990) found that black-backed jackal showed a tendency to utilize only certain areas within their range, although in these instances the areas were selected for their cover.

Black-backed jackals generally forage alone or as mated pairs. Exceptions of pack hunting have, however, been observed in instances where the prey animal was too large to be killed by a single pair (Hiscocks & Perrin 1987; Moehlman 1987; McKenzie 1990). It was also found by McKenzie (1990) that such pack hunting was only temporary and involved individuals from different family groups. McKenzie (1990) further hypothesized that pack hunting to kill larger prey items will, generally, be confined to periods when alternative prey densities are low. A few isolated cases of black-backed jackal being seen to hunt in packs on cattle have been reported by South African farmers (P. de Wet, 2011, Chair: Predation Management Forum of South Africa, *pers. comm.*).

3.4.2.4 Habitat utilization

Black-backed jackals show a preference for specific habitat types. They select habitats with sufficient food resources (Ferguson 1980; Kaunda 2001; Loveridge & Macdonald 2002, 2003) and habitats which provide shelter or cover against natural elements, competitors and human persecution (Ferguson 1980; McKenzie 1990; Kaunda 2001). Dreyer & Nel (1990) further noted that, in their study area where sparse vegetation cover and severe temperature fluctuations was predominant, black-backed jackals moved directly to habitats which provided sufficient cover against such elements.

3.4.2.5 Reproduction

Black-backed jackals in southern Africa generally reproduce from June to September (Hall-Martin & Botha 1980; Stuart 1981; Kaunda 1998; Loveridge & Macdonald 2001; Bingham & Purchase 2002). Exceptions have, however, been found: Rowe-Rowe (1978) and Bernard & Stuart (1992) reported earlier onsets of reproduction, and Ferguson *et al.* (1983) noted that reproduction in their study area occurred outside of the assumed normal reproduction season. Bernard & Stuart (1992) hypothesized that such variations could be attributed to changes in food availability. In the latter study area a higher availability of small mammals was noted in summer and more ungulate carcasses in winter, enabling black-backed jackal to extend their reproduction timing to concur with these food sources.

The average litter size of black-backed jackal (between 3.5 and 5.6: Bothma 1971a; Stuart 1981; Rowe-Rowe 1984; Bingham & Purchase 2002) is spatially similar, with no evidence to suggest temporal differences. South African farmers and specialist predator hunters now, however, increasingly report foetus numbers of between seven and nine (Avenant & Du Plessis 2008), but it is not clear how many pups survive at birth or any specific period thereafter. It has not yet been scientifically investigated whether litter sizes have in fact increased or whether these increases, if true, are restricted to livestock farming areas; nor are the factors known that are driving such disparities.

Black-backed jackal is monoestrus (similarly to coyote: Bekoff & Gese 1977) and breeds only once a year. The females reach maturity at 11 months (Moehlman 1979; Ferguson *et al*. 1983) and hence can start reproduction from the age of *ca.* 1 year. They generally, however, will not breed until their second year (Bingham & Purchase 2003). This is presumably as a result of their territorial behaviour, pair bonding and alloparental behaviour (Ferguson *et al*. 1983). It is, however, now claimed that younger black-backed jackal females (even younger than one year) are increasingly found to also carry foetuses (Avenant & Du Plessis 2008). Again, this remains to be validated and, if true, the drivers need to be determined.

Although it is assumed that only territorial black-backed jackal pairs reproduce, Ferguson *et al*. (1983) reported a territorial male that mated with both the territorial female and one of their daughters (≈ helpers), and attributed it to an overexploitation of the local black-backed jackal population. Canids may have the ability to exhibit compensatory breeding when their populations are under stress or when numbers decrease rapidly (Knowlton 1972; Connolly & Longhurst 1975; Sterling *et al*. 1983; McNay *et al.* 1999; Bingham & Purchase 2002). Knowlton *et al*. (1999) suggested that increased reproduction rates by female coyotes in a persecuted population are likely due to the fact that more food is available for the remaining individuals. A release of social pressure on young females may further result in them being in a better condition for reproduction.

Other mechanisms which could also potentially be employed during compensatory breeding include larger litter sizes (Knowlton 1972), females breeding at a younger age, or increasing their reproductive lifespan (Cypher & Schrivner 1992; Knowlton *et al*. 1999), more females breeding in a specific area (theoretically, during the absence of territorial females), or as assumed previously the fewer remaining individuals being in a better physical condition due to an increased availability of food (Knowlton *et al*. 1999). Although none of these mechanisms have been studied in black-backed jackal, it seems plausible that in areas where black-backed jackal is persecuted extensively, their social and reproductive behaviour could change and compensatory breeding triggered, resulting in rapid population increases (Bingham & Purchase 2002).

3.4.3 Current knowledge of caracal ecology

Some ecological patterns and underlying factors crucial for the development of sustainable livestock farming and wildlife ranching practices, and an HPCM strategy for caracal in different southern African regions and habitats, were identified and are discussed below.

3.4.3.1 Social structure and behaviour

Caracals are solitary individuals that actively defend their territories against other individuals from the same sex (Stuart 1982; Mills *et al*. 1984; Norton & Lawson 1985; Bothma & Le Riche 1994; Melville & Bothma 2006). According to Avenant & Nel (1998), in the West Coast National Park, these territories overlap between 0 and 19% of total territory size between females, while male territories overlap between 81 to 99% of each female territory. Moolman (1986) also calculated the proportion of overlap in female and male territories to be small in the Mountain Zebra National Park (overlap between 2.5% and 3% for female territories; between 2% and 14% in males). Moolman (1986), however, did not indicate to what extent male territories overlapped with female territories. In cases where same sex territories do overlap, overlapping areas are apparently not used simultaneously (Stuart 1982; Avenant & Nel 1998; Marker & Dickman 2005). The reasons for these territorial overlaps, and why it differs from area to area, have not yet been studied.

Only one incidence of extraterritorial movement was recorded for caracal (Melville & Bothma 2006): territorial individuals moved temporarily into adjacent livestock farming areas to feed when natural prey abundance in their own territories decreased. It has, however, not been observed whether these visitors were tolerated by the resident individuals (i.e. territorial breakdown). The latter phenomenon, as described in other solitary territorial felid species, may temporarily occur when there are abundant food resources in the resident territory (Bergerud 1971; Bailey 1974; Knick 1990; Poole 1997).

The home-range size of caracal is flexible and include spatial (≈ between different areas), temporal (≈ over time) and local (≈ within a population) differences. These differences are attributed to differences in food availability and the social status of individuals. Firstly, in natural areas, caracal home-range size is smaller where food availability is higher (Bothma & Le Riche 1994; Avenant & Nel 1998; Van Heezik & Seddon 1998). Secondly, caracal females contract their range temporarily when kittens are present (Stuart 1982; Avenant & Nel 1998). Thirdly, the range size of dispersers increases temporarily until they settle in a smaller, more permanent area (Stuart 1982; Norton & Lawson 1985). Fourthly, Litvaitis *et al*. (1986) argued that in species with a polygamous mating system, such as caracal, territorial males need to include more than one female in their range and hence they will have larger home-ranges.

3.4.3.2 Activity patterns

Only a few studies investigated caracal activity periods, with most of them noting peak activity at night (Grobler 1981; Mills *et al.* 1984; Avenant & Nel 1998). In the West Coast National Park, Avenant & Nel (1998) also noted frequent caracal activity during the day at ambient temperatures below 22°C. Activities are further, seemingly, also influenced by food availability with peak caracal activity coinciding with the peak activity of their most abundant prey (Avenant & Nel 2002). However, it is not known whether caracal can or do alter their activity in response to human activity/persecution.

3.4.3.3 Feeding

According to Kok & Nel (2004) caracal is generally more specialized than the sympatric black-backed jackal in its dietary behaviour. Various studies have found that mammals constitute the main proportion of the diet of caracal (Pringle & Pringle 1979; Grobler 1981; Stuart 1981, 1982; Moolman 1984, 1986; Palmer & Fairall 1988; Stuart & Hickman 1991; Avenant & Nel 1997, 2002; Kok & Nel 2004; Melville 2004; Melville *et al.* 2004; Braczkowski *et al*. 2012), while it has also been noted that they may specialize on specific food resources throughout the year (Pringle & Pringle

1979; Stuart 1982; Moolman 1984). It is, however, not known whether they will specialize on livestock or some introduced wildlife species. Melville *et al*. (2004) speculated that, if caracals consume livestock, they will do this opportunistically rather than select for it. Stuart (1982) and Avenant & Nel (1998, 2002) also noted a temporary level of dietary specialization for some caracal individuals. Despite their general specialized diet a number of studies have noted caracal to utilize some prey taxa opportunistically (Moolman 1984; Palmer & Fairrall 1988; Avenant 1993; Avenant & Nel 1997; Van Heezik & Seddon 1998; Avenant & Nel 2002; Melville *et al.* 2004). Avenant (1993) also found that non-territorial animals took springbok *Antidorcas marsupialis* carcasses opportunistically, but that none of the territorial cats were associated with this carrion.

The varying nature of caracal diet has been attributed to a number of factors. Firstly, the relative abundance of prey items in an area are reflected in caracal diet (Moolman 1984; Avenant & Nel 1997, 2002; Kok & Nel 2004; Melville 2004; Melville *et al*. 2004; Braczkowski *et al*. 2012), while temporal differences in food abundance are also reflected in the diet (Stuart 1982; Palmer & Fairall 1988; Stuart & Hickman 1991; Avenant & Nel 2002). Some evidence, however, suggests that the diet of caracal does not reflect "unnatural" livestock availability (Pringle & Pringle 1979; Stuart 1982; Moolman 1984). Secondly, caracal individuals may also select prey items based on their vulnerability, such as young individuals and older, less mobile individuals (Stuart 1981; Melville *et al*. 2004). Thirdly, the social and reproductive status of individuals is also expected to influence caracal diet. Avenant & Nel (1998, 2002) noted that lactating females selected larger prey species (ungulates, livestock); Stuart (1982) noted that female caracal with kittens was involved in excessive livestock killings; and Avenant & Nel (1997) found that non-territorial individuals utilized carrion. Again, reflecting on the paucity of published information, there is virtually no available evidence for caracal on the dietary behaviour of breeding and non-breeding males, non-breeding females, transients, and juveniles. Information on dietary composition in the presence of livestock or introduced wildlife is also limited.

Caracal may use one of two strategies when searching for their food. They may either move directly between core areas were food is abundant (Stuart 1982;

Avenant & Nel 1998; Melville & Bothma 2006) or they may move randomly throughout their entire range and consume food as it is encountered (Avenant & Nel 1998; Van Heezik & Seddon 1998; Melville & Bothma 2006). The latter conforms to the feeding strategy observed for sympatric black-backed jackals (see **section 3.4.2.3**). In their study area, Melville & Bothma (2006) noted that food abundance determines the forage pattern used by caracal. According to Melville & Bothma (2006), caracal used an "optimal foraging strategy" (≈ "time maximizer strategy"; Sacks & Neale 2002) and moved directly between core areas when prey was abundant; a phenomenon also observed for males in the West Coast National Park (Avenant 1993). But as prey abundance decreased, caracal switched to a "random foraging strategy" (≈ "time minimizer strategy"; Sacks & Neale 2002) and moved randomly throughout the entire range to consume prey as it were encountered by chance (Melville & Bothma 2006).

3.4.3.4 Habitat utilization

A limited number of studies have reported on habitat use by caracal. In general, caracal shows preference for specific habitats in an area (Norton & Lawson 1985; Moolman 1986; Brand 1989; Avenant & Nel 1998; Melville 2004), although there is evidence that some individuals may utilize habitats randomly (Stuart 1981, 1982; Mills *et al*. 1984). Similar to sympatric black-backed jackals (see **section 3.4.2.4**), habitat utilization in caracal are influenced by food availability (Moolman 1986; Avenant & Nel 1998; Van Heezik & Seddon 1998; Melville 2004) and or the degree to which the habitat provide shelter or cover (Norton & Lawson 1985; Moolman 1986; Van Heezik & Seddon 1998; Melville 2004).

3.4.3.5 Reproduction

Pringle & Pringle (1979) noted that reproduction in caracal occur from April (spring) to November (early summer), while Avenant & Nel (1998) observed reproduction timing from December to April (summer). Stuart (1981, 1982) and Bernard & Stuart (1987) noted that reproduction in caracal may occur opportunistically at any time of the year, and speculated that reproduction timing is coupled to high food availability and the nutritional status of females.

A comparison of caracal litter sizes (Pringle & Pringle 1979; Stuart 1981, 1982; Avenant & Nel 1998) indicates spatial similarity (≈ 2 to 3 kittens) with no evidence to suggest temporal differences. However, as in the case of sympatric black-backed jackal, many South African farmers and problem-animal hunters today claim larger foetus litter sizes (Avenant & Du Plessis 2008). It is, however, not certain what is driving these changes, and if it is true, because no information in this regard has yet been published.

There are no detailed studies available on caracal reproduction behaviour such as age of first breeding and breeding duration. All that is known is that they are sexually mature at around 12 months (Stuart 1982; Bernard & Stuart 1987). It is, however, increasingly claimed for caracal, as is the case for sympatric black-backed jackal, that more young individuals (even < 1 year) are now also carrying foetuses (Avenant & Du Plessis 2008).

3.4.4 Identification of information needs

As pointed out in the preceding section, important gaps still exist in the knowledge and understanding of the ecology of black-backed jackal and caracal relating to HPCM; particularly in livestock farming and wildlife ranching areas. By looking at research conducted on other, ecologically similar species, it is possible to identify some of these gaps.

There is still a lack of scientific estimations on black-backed jackal and caracal densities. Although it is claimed that black-backed jackal and caracal densities have increased and that they are now more widespread (Avenant & Du Plessis 2008; De Waal 2009), there is no scientific information to support this. If true, it needs to be determined what is driving these increases and shifts (also see **Chapter 2**), how this correlates with different environmental (e.g. vegetation, topography, farming types, management practices, etc.) and farming conditions (e.g. the numbers, flock size, flock movement and type of livestock), and how this relates to the number and frequency of livestock or wildlife losses. Gathering this information could give a better insight into the effect of HPMC strategies on black-backed jackal and caracal populations in a specific area (Allen *et al*. 2012).

Food availability plays a major role in both black-backed jackal and caracal social structure, behaviour, activity, diet, habitat utilization and reproduction (see **sections 3.4.2 and 3.4.3**). However, the impact of lower natural prey densities together with the increase of potentially clumped food resources (≈ livestock or introduced wildlife flocks/herds) in rangeland areas on the ranging behaviour, densities, territorially and reproduction of these two predators are poorly understood. Multiple studies on different, but ecologically similar, predators (including coyote, wolf *C. lupus*, bobcat *Lynx rufus*, Eurasian lynx *L. lynx* and the Canadian lynx *L. canadensis*) have indicated how a change in food availability influences their dispersal, family structure, and densities (Bekoff & Wells 1983; Gese *et al*. 1996; Knowlton *et al*. 1999; Bianco & Cortes 2007); territorial overlap and breakdown (Bergerud 1971; Bailey 1974; Danner & Smith 1980; Knick & Bailey 1986; Knick 1990; Poole 1994; Shivik *et al*. 1996; Poole 1997; Admasu *et al*. 2004; Bianco & Cortes 2007; Schmidt 2008; Young *et al*. 2008); and ranging behaviour (Danner & Smith 1980; Althoff & Gipson 1981; Young *et al*. 2008). To increase our understanding, it is important to concurrently know what food black-backed jackal and caracal utilize in rangelands, how these resources are distributed throughout their range, and how they fluctuate over seasons (Avenant 1993, Avenant & Nel 1997, 2002). The information gained from such studies may provide insight on whether social interactions and territoriality remains intact under rangeland conditions, thereby offering a better opportunity to predict on the usefulness of different HPCM approaches. For instance, the results may demonstrate whether an ecological HPCM approach which does not remove territorial individuals, because they control conspecifics within their territories (Avenant & Du Plessis 2008), could be viable.

There is also a poor understanding of which proportion of black-backed jackal and caracal may feed on introduced prey in livestock farming or wildlife ranching areas, how much of the diet this constitutes, or how this is spread throughout the year. It is further not known which individuals (e.g. lactating females or territorial males) will be involved in killing of livestock or introduced wildlife (as observed in coyote and Eurasian lynx populations - Windberg *et al*. 1997; Stahl *et al*. 2001a; Odden *et al*. 2002, 2006); if and under which conditions they will switch between natural prey and introduced prey (for example during the breeding season, as observed in coyote populations - Till & Knowlton 1983; Wagner & Conover 1999; Bromley & Gese

2001a; Blejwas *et al*. 2002); whether they will specialize on introduced prey (as observed in wolf, Eurasian lynx and Canadian lynx populations - Bangs & Shivik 2001; Stahl *et al*. 2001a,b; Squires & Ruggiero 2007) and which introduced prey will be targeted (for example young individuals or smaller species, as observed in coyote, wolf, bobcat, Eurasian lynx, jaguar *Panthera onca* and puma *Puma concolor* populations - Litvaitis *et al.* 1986; Windberg *et al*. 1997; Cuicci & Boitani 1998; Bangs & Shivik 2001; Stahl *et al*. 2001a; Blejwas *et al*. 2002; Odden *et al*. 2002; Polisar *et al.* 2003; Bradley & Pletcher 2005; Michalski *et al*. 2006; De Azevedo & Murray 2007). It is also not known whether black-backed jackals will form packs to utilize larger livestock or introduced wildlife species and, if it happens, under what circumstances it occurs (as observed in coyote - Blejwas *et al.* 2002). Such information on black-backed jackal and caracal feeding ecology would enable us to know whether HPCM management should focus on certain periods of the year (e.g. when livestock or wildlife predation increase; natural prey densities decrease) or on the protection of only certain species or individuals, and whether only certain predator individuals should be targeted (e.g. breeding females, territorial males, pups/kittens, sub-adults). The information may also help to inform the development of improved rangeland management practices (e.g. ensure that natural prey densities stay intact, designing grazing plans that rotate or move flocks from high risk areas during specific times of the year, and prevent lambing in camps that have a higher risk of predation).

The impact of food composition changes in rangeland areas are also expected to impact the reproduction of black-backed jackal and caracal. For example, where these carnivores utilize livestock or introduced wildlife, the constant availability of this food source may change the reproduction timing in a similar way as was observed by Bernard & Stuart (1992). It may also contribute to larger litter sizes (as observed in related predator populations - Mech 1977; Parker *et al.* 1983; Todd & Keith 1983; Lindstrom 1989; Knick 1990; Cypher & Schrivner 1992; Poole 1994; Mowat *et al*. 1996) and impact their breeding behaviour, such as age of first breeding (as observed in coyote populations - Todd & Keith 1983; Cypher & Schrivner 1992).

Another factor that may change black-backed jackal and caracal ecology markedly in farming areas is human persecution. Information on how different levels of human persecution influence black-backed jackal and caracal dispersal, and how this impacts their densities, territorial behaviour and activity patterns, is virtually non-existent (see e.g. Bradley & Fagre 1988 and Bunnefeld *et al*. 2006 for examples on ecologically similar species). Although there are some indications that black-backed jackal may apply compensatory breeding under high persecution (see **section 3.4.2.5**), it is important to find evidence on what triggers this behaviour, and at what levels of persecution. It is also not clear what compensatory breeding in these species may entail. It should still be determined whether human persecution may trigger compensatory breeding in caracal (as has been observed in other felid species: see Parker *et al.* 1983; Knick 1990).

Overall, if compensatory breeding do occur in black-backed jackal and caracal populations, it is important to examine the impact that this may have on their densities, distribution and territorial behaviour. It is also important to understand how this may influence their feeding behaviour in rangeland areas. For instance, when black-backed jackal and caracal densities increase, could they be "forced" to predate more on introduced livestock and wildlife when natural prey availability are limited (Avenant & Du Plessis 2008; see **Chapter 2**), and could this ultimately lead to a situation where they "learn" to predate almost exclusively on introduced livestock and wildlife, notwithstanding the presence of high natural prey densities?

3.5 Conclusions

The critical review of the few available publications on black-backed jackal and caracal should not be regarded as criticism of the scientific content. At the time the published results were in line with the objectives of these studies. However, it is obvious that very few if any of the results published were in any substantial way intended to inform the development of HPCM strategies. Furthermore, the harvest of local published information features poorly compared to the wealth of published information on some other damage-causing predators. Therefore, it is proposed that new studies be designed in a more comprehensive way to enhance existing knowledge and contribute to a more meaningful development of HPCM strategies. Here the extensive work conducted on coyote, of which both the ecological and damage-causing aspects are strikingly similar to that of black-backed jackal, can serve as a useful reference.

A prerequisite for sustainable HPCM programs is a sound ecological understanding of the animals that needs to be managed. Without such an understanding it is difficult to predict the contribution of different management interventions to damage alleviation and the effect of these interventions on target animals, their behaviour and ecology (Knowlton *et al.* 1999; Wagner & Conover 1999; Blejwas *et al.* 2002). The paucity of ecological information on damage-causing black-backed jackal and caracal in southern Africa has been clearly demonstrated. Generally there is a lack of information on most ecological aspects, the information is of a fragmented nature, a large proportion of the studies are dated, and only a few are from livestock farming or wildlife ranching areas. In effect, there is very limited ecological information on which to base black-backed jackal and caracal management or whereby innovative livestock farming and wildlife ranching practices in southern Africa can be motivated. For instance, it is not known which individuals predate on livestock or introduced wildlife, and if so, during which periods. Without this information the effectiveness of selective HPCM strategies cannot be predicted. It is also not known if territorial behaviour persists under livestock farming and wildlife ranching conditions. This may limit the successful implementation of HPCM strategies based on the hypothesis that territorial individuals (in caracal) or pairs (in black-backed jackal) will help to control livestock losses by excluding other potential damage-causing individuals or pairs (Avenant *et al*. 2006; Avenant & Du Plessis 2008). Such shortcomings should be addressed as a priority before the development of successful HPCM strategy can be ensured (see **section 3.4.4**). However, despite shortcomings, available information provides valuable insight into black-backed jackal and caracal ecology which can already be applied in HPCM strategies. For instance, it has been demonstrated that both species utilise habitats where prey densities are highest or where they are protected from various elements; it could thus be suggested that small livestock grazing programmes are developed where specific habitats are grazed only when the risk of predation is relatively low, such as during the time of year when natural prey densities are high and or when no young lambs are present.

In conclusion it is evident that, for HPCM strategies to be successful, future ecological studies need to be developed, executed and documented in ways that complement current knowledge on black-backed jackal and caracal ecology. As such it should help if livestock farmers, wildlife ranchers, scientists and wildlife managers work together in a co-ordinated manner to identify priority information gaps and areas.

4. Economics of human-predator conflict and management: black-backed jackal and caracal in rangelands in South Africa

4.1 Introduction

Economic losses ascribed to predation are often used as the motivation to implement HPCM (Connolly 1992; Shwiff 2004). In South Africa, the high level of losses attributed to predation is similarly used to justify widespread predation control, especially where the black-backed jackal *Canis mesomelas* and caracal *Caracal caracal* have been implicated as the major culprits (Stadler 2006; Gouws 2008; Van Niekerk 2010).

Despite their apparent high economic impact not much is known on the actual financial value of black-backed jackal and caracal in South African rangelands. This value can be obtained by determining all potential benefits and costs associated with these two species, and with all management options associated with them (Cooper *et al*. 2002; Shwiff & Sterner 2002; Engeman *et al*. 2003). As such, it is important to include the direct and indirect costs associated with their presence and the benefits derived from having them in the ecosystem. It should also include an estimate of the economic costs and benefits of different HPCM strategies (Connolly 1992; Knowlton *et al*. 1999; Shwiff & Sterner 2002; Bissonette *et al*. 2008). For instance, Bodenchuck *et al*. (2002) estimated that the economic benefits of predation management to protect agricultural resources in the United States of America outweighed the costs by a factor of 12.2:1 when all potential benefits are included; markedly higher than the 6.75:1 when only the direct benefits were taken into account.

Available information was used to assess the benefits and costs associated with black-backed jackal and caracal predation on livestock farms and wildlife ranches in South Africa and the value of HPCM operations directed at black-backed jackal and caracal. This knowledge should contribute to a better understanding of the overall economic value of these two medium-sized carnivores in rangeland ecosystems in South Africa.

4.2 Materials and methods

A literature search (using Academic Search Complete, EBSCOHost, ISI Web of Knowledge, Reference lists) was conducted to retrieve scientific publications and reports on the financial value of predation ascribed to black-backed jackal and caracal in South Africa, and on HPCM operations for these two species (Keywords included in the search: black-backed jackal, *Canis mesomelas*, caracal, *Caracal caracal*, cost, economics, *Felis caracal*; management, predation, South Africa, value).

Each publication was reviewed for information on the:

- cost of black-backed jackal and or caracal predation on livestock and wildlife;
- benefits of black-backed jackal or caracal predation;
- cost of HPCM operations used against black-backed jackal and caracal; and
- benefits of HPCM operations used against black-backed jackal and caracal.

