Livestock Predation and its Management in South Africa: A Scientific Assessment

Editors

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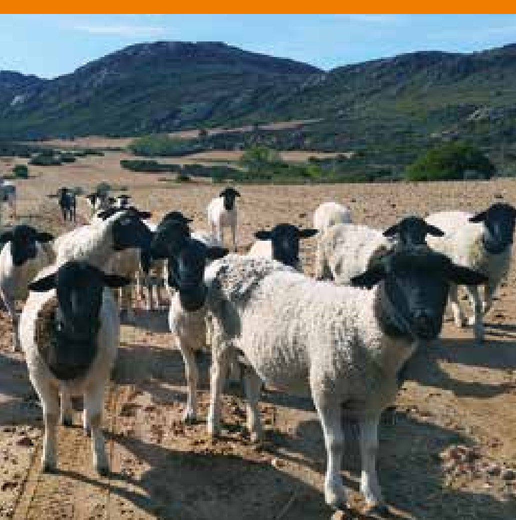

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BIOLOGY, ECOLOGY AND INTERACTION OF OTHER PREDATORS WITH LIVESTOCK

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INTRODUCTION

In South Africa, two of the smaller carnivores – caracals Caracal caracal *and black-backed jackals* Canis mesomelas *– are reportedly responsible for most predation on small livestock (van Niekerk, 2010; Badenhorst, 2014; Kerley* et al. *2017). However, other species are also implicated in livestock predation in the country including lions* Panthera leo*, leopards* Panthera pardus*, cheetahs* Acinonyx jubatus*, servals* Leptailurus serval*, African wild dogs* Lycaon pictus*, side-striped jackals* Canis adustus*, Cape foxes* Vulpes chama*, free-roaming dogs (feral or controlled)* Canis lupus familiaris*, spotted hyenas* Crocuta crocuta*, brown hyenas* Parahyaena brunnea*, honey badgers* Mellivora capensis*, bushpigs* Potamochoerus larvatus*, chacma baboons* Papio ursinus*, Nile crocodiles* Crocodylus niloticus*, and various corvids and raptors (e.g. Badenhorst, 2014). While it is well known that large carnivores are important in the top-down regulation of food webs, small carnivores can also, especially in the absence of the large carnivores, play a pivotal role in ecological processes (See Do Linh San & Somers, 2013; Chapter 8). Predators can affect*

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the density and dynamics of prey species, with cascading effects on whole ecosystems (Beschta & Ripple, 2006; Ripple & Beschta, 2007; Wallach, Johnson, Richie & O'Neill, 2010). Large predators, for example, African wild dogs, are also important tourist attractions (Lindsey, Alexander, du Toit & Mills, 2005a). The removal of large predators from an ecosystem may have many unexpected consequences, which from an ecosystem services perspective, can often be negative. In South Africa, many top-order predators have been historically extirpated from much of the land (Boshoff, Landman & Kerley, 2016), with some species (e.g. lions) now surviving mostly in formally protected areas. Some other species such as cheetahs, spotted hyenas, and African wild dogs, although still occurring outside protected areas, are probably dependent on them for continued survival (Mills & Hofer, 1998).

AN estimated 69% (839,281 km^2) of South African land is used for domestic livestock farming and game ranching (Thorn, Green, Scott & Marnewick, 2013). The resulting habitat fragmentation caused by this extensive farming restricts the movement of animals with large home ranges, including many predators and their prey (Woodroffe & Ginsberg, 1998), which brings them into conflict with people and their livestock (Thirgood, Woodroffe & Rabinowitz, 2005). In addition, the increasing human density along South Africa's reserve borders is escalating the conflict. There have been numerous reintroduction attempts of especially large predators (some successful, some not) around the world, including South Africa (Hayward & Somers, 2009). Many of these have taken place in small protected areas with substantial edge effects and with a high chance of escape (Hayward & Somers, 2009). In those areas where there has been a historical eradication of predators, there is little culture of shepherding livestock. Conflict is therefore unlikely to decrease and needs to be identified and mitigated against.

Many predators in South Africa exist outside protected areas, and modifications to their habitat by agriculture and other human activities can increase the frequency and intensity of carnivore conflict situations (Thorn, Green, Dalerum, Bateman & Scott, 2012). Humans are now the primary cause of predator mortality (Lindsey, du Toit & Mills, 2005b; Hemson, Maclennan, Mill, Johnson & Macdonald, 2009). This is often because predators may compromise the health and livelihoods of humans living near carnivores (Gusset, Swarmer, Mponwane, Keletile & McNutt, 2009; Dickman, 2010). Livestock production in Africa varies from large scale operations to small scale subsistence livestock farming, typical of most of rural Africa, and many of these people face formidable economic pressures (Hemson, 2003). With the presence of livestock, the dynamics of natural predator-prey systems may change. Predators may alter their activity and movement patterns based on the presence of abundant, easy-to-catch prey (e.g. Somers & Nel, 2004). Much of the discussion below thus needs to be seen in the light that predation is context dependent.