4.3 Results and Discussion

4.3.1 Current information

A small number of scientific publications and reports (n = 11) were retrieved (Table 4.1). Most studies (n = 10) covered the economic cost of black-backed jackal and caracal predation on livestock, while one (1) report is available on wildlife predation or on related HPCM. Overall, the information is relatively dated with *ca.* 45% of the publications reporting on depredation rates prior to 2000. Only two publications (Van Niekerk 2010; Thorn *et al*. 2012) appeared since 2010. In most instances the studies were conducted in isolation (in small areas; over one year). The available information could thus be regarded as useful to describe the impact of predation in a specific area at a specific time, but it may not be very useful to describe the countrywide financial impact of predators, nor their impact in any smaller area over successive years.

Most of the publications analysed depredation rates as reported by producers or government officials involved with predator management (with the information mostly gathered using questionnaires; Table 4.2). Such approaches may limit comparisons

Table 4.1: Reported predation losses in rangelands in South Africa

Study	Locality	Predators responsible for losses[1]	Production animals predated on	Study period	Estimated annual cost of predation (ZAR)
		National			
StatsSA 2005	South Africa (Commercial farmers)	*Not specified*	*Not specified*	March 2001 – February 2002	662 357 000[2]
		Regions			
NWGA 2002	Eastern district (Eastern Transvaal; Eastern Free State; Central Free State)	*Not specified*	Small stock	*Not specified*	17 644 000[3]
	Western district (South-Western Cape; Boland; Karoo)				14 289 600[3]
	Central district (Eastern Cape; Eastern Karoo)				11 989 600[3]
		Provincial			
Janse van Rensburg 1966	Transvaal Province (Gauteng, Mpumalanga, Limpopo)	*Not specified* (BBJ assumed to cause highest predation)	Sheep	1949 – 1954 1959 – 1960	34 170 900[3] min: 22 460 000 max: 32 650 400
Lawson 1989	Kwazulu-Natal	*Not specified* (BBJ, CAR and VD assumed to cause highest predation)	Sheep	July 1986 – June 1987	30 780 000[3]
StatsSA 2005	Western Cape	*Not specified*	*Not specified*	March 2001 – February 2002	64 483 000[2]
	Northern Cape				379 967 000[2]
	Eastern Cape				58 114 000[2]
	Free State				38 622 000[2]
	Mpumalanga				17 184 000[2]
	Limpopo				36 535 000[2]
	North-West				25 417 000[2]
	Gauteng				2 725 000[2]
	Kwazulu-Natal				39 310 000[2]
Van Niekerk 2010	Western Cape;	BBJ; CAR; VD	Sheep; Goats	2006/7	138 485 600[3]
	Northern Cape				717 450 400[3]
	Eastern Cape				535 292 000[3]
	Free State				323 840 000[3]
	Mpumalanga				112 897 600[3]
Thorn *et al*. 2012	North-West	*Not specified*	Sheep; Goats; Cattle; Poultry; Game	2005	4 334 454[2]
		District			
Rowe-Rowe 1975	Kamberg district, Kwazulu-Natal	BBJ	Sheep	*Not specified*	172 800[3]
Vorster 1987	Sutherland and Fraserburg districts, Northern Cape	*Not specified* (BBJ rated as the major predator)	Small stock	July 1984 – June 1985	1 364 800[3]
Gunter 2008	Mossel Bay district, Western Cape	*Not specified*	Sheep; Goats	1976 – 1992	101 600[3] min: 2 400; max: 276 000

[1]BBJ = Black-backed jackal *Canis mesomelas*; CAR = Caracal *Caracal caracal*; VD = Vagrant dog *Canis familiaris*;
[2]Actual costs reported by respondents/studies;
[3]Cost estimated from reported numbers of livestock killed (average unit cost per livestock head taken as ZAR800; adapted from Van Niekerk 2010);
[4]Assuming constant monthly depredation losses

Table 4.1 (cont.): Reported predation losses in rangelands in South Africa

Study	Locality	Predators responsible for losses[1]	Production animals predated on	Study period	Estimated annual cost of predation (ZAR)
		Farms			
Strauss 2009	Glen Agricultural Institute, Bloemfontein, Free State	BBJ; CAR; VD	Sheep	2003 – 2007	114 352[3] min: 84 288; max: 152 129
Avenant *et al*. 2009	Doornboomsfontein and Gansfontein, Beaufort-West, Western Cape	CAR	Sheep	January 1993 – December 1995	118 400[3;4] min: 63 200; max: 201 600
				January 1996 – April 1996	580 000[3;4]
				May 1996 – December 2009	4 886[3;4] min: 0; max: 14 400

[1]BBJ = Black-backed jackal *Canis mesomelas*; CAR = Caracal *Caracal caracal*; VD = Vagrant dog *Canis familiaris*;
[2]Actual costs reported by respondents;
[3]Cost estimated from reported numbers of livestock killed (average unit cost per livestock head taken as ZAR800; adapted from Van Niekerk 2010);
[4]Assuming constant monthly depredation losses

between different sources due to a variety of reasons (Knowlton *et al*. 1999; see paragraph below). Additionally, 1) it is possible that reported depredation rates in the same area may differ when different stakeholders report on these (Brand 1989); 2) questionnaires are often an indication of perceptions and could thus reflect higher than actual losses (Graham *et al*. 2005; Baker *et al.* 2008); and 3) the monetary value of reported losses may vary among different respondents because of *inter alia* fluctuating or unrealistic market values assigned to lost stock (Connolly 1992; Bodenchuck *et al*. 2002; Shwiff & Merrell 2004) or different average values allocated to different livestock classes such as breeding livestock vs. non-breeding livestock vs. lambs (Shwiff *et al*. 2006).

Reflecting on coyote predation on sheep in the USA, Knowlton *et al*. (1999) discussed the advantages and biases which could be associated with three major types of studies that are generally used to asses the extent of predation. The types of studies include: 1) studies where research personnel monitored flocks to account for missing sheep and lambs; 2) producer interviews; and 3) questionnaires mailed to producers or telephone surveys soliciting responses. According to Knowlton *et al*. (1999), 1) field studies provide the best estimates of losses, but they are costly in terms of time and resources and thus have only been used in the context of a few research studies; 2) interviews with producers are also labour intensive, but larger samples can be accrued; and 3) mailed questionnaires or telephone interviews provide the largest amount of information for the time and effort expended, but are subject to the same biases as interview response, with additional biases with non-responders. As a result, predation loss estimates vary considerably, as does the degree to which the results can be generalised among different sheep areas (Knowlton *et al*. 1999).

Table 4.2: Information on how data were gathered for scientific studies on livestock and wildlife predations in South Africa

Study	How data was obtained
Janse van Rensburg 1966	Government records
Rowe-Rowe 1975	Investigator / research records
Vorster 1987	Mailed questionnaires
Lawson 1989	Personal and telephonic interviews
NWGA 2002	Farmer's records
StatsSA 2005	Telephonic and personal interviews; mailed questionnaires
Gunter 2008	Hunting records from government subsidised hunting clubs
Avenant *et al*. 2009	Farmer's records
Strauss 2009	Investigator / research records
Van Niekerk 2010	Telephonic interviews
Thorn *et al*. 2012	Personal interviews

4.3.2 Economic value of black-backed jackal and caracal predation

It is widely considered that black-backed jackal and caracal predation on livestock farms and wildlife ranches are causing major economic losses in South Africa (Lawson 1989; Strauss 2009; Norval 2010; Van Niekerk 2010). Such estimations, however, could be conservative or an overestimation if it does not include any indirect costs (Knowlton *et al*. 1999). Further, these estimates rarely include any of the potential benefits when black-backed jackal and caracal predate on their natural prey in agricultural dominated landscapes, namely when predators control competing herbivore or potential damage-causing species (Berger 2006; Letnic *et al*. 2012). The potential benefits and costs associated with black-backed jackal and caracal predation in rangeland areas of South Africa are summarised in Table 4.3.

Table 4.3: Summary of potential costs and benefits associated with black-backed jackal and caracal predation in rangeland in South Africa (see text for detailed explanations)

Black-backed jackal and or caracal predation	
Costs	Benefits
Predation on livestock or wildlife	
Direct:	
1) Losses to predation	
Indirect:	
1) Increased costs of predator control	
2) Increased costs of livestock and wildlife protection	
3) Increased costs of replacement stock	
4) Labour costs	
5) Production costs	
6) Higher product prices (supply/demand)	
7) Loss of jobs	
8) Increased taxes	
Predation on natural prey	
Direct:	*Direct:*
1) Hyperpredation causing biodiversity loss; impact on ecosystem functioning	1) Biodiversity protection and impact on ecosystem functioning
Indirect:	*Indirect and intangible:*
1) Impact on agriculturally important habitats and species	1) Preservation of agriculturally important habitats and species
2) Recreational costs (wildlife viewing, etc.)	2) Recreational benefits (wildlife viewing, etc.)
3) Cultural costs	3) Cultural benefits
4) Increased taxes	

4.3.2.1 Direct costs

The direct costs of predation are generally related to the actual number of production animals killed by predators (Scrivner & Conner 1984). In South Africa, estimations of direct predation costs are relatively rare (see Table 4.1) but indications are that it may impact severely on livestock enterprises in some areas (Strauss 2009; Van Niekerk 2010). A national survey conducted during 2001/2002 estimated the cost of all predation in the commercial farming sector at ZAR662 357 000; *ca.* 3% of the gross farming income derived from animals during that period (StatsSA 2005). Regionally, depredations in the wool sector alone have been valued to cost between ZAR11 989 000 and ZAR17 644 000 during 2005 (NWGA 2002); *ca.* 2% of the current value of annual wool export from South Africa (J. Klopper, 2011, Chair: Predation Management Forum of South Africa, *pers. comm.*). Provincially, it was estimated that predation cost between ZAR2 725 000 in Gauteng and ZAR379 967 000 in the Northern Cape during 2001/2002; *ca.* 0.2% and 28% respectively of the gross farming income derived from animals during that period in these respective provinces (StatsSA 2005). Van Niekerk (2010) estimated direct losses due to predation on small livestock ranging from ZAR112 897 600 in Mpumalanga to ZAR717 450 400 in the Northern Cape; *ca.* 0.2% and 1% respectively of the national gross farming income derived from animals (DAFF 2011). On a district level annual predation costs on small livestock of ZAR1 364 800 have been recorded (Vorster 1987), while amounts in excess of ZAR100 000 have been recorded on individual farms (Avenant *et al*. 2009; Strauss 2009). There are also indications that livestock predation costs may vary among areas (StatsSA 2005; Van Niekerk 2010) and among years (Janse van Rensburg 1966; Avenant *et al*. 2009; Strauss 2009), and that it may have increased in recent years (Janse van Rensburg 1966; Lawson 1989 vs. StatsSA 2005; Van Niekerk 2010); although the latter trend could also be attributed to the manner in which the different depredation data were collected.

Although there is only limited information on the cost of predation in the wildlife ranching industry (Table 4.1), it is possible that this amount could also be large. In the North-West Province for example, Thorn *et al*. (2012) found that one wildlife rancher indicated losses of ZAR1 393 650 during 2005 which could be accounted for by the loss of only 10 high-value game individuals.

It is important to also assess the potential costs derived when predators consume natural prey in agricultural areas. In the absence of larger predators, black-backed jackal or caracal numbers could increase rapidly, resulting in overexploitation of natural prey species (hyperpredation) and altering of biodiversity and ecosystem functioning (see **Chapter 2**) with significant economical ramifications (Shwiff & Bodenchuck 2004; O'Farrell *et al*. 2008).

4.3.2.2 Indirect costs

Various indirect costs can also increase predation losses. Strauss (2009) calculated that the indirect costs of predation on sheep at the Glen Agricultural Institute, Bloemfontein contributed *ca.* 10.5% or ZAR67 764 to the overall economic costs of predation over a five year period. These expenditures included associated production costs of the lost sheep. Some other indirect costs which have not yet been quantified, include 1) additional costs to tend to injured livestock as a result of predator attacks; 2) the loss of potential earnings from offspring, wool and by-products which predated sheep could have produced within its normal lifespan (opportunity costs); and 3) the cost of livestock protection already spent on lost livestock or wildlife and that will be spent to intensify protection (Lawson 1989; Van Niekerk 2010). Other expected indirect costs, which have already been quantified for predators elsewhere, include 4) the cost of predation control – already expended on lost livestock or wildlife and which will be expended to intensify control (Connolly 1992; Jones 2004); 5) increased costs of replacement animals (Knowlton *et al*. 1999); 6) labour costs to intensify predation control (Scrivner & Connor 1984; Jones 2004; Shwiff *et al*. 2006); and 7) costs to rear orphaned offspring after predation (Knowlton *et al*. 1999). The impact of predation may also ripple through to other sectors, adding further to the cost of predation. These include 8) higher product prices brought about by decreased supply (Knowlton *et al*. 1999); 9) a potential loss of business and employment in urban areas where the economies are often dependant on agricultural activities (Asheim & Mysterud 2004; Jones 2004; Shwiff & Bodenchuck 2004; Thornton & Quinn 2009); and 10) an increase in taxes to aid in predation management (Knowlton *et al*. 1999).

When increased predation on natural prey (hyperpredation) lead to an alteration in biodiversity composition and ecosystem functioning (see **Chapter 2**), further indirect costs may also be added. These include 1) a loss of agriculturally important habitats and species resulting in additional expenses to substitute or restore, for instance palatable species were lost and supplemental feeding needs to be implemented

(Folke *et al*. 1993, Henke & Bryant 1999); 2) a loss of species or habitats of recreational value with implications for sectors with a financial interest, such as wildlife enterprises (Hay & McConnell 1979; Benson 1991; Freese & Trauger 2000: Duffield *et al*. 2006); 3) a loss of species or habitats of cultural value (McNeely 1988; Bodenchuck *et al*. 2002); and 4) people could be forced to pay for predator control or biodiversity restoration through the implementation of levies or taxes (Connolly 1992; Bodenchuck *et al*. 2002).

4.3.2.3 Direct, indirect and intangible benefits

The benefits of black-backed jackal or caracal predation could be related to the impact they may have on natural prey. In contrast to their potential negative impact on biodiversity and ecosystems (see **section 4.3.2.1**), these predators may instead play an important preservation role as a top-predator that control competitors and prey species (see **Chapter 2**). Indirect benefits may then result, such as 1) the preservation of agricultural important habitats (Folke *et al*. 1993; Henke & Bryant 1999; Berger 2006); 2) increased benefits for people who receive financial gains from the recreational use of biodiversity or habitats (Hay & McConnell 1979; Freese & Trauger 2000); and 3) increased benefits for people with a cultural value for biodiversity or habitats (McNeely 1988).

4.3.3 Economic value of human-predator conflict management against black-backed jackal and caracal

Various HPCM methods are currently used to manage black-backed jackal and caracal predation in South Africa (De Wet 2006; Avenant & Du Plessis 2008; Smuts 2008; Snow 2008; see **Chapter 5**). Despite the wide use, however, not much information is available on their economic viability (benefits vs. costs). It is important to gather such information for a better assessment of the current economic value of black-backed jackal and caracal predation on livestock and wildlife in South Africa. The potential benefits and costs associated with HPCM for black-backed jackal and caracal predation in rangeland areas of South Africa are listed in Table 4.4.

Table 4.4: Summary of potential costs and benefits associated with human-predator conflict management aimed at black-backed jackal and caracal in South Africa (see text for detailed explanations)

Human-wildlife conflict management for black-backed jackal and caracal	
Costs	Benefits
Direct: 1) Cost of control (manufacturing and installation costs; labour costs, maintenance costs, etc.) 2) Cost of protection (manufacturing and installation costs; labour costs; maintenance costs, etc.) 3) Biodiversity losses and impact on ecosystem functioning	*Direct:* 1) Number of livestock and wildlife saved 2) Income derived from control 3) Recreational benefits (income from hunting) 4) Biodiversity protection and impact on ecosystem functioning
Indirect: 1) Loss of agricultural important habitats and species 2) Cultural costs 3) Recreational costs (wildlife viewing, etc.) 4) Escalated stock losses and intensified management effort	*Indirect and intangible:* 1) Saving of production costs 2) Jobs saved/created 3) Disease control 4) Recreational benefits (wildlife viewing, etc.)

4.3.3.1 Direct costs

The economic costs of predation management are mainly linked to the expenses associated with different HPCM methods (Shwiff & Bodenchuck 2004). No estimate is available on the costs of the total or individual activities of applying HPCM methods in South Africa. As part of reference point, the total annual cost of HPCM activities in the USA is estimated to be more than US$20 million (Bodenchuck *et al*. 2002). However, it is assumed that presently the actual cost of HPCM may be relatively much more in South Africa due to various reasons. The South African farmers and wildlife ranchers are solely responsible for predation management on their properties and often use private problem-animal hunters (hunters generally charge between ZAR600 and ZAR800 per predator killed, plus travel expenses; H.O. de Waal, 2012, University of the Free State, *pers. comm.*). It could be assumed that private hunters will cost more than government employed/subsidized hunters because the former have to include profit margins while the latter do not depend on it. Also, South African farmers and wildlife ranchers additionally have to implement their own control and protection measures which further escalate costs. For example, a single farmer in the Aberdeen district, Eastern Cape Province reported expenses in excess of ZAR500 000 on livestock protection measures over three years. For some days during the same period he additionally rented a helicopter at a tariff of ZAR3 000 per hour to hunt damage-causing animals, and acquired relatively expensive alpacas *Vicugna pacos* to guard his livestock (Botha 2008). Other operational costs which may further increase the cost of control under local conditions include costs to acquire, manufacture and maintain control or protection equipment (McKenzie 1989); labour costs to monitor such equipment (Heard & Stephenson 1987); and costs to acquire and maintain guarding animals (Marker *et al*. 2005a).

Certain HPCM strategies may attempt to eliminate or exclude black-backed jackal or caracal from farms. The absence of these predators may cause a rapid increase in competitor numbers with negative impacts on prey numbers and associated ecosystems, additionally adding economic costs (see **Chapter 2** and **section 4.3.2.3**).

4.3.3.2 Indirect costs

Apart from the direct costs associated with predation management some indirect costs may also accrue when certain strategies are applied. Such costs could occur where black-backed jackal and or caracal are excluded from rangeland, resulting in lower-predator release or hyperpredation and an associated loss of agricultural, recreational or cultural important species (see **Chapter 3** and **section 4.3.2.2**). Alternatively, some HPCM methods may cause increased black-backed jackal or caracal numbers (e.g. unselective shooting may cause compensatory breeding and higher predator densities; see **Chapter 3**). Resultantly, escalated stock losses and intensified management efforts may follow.

4.3.3.3 Direct, indirect and intangible benefits

The most apparent economic benefit of HPCM is where the number of stock losses decreases due to the implementation of such operations (Bodenchuck *et al*. 2002; Shwiff & Bodenchuck 2004). This value can be determined when comparing the number of livestock or wildlife losses before and after the implementation of such programs (Bodenchuck *et al*. 2002; Shwiff *et al*. 2006). There are currently, however, very few such calculations in South Africa. Avenant *et al*. (2009) reported an average decrease in annual sheep losses due to predation by caracal on a farm in the Beaufort-West district, Western Cape: from *ca.* 150 individuals lost annually, to less than 10 individuals after the implementation of an improved predation management plan. Assuming an average value of sheep at ZAR800 (adapted from Van Niekerk 2010) it means that predation management in this instance has contributed a direct annual economic benefit of ZAR115 200 on that farm (excluding the increases in management costs).

In addition to the abovementioned benefits of HPCM methods, there are also other potential benefits. This include 1) income derived from the hunting of problem-animals (Lindsey *et al*. 2006; Stein *et al*. 2010); 2) savings associated with additional production costs of replacement stock (Strauss 2009); 3) jobs and income saved or created because of the decreased economic impact of predation, both on farms and interrelated rural areas (Shwiff & Bodenchuck 2004; Thornton & Quinn 2009); 4) benefits accrued from the preservation of agricultural, recreational or cultural important species (Shwiff & Bodenchuck 2004), and 5) the economic benefits derived from predator management to control wildlife diseases (Finley 1998, Meltzer & Rupprecht 1998).

4.4 Conclusions

The overall lack of scientific estimations on the economics of black-backed jackal and caracal predation, and associated HPCM operations, in South Africa has been highlighted. There are only some isolated pieces of evidence which suggest that the current costs associated with predation by these two species to the livestock industry are high and may have increased recently, while a first study to determine the impact of predation on the wildlife industry has only been initiated recently (H.O. de Waal, 2012, University of the Free State, *pers. comm.*). Currently, there is thus limited information to confirm or refute the claims of high levels of losses by producers. Comprehensive economic estimations on predation rates should thus provide a good baseline whereby HPCM programs can be allowed or disproved within different areas. Additionally, from a management perspective a proper evaluation of the value of predation should also be useful to examine the relative economic impact of black-backed jackal and caracal predation at various levels (e.g. impact on individual farmers, the wider economy and the rural economy).

This chapter also emphasized a variety of additional benefits and costs associated with these two damage-causing species. These may contribute significantly to the value of black-backed jackal and caracal in rangelands and provide further justification to initiate and fund relevant management plans. For instance, detailed economic calculations may identify that there is a high cost where black-backed jackal and caracal are not present in rangeland ecosystems (≈ potential costs accrued due to mesopredator release, hyperpredation and overconsumption of plant species by high-density prey populations), thereby prompting the development of HPCM plans which do not try to remove or exclude them from rangelands completely. The potential benefits or costs of different HPCM methods were also highlighted. Apart form contributing to the overall economic value of black-backed jackal or caracal this information will also provide valuable input to demonstrate the short and long-term costs and benefits of the different methods to different sectors of society.

Based on results from the current study, it is evident that well planned economic evaluations still needs to be conducted to determine the real economic value, including the various direct and indirect losses and benefits, of black-backed jackal and caracal in South Africa. Shwiff & Sterner (2002) provides a useful framework for conducting a benefit-cost analysis (BCA) of wildlife-damage, while Taylor *et al*. (2009) provides a further summary of BCA and other economic models which could potentially be used. The information from such analysis is vital to improve the understanding of the sustainability of different HPCM strategies.

An important consideration when gathering economic information is to evaluate its significance for different levels and sections of society; it is important to understand the real meaning of calculated monetary values to specific stakeholders or individuals (Bodenchuck *et al*. 2002; Rashford *et al*. 2008). For example, when livestock or wildlife losses are estimated on a national or regional level the impact might not seem that high. However, these losses might only be confined to a few farms or ranches, therefore the losses are much more important to the affected enterprises (Burger *et al*. 1999; Jones 2004). Furthermore, when the economic losses associated with predation on farms or ranches are viewed in isolation it might not seem that high. However, often predation is not the only losses incurred by farmers and ranchers, making the economic impact of predation less affordable (Mitchell *et al*. 2004; Berger 2006). Scale of enterprise is also important: a loss of 20 sheep might be affordable for a farmer with a flock of 1000 sheep, but the same loss will be difficult to bear for small scale or communal farmers who depend on much smaller flocks of livestock. Also, in some areas ranchers may, due to environmental constraints, not have alternative options than keeping livestock or certain wildlife species and thus will be more vulnerable to predation than ranchers whom may have the ability to switch to alternative farming enterprises (Asheim & Mysterud 2004).

5. The management of black-backed jackal and caracal in South Africa: a review of methods

5.1 Introduction

Black-backed jackal *Canis mesomelas* and caracal *Caracal caracal* have been implicated as the major contributors to livestock and wildlife losses in South Africa (see **Chapters 4** and **6**). To curb these losses a variety of control methods have been implemented (De Wet 2006; Avenant & Du Plessis 2008; Smuts 2008; Snow 2008).

Historically, predator control efforts in South Africa have mostly focussed on ways to remove the problem species in a specific area (De Wet 2006). Methods applied included the use of hunting dogs, poison, traps, shooting, denning, the implementation of bounty systems, and the formation of problem-animal hunting clubs. In addition, jackal-proof fences were erected in an attempt to exclude predators from livestock areas (Beinart 1998; Stadler 2006). Currently many South African farmers are trying to lower caracal and black-backed jackal numbers by shooting them on sight. However, evidence suggests that not all predators are problem-animals (Linnell *et al*. 1999) and that territorial individuals may act as a catalyst to exclude problem individuals (Avenant 1993; Avenant & Du Plessis 2008). Public pressure against the use of some predator control methods has also increased (Feldman 2008; Landmark Foundation 2008; Animal Rights Africa 2010; Natrass & Conradie 2013), while new insight has been gained into the environmental impact of certain control methods (Bulte & Rondeau 2005). As a result the emphasis of more and more predator control efforts in South Africa, similar to that in other parts of the world (Mason 2001; Shivik 2004; see **Chapter 1**), has shifted away from attempts to eradicate problem species to non-lethal methods and ways where only problem individuals are managed (De Wet 2006). As a result other methods are now also implemented, including non-lethal and preventative methods such as guarding animals, deterrents, electric fences and selective control methods such as livestock protection collars (LPC).

Much research has been conducted on damage-causing predator control in various countries (Fall 1990; Knowlton *et al*. 1999; Smith *et al*. 2000a,b; Mason 2001;

Gilsdorf *et al*. 2002; Gese 2003; Shivik *et al*. 2003; Mitchell *et al*. 2004; Shivik 2004; Sillero-Zubiri & Switzer 2004). Similar research, however, has not been carried out in South Africa (De Wet 2006). Fall (1990) highlighted the importance of local research on damage-causing predator management to improve our understanding on the biological basis of different management methods and to test their effectiveness under local conditions. It also provides an important basis for constant refinement of HPCM methodology and application, and gives insight into the usefulness of management methods under specific conditions and for local predator species. Such research also provides valuable information on the potential environmental impacts of these methods, and ultimately their social acceptability.

Available information (scientific and popular) on different HPCM methods for black-backed jackal and caracal in South Africa was collated to assess the availability of information on black-backed jackal and caracal management, assess the effectiveness of the different management methods, and identify information needs.

5.2 Materials and methods

A literature search (using Academic Search Complete, EBSCOHost, ISI Web of Knowledge, Reference lists) was conducted for scientific information on the management of damage-causing predators worldwide, and literature with specific reference to this topic in South Africa was identified (Keywords included in the search: black-backed jackal, *Canis mesomelas*, caracal, *Caracal caracal*, control methods, depredation management, *Felis* caraca*l*, predators). To supplement the latter, popular South African agricultural magazines (such as Landbouweekblad, Farmer's Weekly, SA Studbreeder, Farming SA) were also consulted to gather additional information on predator management in South Africa; only popular information appearing from 2000 to 2012 was included.

For each South African source it was noted whether the management option discussed referred specifically to the management of black-backed jackal, caracal, or any other predator species. Thereafter, the information gathered from South Africa and other countries were used to compile a list of potential methods which can be used for the management of black-backed jackal and or caracal in South Africa. The methods were grouped according to lethality. The frequency that each method has been cited in South African literature was noted to form a perception on the awareness for the different methods in South Africa.

The information was reviewed to develop an understanding on what is known about the application of different methods to specifically manage damage-causing black-backed jackal and caracal in South Africa, and to identify information that is still required.

5.3 Results and Discussion

5.3.1 Information on the management of black-backed jackal and caracal

A relatively large number of sources were obtained which discuss the management of damage-causing predators in South Africa (n = 83 sources; Fig. 5.1). Most of these articles appeared in popular literature (n = 60); this number has increased relatively fast in latter years with *ca.* 40% of the total number appearing in 2011 and 2012. Only 18 scientific publications were available, an indication that current knowledge on damage-causing predator management might be a reflection of personal experiences without the necessary scientific scrutiny.

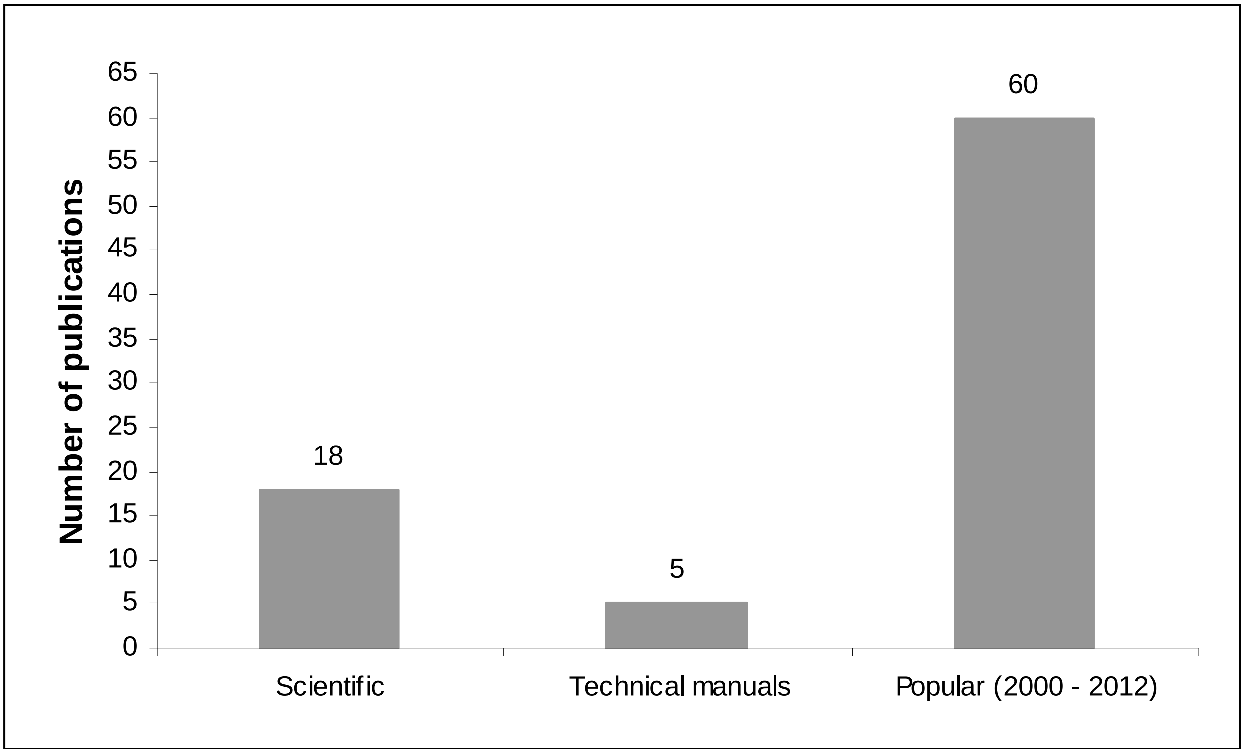


Fig. 5.1: Number of publications pertaining to the management of damage-causing predators in South Africa.

Most South African literature did not refer to the management of specific predator species (n = 45) while only 30 and 18 sources, respectively, referred specifically to the management of black-backed jackal or caracal (Fig. 5.2). It is expected that different management methods varies in efficacy against different predator species (Gilsdorf *et al*. 2002; Sillero-Zubiri & Switzer 2004). The same may apply for black-backed jackal and caracal and it is, therefore, important to conduct more research on the management methods aimed specifically at these damage-causing species.

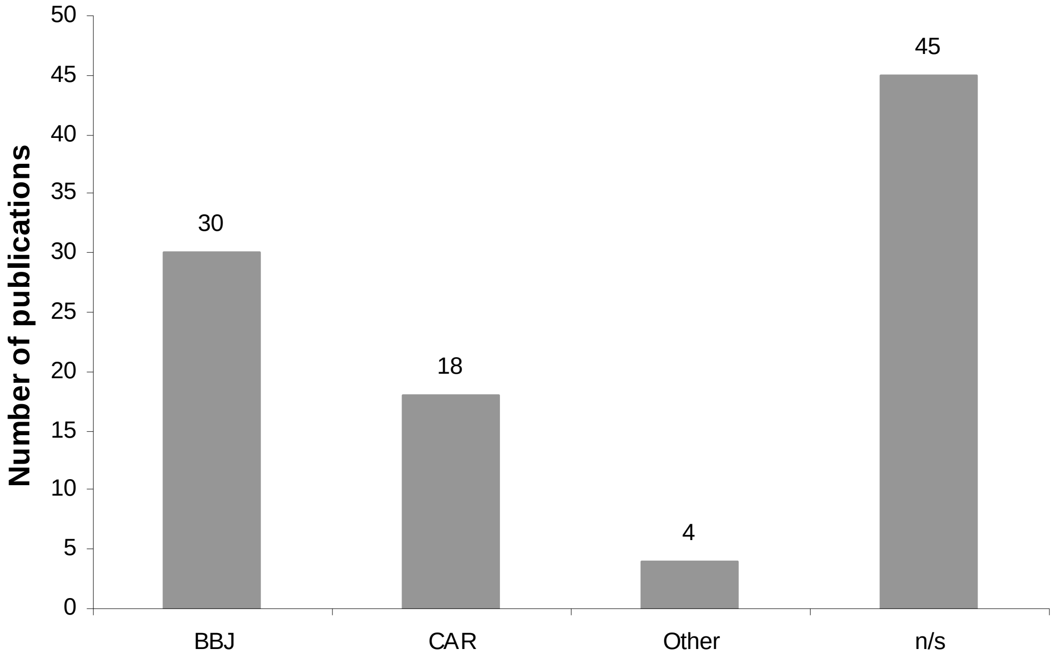


Fig. 5.2: Number of publications (scientific; technical manuals; popular from 2000 to 2012) pertaining to the management of specific damage-causing predators in South Africa. BBJ = black-backed jackal (*Canis mesomelas*); CAR = caracal (*Caracal caracal*); Other = other predators; n/s = predator not specified.

5.3.2 Potential management options for black-backed jackal and caracal

Several methods were identified which can potentially be used for the management of black-backed jackal and caracal (Table 5.1). The majority of these methods (*ca.* 76% of the 33 listed) are non-lethal. However, it is important to keep in mind that the lethality of some of these methods may vary under different conditions. For example, livestock guarding dogs are generally considered a non-lethal method although it is possible that they may kill intruding predators under certain conditions (Gese 2003).

Table 5.1: An alphabetical list of internationally used methods that may assist in the management of damage-causing black-backed jackal and caracal in South Africa

Method	Lethality [1]		Articles in South African literature [2]	
	Lethal	Non-lethal	Scientific	Popular
Cellular technology (collars)		x		5
Compensation		x		
Contraception or sterilization		x		1
Denning	x			3
Fencing:				
Electric		x	1	13
Predator proof		x	1	12
Flerds (multispecies grazing)		x		3
Guarding animals:				
Alpacas		x		4
Donkeys		x		6
Llamas		x		1
Guarding dogs		x	4	12
Herdsman		x		3
Hunting dogs	x			9
Insurance		x		1
Kraaling		x		5
Livestock breed selection		x		2
Poisons:				
Baiting	x			8
Collars	x			8
Coyote getters	x		1	10
Protection collars		x		6
Regulation of livestock breeding season		x		4
Repellents/Aversions:				
Lights		x		6
Noises		x		9
Smells/Chemicals		x		7
Conditioned Taste Aversion (CTA)		x		1
Electronic training collars		x		
Sanitation		x		
Selective pasturing		x		3
Shooting	x			15
Supplemental feeding		x		
Translocation		x		
Traps:				
Cage		x	1	10
Foothold/gin traps	x		2	11
Snares	x			

[1] Conditions under which the control method are applied may influence its lethality;
[2] Frequency of citing in South African literature pertaining to the management of damage-causing predators

Snares may lead to the death of the captured animal, but some adjustments may make it a non-lethal alternative (Frey *et al*. 2007). Additionally, many current lethal methods are considered target specific. It is, however, important to distinguish between species specificity and individual specificity (Windberg & Knowlton 1990; Connor *et al*. 1998; Avenant & Du Plessis 2008). For instance calling, which is used in conjunction with shooting, may attract the target species but not necessarily the problem-causing individuals. More research, under different conditions, is therefore needed to confirm the level of lethality and target-specificity of different predation management methods.

Most of the identified methods have already been cited in the South African literature (Table 5.1), an indication of a general awareness of most of these methods. However, only some of the methods [fencing (electric and predator-proof), guarding dogs, coyote getters, shooting, cage traps and foothold traps] were cited on a regular basis (in more than 10 publications), possibly indicating that these are the most preferred or used methods in South Africa. Van Niekerk (2010) found that small stock farmers in South Africa also preferred most of these methods for combating predation. Other methods were cited in only a few South African publications [contraception or sterilization; conditioned taste aversion (CTA); denning; flerds; alternative guarding animals (alpacas *Vicugna pacos*, llamas *Lama glama*); herdsman; insurance; livestock breed selection; regulation of livestock breeding season; selective pasturing], possibly indicating that these methods are not commonly preferred or used. Some other methods were not cited at all (e.g. compensation, snaring, supplemental feeding; translocation), again a possible indication that these methods are not commonly preferred or used in South Africa. Only *ca.* 25% of the methods were mentioned in the South African scientific literature, suggesting that there are no or little empirical data available on the successes and or environmental impact for the majority of the methods.

A large proportion of the South African literature cited non-lethal methods (Fig. 5.3), possibly an indication of a local rise in consideration and or awareness for these alternatives. Van Niekerk (2010), in a questionnaire study to investigate the impact of predators on South African small stock farmers, found that a majority of respondents now prefer to employ non-lethal predation control methods. These preferences could be ascribed to amongst other the growing rejection by South Africans for certain HPCM methods (Landmark Foundation 2008; Animal Rights Africa 2010) and a growing realization of the positive ecological value of predators in farming ecosystems (Avenant & Du Plessis 2008).

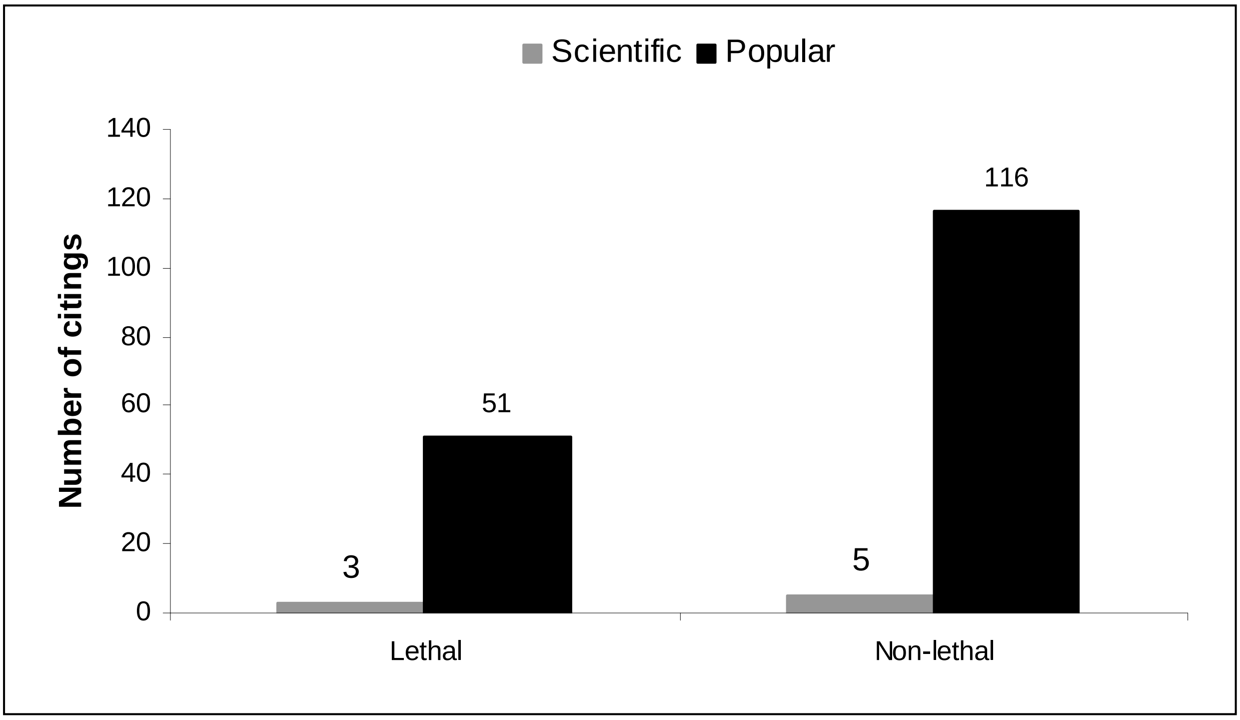


Fig. 5.3: Number of citings in available South African literature on methods to manage damage-causing predators based on lethality.

5.3.3 A review of available information on methods to manage black-backed jackal and caracal

The review of published information on various HPCM methods has identified what is known regarding the effectiveness of these methods to decrease livestock or wildlife predations, their cost-effectiveness, and environmental impacts associated with them. These aspects are discussed below.

5.3.3.1 Lethal methods

Shooting: This method is one of the most frequently cited predation control methods in the South African literature (Table 5.1), and today also a preferred method used by many farmers and damage-causing predator hunters throughout the country (Van Niekerk 2010; H. Grobbelaar, 2012, Chair: Tafelkop Hunting Club, Bethulie, *pers. comm.*; L. Goosen, 2012, Department of Economic Development, Tourism and Environmental Affairs, Free State, *pers. comm.*). Despite its reported attractiveness, there are no scientific studies available on its effectiveness to specifically reduce the impact of predation by black-backed jackal and caracal.

Shooting is mostly applied in two ways. It is used to reduce population numbers (Mason 2001), generally most effective when used just prior to the livestock breeding season (Mitchell *et al.* 2004; Deacon 2010). This approach is species-selective because only individuals from the target species are shot; however, it does not always remove the problem individual (Gese 2003). The method has been proven effective to control coyote *C. latrans* and lynx *Lynx lynx* predation on sheep when applied at the right time (Wagner & Conover 1999; Herfindal *et al*. 2005; Connor *et al*. 2008). These successes were attributed to the fact that some of the individuals responsible for livestock killings might have been removed. Knowlton *et al*. (1985) and Wagner & Conover (1999), however, noted that predator densities are generally not permanently affected by population reductions as dispersers move into the vacated areas. Windberg & Knowlton (1990) and Baker & Harris (2006) also noted a capture bias towards young individuals during population reductions, presumably because the older individuals were habituated. Furthermore, apart from the potential to reduce immediate livestock predation, Wagner & Conover (1999) also noted that aerial hunting (≈ shooting from fixed-wing aircraft) of coyotes may decrease the effort for predation management during the following summer. As a result the financial benefits of this method outweighed the cost by 2.1:1. However, they (Wagner & Conover 1999) cautioned that the costs and benefits may vary depending on several factors, including the type of aircraft used, experience of the pilot and aerial hunter, size of the area hunted, topography, density of foliage, and weather conditions.

It remains to be tested how different shooting-related population reduction strategies influence black-backed jackal and caracal populations in the short and longer term under different South African conditions, and its impact when applied at different times of the year. It also needs to be tested how effective these methods are in reducing predation on livestock or wildlife. It is further important to determine the costs and benefits of different methods of shooting under local conditions, namely aerial hunting, fixed point shooting and continuous culling to reduce predator populations. Most importantly, the environmental impacts of these population reduction methods need to be tested, both in the short- and long-term, under different South African conditions.

Apart from population reduction, shooting is also used in combination with calling. When applied correctly this is believed to be an inexpensive, species selective, and effective way to reduce predation by certain species (Reynolds & Tapper 1996; Mitchell *et al*. 2004). Calling has been shown to attract more male coyotes, presumably because they are the main defenders of territories (Sacks *et al*. 1999). Calling has also been noted to successfully attract breeding coyotes (≈ the individuals which, during the breeding season, predated more on livestock), presumably because of their need to defend their litters (Sacks *et al*. 1999). As a result, Knowlton *et al*. (1999) concluded that, if calling is restricted to the areas where predation occurs, it could be used effectively to attract problem-causing coyotes. However, despite the observed successes, Windberg & Knowlton (1990) noted that calling in their study area attracted more juvenile coyotes and they believed this was due to an avoidance behaviour which developed in the older individuals. Although claims are made by many South African ranchers and hunters that calling is successful to suppress black-backed jackal predation (L. Goosen, 2012, Department of Economic Development, Tourism and Environmental Affairs, Free State, *pers. comm.*; N.L. Avenant, 2012, National Museum, Bloemfontein, *pers. comm.*; H.O. de Waal, 2012, University of the Free State *pers. comm.*), its effectiveness to reduce the impact of damage-causing black-backed jackal and caracal remains to be tested scientifically.

Foothold traps: Foothold traps, which generally consists of two interlocking steel jaws that are triggered when an animal steps on the trigger plate, are set at strategic positions (e.g. inside paths) to capture predators. Although some evidence exist that this method can be used effectively to capture problem-causing predators (Fall 1990; Mitchell *et al*. 2004; De Wet 2006; Snow 2008; Saffy & De Waal 2010), the use of foothold traps (especially the older gin traps) is often strongly challenged because of its perceived non-selectiveness and inhumane nature (Landmark Foundation 2008). Studies by Rowe-Rowe & Green (1981) and Brand (1989) found that foothold traps were effective in capturing black-backed jackal and caracal, although successes were generally only achieved after an extended period. Both these studies, however, noted that the traps were relatively unselective and captured a large percentage of non-target species while it also caused various injuries to captured individuals. To decrease the potential for injuries, McKenzie (1989) and Kamler *et al.* (2008) tested a modified trap and found that it decreased injuries incurred by captured black-backed jackal. Kamler *et al*. (2008) also found that the modification captured less non-target species. Another modification is tranquilizer traps, which apply a tranquilizer to the captured animal when gnawing at the trap jaws, thus reducing the pain (Sahr & Knowlton 2000); this modification has not been tested on black-backed jackal or caracal. Linhart *et al*. (1986) found that modified traps, in this instance padded traps, may however be less effective to capture the ecologically much similar coyote. Windberg & Knowlton (1990) also noted that foothold traps may be less effective to capture territorial predators within their territories, because they are familiar with these areas. As a result they recommended that trapping for territorial predators needed to be conducted at the periphery of their ranges. Thus, the experience of the trapper and its familiarity with the area where trapping occur may be other important factors that could impact the effectiveness of foothold traps.

In summary, although there is some scientific evidence on the successful application of different variations of foothold traps to control black-backed jackal and caracal predation, it is important to gather more information on their effectiveness, selectiveness and harmfulness under South African conditions.

Snares: Two types of snares exist, namely body or neck snares and foot snares (Gese 2003). The former consists of a looped wire cable which tightens around the body or neck once the animal pass through it and thrust forward; they are generally set at a hole under a fence line where predators pass through or along pathways or at den entrances. The latter are set on the ground, generally in pathways, and when an animal steps on the trigger the cable are released and tighten around its foot (Logan *et al*. 1999; Gese 2003; Texas A&M 2004). Because of its relative simplicity, low cost and because it is easy to handle, snares are often used in the United States of America to control damage-causing predators (Gese 2003); there is, however, no scientific studies that have tested the use of snares to counter damage-causing black-backed jackal or caracal in South Africa. Some questions regarding its selectivity remains, while it may also inflict harm and cause injuries to captured animals in instances where they are not killed (Texas A&M 2004). Modifications have been suggested to make snares a non-lethal alternative (Frey *et al*. 2007). They (Frey *et al*. 2007) further demonstrated that these modifications may be less intrusive on the wellbeing and social behaviour of captured predators. Nonetheless, when the captured animal is not removed, it is difficult to determine whether the problem-causing individual has been captured. To achieve this, the captured animal will have to be killed (Gese 2003).

Coyote getters: The coyote getter or M44 (the latter is a modification to the original coyote getter) contains a cartridge that ejects a poison (sodium cyanide; often in the mouth) when the trigger is pulled by a predator (Blom & Connolly 2003). The method is widely disapproved of because it is perceived to be non-selective (Sillero-Zubiri & Switzer 2004). Although some effort has been put into making these devices more species selective (Marks & Wilson 2005), their use is banned in many countries (Mitchell *et al*. 2004). In South Africa the environmental impact of the poison used in these devices has also been contested (Smuts 2008). Unlike the extensive research and development completed in the USA (Blom & Connolly 2003), scientific research on the use of coyote getters to reduce black-backed jackal and caracal predation has mainly focused on the avoidance behaviour of black-backed jackal (Brand *et al.* 1995; Brand & Nel 1997) and on the method's success to control black-backed jackal numbers (Bothma 1971a); nothing has been done on its selectivity for specific species or harmfulness to captured individuals. Brand *et al.* (1995) and Brand & Nel (1997) found a capture bias towards younger black-backed jackal individuals, with older individuals showing avoidance behaviour. Sacks *et al*. (1999) similarly observed a bias towards coyote juveniles when M44s were used. Since territorial coyotes are mostly implicated in livestock predations, they (Sacks *et al*. 1999) deemed the method ineffective to reduce livestock predation. Bothma (1971a) found that only *ca*. 45% of coyote getters set, successfully killed black-backed jackal. In the USA, a significantly higher capture rate was reported for coyotes, with up to 85% (n = 650 of 661) of coyote getters pulled by coyotes resulting in a recovered carcass (Blom & Connolly 2003). Regarding its selectivity, Marks & Wilson (2005) noted that M44s used in Australia obtained a high species-specificity when the devices were designed and used according to the feeding habits and body size of target species.

Poisoned baits: Poisoned baits contain a lethal dose of poison (sodium fluroacetate; strychnine), which are either placed at baiting stations or dropped from vehicles or aircraft; in the latter instance, control can be conducted over a relatively large area (Kinnear *et al*. 2010). Similar to coyote getters, poisoned baits are considered an unselective method and its use are widely disapproved (Sillero-Zubiri & Switzer 2004). Currently there is not much scientific evidence on the effectiveness and selectiveness of this method to decrease black-backed jackal and caracal predation in South Africa or its humaneness, and many untested concerns regarding the possible negative environmental impact of the method remains (Harrison-White 2001; De Wet 2006; Bothma 2011). There have been earlier attempts to conduct research on successful delivery methods of a standard dose of Compound 1080 (sodium fluroacetate) in poisoned baits, to ensure the least environmental impact under South African conditions. These have, however, all been aborted without producing conclusive results (Cilliers 2004). The reason for cancelling these studies remains unknown.