Here we briefly assess aspects of the biology and ecology of predators and how these affect livestock predation. We then review the evidence of their involvement in predation, and we identify which livestock are attacked, categorise the evidence of the predators attacking livestock, and broadly categorise the severity of this predation from injury to death. The ecology and behaviour of the main livestock predators are reviewed to determine how these affect the interaction with livestock. We also identify any potential gaps in the knowledge base which require future research.

DETERMINING FACTORS FOR LIVESTOCK PREDATION

Carnivore-livestock conflict has driven human-carnivore conflict since the domestication of animals and needs to be addressed to secure the livelihood of farmers and conservation of predators (Minnie, Boshoff & Kerley, 2015). Unfortunately, there are few data on the spatial distribution of livestock predation and the associated management responses by farmers (Minnie *et al.*, 2015). Ultimately, the primary cause of conflict is competition for the livestock between humans and predators.

Many ecological and biological variables can affect the likelihood of livestock predation. Factors such as the distance from water sources, distance from protected areas, elevation and surrounding vegetative cover may all play a role (Knowlton, Gese & Jaeger, 1999; Kolowski

& Holekamp, 2006; Dickman, 2010; Mattisson *et al.*, 2011; Thorn *et al.*, 2013; Minnie *et al.*, 2015). Thorn *et al.* (2013) concluded from their work in North West Province that the distance to protected areas is the most influential variable that determines the risk of predation. This could suggest that predator communities in protected areas that incorporate the surrounding farming matrix in their home ranges are more prone to conflict (Distefano, 2005).

Owing to the behaviour of many predators and the influence of prey size, cattle are less likely to be targeted as prey by predators such as cheetahs and leopards (Sinclair, Mduma & Brashares, 2003). Data on predation events depend on the farmers and their ability to keep accurate records of species affected and numbers lost, and their willingness to share the information. Some farmers are not always willing to report on predation, especially if they practice illegal predator control methods (L. Dumalisile pers. obs. 2017).

Diet and prey selection of predators in South Africa

Diet and prey selection of vertebrate predators are primarily driven by mass-related energy requirements and hence body size (Carbone, Mace, Roberts & Macdonald, 1999; Clements, Tambling, Hayward & Kerley, 2014). The threshold for obligate vertebrate carnivory is around 21.5 kg (Carbone *et al.*, 1999). Thus predators such as lions, leopards, spotted hyenas, cheetahs, and to a lesser extent free-roaming dogs, are suggested to predate on prey exceeding 45% of their body mass. It is therefore predicted that these predators are more likely to be livestock predators than smaller vertebrate predators (e.g. servals, side-striped jackals, Cape foxes, honey badgers and otters). While mass-related energy requirements and body size provide a framework to quantify the inclusion of prey weight categories into predator diet, other factors related to predator behaviour (e.g. ambush versus cursorial predators), prey behaviour (e.g. vigilance behaviour), predator morphology, and habitat requirements related to hunting or escape can all affect prey selection (Kruuk, 1986; Clements, Tambling & Kerley, 2016). Furthermore, factors like prey catchability, which is related to habitat characteristics (Balme, Hunter & Slotow, 2007) and prey vulnerability (Quinn & Cresswell, 2004) are key factors affecting prey selection (and hence diet) of predators. Therefore, the inclusion of livestock in predator diets will be affected by predator distribution, predator density, predator size, predator hunting behaviour, prey behaviour, prey vulnerability, prey catchability, and density of natural prey.

Carnivore diets estimated from scat analysis alone should be viewed in the context of the biology of the predator. This is because some predators will scavenge and include carrion in their diet, which was not necessarily killed by the predator. So not all predators that eat livestock (as determined from scat analyses) kill livestock. Scat analysis should therefore always be kept in context of other evidence such as direct observations.