The application of poisoned baits (sodium fluroacetate; strychnine) to reduce damage-causing predator populations has been scientifically tested in other countries (Gunson 1992; Thomson & Algar 2002; Eldridge *et al*. 2002; Burrows *et al.* 2003). In these studies reductions in the target species varied significantly, ranging between *ca.* 20% and 100% of the population. However, in Australia Gentle *et al.* (2007) reported a quick recovery of fox *Vulpes vulpes* densities after poisoning, due to the effect of immigration. They (Gentle *et al*. 2007) concluded that, for poisoning of this matter to be effective, application has to take place over a relatively large area to exclude the impact of immigration. Eldridge *et al*. (2002) also noted that, despite a decline in dingo *C. lupus dingo* population densities after the application of poisoned baits, there was no difference in cattle damages between poisoned and un-poisoned areas in Australia. Consequently, they concluded that the problem-causing individuals were not affected by these baits, presumably because they did not utilize these food sources. It was also noted that baits may remain toxic for long periods (≈ up to 8 months) and pose an extended risk for non-target species if not removed from the environment (Twigg *et al*. 2000).

Poison collars: Poison can be used more selectively when placed in a livestock protection collar (LPC; Mitchell *et al*. 2004), thereby ensuring that only predators which attack livestock are being targeted. However, for the method to be successful the predator will have to bite into the poison pouches that are generally situated in the throat area (Conover 2002). Poison collars are often considered an effective alternative to remove damage-causing individuals which evade other control methods (Gese 2003; Sillero-Zubiri & Switzer 2004). In South Africa, livestock protection collars used in combination with other methods (bells, stock management, range management) has been proven effective to control caracal damage to sheep (Avenant *et al*. 2009). The method has also demonstrated success to control damage-causing coyotes under pen tests (using Compound 1080 collars; Connolly & Burns 1990; Burns *et al*. 1996). Connolly & Burns (1990), in field tests, also recorded a puncture rate of 43%. It was, however, not monitored how many coyotes were killed in these experiments. Burns *et al*. (1996), further, showed that coyotes did not show any aversive behaviour towards LPC. Blejwas *et al*. (2002) found it to be the most effective method to reduce sheep losses when compared to non-selective methods and no-control efforts. Despite its apparent successes it is, however, possible that accidental spillages of Compound 1080 from LPC could kill livestock (Burns & Connolly 1995), and scavengers can be affected when they eat poisoned carcasses (Burns *et al*. 1991). The humaneness of the poison in collars can also be questioned (Sherley 2007). It is evident that more scientific studies should be conducted on the potential successfulness, environmental impacts, humanness and other negative aspects of various poison collars to control damage-causing black-backed jackal and caracal under South African conditions.

Denning: Denning involves the removal and or killing of pups/cubs at their dens without killing the adults. It assumes that removing the young will decrease depredation by the provisioning adults (Gese 2003). Till & Knowlton (1983) showed the effectiveness of denning to control coyote predation on sheep, when predation stopped after the removal of pups. Gese (2003), however, noted that denning can be a very time consuming method depending on, amongst others, the cover and terrain. There is currently no scientific evidence to support the use of this method to control black-backed jackal and caracal predation on livestock and wildlife in South Africa. Some evidence indicates that both these species increase their predation on livestock during the breeding season while providing for their young (see **Chapter 3**), suggesting that denning can be considered as a potential useful HPCM method in South Africa. Its cost-effectiveness, however, also remains to be tested under South African conditions.

Hunting dogs: Hunting with hounds is currently widely perceived as non-selective although some efforts have been made to increase its selectivity (Snow 2008). Hounds have been used extensively in the past to capture or chase-and-shoot both black-backed jackal and caracal in South Africa (Hey 1964; Rowe-Rowe 1974, 1975; H. Grobbelaar, 2012, Chair: Tafelkop Hunting Club, Bethulie, *pers. comm.*). Some restrictions for using this method, associated with seasonality, climatic conditions and topography, have been identified (Hey 1964). There is, however, still no scientific evidence on the effectiveness of these efforts to reduce the impact of predation. Based on the results obtained from historical hunting records from former hunting clubs in South Africa, its efficacy has been questioned (Gunter 2008; Bothma 2011).

5.3.3.2 Non-lethal methods

Guarding animals: Guarding animals, mostly livestock guarding dogs (LGD), is a non-lethal alternative often discussed in the literature (Table 5.1), although only a few scientific publications have looked at this alternative in South Africa. Some scientific evidence are available on the effectiveness of LGD to reduce livestock predation (Herselman 2006) and on aspects of LGD breeding and performance under different conditions (Stannard 2006a,b). Studies in neighbouring Namibia have been conducted on the effectiveness of LGD to reduce livestock depredation (Marker *et al*. 2005a,b,c; Potgieter 2011; Potgieter *et al*. In press). Results from these studies demonstrated associated decreases in predation: e.g. from 7.6% to 2.6% on lambs before weaning and from 2.9% to 0.6% on lambs after weaning (Herselman 2006); noteworthy decreases in livestock losses to predation in more than 75% of cases (Marker *et al.* 2000a,b); reports that, in 91% of the cases where LGDs were used, this method caused a significant decrease in livestock depredations (Potgieter 2011); and 96% and 83% of commercial and subsistence farmers, respectively, reported reduced livestock losses since LGD introduction (Potgieter *et al*. In press).

Positive results have also been reported in cases where LGD were used against other damage-causing predators such as coyotes, lynx, and wolves *C. lupus* (Andelt 1992; Andelt & Hopper 2000; Rigg 2001). Andelt (1992) estimated that it is also a relatively cost-effective method to control livestock predation. However, despite the effectiveness of LGD to control livestock predation Mason (2001) questioned its usefulness to protect wildlife. This was attributed to the fact that wildlife species often prefer habitats where LGD are least effective, and that LGD may harass or kill wildlife species because they are not accustomed to them. Knowlton *et al*. (1999) and Hansen & Smith (1999) predicted that the efficiency of LGD may be influenced by the size and dispersal of the flock or herd that the LGD need to guard, the topography of the grazing area, and the cover in that area. Green *et al*. (1994) found a decrease in efficiency of LGD over time due to the grazing conditions, predator densities, and the maturity of the dogs. Hansen & Bakken (1999) and Gingold *et al*. (2009) noted how LGD had a negative impact on the environment by continually chasing ungulate species. Timm & Schmidtz (1989) reported some isolated cases where individual LGD killed livestock and wildlife, and Snow (2008) questioned the behaviour of LGD where more than one animal is used in the same area. Overall, it is evident that more research should be conducted on the performance of LGD to protect different stock species from black-backed jackal or caracal under various South African conditions.

Although it is used in some instances (Table 5.1), no scientific information is available on the use of alternative guarding animals, such as alpacas, donkeys and llamas, to specifically control black-backed jackal and caracal predation. For other damage-causing predators, Landry (2000) and Marker (2000) reported overall successes with donkeys to decrease livestock losses. There were, however, also some isolated reports of unsuccessful attempts in both these studies; the varying successes were attributed to topography and size of the area, size of the flock or herd, and number of donkeys used. Meadows & Knowlton (2000) similarly reported variable successes with llamas. Cavalcanti & Knowlton (1998) further noted that llama efficiency to deter predators may differ depending on the size, alertness, and leadership qualities of an individual. Disadvantages associated with using donkeys or llamas may include that they harass and injure livestock or wildlife and impact on their breeding behaviour (Cavalcanti & Knowlton 1998; Marker 2000).

Fencing: Fencing, which is employed to exclude predators from ranching areas (Sillero-Zubiri & Switzer 2004), is one of the most preferred predation control methods on livestock farms throughout South Africa (Van Niekerk 2010). There is, however, not much scientific information available on its effectiveness to control predation in South Africa. A study by Heard & Stephenson (1987) noted that the electrification of an existing jackal-proof fence (wire mesh or closely-spaced wire strand fences, with a height of 1,3 m) on a South African farm resulted in less burrows underneath the fence and hence black-backed jackals were more effectively excluded. Nass & Theade (1988) similarly noted a decrease in sheep predation by coyote after the introduction of electric fences, while Poole & McKillop (2002) noted the effective exclusion of foxes with the use of electric fences. Nass & Theade (1988) also noted that the effectiveness of electric fencing decreased as the size of the fenced area increased; they contributed this decrease to the potential for more malfunctions and physical damage, the presence of more gates, more washouts, and increased predator access. Newsome *et al*. (2001) pointed to the potential environmental impact of fencing when it excludes predators from an area (also see **Chapter 2**). In this instance, predators were excluded from parts of Australia by the dingo-barrier fence; as a result these areas contained more ungulates and other carnivores because of the effect of meso-predator release. Apart from its effectiveness to exclude predators, Nass & Theade (1988) calculated electric fencing to be a relatively cost-effective predation management technique in the USA. They estimated that although the initial input costs of fencing were high, the financial benefits due to decreased livestock predation, may outweigh these costs in the long-run. It remains to be calculated if the same long-term financial benefits also apply under South African conditions today.

Box traps: There is currently only limited scientific information available on the use of box traps to capture damage-causing black-backed jackal and caracal. Box traps have only been tested on caracal and have been found to capture these animals successfully (Brand 1989; Avenant 1993; H. Grobbelaar, 2012, Chair: Tafelkop Hunting Club, Bethulie, *pers. comm.*). A major disadvantage of box traps, however, is that it is not easy to determine whether it is the specific problem-causing animal that has been caught (Gese 2003). The captured animal generally has to be killed to achieve this.

Translocation: After an animal has been live-captured it is possible to re-locate the animal to an area away from the existing conflict. There is currently no scientific information on the usefulness of this method to manage black-backed jackal and caracal predation in South Africa. A review by Linnell *et al*. (1997) suggested that this method is generally successful only when the animal can be relocated to an area with a relatively low density of co-existing predators. Further, the area must be far enough from the capture site to prevent the animal from returning. It should also contain few, or no, livestock or wildlife species because it is possible that the relocated predator may again predate on them in its new environment.

Frightening devices: Frightening devices generally consists of objects which generate noises, lights or smells (Pfeifer & Goos 1982; Bomford & O'Brien 1990; Shivik & Martin 2000; Shivik *et al*. 2003; VerCauteren *et al*. 2003). None of these devices have, however, been tested scientifically on black-backed jackal or caracal in South Africa. Breck *et al*. (2002) and Darrow & Shivik (2009) noted that lights and noises were effective to deter coyotes and wolves under pen conditions, while Linhart *et al*. (1992) recorded a decrease of *ca.* 60% in sheep losses to coyotes when a frightening device which produced a combination of lights and noises was used. Pfeifer & Goos (1982) noted an average period of 31 days without any sheep losses to coyotes when gas exploders were used, while VerCauteren *et al*. (2003) recorded no coyote kills over a period of two months in a sheep flock where an acoustic device was used. However, Smith *et al*. (2000b) and Shivik *et al*. (2003) cautioned that the effectiveness of frightening devices may only be short lived since animals are likely to habituate to these. Also, most frightening devices are only effective in relatively small areas while costs can be high (Gilsdorf *et al*. 2002).

Aversions: Aversions may be used to repel target species from a specific prey type (Pfeifer & Goos 1982; Bomford & O'Brien 1990; Shivik & Martin 2000; Shivik *et al*. 2003; VerCauteren *et al*. 2003). It includes the use of chemicals which are placed in specific baits, usually carcasses of livestock, and as the predator scavenges on the carcass it causes nausea. The nausea is supposed to cause an avoidance behaviour against these prey species, known as conditioning taste aversion (CTA; Smith *et al*. 2000b). Field studies suggest that CTA have been effective in some cases to decrease livestock predation by non-South African predators (Ellins & Catalano 1980; Gustavson 1982); the majority of studies have, however, found the method ineffective (Burns & Connolly 1980; Conover & Kessler 1994; Hansen *et al*. 1997). In the latter instances predators developed an aversion against the baits but they continued to kill livestock, presumably because the baits did not successfully mimic live livestock (Conover & Kessler 1994). Hansen *et al*. (1997) also observed increased aggressiveness in predators exposed to treated baits, which ultimately resulted in a greater intensity of livestock killings.

Another aversion alternative is the use of electronic training collars which are attached to problem-predators, and as they attack specific prey individuals or groups, an electric shock are generated. The shock should then cause an avoidance behaviour (Shivik 2004). An experimental study under pen conditions demonstrated the effectiveness of training collars to decrease coyote attacks on sheep (Andelt *et al*. 1999). During its application over a two week period it averted 13 attacks on lambs by five coyotes and thereafter the coyotes avoided lambs for over four months. However, despite its proven effectiveness under pen conditions, no field tests have yet been conducted. Further, Shivik (2004) cautioned against the potential high cost and efforts associated with this method since the predators need to be trapped for the collars to be fitted and retrieved. Knowlton *et al* (1999) also pointed to the fact that aversions may only stop the consumption of certain prey species but it may not effectively stop predatory or killing behaviour of predators.

It remains to be tested whether aversions could successfully be used to deter black-backed jackal and caracal from predating on livestock or wildlife under different ranching conditions in South Africa.

Reproductive interference: This approach includes interventions such as contraception and sterilization and is employed to decrease birth rates and associated energy requirements, thereby altering predator killing behaviour and livestock predation. No scientific evidence is available on the effectiveness of these interventions to reduce black-backed jackal and caracal predation on livestock or wildlife. Bromley & Gese (2001a) established that surgical sterilization of whole coyote packs successfully reduced small scale livestock predation. They noted on average six times more lamb killings in fertile packs with pups compared to sterile packs, contributing this to the hypothesis that coyotes kill more livestock when pups are present. Till & Knowlton (1983) showed that the need to nurse pups by lactating coyote females was a key driver to increase the level of predation on sheep. Knowlton *et al*. (1999) predicted that contraceptives should have a similar effect in coyote populations. Additionally, Bromley & Gese (2001b) noted that surgical sterilization did not affect coyote territoriality or affiliative behaviour. However, despite the potential effectiveness of contraceptives and sterilization there are some shortcomings to consider. It is possible that factors, other than pup or kitten presence, may influence livestock or wildlife predation patterns and under such conditions reproduction interference will not be effective to reduce livestock or wildlife killings (Knowlton *et al*. 1999). Mitchell *et al*. (2004) also cautioned that surgical sterilization can be a time consuming and costly technique, and pointed out the difficulty to distinguish between territorial and non-territorial individuals. Its successful application would, therefore, require the capturing and sterilization of all adults within an area. There are currently no delivery systems to apply contraception to specific individuals or species without physically capturing them (Shivik 2004; Connor *et al*. 2008). Currently there are also no species specific contraceptives available (Gese 2003), and it can thus not be applied in baits due to its possible impact on non-target species.

Supplemental feeding: There is no scientific information available on the application of supplemental feeding to reduce predation on livestock or wildlife by any damage-causing canids or felids. It has been used effectively to deter predation on livestock (Witmer & Wittaker 2001) and damage to vegetation (Partridge *et al*. 2001) by bears *Ursus americanus* and predation by predatory birds (Redpath *et al*. 2001). This method may, however, influence the social and reproductive behaviour of predators (Witmer & Whittaker 2001, Gese 2003; Godboise *et al*. 2004). It is possible that supplemental feeding could influence the territorial, ranging and reproduction behaviour of black-backed jackal and caracal in similar ways (see **Chapter 3**).

Husbandry: Husbandry practices include the use of herdsmen and shed lambing or kraaling, and are employed to protect livestock during the most vulnerable times (e.g. during lambing seasons or at night; Gese 2003). Although there is currently no scientific publications on the use of these methods to control black-backed jackal and caracal predation, McAdoo & Glimp (2000) mentioned some advantages in deterring coyote depredations on sheep in the USA. According to them (McAdoo & Glimp 2000) herding does not only provide a potentially reliable deterrent to scare damage-causing animals away, but herdsman may also be in a good position to eliminate the problem-causing individual as it is often these individuals who approach the sheep herds. With regards to shed lambing, they (McAdoo & Glimp 2000) mentioned the protection of newborn and younger lambs, increased lambing productivity (lamb crops of 150 to 200% compared to 60 to 130% in the veld), an increased possibility to save lambs or ewes which are affected by lambing complications, and the possibility to lamb earlier thereby protecting the younger lambs from periods with predation peaks (in the western parts of the USA shed lambing may shift the lambing season earlier by up to 2 months) as advantages of this method. Some factors may, however, also influence the success of husbandry practices. Herdsmen are generally less effective as flock size increase, when flocks are more widely dispersed, or as grazing units increase; kraaling is generally less practical as the size of the grazing unit increase (Shivik 2004). Kraaling may also influence grazing conditioning (due to spot deterioration), livestock condition (parasites and illnesses may be transferred more easily under kraaling conditions) and the quality of wool may be affected (Snow 2008). Shed lambing could be a costly operation and would require prolific breeds to be economically viable (in the USA it was estimated that the cost of shed lambing may be as much as 0.3 to 0.5 of lambs weaned per ewe; McAdoo & Glimp 2000).

Protective collars and cellular technology: The use of technologies such as protective or cellular collars has also been suggested as non-lethal alternatives to control predation. The former consists of a plastic type collar that protects small stock against neck and throat bites (King 2006). The latter involves a collar that is fitted with cellphone type technology which sends a cellular signal when abnormal behaviour (e.g. frantic movements) is detected within a herd (Lotter 2006). However, various sources (Shivik 2004; L. Goosen, 2006, Department of Economic

Development, Tourism and Environmental Affairs, Free State, *pers. comm.*; P. de Wet, 2007, Chair: Predation Management Forum of South Africa, *pers. comm.*; A. Strauss, 2008, Free State Department of Agriculture, *pers. comm.*; Bothma 2011) cautioned against carnivores' ability to habituate to protective collars. Such predators may then bite and capture small stock (that is fitted with these collars) on parts other than their throat. Further, cellular technology is limited by its ability to transfer a signal, and as a result, it may not work effectively under all South African conditions. It remains to be scientifically tested whether these technologies could be applied to manage damage-causing black-backed jackal and caracal under different South African conditions.

Financial incentives: This approach (compensation, insurance) has not been implemented as a predation management strategy before in South Africa where black-backed jackal or caracal is involved; nor has its feasibility been studied to reduce the conflict between producers and black-backed jackal or caracal. Several general issues have been highlighted which can influence the successful implementation of financial incentive programs (Shivik 2004; Bulte & Rondeau 2005). It is argued that, when compensation programs are available, producers may stop putting sufficient effort into protecting their stocks or managing the damage-causing animals. As a result damage may increase, with potential negative implications for biodiversity. It is often also difficult to monitor or verify predation claims, and as a result, producers may be over or under compensated. Further, compensation or insurance programs may be over costly when indirect costs are included. There may also not be a large enough group of participating livestock farmers to justify the capital investment of an insurance scheme, resulting in costly premiums. Lastly, a lack of accurate information on depredation rates and the success of different HPCM methods make it difficult for insurance companies to develop viable insurance models/plans (J. van den Berg, 2008, Santam Agriculture, Bloemfontein, *pers. comm.*).

Adaptive rangeland and herd management: Another non-lethal option to manage damage-causing predators is to adapt rangeland management practices in manners that may decrease predation risk. These adaptations could include 1) the implementation of multi-species grazing (flerds); 2) the selection of breeds that are less vulnerable to predation; 3) the selection of pastures which are less prone to predation, also considering seasonality (e.g. during lambing season camps nearer to the homestead are used, or herds are moved away from higher risk areas during times when natural prey densities are low); 4) a change in livestock or wildlife breeding season; and 5) increased sanitation. No scientific information is currently available on the effectiveness of any of these methods to control black-backed jackal and caracal predation under South African conditions.

The practice of flerds (mixing sheep flocks and cattle herds) has been shown to effectively control coyote predation on sheep (Hulet *et al*. 1987; Anderson 1998), while it was less effective to control predation on goats (Hulet *et al*. 1989); the latter was contributed to the tendency of goats not to form a bond with cattle. Further, Shivik (2004) listed some more potential disadvantages associated with multi-species grazing: it can be a very time consuming and strenuous process to bond different livestock species; in some areas it could be difficult, or even impossible, to introduce cattle or small livestock because of grazing conditions and predators could habituate to the presence of larger livestock species and even start predating on them.

It is possible that some livestock breeds or wildlife species are less vulnerable to predation, and by choosing these animals for an enterprise it may decrease black-backed jackal and caracal predation (Melville 2004). However, there are some important factors to be considered when implementing such a strategy. Certain behavioural traits of a breed such as aggressiveness, agility, size, tendency to flock together, hardiness could influence a species vulnerability to predation. The grazing conditions in an area may only suit certain species while the market settings, such as market price of selected species, may make it less feasible to keep certain species.

Livestock and wildlife predation are often spatially confined and in such instances predation could be limited by excluding these areas for grazing, or by grazing only less vulnerable stock in these areas (Shivik 2004). Knowing which areas are prone to black-backed jackal and caracal predation, and at what time of the year, (see **Chapter 6**) would thus be an important factor if this strategy is used. Further, it is important to assess the impact that repeated moving may have on livestock. It is also necessary to test whether damage-causing black-backed jackal and caracal have the ability to track livestock or game and shift their ranges accordingly (see **Chapter 3**).

Predation may also be temporally influenced or confined and peak when the lambing season coincides with the pup or kitten rearing season. In such instances, a shift in lambing season could result in lower livestock and game predation (McAdoo & Glimp 2000). However, there are again some factors which may limit the feasibility of this method, including market and grazing conditions, increased veterinary costs and biological limits (Shivik 2004).

Both black-backed jackal and caracal are known to scavenge in some instances (see **Chapter 2**). Furthermore, in the case of black-backed jackal it is known that their densities may increase where carcass numbers are high (see **section 3.4.2.1**): the impact that overabundant carcass numbers may have on caracal is not yet understood. Resultantly, due to the potential increased densities of black-backed jackal and caracal where livestock or introduced wildlife carcasses are abundant, this may lead to a situation where these two species may predate more on livestock or introduced wildlife, especially when carcass abundance decrease (see **section 2.3.3**). Also, it is possible that in instances where black-backed jackal or caracal does make use of carcasses, this could potentially have a lasting behavioural effect on these individuals, leading them to recognize unnatural prey as part of their natural diet (Avenant 1993). To counter the possible indirect contribution of carcass densities to livestock or wildlife predations by black-backed jackal and caracal, sanitation practices (mainly the continuous removal of carcasses) could be implemented. Bino *et al*. (2010) demonstrated how sanitation practises can be used to successfully and rapidly decrease overabundant fox densities. However, Fuller & Sievert (2001) cautioned that sanitation may only be successful on the long-term because numerical population responses may be lagged and can be preceded by overexploitation of surrounding resources.

5.3.3.3 Integration of methods

The preceding sections provided valuable information to suggest in which manner different HPCM methods could contribute to the effective management of black-backed jackal or caracal predation on South African rangelands. However, Knowlton *et al*. (1999) stated that it is unlikely that any single HPCM method will provide a simple solution to counter predation related damages. To achieve success, they (Knowlton *et al*. 1999) proposed that HPCM methods should be integrated based on the problem at hand and the area wherein it occurs. Therefore, it is important to also understand how the methods, as discussed above, may work in conjunction to counter black-backed jackal and or caracal predations.

Currently, there is limited scientific information to demonstrate the successful integration of different HPCM methods to counter black-backed jackal or caracal predations in South African rangelands. Avenant *et al*. (2009) demonstrated how a combination of rangeland management practices (≈ management of the natural prey base), flock management practices (≈ lambing in designated camps; regular and continuous flock monitoring and moving; removal of carcasses), preventative non-lethal methods (≈ bells, protection collars) and selective lethal methods (≈ poison collars) were integrated effectively to decrease damages by caracal on a sheep farm in the Beaufort-West district, Western Cape. In this instance, they (Avenant *et al*. 2009) concluded that caracal predation could largely be hindered with non-lethal methods used in combination to prevent habituation, although in some cases lethal alternatives will have to be employed to capture damage-causing individuals whom are not deterred by preventative methods. More such studies, on both black-backed jackal and caracal, are needed under different South African conditions.

5.4 Conclusions

The general lack of scientific information on HPCM methods for black-backed jackal and caracal in South Africa was highlighted. Current knowledge is mostly documented in popular literature, while the discussions often do not apply to specific damage-causing species. Overall, the conclusions that can be drawn from the available information on predation management are limited, while it cannot be applied specifically to black-backed jackal and caracal management.

A review of the available information has highlighted what is already known on various internationally known methods, and which could potentially also be used to manage damage-causing black-backed jackal and caracal. It is evident that a variety of management options exist. There is a general awareness of most of these methods in South Africa, and today non-lethal methods are receiving most of the discussion in the literature. However, there is generally a widespread lack of scientific support for the use of most of the methods and virtually nothing is known on their application to specifically manage black-backed jackal and caracal predation on livestock or game. The scientific information that is needed on the different methods includes 1) its effectiveness to decrease livestock or game depredation, in both the short- and long-term; 2) its cost-effectiveness; 3) its associated environmental impacts; 4) its impact on livestock or game; and 5) its selectivity and lethality. It is also important to note respective factors contributing to the successes and failures of each method, and similarly, to test how different methods perform in conjunction.

6. A review of scientific information on livestock and wildlife predation in South Africa

6.1 Introduction

Livestock and wildlife predation is common in much of South Africa (Avenant & Du Plessis 2008; Gunter 2008; Strauss 2009; Van Niekerk 2010) with black-backed jackal *Canis mesomelas* and caracal *Caracal caracal* implicated as the major contributors of small livestock predation losses. Lately these two species have also been associated with predation on larger livestock and wildlife (De Waal 2009).

The latest, questionnaire-based assessment has estimated that the direct cost of predation to the small livestock industry in South Africa exceeds ZAR 1.39 thousand million (Van Niekerk 2010). In recent years claims have also been made that a number of farmers had to sell out small livestock farming enterprises in specific areas as a result of the impact of predation (Bezuidenhout 2011), with widespread impact on the small livestock industry in South Africa (P. de Wet, 2011, Chair: Predation Management Forum of South Africa, *pers. comm.*). It is believed that, if predation continues at its current rate, it may impact small livestock farming in South Africa adversely within the next decade (Schoeman 2011). However, most of the statements regarding the impact of predation have been made in popular literature (e.g. Farmer's Weekly; Landbouweekblad; Emmett 2006) with only limited scientific examples (see **Chapter 4**).

Without the scientific backing it is difficult to substantiate the increasing amount of claims, but also to understand the drivers of spatial and temporal differences in predation rates. The information can, therefore, also not be applied with confidence to human-predator conflict management (HPCM) operations (Gunter 2008; Snow 2008; Van Niekerk 2010).

In line with this work, all available scientific information on predation in South Africa was collated to (1) assess the current knowledge of these predations and, more particularly, predation ascribed to the damage-causing black-backed jackal and caracal, and (2) to assess the usefulness of such information to substantiate and understand livestock and wildlife predation with a view to explain their dynamics.

Scientifically gathered evidence that reports on the number of losses per area/time/individual farmer; seasonal and annual changes in predation losses; management methods coupled to changes in the number of losses; and predation hotspots associated to any specific region/geographical or biological phenomena/farming practice or type of livestock, could markedly affect the motivation for and direction of a HPCM strategy in southern Africa.

6.2 Materials and methods

A literature search (using Academic Search Complete; EBSCOHost; ISI Web of Knowledge; Reference lists) was conducted for scientific information on livestock and wildlife predation in South Africa (Keywords included in the search: black-backed jackal, *Canis mesomelas*, caracal, *Caracal caracal*, *Felis caracal*, livestock predation, South Africa, wildlife predation). The type of information included scientific reports submitted to Conservation Authorities, research conducted and published in postgraduate studies by universities, preliminary results, and peer-reviewed publications. In instances where only reference was made to a study but the original publication (≈ mainly older, unpublished reports) could not be obtained, this information was also included.

To analyse the nature of the available information the boundaries of each study area were noted and mapped to indicate the distribution of available information. The temporal and spatial nature of these studies was also noted, using the following categories:

- *Spatial* – the extent of the area for which predation data was grouped.
    - camps – data grouped per camp
    - farm – data grouped per farming unit
    - district – data grouped for all the farm units in a hunting club or district
    - province - information grouped for all the farm units in a province
- *Study period* – the duration over which predation data was reported.
- *Interval of analysis* – the time interval for which predation data were grouped.
    - monthly – data analysed on a monthly basis
    - annually – data analysed on an annual basis
    - study period – data grouped for the entire study period

To analyse predation patterns on livestock and wildlife in South Africa, the reported predation rates (where available) were extracted. The data were assessed with the following questions in mind: (1) what is the extent of predation on livestock and on wildlife by black-backed jackal and caracal, respectively? (2) do predation patterns change through the course of the year?, and (3) have predation increased recently in South Africa?

6.3 Results

Thirteen (13) scientific studies could be found which contained actual data on losses (Table 6.1). All of these studies reported on livestock predation, and none referred to

Table 6.1: Scientific studies on livestock predation in South Africa

Study	Study period	How data was obtained
Janse van Rensburg 1966	1949 – 1954; 1959-1960	Government records
Ferreira 1988	1955, 1970, 1980, 1986	Personal interviews
Rowe-Rowe 1975	September 1972 – March 1974	Investigator / research records
Gunter 2008	1976 – 1992	Hunting records from government subsidised hunting clubs
Brand 1989	1982 – 1987	Hunting records from government subsidised hunting clubs
Vorster 1987	July 1984 - June 1985	Mailed questionnaires
Lawson 1989	July 1986 - June 1987	Personal and telephonic interviews
Avenant *et al*. 2009	1986 - June 2009	Farmer's records
De Villiers 1979[1]	1987	Unknown
Strauss 2009	1999 – 2007	Investigator / research records
Rowe-Rowe 1974[1]	10 years (exact dates unknown)	Unknown
StatsSA 2005	March 2002 – February 2003	Telephonic and personal interviews; mailed questionnaires
Van Niekerk 2010	2006/07	Telephonic interviews

[1] Study referenced within another study; original publication could not be obtained.

wildlife. The oldest predation records are from 1949 (Janse van Rensburg 1966), and the latest from 2009 (Avenant *et al*. 2009; Strauss 2009). These records originated from individual research records, farmer's statistics, census data collected on a district level, and hunting reports collected from hunting clubs and or previously government subsidised "problem animal hunters". Together these studies came from a wide area (Fig. 6.1), covering seven of the current nine provinces in South Africa.

Seven (7) studies (54% of total) included records on black-backed jackal predation specifically, and nine (9) studies (69% of total) on caracal predation (Fig. 6.2). These studies were mainly conducted in the Free State, the Cape provinces (Western-, Eastern- and Northern Cape) and Kwazulu-Natal. Six (6) studies reported on both black-backed jackal and caracal predation, while two (2) studies (Janse van Rensburg 1966; StatsSA 2005) did not distinguish between different predators.

In 10 of the studies available (*ca.* 83% of total) reported livestock losses consisted of only small livestock. Of these, in five (5) instances only sheep were predated on, in one (1) instance sheep and goats were predated on, and in four (4) instances it was not specified whether sheep or goats were killed (Table 6.2).

Most of the studies combined predation data for an entire hunting club or district (n = 5 studies for black-backed jackal; n = 4 for caracal). The smallest spatial unit for which data is available, is a camp (n = 1, for black-backed jackal and caracal, respectively); the largest unit for which predation data was reported, is a province (n = 2 each for black-backed jackal and caracal, plus one study where the predators were not specified) (Fig. 6.3).

Eight (8) studies reported on relatively old predation data (< 1990), while only four (4) studies reported on data collected after 2000 (Table 6.1). Most of the studies reported on data of multiple years (average study period = *c.* 7 years; range between 1 and 22 years). For the majority of the studies on black-backed jackal (n = 5) and caracal (n = 6), the data were grouped on an annual basis. Only two (2) black-backed jackal and three (3) caracal studies presented data on a monthly basis, while one (1) black-backed jackal study grouped data over the entire 10-year study period (Fig. 6.4).

Table 6.2: Type of livestock predated on in scientific studies on livestock predation in South Africa

Study	Livestock predated on
Janse van Rensburg 1966	Sheep
Ferreira 1988	Small stock
Rowe-Rowe 1975	Sheep
Gunter 2008	Sheep; Goats
Brand 1989	Small stock
Vorster 1987	Small stock
Lawson 1989	Sheep
Avenant *et al*. 2009	Sheep
De Villiers 1979	Small stock
Strauss 2009	Sheep
Rowe-Rowe 1974	Unknown
StatsSA 2005	Not specified
Van Niekerk 2010	Sheep; Goats

The average number of small stock losses reported in scientific studies showed major differences (Table 6.3). Average annual losses on farm level ranged from 78 (by caracal) to 191 (by caracal, black-backed jackal and vagrant dogs), and on district level from 127 (by caracal and black-backed jackal) to 1 706 (by caracal and black- backed jackal). On a provincial level, one study reported annual losses of 34 209, caused by all predators. Total monthly losses on district level ranged from 16 (by caracal and black-backed jackal) to 18 (by black-backed jackal), while one study on a Provincial level reported 263 cases of predation in one month, caused by caracal and black-backed jackal. Predation contributed to 50.2% of small stock losses at farm level (black-backed jackal, caracal and vagrants dogs indicated), on a district level it ranged between 26% and 31.25% (by black-backed jackal and caracal) and on provincial level it contributed 12.8% (predators were not specified). Average losses per 1 000 ha varied between 0.98 and 14.7 small stock units, with only damage ascribed to caracal available in this format.

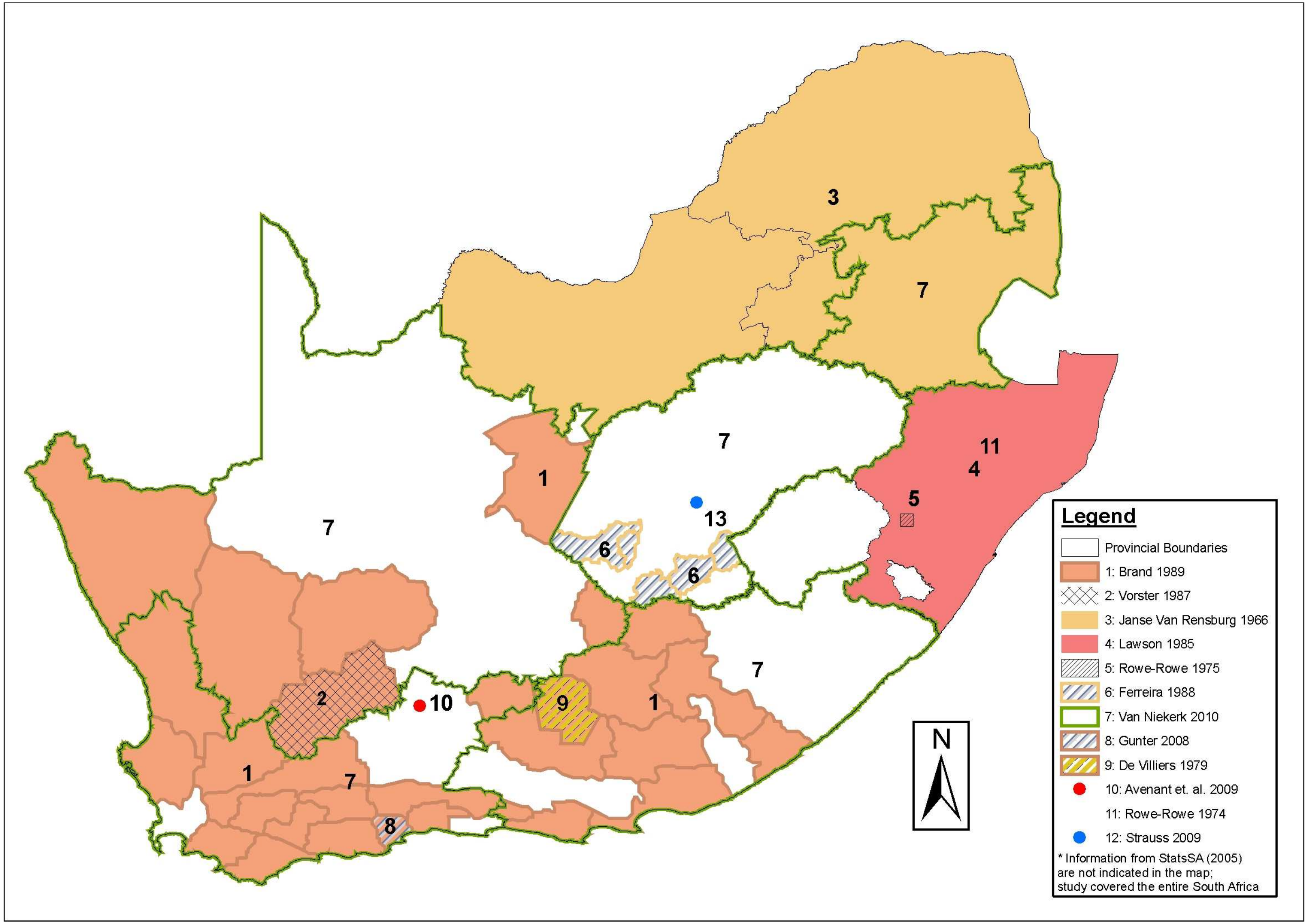


Fig. 6.1: The distribution of scientific studies containing data on livestock predation in South Africa.

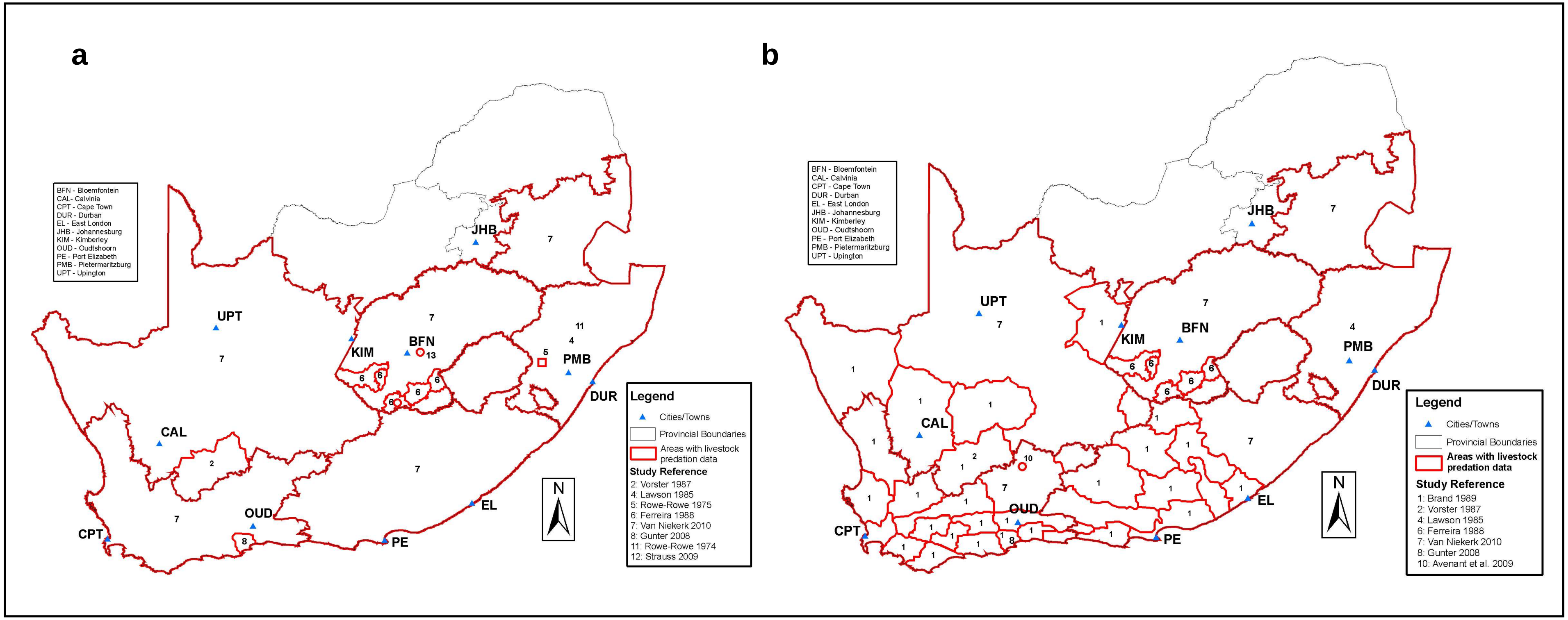


Fig. 6.2: The distribution of scientific studies containing data on livestock predation by (a) black-backed jackal *Canis mesomelas* and (b) caracal *Caracal caracal* in South Africa.

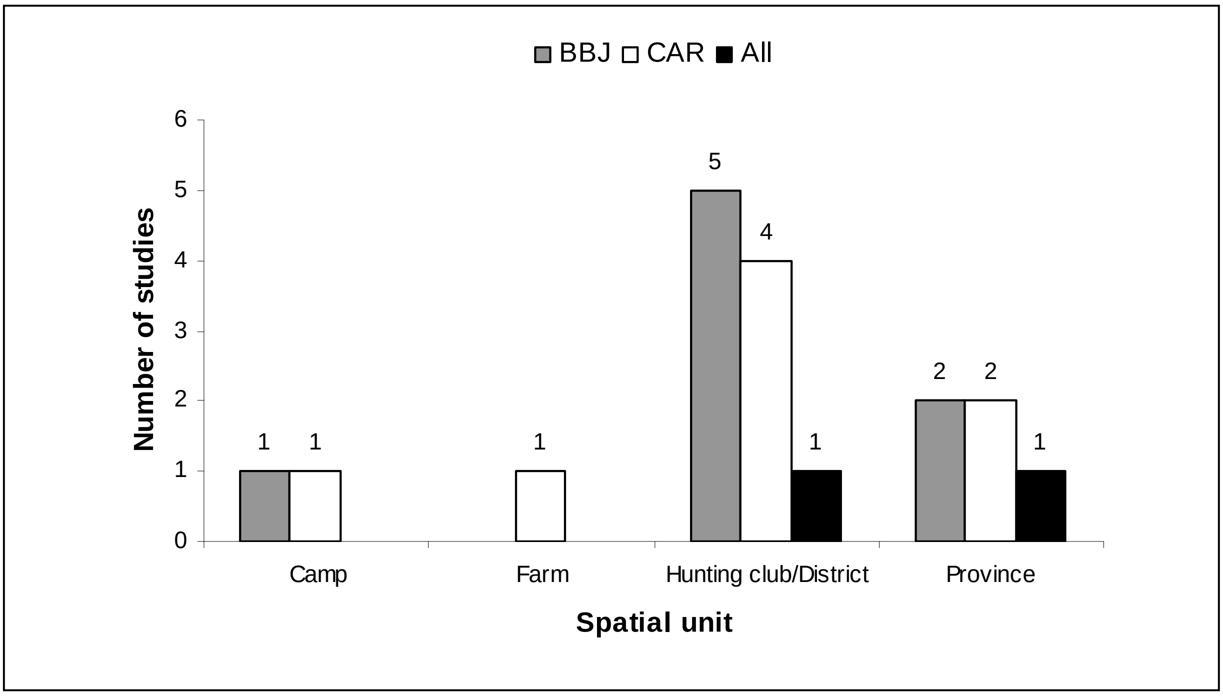


Fig. 6.3: Spatial extent of livestock predation data in South Africa as reported in scientific studies (BBJ = Black-backed jackal *Canis mesomelas*; CAR = Caracal *Caracal caracal*; All = predator not specified).

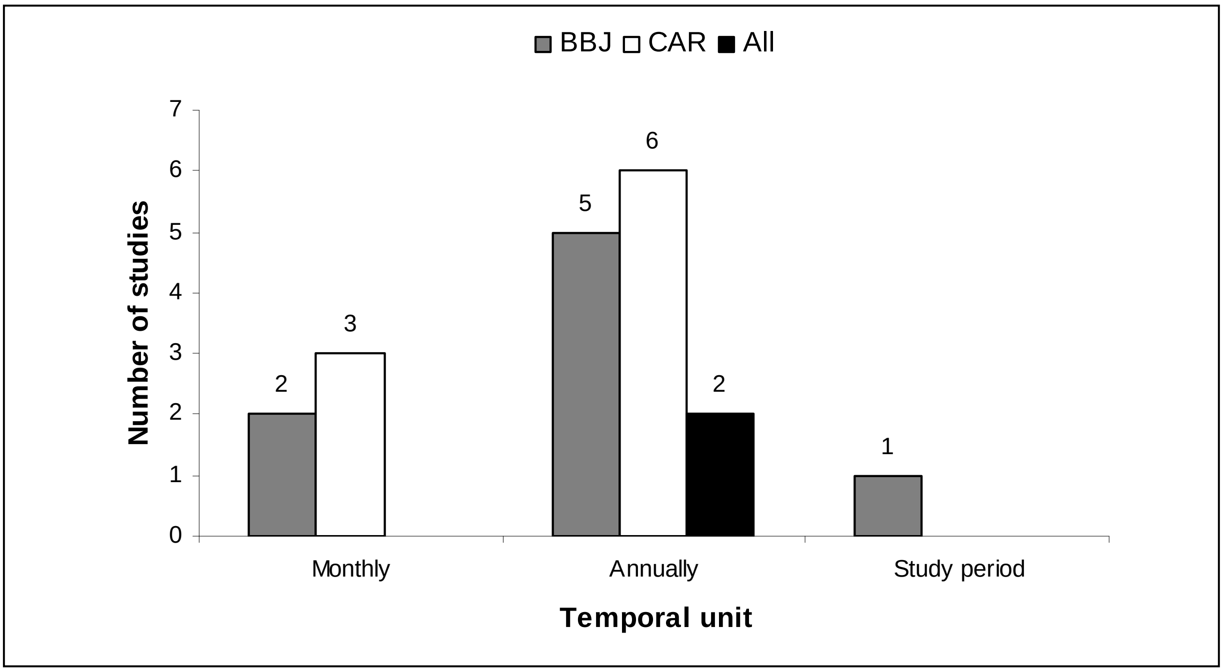


Fig. 6.4: Temporal extent of livestock predation data in South Africa as reported in scientific studies (BBJ = Black-backed jackal *Canis mesomelas*; CAR = Caracal *Caracal caracal*; All = Predator not specified).

Table 6.3: Small stock predation figures in South Africa as reported in scientific studies

Study	Species[1]	Average predation rate[2]			
		Total losses per year	Total losses per month	Percentage of total small stock losses per year	Losses per 1 000 ha
Avenant *et. al*. 2009	CAR	78 (0 – 247)			
Brand 1989	CAR				2.21
De Villiers 1979[3]	CAR				14.7
Ferreira 1988	BBJ			22.5% (0% - 52%)	
	CAR			40% (8% - 80%)	
Gunter 2008	BBJ; CAR	127 (3 – 345)			
	BBJ; CAR		16		
Janse van Rensburg 1966	All	34 209			
	All			12,8%	
Lawson 1989	BBJ; CAR		263 (62 – 499)		
Rowe-Rowe 1975	BBJ		18 (0 – 78)		
Strauss 2009	BBJ; CAR; CF	191 (97 – 277)			
	BBJ; CAR; CF			50.2% (30.32% - 69.4%)	
Van Niekerk 2010	All	607 519			
Vorster 1987	CAR				0.98
	BBJ			33.3%	
	CAR			18.7%	
	BBJ	1092			
	CAR	614			

[1] BBJ = Black-backed jackal *Canis mesomelas*; CAR = Caracal *Caracal caracal*; CF = Domestic dog *Canis familiaris*; All = Predators not specified
[2] Range in brackets
[3] Study referenced in another study; original publication not obtained

Variation in monthly or seasonal predation rates was reported for some studies (Table 6.3). Rowe-Rowe (1975) recorded highest losses from June to October in the Kamberg district, Kwazulu-Natal; Lawson (1989) from March to August throughout Kwazulu-Natal; and Gunter (2008) from April to August in the Mosselbaai district, Western Cape. With reference to the latter, Stuart (1982), who also worked in the vicinity of the Mosselbaai district, mentioned a similar predation peak during winter; unfortunately none of these records were published anywhere. Other studies that have also referred to seasonal variations in predation rates include those of Avenant & Nel (2002), Melville *et al*. (2004), Strauss (2009), and Deacon (2010); they ascribed these variations to lambing season, low natural prey densities, carnivore breeding season, time when carnivore young start to eat meat, and the time when carnivore young disperse.

Annual variation was also demonstrated in some studies (Table 6.3). Ferreira (1988) found that annual relative predation by caracal on farms in the western Free State increased markedly from *c.* 8% of total livestock losses in 1955, to *c.* 80% in 1980; during the same period, and in the same area, black-backed jackal relative predation decreased from *c.* 52% to 0%. Strauss (2009) recorded increased predation from 2003 to 2006 on a government farm (Glen Agricultural Institute) in the Bloemfontein district, Free State, where after it decreased markedly due to the implementation of increased livestock protection measures. Avenant *et al*. (2009) recorded high losses (17.6 ± 15.5 lambs/month) before mid-1996 on a farm in the Beaufort-West district, Western Cape, followed by a marked and seemingly sustained decrease in livestock predation losses thereafter, following the implementation of new HPCM measures (≈ from 242 in the first five months of 1996, to 5 in the last 7 months; livestock predation then remained low for the rest of the 13 year study period, at 6.0 ± 5.1 per annum). Gunter (2008), who analysed data from official, historical, monthly hunting reports, demonstrated that the extent of damage and relative impacts of the various predators fluctuated markedly between years, although these observations could at least partly be attributed to the activity of the hunter(s). Apart from these actual records, Deacon (2010) similarly referred to a marked total increase in caracal and black-backed jackal predation from 1927 to the late 1980s (based on individual farmer and hunting club reports from the southern Free State), and from the early 1990s to 2009 sheep losses of participating farmers decreased from *c*. 200 losses/farmer/year to *c*. 40/farmer/year following a change in farm management and hunting methods.

6.4 Discussion

6.4.1 Nature of available information

The small pool of available predation data in South Africa has limited value, but it may form a basis to verify predation claims in some areas and to identify potential predation hotspots. It could, also, be useful for future comparative studies to test predation dynamics.

Furthermore, the majority of the predation data cover multiple years or seasons. Such long-term data could be valuable to identify changes in predation patterns over time and, from these, identify the underlying factors which may have caused the changes (Gunter 2008). For example, Avenant *et al.* (2009) reported marked changes in annual predation rates over multiple seasons on a small livestock farm in South Africa, which subsequently could be coupled to changes that were made in management practices on the farm (a combination of precautionary, selective removal and clever farm management practices replaced blanket-control). As habitat, climate and farm conditions differ substantially between geographic areas, and even between neighbouring farms, it is evident that more current and detailed long-term records are needed from different regions to identify and understand the predation patterns and causal factors before it can make a meaningful contribution towards HPCM over the larger area. From an HPCM viewpoint, this information will also help to scientifically confirm the wider application and appropriateness of proposed HPCM techniques and strategies (e.g. Avenant *et al.* 2009; Strauss 2009; Deacon 2010).

Apart from the valuable contributions of current predation information there are, however, some shortcomings which impede further understanding of livestock predation. The data also only reports on small stock predations and does not contain any information to verify or substantiate cattle or wildlife predation.

Most South African studies on livestock predation analysed the data for a relatively long temporal interval (annually or longer). There is, however, evidence that predation fluctuate markedly over shorter periods (e.g. monthly or seasonally). These temporal changes can be attributed to 1) seasonality - i.e. more livestock are consumed during the breeding season because of increased energy needs; 2) lambing or calving season – i.e. more small and easy prey is presumably available during this period; and 3) natural food availability – i.e. less natural food is available during specific times of the year (Rowe & Rowe 1975; Lawson 1989; Blejwas *et al.* 2002; Sidorowich *et al.* 2003; Bradley & Pletcher 2005; Nowak *et al*. 2005; Michalski *et al*. 2006; Avenant & Du Plessis 2008; Avenant 2011). As a result, the value of available predation information for HPCM purposes is therefore not as high, since it cannot test these short-term fluctuations. It is important that more scientific studies analyse livestock and wildlife predation in South Africa over shorter (≈ monthly or seasonal) periods to better understand predation patterns. It also needs to be ascertained whether these patterns fluctuate over even shorter temporal periods (e.g. coupled to moon phase and or climate variables) and how long the intervals between predation cases are in a relatively small area and coupled to specific species.

In some of the studies the predators responsible for the reported predation were not identified. Different predator species act differently, and con-specifics may act differently under different conditions (Fleming *et al*. 2007). Some sympatric predators may also exclude each other from an area, thereby influencing their predation rate on livestock or wildlife (Ferreira 1988). From a HPCM perspective the value of studies where the predators were unknown are therefore not as high as those where the predators were specified. This shortcoming does not only limit our understanding of predation, but also the application and testing of predator-specific management techniques that may follow. Furthermore, it also limits the ability to confirm or explain predator-predator interactions.

Various studies on different predators have indicated that livestock predation were concentrated or confined to specific farms within a larger area (Rowe-Rowe 1975; Vorster 1987; Bangs & Shivik 2001; Stahl *et al.* 2001a, 2002; Bradley & Pletcher 2005;

Nowak *et al*. 2005; Michalski *et al*. 2006; De Azevedo & Murray 2007; Schiess-Meier *et al*. 2007), or even to specific patches within the boundaries of a single farm (Stahl *et al*. 2001a; Woodroffe *et al*. 2005; Strauss 2009). These local patterns have been attributed to the topography, habitat structure, type of fencing used (e.g. 1.33 m, 5- or 7-strand vs. jackal proof vs. electric fences) and the proximity to humans. It is evident that there is a lack of such detailed information on livestock and wildlife predation in South Africa. Such detailed information is crucial 1) to understand predation problems in general, 2) to understand the potential impact of predation on single properties and farmers (Knowlton *et al*. 1999), 3) to understand the relative vulnerability of individual properties to species-specific predation (Baker *et al*. 2008; Odden *et al*. 2009), 4) for the planning of clever farm management practises (Odden *et al*. 2009), and 5) to assist in testing the efficacy of specific HWCM strategies on single farms (Avenant *et al*. 2009).

Most of the available South African studies reported on relatively old predation data. Considering the recent widespread claims of increasing black-backed jackal and caracal predation on livestock and wildlife in South Africa (Avenant & Du Plessis 2008; De Waal 2009), it is important that more recent data should be gathered and analysed scientifically to substantiate these claims (also see **section 6.4.2**). Such data is also necessary to help point out underlying factors which may have caused these recent predation changes.

6.4.2 Comparison of predation rates

Despite the apparent expanse of available predation data, it was in most instances not comparable due to the different reporting formats. These variations highlight the importance of using a standard data collecting format, thereby providing an opportunity to develop an overall picture on the extent of predation, to compare how it differs between different areas and changes over time, and to evaluate the effect of predation management efforts. Regarding this, Gunter (2008) developed a useful GIS tool which may ensure the future compatibility, usefulness and application of information relating to predation. For example, it provides the necessary framework to capture and report data in the smallest possible units (single predation case per point). The primary data can then be translated to demonstrate the number of losses per day, month, season, year, moon phase or climate variable. Similarly, primary data can be translated into losses associated with topographical variables or per farm, district, province, region or biome.

Some of the older, comparable studies hinted at major differences among areas. These differences are, however, not necessarily a true reflection of the predation situation and could partly be attributed to 1) inconsistencies in the study methods used, 2) differences in study periods, 3) differences in study area size (e.g. Janse van Rensburg 1966 vs. Avenant *et al*. 2009), 4) different damage-causing predator species or combinations of species reported on (Connolly 1992), and 5) the way in which the data has been collected. It is important that these inconsistencies be addressed in the gathering and analysis of predation studies to ensure greater compatibility.

6.4.2.1 Data collection

A very important consideration when predation data are interpreted is to consider the manner in which the data have been collected. It is important to discuss the value and limitations of these methods (also see **section 4.3.1.**).

Questionnaire based surveys have been shown to give an overestimation of predation rates when compared to hunting reports and actual observations (Brand 1989; De Villiers 1979; Vorster 1987), and warnings have been issued that questionnaires may reflect higher than actual losses (Graham *et al*. 2005; Baker *et al.* 2008). However, it remains an acceptable scientific method to collect large amounts of data over extensive areas (Knowlton *et al*. 1999).

Hunting reports completed by official problem-animal hunters (Gunter 2008) may also have their limitations. It could be that hunters may not be able to attend to all predation cases within the designated area and as a result not all are reported. Similarly, where these hunting records are not co-ordinated (e.g. where more than one hunter or farmer hunts simultaneously in the specified area), predation rates may be understated or duplicated. Hunters may also complete the forms inconsistently. Gunter (2008), therefore, concluded that the standardization of a data collection protocol for hunters is most important in future, since these reports may provide a relatively easy and cost-effective way in which to gather large amounts of long-term data over large areas and within a relatively short period of time (see Gunter 2008 for an example of such a data form).

Individual farmers' records may be useful in gathering long-term information, but then it reports only on the situation in a relatively small area; here, a co-ordinated program on a provincial or national level should be of marked value. However, farmers' records are often contested on the basis that it gets inflated by respondents to justify their cause (Landmark Foundation 2008, Smuts 2008, Animal Rights Africa 2010).

Actual observations made by research personnel on a regular (daily, if possible) basis, especially when combining regular livestock counts with observation/carcass counts, may provide an accurate and most useful source of information. These types of data collection may, however, be most difficult to achieve because it is very costly and time consuming (Knowlton *et al*. 1999). It will also be difficult to cover a large area. To demonstrate the value of this type of study, the work by Strauss (2009) is used as example. The data was collected over a nine year period (1999 – 2007) and *inter alia* confirmed: high actual predation losses (38.58 ± 15.96% of all lambs born in the open were predated/killed before they weaned); that Merinos and Dorpers of all age groups (0-4 months, 4-12 months, 2-tooth and mature sheep) and both sexes have been predated on, with highest losses amongst the pre-weaned and younger individuals, and least losses amongst adult rams; the relative losses due to specific predators (black backed jackal 70.4%, caracal 10.1%, vagrant dogs 19.5%), diseases, metabolic disorders or accidents and livestock theft in the specific area; the direct and indirect economic impact on a sheep enterprise; and gradual increasing livestock losses due to predation, from 1999 to 2007 (from 6.7% to 25.8% of total flock size). Strauss (2009) could conclude that ewe productivity was negatively influenced by predation, black-backed jackal specifically had a big impact on the sheep flocks (among others accounting for 70% of the 730 post-weaning losses from 2003 to 2007), that losses ascribed to total predation contributed ZAR 129 562/year (or 72%) to the total annual financial losses, and that a large component of the genetic base of both the Merino and Dorper breeds at the Glen Agricultural Institute has been lost for the future.

Scat collection and analyses may also give some indirect indication of fluctuations in the impact or relative impact of specific carnivores on livestock (Avenant & Nel 1997, 2002). Comparison will, however, be controversial when comparing predation losses over different areas or over long periods within the same area without knowing, for example, the carnivore species composition and individual carnivore and livestock species age structure and numbers.

6.5 Conclusions

The analysis of available scientific information on livestock and wildlife predation in South Africa has highlighted the paucity of usable information. It is evident that the majority of the current widespread predation reports are documented in popular literature without the necessary scientific backing. Furthermore, Knowlton *et al*. (1999) cautioned against the generalization of predation rates over extended areas, highlighting the need for more scientific information in specific areas on livestock and wildlife predation.

Apart from its limited availability some major shortcomings have also been identified in the current predation information: 1) no information exists on cattle and wildlife predation; 2) in many instances it is unclear which predators are responsible for the reported predation; 3) most studies analysed predation data on a large spatial unit (farms, districts, provinces) and cannot be used to understand predation within small patches such as camps; 4) most studies analysed relatively old predation data and cannot be used to explain more recent claims of elevated predation; 5) most studies grouped predation data for a long temporal unit (annually or longer) and cannot be used to understand seasonal variations.

A few, recent (post 2000), studies made valuable contributions while the information from most of the earlier studies is limited and or dated. Two recent studies (StatsSA 2005; Van Niekerk 2010) exist which provides a valuable baseline for future predation studies throughout South Africa; the latter also provides valuable information to understand the cascading effects of predation. Such data is most important for regions where livestock farming and wildlife ranching are considered to be major economic contributors; especially in the rural areas and where recently there have been allegations of sharp increases in livestock and wildlife predation. From a predator management perspective, therefore, more such widespread scientific studies are needed to substantiate predation claims, identify priority predation areas, understand the underlying patterns of predation on livestock (Gunter 2008; Snow 2008), and to develop practical HPCM strategies. From a research perspective, the information could be used to identify areas where small scale research on specific predation issues could be conducted.

Based on all of the above it is evident that more scientific information is needed on livestock and wildlife predation by black-backed jackal and caracal in South Africa. It highlights the importance of national or regional co-ordinated programs through which thorough predation information can be gathered. To make the predation information more useful each report should be gathered in a consistent manner (i.e. data gathered in a standard manner to enable comparisons; see Gunter 2008), separately account for different damage-causing predator species and capture, and analyse predation data on the smallest possible spatial (latitude/longitude for each predation incidence) and temporal (daily) scales. Incorporating this small scale information should ensure a more complete understanding of the dynamics of livestock and wildlife predation over South Africa and help to identify the factors that influence these predations (see Strauss 2009). Such small scale information will also illustrate the impact of predation on single farmers and could identify the relative vulnerability of individual properties to species-specific predation; thereby contributing to the formation of workable HPCM strategies.

7. The social dimension of human-predator conflicts with black-backed jackal and caracal in South Africa: available scientific information

7.1 Introduction

South Africa has a long history of human-predator conflict within the livestock industry (Beinart 1998; Stadler 2006; Gunter 2008). These conflicts created a situation where many South African livestock farmers today firmly believe that predation is a major threat to their livelihood and a major stumbling block which needs to be overcome to ensure their continued existence (Botes 2008; Gouws 2008; Deacon 2011; Norval 2010; Bezuidenhout 2011; Schoeman 2011). Many wildlife ranchers have recently joined the chorus, claiming that predators are increasingly causing significant damage in the wildlife ranching industry (De Waal 2009, 2012).

The two sympatric predators, black-backed jackal *Canis mesomelas* and caracal *Caracal caracal*, are implicated as the major contributors to these damages (Stadler 2006; Strauss 2009; Van Niekerk 2010). In reaction, a variety of control interventions have been implemented. Many focus on eradicating the damage-causing species by means of lethal methods such as calling and shooting, hunting with dog packs, traps and poison, although a range of non-lethal methods such as jackal-proof fences, bells, collars, herders and guard dogs are also used (see **Chapter 5**).

Many of these methods are receiving resistance from various quarters (Landmark Foundation 2008; Animal Rights Africa 2010; Natrass & Conradie 2013), forcing decision makers to revisit policies regarding human-predator conflict management (HPCM) in South Africa. However, a substantial number of livestock farmers and wildlife ranchers believe that newly proposed policies will interfere with current management strategies and impact negatively on their existence (Anon 2006; Natrass & Conradie 2013).

The social dimension of HPCM addresses the human aspect of the conflict, and has emerged as a most important aspect of HPCM (Manfredo *et al*. 1998; Kleiven *et al*.

2004; Marshall *et al*. 2007; Tegt *et al*. 2010; White & Ward 2010). A major objective of human-dimension research is to analyse the perceptions of different stakeholders towards the conflicting wildlife, the different HPCM strategies used, and the other stakeholder groups (Curtis *et al*. 1993; Miller 2009; Teel & Manfredo 2010). Consequently it attempts to understand the conflicts which may arise because of divergent perceptions (Andersen *et al*. 2003).

Research on human perceptions has found that a person's beliefs and perceptions are generally interrelated (Kennedy *et al*. 1995; Kalternborn *et al*. 1998; Messmer 2000; Miller 2009). Resultantly, human perceptions of HPC or HPCM are a reflection of how these humans are, or may be, affected by these situations (Messmer 2009). This in turn impacts on how that person will react to HPC or HPCM (Hill 2004; Marshall *et al*. 2007; Reiter *et al*. 1999). For example, livestock farmers may perceive a predator species as a potential threat to their livelihood once they believe that it predates on their livestock. In reaction, they will support strategies to decrease the possible impact of predators in their area, including programs which may eliminate or decrease the population numbers of the damage-causing predator. On the other hand, an environmental group may perceive the same species as an imperative part of nature because they believe that it plays an important ecological role in the ecosystem. They would, contrary to the farmers, support strategies to conserve these species. It is evident that conflict will arise from these opposing reactions. People may also feel that they have a personal interest in the wildlife they are in conflict with, and thus also the fate of that wildlife (Conover & Conover 2003; Curtis *et al*. 1993; Reiter *et al*. 1999). As a result Bath *et al*. (2008), Brown & Decker (2005), Martinez-Espineira (2006) and Miller (2009) suggested that people will be non-receptive to HPCM strategies which they feel disregard these interests, often resulting in the failure of such strategies. Daley *et al*. (2004) also suggested that perceptions of conflicting wildlife and associated HPCM strategies may vary markedly in different areas. Therefore, for HPCM strategies to succeed overall, it is imperative to gather information on human perceptions related to the HPC in various areas (Madden 2004; Sillero-Zubiri *et al*. 2007; Dickman 2010).

Past human-dimension studies on human-predator conflicts have mostly focused on endangered species (Ericsson & Heberlein 2003; Marker & Dickman 2004; Bath *et* *al*. 2008; Bisi *et al*. 2008), but research has also been conducted on widespread damage-causing predators in North America (Arthur 1981; Martinez-Espineira 2006; Thornton & Quinn 2009). In South Africa, only a few studies have examined aspects of the human-dimension of black-backed jackal and caracal conflicts with livestock farmers (Bekker 1994; Janse van Rensburg 1991; Minnie *et al*. 2012; Thorn *et al*. 2012). However, there are many examples in the popular literature where people have strong and opposing perceptions regarding problem-causing predators in South Africa, especially black-backed jackal and caracal (e.g. Anon 2006; Gouws 2008; Landmark Foundation 2008).

The available information on the social dimension of human-wildlife conflicts with black-backed jackal and caracal in South Africa was reviewed. It elaborates on the different stakeholder groups associated with the conflicts, the different perceptions which people may hold towards these two predator species and associated HPCM strategies and the different factors that are influencing the above mentioned perceptions. Important social information gaps are identified that needs to be addressed.

7.2 Materials and methods

A literature search (Keywords included in the search: black-backed jackal, *Canis mesomelas*, caracal, *Caracal caracal*, *Felis caracal*, human dimensions, perceptions, social aspects, stakeholders) was conducted for scientific information on social aspects of human-wildlife conflicts with black-backed jackal and caracal (using Academic Search Complete, EBSCOHost, ISI Web of Knowledge, Reference lists). The sources were checked for the following information:

- stakeholder groups;
- stakeholder interests in black-backed jackal and caracal conflicts;
- perceptions of the different stakeholder groups towards black-backed jackal or caracal, associated HWCM strategies, and other stakeholder groups; and
- factors that may influence the different perceptions.

The information is discussed to assess the current understanding on the social aspects of HPC pertaining to black-backed jackal and caracal.

7.3 Results and Discussion

7.3.1 Current information

Only five (5) scientific publications were obtained with information on the social aspects of HPC with black-backed jackal and caracal in South Africa. These include relatively dated studies on the attitudes of farmers towards damage-causing predators in the Eastern Cape (Janse van Rensburg 1991), and on the social and ecological aspects of HPC in farming areas of the south-eastern Cape (Bekker 1994). More recent publications include a listing of different stakeholder groups with a potential interest in HPC in South Africa (Daly *et al*. 2006), an analysis of perceived causes of livestock predations in the Baviaanskloof Mega-Reserve, Eastern Cape (Minnie *et al*. 2012), and an analysis of the drivers responsible for human-carnivore conflicts in rangeland in the North West Province (Thorn *et al*. 2012). This lack of human-dimension information is important, considering the magnitude of conflict with black-backed jackal and caracal in South Africa. Without the necessary human-dimension information it could be difficult to implement sustainable HPCM strategies (Dickman 2010).

7.3.2 Stakeholder groups

In the context of this study a stakeholder is defined as any person or group which possess a particular knowledge of or experience in, or who is affected by, damage-causing predators and the management thereof. Based on this definition, a number of potential stakeholder groups related to HPC with black-backed jackal and caracal in South Africa was identified (Table 7.1). These groups cover a wide range of sectors, including government, livestock farmers and wildlife ranchers, consumers, traditional communities, hunters, environmental groups, and subject experts; within these groups there are currently more than 50 different organizations or institutions in South Africa (Appendix 2). It is important to consider all the stakeholders in HPCM strategies, but Clay (2007) highlighted the importance to also explore the different interests of these groups. The following paragraphs elaborate on potential interests of identified groups. It is important to verify the extent to which these interests apply specifically to black-backed jackal and caracal in South Africa.

Table 7.1: A summary of potential stakeholder groups with interests in human-predator conflicts with black-backed jackal and caracal on livestock farms and wildlife ranches in South Africa (as expanded on from Daly *et al*. 2006)

Group	Stakeholders
Government	National Departments; Provincial Departments
Livestock farmers and wildlife ranchers (commercial and subsistence)	Livestock producer organizations; Wildlife ranching association; Communal farmers
Consumers	Urban, rural and metropolitan communities; Supermarket chain suppliers
Traditional communities	Traditional healers; Herbalists
Hunters	Problem-animal hunters; Recreational hunters
Environmental groups: including non-governmental organizations (NGO's) and non-profit organizations (NPO's)	Conservation groups; Animal rights groups; Animal welfare groups
Subject experts	Scientists; Higher education institutes

7.3.2.1 Government

Governments are generally entrusted with the responsibility to conserve biodiversity and regulate wildlife and wildlife related activities through the development and application of acceptable laws and policies (Conover & Conover 2003). This also applies to South Africa, where HPCM is currently the responsibility of the National Department of Environmental Affairs (DEA) together with the Environmental Departments in each of its nine provinces (Greyling 2006; De Waal 2009, 2012). However, it is often the agricultural sector that suffers most from the impact of human-predator conflicts (Baker *et al*. 2008; De Waal 2012); therefore the National Department of Agriculture, Forestry and Fisheries (DAFF) should also play an important regulatory interest in black-backed jackal and caracal related HPC. Recently, efforts have been made by the Predator Management Forum (PMF) to involve both DEA and DAFF in this specific issue, however, no formal initiatives have been tabled (N.L. Avenant, 2012, National Museum, Bloemfontein, *pers. comm.*).

7.3.2.2 Farmers and Ranchers

The livestock farming and wildlife ranching sectors of South Africa are affected financially by the predation of black-backed jackal and caracal when these species predate on livestock or wildlife. These financial burdens are even more heightened as livestock farmers and wildlife ranchers often need to manage these damage-causing predators themselves (Janse van Rensburg 1991; Bekker 1994; Avenant & Du Plessis 2008).

Besides the negative interests, it is also possible that these two species may contribute positively to the interests of livestock farmers and wildlife ranchers. For example, they may contribute to overall species diversity on ranches, which can be used to attract tourism (Benson 1991) and recreational hunting (Damm 2003). Hence, the presence of black-backed jackal and caracal could increase the financial opportunities for such enterprises. Bekker (1994) also indicated that some South African farmers value predators on their ranches because they are believed to control prey numbers; and in the absence of these predators the latter may increase and compete with livestock for grazing. Increased densities in prey and con-specifics could, additionally, also damage crops and farming equipment, and increase the risk of diseases (see **Chapter 2**). Black-backed jackal and caracal may, in these roles, thus contribute positively to the financial interest of farmers. Messmer (2000, 2009) further noted the emotional satisfaction that many farmers get from seeing and experiencing predators on their properties.

7.3.2.3 Consumers

Consumers, which include supermarket chain suppliers and urban, rural and metropolitan communities, show a variety of interests in wildlife. Suppliers may have an indirect financial interest in black-backed jackal and caracal when clients are lobbied to boycott their products as a result of perceived inhumane HPCM strategies aimed at these species (Bezuidenhout 2008). Consumers of meat products, which include urban, rural and metropolitan communities, may also have an indirect financial interest in damage-causing black-backed jackal and caracal when meat prices escalate due to the impact of predation (Knowlton *et al*. 1999). Furthermore, rural economies often depend on agricultural activities and these communities could thus be affected financially when farming activities or income decrease in their areas due to the impact of black-backed jackal and caracal predation (Asheim & Mysterud 2004; Jones 2004; Shwiff & Bodenchuck 2004; Thornton & Quinn 2009).

However, similar to livestock farmers, the rural communities may also have a psychological interest in these two animals because of the enjoyment to live close to them (Erricson & Heberlein 2003). Metropolitan residents may have recreational interest in black-backed jackal and caracal when they visit natural areas (Feldman 2007), while they may have interests in the contributions made by these two species towards functional ecosystems (Schwartz *et al*. 2003). Urban communities, as a whole, may be interested in the overall well-being of black-backed jackal and caracal (Reiter *et al*. 1995; Andersen *et al*. 2003).

7.3.2.4 Traditional communities

Although not generally considered in HPCM, traditional communities are often acknowledged as an integral sector of South African society. It is therefore important to determine these people’s cultural interest in black-backed jackal and caracal, and the HPCM strategies aimed at predators.

7.3.2.5 Hunters

Hunters in South Africa may have a financial and a recreational interest in black-backed jackal and caracal. Many hunters in South Africa make a living from hunting damage-causing predators (Funk 2010; De Waal 2012), while others hunt damage-causing animals recreationally (Stewart 1995; Damm 2003). Furthermore, black-backed jackal or caracal may have potential negative impacts on game numbers (see **Chapter 2**), indirectly affecting the interest of hunters.

7.3.2.6 Environmental groups

Environmental groups have emerged as important stakeholders in HPC (Conover & Conover 1997). This group is generally comprised of conservation groups whose main interests are to conserve species and or ecosystems (EWT 2010); animal welfare groups whose interest lie with ensuring that wildlife does not suffer unnecessary; and animal rights groups whom are interested in defending the rights of animals (Miller 2003; Feldman 2007).

7.3.2.7 Subject experts

Subject experts may have a research interest in HPC that involves black-backed jackal and caracal. Several studies have mentioned the importance of research and education to implement successful HPCM strategies (Messmer 2000; Ericsson & Heberlein 2003; Kleiven *et al*. 2004), thereby highlighting the importance of subject expert interest in HPCM.

7.3.3 Perceptions towards black-backed jackal and caracal, and the associated human-predator conflict management strategies

Apart from knowing the stakeholders and their interests, for HPCM to be successful it is imperative to understand the different perceptions which these groups may have towards conflicting wildlife and HPCM methods/strategies aimed towards these species (Teel & Manfredo 2010). These perceptions are generally a reflection of how humans are affected (Messmer 2009), it is not fixed (Thornton & Quinn 2009), and its degree may differ (Messmer 2000). There is currently virtually no information published in scientific literature on people’s perceptions on HPC involving black-backed jackal and caracal, or on HPCM methods/strategies used for these species in South Africa (Janse van Rensburg 1991; Bekker 1994; Minnie *et al*. 2012; Thorn *et al*. 2012). There are, however, various indications in the popular literature that the South African society may form strong perceptions about these predators and related HPCM strategies (Anon 2006; Gouws 2008; Landmark Foundation 2008), while published work on other related damage-causing predators can also be used to increase comprehension. Nonetheless, it remains important to study the degree to which these perceptions are associated with the different stakeholders related to black-backed jackal and caracal, and associated HPCM in different areas of South Africa.

7.3.3.1 Damage-causing species

A large proportion of South African livestock farmers and wildlife ranchers perceive black-backed jackal and caracal as damage-causing predators that may cause significant stock losses (Van Niekerk 2010; Minnie *et al*. 2012). As a result they are reluctant to tolerate these species on their farms, find it difficult to recognize the potential role of these species in “rangeland” ecosystems (see **Chapter 2**) and generally want to see the numbers of these species controlled (Bekker 1994). Studies on other predators have similarly noted the low tolerance of people towards these perceived damage-causing predators once they have experienced losses that could be ascribed to these species (Andersen *et al*. 2003; Gianattos 2004; Marker & Dickman 2004). Bekker (1994), Thornton & Quinn (2009) and Thorn *et al*. (2012) noted that the extent of the perception that predators are damage-causing animals may, however, vary mostly due to the level of losses that have been experienced (personally, or aware off) in the past. Resultantly, a producer who has experience of high levels of predation by a specific predator may have a more antagonistic attitude towards this predator than a producer that have experience of less damage.

Furthermore, Messmer *et al*. (1999) noted that other stakeholders, who do not personally experience damages from a specific predator but are aware of it, may also perceive these predators as damage-causing – but then usually to a lesser degree.

7.3.3.2 Environmental importance of species

Bekker (1994) noted that some livestock farmers in South Africa value predators for their role in controlling competing herbivore species on their ranches. In the same way, some people (including consumers, the general public and environmentalists) may have the perception that predators should exist because of their role in nature. These people could be interested in the fact that predators form an integral part of ecosystems and contribute to biodiversity regulation (Andersen *et al*. 2003) or that they have an inherent right to exist in nature (Messmer *et al*. 1999; Martinez-Espineira 2006). In contrast, some people may also perceive predators negatively because of their negative impact on the environment (Nimmo *et al*. 2007). The contribution of predators to overall biodiversity numbers, without considering the potential role they play in biodiversity regulation, have also be found to be valued (Messmer *et al*. 1999; Messmer 2000; Conover & Conover 2003; Schwartz *et al*. 2003; Messmer 2009).

Generally, people that value predators for their positive environmental significance do not want to see the predators of concern being exterminated. On the contrary, people who believed that predators impact negatively on biodiversity generally wants these predators under control.

7.3.3.3 Humaneness/Environmental friendliness of HPCM strategy/method

Apart from having perceptions about conflicting wildlife, people may have strong perceptions about certain HPCM strategies or methods (Clay 2007; Baker *et al*. 2008). This may include that some strategies/methods are inhumane (Feldman 2007), does not consider the welfare of the target animals (Andersen *et al*. 2003), and it has various impacts on the surrounding environment (Sillero-Zubiri & Switzer 2004). These people are generally against the use of such strategies/methods.

7.3.3.4 Effectiveness of HPCM strategy/method

Some people view certain HWCM strategies and or methods as ineffective (Natrass & Conradie 2013) or expensive (Curtis *et al*. 1993) and will be reluctant to use these approaches.

7.3.4 Potential factors influencing the perceptions on black-backed jackal, caracal and associated HPCM strategies

Human perceptions towards wildlife and HPCM are generally not fixed (Thornton & Quinn 2009), and levels may also differ (Messmer 2000). Therefore, apart from being aware of the different perceptions, it is vitally important to understand the dynamics (Miller 2009). Factors that may influence these perceptions are discussed below. However, only some of these factors are currently known to apply to the perceptions on black-backed jackal, caracal, and the HPCM used to control these species in South Africa (Janse van Rensburg 1991; Bekker 1994; Minnie *et al*. 2012; Thorn *et al*. 2012).

7.3.4.1 Potential threat of wildlife

The threat which a specific wildlife species poses to humans or their existence may influence their perceptions of that species. Many South African livestock farmers perceive black-backed jackal and caracal as a threat to their existence because of the economic losses caused by predation, and as a result the ranchers generally want these species removed from their farms (Bekker 1994). Several studies, on other predators, similarly, indicated that ranchers may develop strong perceptions on predators that cause economic losses and presumably threaten their existence (Arthur 1981; Reiter *et al*. 1995; Messmer 2000; Kleiven *et al*. 2004). Bekker (1994) and Thorn *et al*. (2012) further noted that the degree of this perception may vary, based on the degree of the economic loss. Ranchers that experience high losses may therefore perceive black-backed jackal and or caracal as a larger threat. Kleiven *et al*. (2004), however, cautioned that the tolerance of a specific wildlife species is often not directly equivalent to the economic losses caused by that species. For example, the specific economic loss caused to a farmer by a specific predator might not be that high, but because the farmer incurs cumulative losses from a variety of causes, the predation losses due to this predator may be less acceptable (Minnie *et al*. 2012). Sillero-Zubiri *et al*. (2007) speculated that people with an alternative option than keeping livestock may also be more tolerant.

Martinez-Espineira (2006) noted that people are less acceptant of a wildlife species which carry diseases. Bath *et al*. (2008) also noted a lower acceptance in people with elevated fear for specific wildlife. In both these instances the people were more in favour of removing these species.

7.3.4.2 The impact of HPCM strategies/methods on wildlife well-being

Animal welfare and ethical considerations have in recent years emerged as important aspects of wildlife management operations (Baker *et al*. 2008). It has not yet been evaluated to what extent these considerations influence human perceptions of black-backed jackal, caracal and their management. Welfare and ethical considerations may influence perceptions of HWCM strategies/methods, with people opposing those strategies/methods which they believe threatens the well-being of wildlife (Martinez-Espineira 2006; Feldman 2007). These people may, for example, fight the use of non-target specific methods, such as poison, (Feldman 2007) and methods which cause physical harm to target species (Reiter *et al*. 1995; Andersen *et al*. 2003; Landmark Foundation 2008).

7.3.4.3 The impact of wildlife or the HPCM strategy/method on the environment

People also form perceptions of wildlife or HPCM strategies/methods based on the perceived positive or negative impact that it may have on the environment. It is still unknown to what extent this applies to black-backed jackal, caracal, and their management. Lybecker *et al*. (2002) and Nimmo *et al.* (2007) noted that wildlife that are believed to cause a marked impact to the environment, such as causing overgrazing, were less accepted. People perceive such wildlife as a threat to the environment, and as a result, are supportive of operations to control them. On the contrary, wildlife which is believed to play an important role in ecosystem functioning is more accepted, and people are reluctant to see such species being controlled (Hewitt 2001). People are, also less receptive of, and generally opposed to, management methods which are believed to have a significant negative impact on the environment, such as poison that accumulate in the environment and potentially impact on non-target species (Martinez-Espineira 2006).

7.3.4.4 Personal experiences of wildlife

Personal experience may influence human perceptions of specific wildlife species. Kleiven *et al*. (2004) noted that by personally experiencing wildlife in natural areas it contributed to some people's overall experience of those areas. Removing the wildlife from these natural areas would thus impact on the experience people would draw from the areas. However, Conover & Conover (2003) also noted that some people may have a similar positive experience of nature by just knowing that wildlife exist somewhere in nature without experiencing it personally. Therefore, just the thought that wildlife exist in a specific area may enhance the experience that people associate with the area. Overall, people who connected certain wildlife species with their personal experiences were generally against the control of the species. It is unsure to what degree this is relevant to black-backed jackal and caracal.

7.3.4.5 Level of knowledge

Some evidence suggests that the various levels of knowledge on the conflicting situation may contribute to human perceptions of conflicting wildlife or HPCM. Kleiven *et al*. (2004) and Bath *et al*. (2008) noted that people had a more positive perception of damage-causing predators when they were better informed on them. Similarly, Martinez-Espineira (2006) found that the public was more tolerant of proposed HPCM after the rationale was explained. Consequently, it could be expected that the human perception of a conflicting predator or HPCM may change once more knowledge are gained and shared.

7.3.4.6 Sense of loss of control

When people feel that they do not have any control over specific HPC, it may impact their perceptions of these conflicts. Lybecker *et al*. (2002), Kleiven *et al*. (2004) and Madden (2004) noted that, when certain predators were protected by law on private land, landowners felt that they lost authority and control over what happened on their land and this contributed to their dislike towards the protected predators. Both Bisi *et al*. (2007) and Bath *et al*. (2008) also experienced that some people disliked specific species more once they felt that they did not have a say in their management.

7.3.5 Importance of multidisciplinary research

Although some information exists on aspects pertaining to the social dimension of HPC with black-backed jackal and caracal in South Africa, it is apparent that information gaps remain. By reviewing human-dimension studies on other similar HPC scenarios it is evident that the wide range of perceptions which various stakeholders may hold towards black-backed jackal, caracal and associated management strategies are not yet understood. Neither is there an understanding of the factors which motivate and or drive these perceptions.

Furthermore, Marker *et al.* (2003) found that farmers were more receptive of certain HPCM strategies towards cheetah *Acinonyx jubatus* in Namibia once they were educated and informed about the species and its' management. From a human perspective, therefore, more research and education are needed for the development of sustainable HPCM strategies for black-backed jackal and caracal (Tegt *et al*. 2010; Natrass & Conradie 2013). With the relevant research (ecological, social and economical) wildlife managers will also better understand how different HPCM policies and strategies could impact black-backed jackal, caracal and the interests of different stakeholders (White & Ward 2010), and from these pre-empt better how predators and stakeholders may respond (Messmer 2000; Lybecker *et al.* 2002; Miller 2003; Treves & Karanth 2003). The knowledge gained from this research can be used to justify selected HPCM policies and strategies towards black-backed jackal and caracal, and to educate stakeholders on its trade-offs (Hewitt 2001; Martinez-Espineira 2006; Marshall *et al.* 2007).

7.4 Conclusions

The general lack of information on the social dimension of HPC with black-backed jackal and caracal in South Africa, and the HPCM strategies implemented against them, was highlighted. This is important, especially when considering the long history of HPCM for black-backed jackal and caracal in rangeland in South Africa.

A number of stakeholder groups with interest in black-backed jackal and caracal were identified. From the limited number of South African and other related studies it is evident that these groups will have different perceptions of the two species and their management. It is important to understand these perceptions and how people may respond to these species and their management. There is also a variety of factors that could influence these perceptions.

The social dimension of HPC involving black-backed jackal and caracal in South Africa is extremely complex. It is important to study these social aspects in a variety of areas in South Africa and to include this information in future HPCM strategies on livestock and wildlife ranches, in order for it to be sustainable (Miller & McGee 2001; Dickman 2010; White & Ward 2010). For example Clay & Schmidt (1998) discussed how, through stakeholder engagement and the development of cooperative research programs, federal predator management programs in the United States of America (USA) have been able to identify public issues regarding management programs and control techniques. They could then adjust policy to address these issues. An important outcome of the engagement process was that research focus has shifted towards non-lethal predator control techniques because concerns were raised regarding certain lethal techniques (Clay & Schmidt 1998). Miller (2007) likewise demonstrated the important role that human-dimension research played in creating awareness regarding certain social aspects and concepts of HPCM associated with the activities of Wildlife Services (WS) in the USA. This research contributed to the formulation of new regulations and the revision of operational control programs within WS. Overall, both Clay & Schmidt (1998) and Miller (2007) mentioned the higher degree of social acceptability, and presumably social sustainability, in WS HPCM programs after the social information were integrated. Human-dimension research has, similarly, played an important role in the restructuring and development of government-led wildlife management processes in recent years in Australia and New Zealand (Miller 2009).

8. Conclusions and the way forward

Available information on black-backed jackal *Canis mesomelas* and caracal *Caracal caracal* in South Africa was collated and explored with the aim to assist in the development of a sustainable human-predator conflict management (HPCM) strategy for these two species in rangeland (livestock farms and wildlife ranches). Several aspects were identified which should help in directing such a strategy; these include information on the ecology of both damage-causing species and the ecological interactions pertaining to them in different ecosystems, their predation patterns, the economic impact of their predation and associated management practices, the success and feasibility of management methods, and the social dimension related to HPCM and the specific animals.

Applicable data for abovementioned aspects is crucial for the development of sustainable HPCM strategies in rangelands. Although some of these aspects have received attention in the past, it is clear that the studies were rarely aimed towards the management of damage-causing black-backed jackal and caracal. Furthermore, the relatively few initiatives aimed at such management were carried out in isolation. The result is a lack of focussed information on these topics. More scientific information is urgently needed by incorporating measures to overcome the shortcomings that have been identified in the current knowledge base.

8.1. Conceptualising the process towards a sustainable human-predator conflict management strategy for black-backed jackal and caracal in rangeland

Despite the long history of black-backed jackal and caracal conflict with livestock farmers and wildlife ranchers in South Africa (Stadler 2006; Nattrass & Conradie 2013), a comprehensive HPCM strategy is still lacking. On the contrary, many efforts have resulted in a perceived increase in population density and distribution of these two species, while the ecological, social and economic sustainability of the efforts are often questionable (Avenant & Du Plessis 2008; De Waal 2009). In view of the apparent flaw of the strategies, the current study was initiated to aid the development of a sustainable HPCM strategy for damage-causing black-backed jackal and caracal in rangelands in South Africa.

A number of aspects have been identified to achieve such a sustainable strategy. In addressing these aspects it is important to engage with a range of scientific disciplines, including animal ethics and welfare experts, biodiversity specialists, economists, ecologists, environmental and wildlife managers, environmental lawyers, ethologists, livestock scientists, pathologists, public relation specialists and social scientists.

The aspects or steps needed to develop such a strategy are provided in a conceptual model (Fig. 8.1) where each step is necessary to reach the desired-state (≈ a sustainable HPCM strategy for damage-causing black-backed jackal and caracal in rangelands in South Africa). The central bold arrow orientate towards the desired-state, while the side arrows pointing to the central arrow indicate the primary steps (≈ aspects identified during this study) necessary to reach the desired-state.

The primary steps include:

- understanding the ecology of black-backed jackal and caracal in rangeland, specifically on livestock farms and wildlife ranches;
- understanding the economic value of black-backed jackal and caracal;
- understanding the patterns of predation losses caused by black-backed jackal and caracal in rangeland;
- evaluating different management options to mitigate the effect of predation by black-backed jackal and caracal in rangeland; and
- understanding the human-dimension of conflict with black-backed jackal and caracal.

It is important to note that although the primary steps are numbered chronologically in the model, this is not suggesting the importance of steps; each step is equally important in the process. In turn, each primary step contains various secondary steps (Fig. 8.1), which also need to be considered. Policy development and HWCM regulation should evidently also play an important part in this process (see **section 8.1.6**).

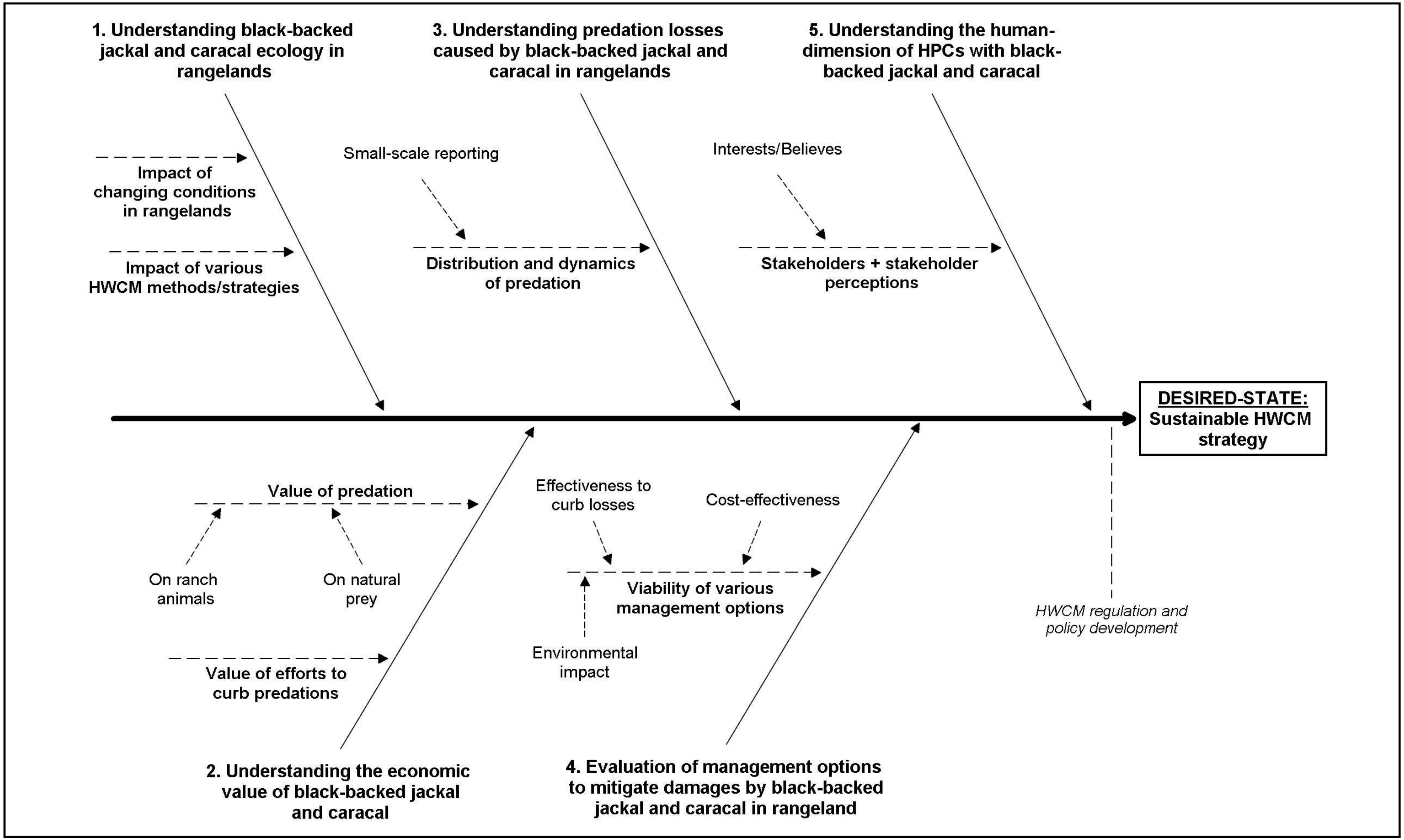


Fig. 8.1: Desired-state fishbone model (adapted from Tague 2005) indicating the primary and secondary steps necessary to develop a sustainable human-predator conflict management strategy for black-backed jackal and caracal in rangelands.

For each of the five primary steps (**sections 8.1.1** through **8.1.5**) a number of research questions can be highlighted. Apart from the information that already exists on various aspects of HPCM related to black-backed jackal and caracal (as discussed in each chapter of the current study), answering some key research questions will systematically complement the existing knowledge on damage-causing black-backed jackal and caracal and their management. Collectively, these should make a valuable contribution towards the development of a sustainable management strategy for these two predators in rangelands in South Africa.

8.1.1 Understanding black-backed jackal and caracal ecology in rangeland

One of the conditions for a sustainable HPCM strategy is a good understanding of the ecology of the species which are to be managed. Without such an understanding it is difficult to 1) know how, when and where to apply management interventions that will ensure effective management of the target species, 2) predict the impact of different interventions on target animals, their behaviour and ecology, and 3) predict the outcome of various interventions to alleviate conflicts. Although some available information on the ecology of black-backed jackal and caracal can be used in HPCM strategies for these two predators, most are unrelated and may not apply directly to their management. Further, most of the available results originate from studies that were conducted in natural areas and the conclusions drawn from these may not apply to rangeland areas. It is evident that more applicable information is needed on the ecology of black-backed jackal and caracal in rangelands. The experiences gained from other, ecological similar, damage-causing predators can be used as a basis to formulate applicable research questions.

Also: predators play an important role in the functioning of ecosystems by suppressing competing predators and prey populations. Removing them from ecosystems may have negative impacts, such as lower-predator release, an eruption of prey numbers, and an overexploitation of associated species. It is, therefore, imperative to understand the potential ecological role of damage-causing carnivores in related environments, and to understand how this may be influenced by different HPCM strategies. Limited available evidence suggests that black-backed jackal and caracal could play an important role to suppress coexisting predator and prey populations. Their exclusion from, or severe suppression in, an area may impact negatively on associated ecosystems and biodiversity. More information is needed on the ecological role of black-backed jackal and caracal under rangeland conditions to accurately pre-empt the impact of certain HPCM strategies on natural biodiversity in rangeland ecosystems, rangeland dynamics, livestock production and predation.

The current investigation suggests that scientific information on the ecology and ecological roles of black-backed jackal and caracal is too limited to develop a sustainable HPCM strategy in rangelands and information gaps needs to be addressed. Some of the key research questions include:

- What are the distribution and relative densities of black-backed jackal and caracal in South Africa?
- What are the drivers behind the recently reported black-backed jackal and caracal population increases and shifts? (If true).
- What is the impact of food availability, as well as fluctuations in availability, on black-backed jackal and caracal social ecology in rangelands?
- Do (have) black-backed jackal and caracal learn (learned) to predate and or specialize on livestock or introduced wildlife?
- Are the densities of dens higher in rangelands and small protected areas than in natural areas?
- Are the litter sizes of black-backed jackal and caracal larger in rangelands and small protected areas than in natural areas?
- If the litter sizes are larger on rangelands, what is driving these increases?
- How many young in a litter are raised successfully in rangelands, and how does this compare with that in larger natural areas?
- Does compensatory breeding occur in black-backed jackal and caracal populations in rangeland, and how does it impact on livestock or introduced wildlife predation?
- If compensatory breeding occur, what are the mechanisms that trigger this adaptation?
- What is the extent and role of black-backed jackal and caracal to suppress associated predator and prey populations in rangelands?
- What are the various indirect ecological impacts of HPCM strategies aimed at black-backed jackal and or caracal?

8.1.2 Understanding the economic value of black-backed jackal and caracal in rangeland

A sustainable HPCM strategy should consider the losses against the economic value of the conflicting wildlife and the value and cost of different HPCM strategies. For an objective view it is important to include both the direct and indirect costs associated with the presence of this component of wildlife in the environment, as well as the benefits to be derived from having them as part of the ecosystem in rangeland areas. It should also include an assessment of the potential costs and benefits of different HPCM strategies.

The pool of scientific information gathered during this study demonstrated the paucity of information that can serve as basis for meaningful economic evaluations of damage-causing black-backed jackal and caracal. Little, mostly isolated, information could be found on some financial costs and benefits associated with black-backed jackal and caracal predation and or their management on livestock farms and wildlife ranches. These demonstrate the potentially high cost of black-backed jackal and caracal predation in rangelands, the short-term financial benefits accrued where these species are continuously controlled on isolated properties, and the financial benefits of using active livestock management and precautionary techniques over continuous, non-selective predator management. A range of other costs and benefits for which no scientific evidence is available, however, still exists hampering our ability to expand on the economic sustainability of different HPCM strategies. It is important to address information gaps such as:

- What are the direct and indirect economic costs of black-backed jackal and caracal to the livestock and wildlife industries in different parts of South Africa?
- What are the costs and benefits associated with black-backed jackal and caracal as predators of natural prey?
- What are the recreational and cultural costs and benefits associated with black-backed jackal and caracal?
- What are the cascading costs and benefits associated with having, and not having, black-backed jackal and caracal present?

- What are the short and long-term costs and benefits of different HPCM methods, as well as the accumulated cost/benefit of the sum of individual management efforts?

8.1.3 Understanding predation losses caused by black-backed jackal and caracal in rangeland

Quantitative information on livestock and wildlife predation is needed to substantiate reported losses, to provide justification for HPCM decisions and most importantly to develop sustainable HPCM strategies through an improved understanding of the dynamics of predation.

From the current study, it is clear that there is insufficient scientific information to substantiate predation losses caused by black-backed jackal or caracal in rangeland in South Africa. Only a small part of the data available can be used to objectively verify predation losses in rangelands. Scientific evidence to support claims that these predators are primarily responsible for the impact to the livestock industry is limited, while there is no scientific information to confirm their impact on the wildlife ranching industry. The information on livestock depredations is mostly dated (before 1990), covers short temporal periods, or are restricted to some localised areas. Hence, while the data published can be used to confirm that predation has occurred in some areas at a specific time it is not suitable to verify the many popular claims that black-backed jackal and caracal predation have increased recently and that it occurs throughout South Africa. There is also insufficient data to illustrate seasonal or annual changes in predation. Similarly, there is a lack of data at a small enough scale to demonstrate the spatial dynamics of the predation. The information, further, mostly does not distinguish between different predators, rendering it difficult to understand the specific part played by black-backed jackal or caracal in livestock predation. The scant information limits our understanding of the dynamics of predation by black-backed jackal and caracal. Overall, it remains important to gather more information on this topic, such as:

- What are the spatial, seasonal and annual patterns of predation losses in the livestock and wildlife industry in South Africa?
- Where and when does livestock or wildlife predations occur?

- How does livestock or wildlife predations relates to ecosystem parameters, such as changes in predator and or prey composition and density?
- What role do factors such as climate, seasonality, topography, habitat composition and structure, management regime and farm type play in predation losses?

8.1.4 Evaluation of management options to mitigate damage caused by black-backed jackal and caracal in rangeland

Specific methods used in a sustainable HPCM strategy presuppose results or effects, namely: it effectively mitigates conflict, is economically viable (i.e. cost effective) and negative environmental impacts are limited.

Of the fairly large number of publications which covered aspects of the management of damage-causing predators in South Africa, the majority was published in popular literature and only a few in scientific journals. Only a small number of these publications refer to the actual management of black-backed jackal or caracal. It is evident that most HPCM interventions currently aimed at black-backed jackal and caracal in South Africa are implemented by farmers, following personal experience or word of mouth. As a result, management efforts are mostly conducted in isolation and without any coordination over larger areas. From the available information it is apparent that a range of management methods are or have been used to manage damage-causing black-backed jackal and caracal, but virtually no scientific information is available on their success, potential or shortcomings.

This study also identified methods reported in local and international literature which can potentially be used to provide insight into the management of damage-causing black-backed jackal and caracal in South Africa. Based on the number of citations in the South African literature, there already appears to be general awareness for most of these methods in South Africa. However, there is a general lack of scientific evidence to support the effectiveness and feasibility of these methods in managing specifically black-backed jackal and caracal in rangelands in South Africa, and the effect these may have on biodiversity and the ecosystem(s).

Clearly, the feasibility of different management options to mitigate the damage by black-backed jackal and caracal under different farming and ranching conditions needs to be researched. The following may provide valuable insight into the use of the different HPCM methods:

- What is the viability and success of the various HPCM methods that are used, or of those that could potentially be used, to manage black-backed jackal and caracal predation?
- How does the viability and success of different HWCM methods change in different parts of South Africa, on different rangeland types, and under different management regimes?
- Which combinations of HPCM methods work well in conjunction, and under which circumstances?

8.1.5 Understanding the human-dimension of HPCs with blacked-backed jackal and caracal

In the course of HPCM, perceptions are formed about conflicting wildlife, the management strategies used, and other stakeholder groups. These perceptions could in some instances be a reflection of their interest in the specific wildlife species, or a specific HPCM strategy. As a result people may be non-receptive for HPCM strategies which they feel are in disregard of these interests, often resulting in the failure of such strategies. Therefore, apart from the need for biological information on HPC, it is also important to understand the social aspects of these conflicts and to build them into HPCM strategies in order to obtain sustainability.

Once again, a limited number of studies were available on the social aspects of human conflict with black-backed jackal and caracal. Some of these are also relatively dated. From the current study it is evident that vital information gaps still exist on the social dimension of HPC with black-backed jackal and caracal, and associated management aspects. Immediate research questions include:

- Who are the stakeholders that have an interest in HPCM related to black-backed jackal and caracal?
- What are their interests in black-backed jackal and or caracal, and their management?

- How does these interests relate to the perceptions that they have of black-backed jackal and or caracal, and their management?
- What can affect the diversity of the relevant perceptions?
- How do the various interests and perceptions reflect in people's actions towards black-backed jackal or caracal and their management?

8.1.6 Considerations for future human-wildlife conflict management policy development and regulation in South Africa

As highlighted earlier (see **section 1.3.2**), existing HWCM policies and regulations in South Africa are fragmented and dated, and need revision. Throughout the current study several factors became evident which may influence the viability of newly developed policies and regulations related to damage-causing black-backed jackal and caracal. Some of these are discussed below, while it is possible that others may also impact HWCM decision making.

The general lack of scientific information on various aspects of HPC with black-backed jackal and caracal in South Africa may have profound implications for the sustainability of future HWCM policies or regulations. For example, policies or regulations developed can have extensive negative implications for livestock and or wildlife producers and their associated economies (Anon 2006). Without the necessary scientific backing, such regulations can lead to successful legal challenges [e.g. SA Predator Breeders Association vs. Minister of Environmental Affairs (72/10) ZASCA 29 November 2010]. Human-wildlife conflict management policies and or regulations developed without knowing the environmental impact of these could also have pronounced long-term negative impacts on the associated ecosystems (Glen & Dickman 2005). It is thus important for policy makers to acknowledge the need for more sound scientific information before attempting to draft sustainable HWCM policies and or strategies in South Africa. It is also important to develop HWCM policies or regulations in a manner that will enable continual refinement as new scientific evidence becomes available. From a policy development perspective, it is also important for policy makers to understand that without the necessary scientific knowledge it could be difficult to inform stakeholders on the validity and trade-offs of different policies and or regulations (Hewitt 2001;

Martinez-Espineira 2006; Marshall *et al*. 2007). Overall, it highlights the obligation of the South African government, as the custodian of both biodiversity and food security in South Africa, and the principle regulator of HWCM policy, to actively get involved in research and development pertaining to damage-causing animals (also see **section 8.2**).

For HWCM policies and or regulations to be sustainable, it is important to consider the impact on a local level. Some HWCM methods may, for example, work effectively in some areas or under specific farming regimes, but is less successful in others (see e.g. Knowlton *et al*. 1999; Andelt & Hopper 2000). Developing HWCM policies and or regulations that favour such methods may thus exclude the interests of the latter areas/farms, thereby losing the collaboration of a significant proportion of role players.

Human-wildlife conflict management policy is currently regulated on a provincial level, with each province applying its own set of policies (Greyling 2006). However, black-backed jackal, for instance, is known to disperse over extensive areas (Bothma 1971b; Ferguson *et al.* 1983), which may include more than one province. It is, therefore, important to formulate consistent policies and regulations which will allow the management of damage-causing species in similar ways across provinces. Human-wildlife conflict management policies and regulations should, further, set systems in place which allow the management of damage-causing animals in a co-ordinated manner over multiple properties. As such, policy makers should acknowledge the importance of co-ordinated HWCM strategies spanning multiple properties and across geopolitical borders.

Human-wildlife conflict management policies and or regulations may also be strongly challenged on social grounds, sometimes based on emotion and without the necessary scientific evidence. Feldman (2007) demonstrated, for instance, how federal predator control policy in the USA has been reformed comprehensively in a large part due to public opinion and perception. Some of the major reforms included the banning of poisons and decreased trapping. Consumer boycotts can also be used in attempts to change HWCM policies and or regulations (Landmark Foundation 2008). Unless current HWCM policies and regulations consider and address the interests and believes of all potential stakeholder groups, its sustainability could be in jeopardy. This, again, highlights the importance to gather more scientific information on HWCs to educate stakeholders and strengthen counter arguments against public outcry.

Finally, it is important that HWCM policies and or regulations consider the economic and social consequences of its implementation. Local economies may rely heavily on specific agricultural activities and, if the latter are limited or shut down by stringent regulations, it may have profound socio-economic consequences for the wider community (Asheim & Mysterud 2004; Jones 2004; Thornton & Quinn 2009). For instance, during mid-2000 the South African government proposed to classify black-backed jackal and caracal as protected species. In order to manage them, producers and managers would then have to gain the necessary permits (National Environmental Management Biodiversity Act: Act no. 10 of 2004). It was widely believed that these regulations would impact severely on livestock and wildlife production in South Africa, and many ranchers feared that this would force them to shutdown business, leading to extensive job losses (Anon 2006) and significant knock-on effects (it has been estimated that for every 5 jobs lost in the South African agricultural sector 25 dependants may be negatively impacted; P. de Wet, 2011, Chair: Predation Management Forum of South Africa, *pers. comm.*). Such stringent regulations could also have hampered livestock or wildlife farming practices, negatively impacting production, product prices and, ultimately, food security (Knowlton *et al*. 1999; J. Klopper, 2012, Chair: Predation Management Forum of South Africa, *pers. comm.*).

8.2 Interrelatedness of steps

It is most important to realise that the abovementioned steps are interrelated (Fig. 8.2). Therefore, to address any step successfully, input may therefore be needed from other steps. For example, to fully understand the human-dimension of HPC with black-backed jackal and caracal, it is important to understand the interests of different stakeholders in these predators and the HPCM strategies used against them. One of these interests may stem from the fact that stakeholders take advantage from the ecological role that black-backed jackal and caracal play in ecosystems. To understand the degree of these interests, it is necessary to have the knowledge or to conduct an ecological study on the role of black-backed jackal and caracal in ecosystem functioning. The information on the ecological role of black-backed jackal or caracal in ecosystems is also necessary to calculate the overall economic value of these two predators in rangelands. Furthermore, an objective economic evaluation of black-backed jackal or caracal in rangelands may require 1) input form human-dimension studies to determine the value of these two predators to applicable stakeholders, 2) information on the exact losses that these two predators cause through predation, 3) an evaluation of the cost effectiveness of different HPCM used against these species, and 4) an understanding of the impact of different management option(s) on the ecology of black-backed jackal, caracal and the ecosystem.

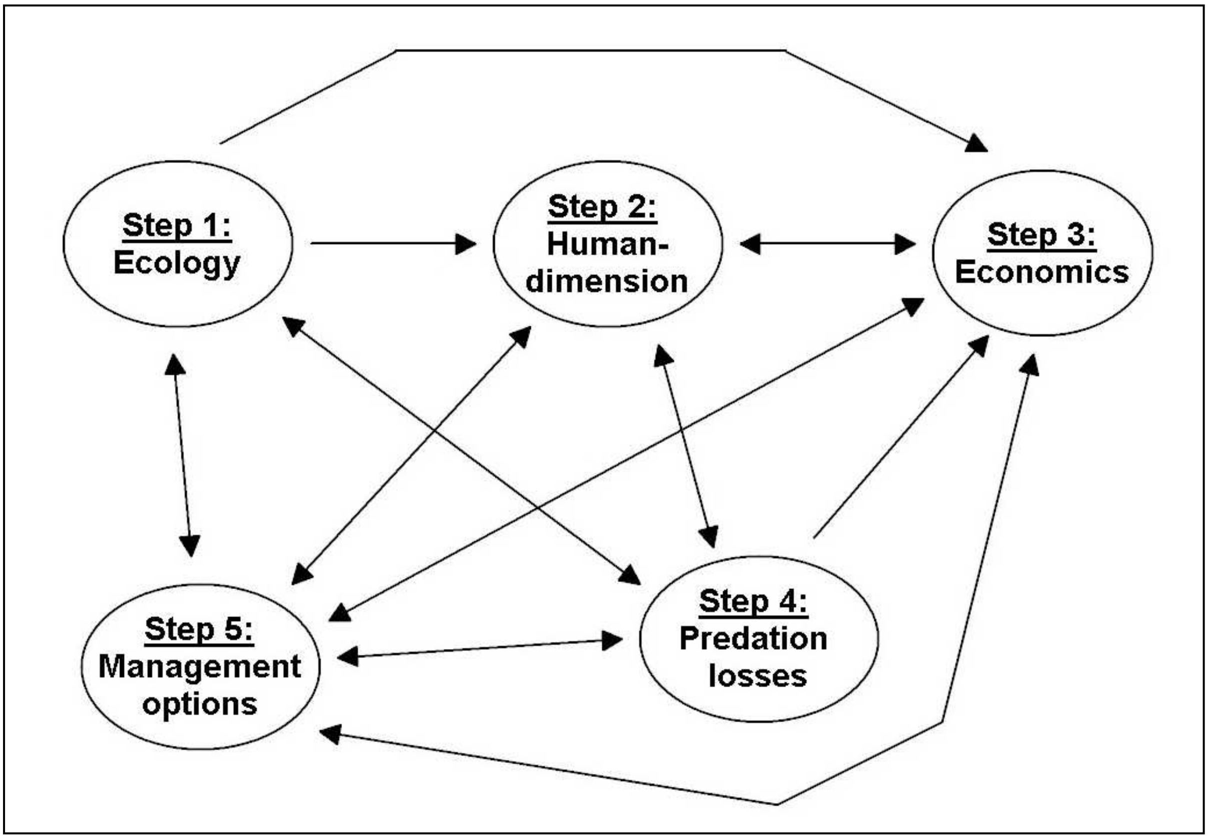


Fig. 8.2: Relationship between different steps necessary for the development of a sustainable human-predator conflict management strategy for damage-causing black-backed jackal and caracal in rangeland.

Considering the interrelatedness of the various aspects it is important to realise that all stakeholders, including ecologists, social scientist, economists, wildlife managers, farmers, ranchers and government officials will have to contribute if a sustainable management strategy for black-backed jackal and caracal in rangeland in South Africa are to be developed. Future research should be directed, co-ordinated and conducted systematically as a combined effort to ensure that the understanding of these damage-causing species is complemented and priority knowledge gaps filled in a focused way. Setting short and long-term goals will be most important, as will be the continuous cooperation and feedback between participating stakeholders.

Coordination of research and management may best be achieved through a system of coordinated predation management. A model, whereby coordination between different stakeholders (see Appendix 2) could be achieved, is proposed in Fig. 8.3. While it is possible that more permutations may develop, this model should provide all stakeholders with an opportunity to give input or feedback into a centralised system. Ideally, such an envisaged system is also the appropriate entity to develop and maintain an integrated institutional memory on related aspects of predation and will provide better opportunities for monitoring and information sharing, as well as training, education and extension.

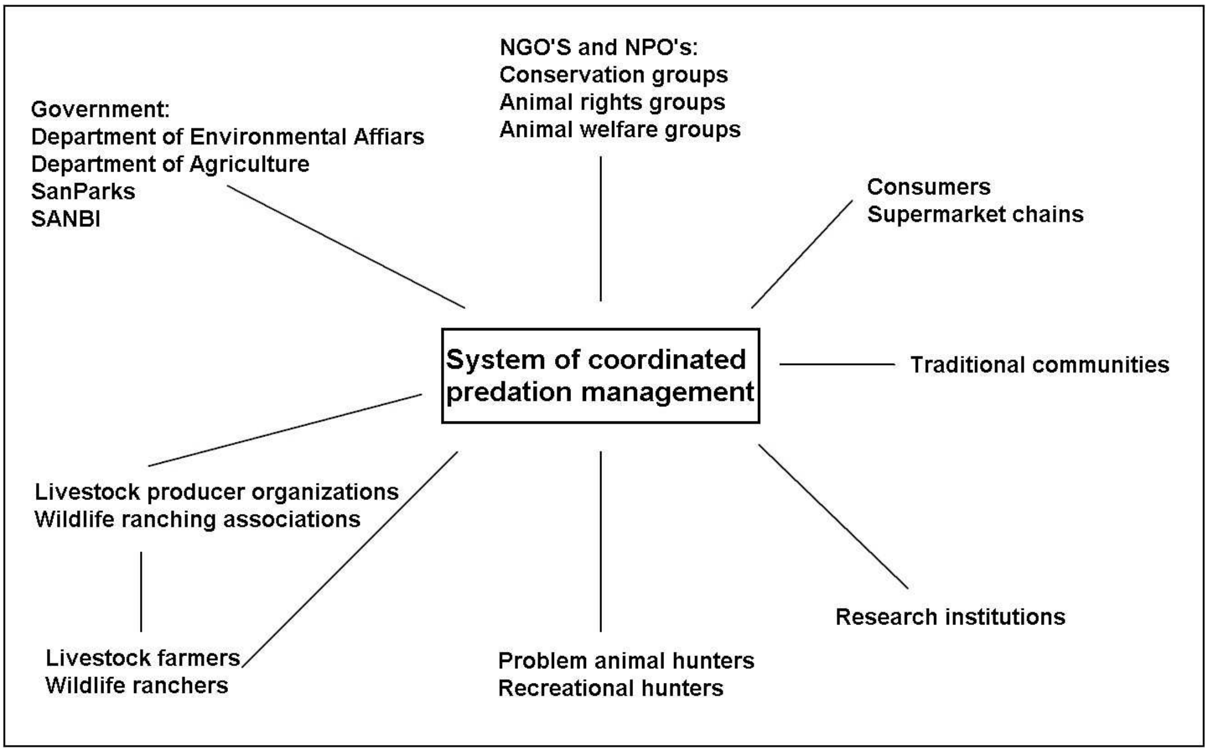


Fig. 8.3: A proposed system of coordinated predation management (adapted from De Waal 2012).

As the custodian of biodiversity and food security, as well as the principle HPCM policy regulator, the South African government should play an important leading role to develop and maintain a coordinated predation management system. Furthermore, for the system to be successful livestock farmers and wildlife ranchers should realize their invaluable contribution. The system should thus focus on ways to motivate and train these stakeholders to gather and share information on predation in a standard, objective manner to prevent stakeholder bias. They should also be encouraged to get involve with the testing of various HPCM techniques on their properties in a scientifically acceptable manner and to allow researchers to study black-backed jackal and caracal ecology on their properties.

The system should also place an emphasis on the human-dimension of black-backed jackal and caracal management. It is often the human aspect that may influence the successful implementation of wildlife management programs (Madden 2004). More research may thus be needed on this aspect. Currently there is no dedicated course or program offered at any higher institution in South Africa which addresses the human-dimensions of wildlife management.

The system should, further, focus on ecological research in rangelands areas. This research should be conducted in a manner that complements our current knowledge on black-backed jackal and caracal ecology. To achieve this, livestock farmers, wildlife ranchers, specialist predator hunters, scientists and wildlife managers should be motivated to work together to prioritise information gaps, and from these design applicable studies to address the priority areas.

Overall, for a national system of co-ordinated predation management to be successful, it should be implemented and managed in a transparent manner to ensure the willingness of all stakeholders to get involved.

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Appendices

Appendix 1: Regulations currently applicable to black-backed jackal and caracal management in South Africa.

Regulation	Spatial extent
Convention on the Conservation of Biological Diversity (CBD)	International
Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES)	International
Protocol on Wildlife Conservation and Law Enforcement in the Southern African Development Community (SADC)	Regional (SADC)
Animal Protection Act – Act 71 of 1962	National
The Constitution of the Republic of South Africa – Act 108 of 1996	National
National Environmental Management Act (NEMA) – Act 107 of 1998	National
National Environmental Management Amendment Act – Act 46 of 2003	National
National Environmental Management: Protected Areas Act – Act 57 of 2003	National
National Environmental Management: Biodiversity Act – Act 10 of 2004	National
- Draft norms and standards for the management of damage-causing animals in South Africa	National
Consumer Protection Act – Act 68 of 2008	National
Nature Conservation Ordinance – Ordinance 8 of 1969 [1]	Provincial (Free State)
Natal Nature Conservation Ordinance – Ordinance 15 of 1974 [1]	Provincial (Kwazulu Natal)
Nature and Environmental Conservation Ordinance – Ordinance 19 of 1974	Provincial (Eastern Cape)
Northern Cape Nature Conservation Act – Act 9 of 2009	Provincial (Northern Cape)
Transvaal Nature Conservation Ordinance – Ordinace 12 of 1983	Provincial (North West)
Mpumalanga Nature Conservation Act – Act 10 of 1998	Provincial (Mpumalanga)
Western Cape Nature Conservation Laws Amendment Act – Act 3 of 2000	Provincial (Western Cape)

[1] Currently in revision

Appendix 1 (cont.): Regulations currently applicable to black-backed jackal and caracal management in South Africa.

Regulation	Spatial extent
Limpopo Environmental Management Act – Act 7 of 2003	Provincial (Limpopo)
Transvaal Nature Conservation Ordinance – Ordinace 12 of 1983 as amended by Gauteng General Law Amendment Act – Act 4 of 2004	Provincial (Gauteng)

[1] Currently in revision

Appendix 2: List of major stakeholders with a potential interest in human-predator conflicts related to black-backed jackal and caracal in South Africa.

Stakeholders	Website
Government	
National:	
Department of Environmental Affairs	www.environment.gov.za
Department of Agriculture, Forestry and Fisheries	www.daff.gov.za
South African National Biodiversity Institute (SANBI)	www.sanbi.org
South African National Parks (SANParks)	www.sanparks.org
Provincial:	
Department of Economic Development and Environmental Affairs, Eastern Cape	www.ecprov.gov.za/department .php?index=3
Department of Agriculture and Rural Development, Eastern Cape	www.agr.ecprov.gov.za
Department of Economic Development, Tourism and Environmental Affairs, Free State	www.detea.fs.gov.za
Department of Agriculture, Free State	www.fs.agric.za
Department of Agriculture and Rural Development, Gauteng	www.gdard.gpg.gov.za
Department: Agriculture, Environmental Affairs and Rural Development, Kwazulu-Natal	www.agriculture.kzntl.gov.za
Department of Economic Development, Environment, and Tourism, Limpopo	www.ledet.gov.za
Department of Agriculture, Limpopo	www.lda.gov.za
Department of Economic Development, Environment, and Tourism, Mpumalanga	www.mpumalanga.gov.za/dedet
Department of Agriculture, Rural Development and Land Administration, Mpumalanga	www.mpumalanga.gov.za/dept/ agriculture
Department of Environment and Nature Conservation, Northern Cape	www.denc.ncpg.gov.za
Department of Agriculture and Land Reform, Northern Cape	www.agrinc.gov.za
Department of Agriculture, Conservation, Environment and Rural Development, North West	
Department of Environmental Affairs and Development Planning, Western Cape	www.capegateway.gov.za/eng/ yourgovernment/gsc/406

Appendix 2 (cont.): List of major stakeholders with a potential interest in human-predator conflicts related to black-backed jackal and caracal in South Africa.

Stakeholders	Website
Government	
Department of Agriculture, Western Cape	www.capegateway.gov.za/eng/yourgovernment/gsc/4182
Cape Nature	www.capenature.co.za
Ezemvelo KZN Wildlife	www.kznwildlife.com
Ranchers	
Agri South Africa (AgriSA)	www.agrisa.co.za
National African Farmers Union of South Africa (NAFU)	
National Woolgrowers Association of South Africa (NWGA)	www.nwga.co.za
Predator Management Forum (PMF)	
Read Meat Producers Organization (RPO)	www.rpo.co.za
Transvaal Agricultural Union (TAU)	www.tlu.co.za
Wildlife Ranching, South Africa (WRSA)	www.wrsa.co.za
Traditional Communities	
Ethnomedicine Practitioners Association of South Africa (EPASA)	www.epasa.co.za
Natural Healers Association	www.naturalhealersassociation.co.za
Consumers	
Good Food Alliance (GFA)	
Pick n Pay	www.pnp.co.za
Shoprite Group of Companies	www.shoprite.co.za
SPAR	www.spar.co.za
Woolworths	www.woolworths.co.za
Hunters	
CHASA	www.chasa.co.za
Problem Animal Control Association of South Africa (PACASA)	
Professional Hunters' Association of South Africa (PHASA)	www.phasa.co.za

Appendix 2 (cont.): List of major stakeholders with a potential interest in human-wildlife conflicts related to black-backed jackal and caracal in South Africa.

Stakeholders	Website
Environmental Groups	
Animal Rights Africa	www.animalrightsafrica.org
Birdlife South Africa	www.birdlife.org.za
Cape Leopard Trust	www.capeleopard.org.za
Cheetah Outreach	www.cheetah.co.za
Conservation International	www.conservation.org
De Wildt Cheetah and Wildlife Trust	www.dewildt.org.za
Endangered Wildlife Trust (EWT)	www.ewt.org.za
International Union for Conservation of Nature (IUCN)	www.iucn.org
Landmark Foundation	www.landmarkfoundation.org.za
National Council of SPCA's (NSPCA - Wildlife)	www.nspca.co.za
The Wildlife Trade Monitoring Network (TRAFFIC)	www.traffic.org
Wildlife and Environmental Society of South Africa (WESSA)	www.wessa.org.za
World Wildlife Fund, South Africa (WWF-SA)	www.wwf.org.za
Subject Experts	
African Large Predator Research Unit (ALPRU), Canis-Caracal Program, University of the Free State	www.ufs.ac.za/faculties/content.php?id=5782&FCode=04&DCode=100&DivCode=D029.
Centre for African Conservation Ecology (ACE), Nelson Mandela Metropolitan University	www.nmmu.ac.za/default.asp?id=2887&bhcp=1
Centre for Veterinary Wildlife Studies (CVWS), University of Pretoria	www.web.up.ac.za/default.asp?ipkCategoryID=1202&sub=0&parentid=50&subid=1174&ipklookid=13
Centre for Wildlife Management, University of Pretoria	http://web.up.ac.za/default.asp?ipkCategoryID=1725&subid=1725&ipklookid=11&parentid=
Department of Mammalogy, National Museum, Bloemfontein	http://www.nasmus.co.za/departments/mammalogy
Department of Zoology and Entomology, University of Stellenbosch	http://academic.sun.ac.za/botzoo/
Grootfontein Agricultural Development Institute (GADI)	www.gadi.agric.za
Mammal Research Institute (MRI), University of Pretoria	www.web.up.ac.za/default.asp?ipkCategoryID=1703
School of Life Sciences, University of Kwazulu-Natal	http://lifesciences.ukzn.ac.za/Homepage.aspx
Wildlife and Reserve Management Research Group (WRMRG), Rhodes University	www.wrmrg.co.za