While there is a rich body of research investigating the prey preference and selection in South African carnivores (e.g. Hayward & Kerley, 2005; Hayward, 2006; Hayward *et al.*, 2006a; Hayward, O'Brian, Hofmeyr & Kerley, 2006b, Clements *et al.*, 2014), little is known about carnivore diets in non-protected areas where predation of livestock would most likely occur (e.g. Forbes, 2011; Humphries, Tharmalingam & Downs, 2016). Several questionnaire-based studies have investigated the predation of livestock by carnivores (van Niekerk, 2010; Chase-Grey, 2011; Thorn *et al.*, 2013; Badenhorst, 2014). The consensus among interview-based studies suggests that carnivores often predate on livestock, which leads to retaliatory killing (Thorn *et al.*, 2012; Thorn *et al.*, 2013). In contrast, several studies have, using scat analysis, quantified carnivore predation in non-protected areas (livestock and game farms), where results often contradict questionnaire-based research (Chase-Grey, Bell & Hill, 2017). For example, in the Waterberg Biosphere (South Africa) and Vhembe Biosphere (Soutpansberg, South Africa) landowner interviews reported high livestock predation by predators (Swanepoel, 2008; Chase-Grey, 2011), while scat analysis and GPS located kills found no livestock in leopard diet (Swanepoel, 2008; Chase-Grey, 2011; Chase Grey *et al.*, 2017). Therefore, there appears to be a mismatch between questionnaire-based research and carnivore diet quantified based on scat analysis and GPS located kills. Predators usually select wild species over domestic stock, but if natural prey are scarce, predators may increase livestock in their diet (Schiess-Meier, Ramsauer & Gabanapelo & Koenig, 2007). The prevalence of livestock predation in a selection of predators for which data are available is reported in the species accounts below, while information on the remaining predators is provided in Table 9.1.

Table 9.1. **Predators (excluding black-backed jackal and caracal) implicated in livestock predation in South Africa.**

Species	Species predated	Evidence	Frequency	Financial implications	Main activity time	Source of information
Leopard	Cattle (calves), sheep, goats	Strong	Common	Local, isolated but can be substantial	Mostly nocturnal	Norton *et al*., 1986; Swanepoel, 2008; Hayward & Slotow, 2009, Martins *et al*., 2011; Minnie *et al*., 2015;
Lion	Cattle, sheep, donkeys, horses	Strong	When out of protected area - rare	Local, isolated but can be substantial	Nocturnal and crepuscular	Hayward & Slotow, 2009; Butler, 2000
Cheetah	Cattle (calves), sheep	Strong	Rare in SA	Local, isolated but can be substantial	Diurnal, crepuscular activity pattern with 62% diurnal	K. Marnewick Pers. Obs. 2017; Wilson, 2006
Serval	Sheep (lambs)	Weak	Rare	Low	Nocturnal and crepuscular	Thorn *et al*., 2012; Griffiths, 2015
African wild cat	Sheep, goats (juveniles)	Strong	Rare	Low		Smuts, 2008; Lutchminarayan, 2014
Black-footed cat	?	?	?	?	Nocturnal	No published information located
Spotted hyena	Cattle, goats	Strong	Rare	Low, but can be locally substantial	Nocturnal but flexible	Parker, Whittington-Jones, Bernard & Davies-Mostert, 2014
Brown hyena	Goats, sheep	Weak	Rare	Low	Nocturnal	Skinner, 1976; Mills, 1990
Aardwolf	Carcasses of various species	Weak	Rare	Low	Nocturnal but flexible	Anderson, 2013
African wild dog	Sheep, goats, seldom cattle	Strong	Rare	Local, isolated but can be substantial	Strictly crepuscular	Davies & Du Toit, 2004; Woodroffe *et al*., 2005; Hayward & Slotow, 2009; Lyamuya, Masenga, Fyumagwa & Røskaft, 2014
Domestic dog	Sheep, goats, seldom cattle, mostly scavenge	Strong	Unknown	Low	Mostly diurnal	Butler & Toit, 2002; Lutchminarayan, 2014
Cape fox	Sheep, goats	Strong	Rare	Low	Nocturnal	Bester, 1982; Stuart, 1982; Hodkinson *et al*., 2007; Edwards *et al*., 2015

Bat-eared fox	None found?	?	Rare if true	Low if true	Crepuscular and nocturnal	Lutchininarayen, 2014; Edwards *et al*., 2015
Honey badger	Sheep	Strong	Rare	Low	Nocturnal but flexible	Begg *et al*., 2016; Do Linh San, Begg, Begg & Abramov, 2016; PMF, 2016
African clawless otter	Sheep	?	Rare	Low	Nocturnal to crepuscular in places	Anecdotes; PMF, 2016
Chacma baboon	Goats, sheep	Strong	Rare to locally abundant (see Butler 2000, for Zimbabwe)	Local, occasional but can be substantial and adds to infrastructure or crop damages	Diurnal	Bolwig, 1959; Hall, 1962; Dart, 1963; Butler, 2000; Tafani *et al*., *in prep*.
Bushpig	Sheep	?	Rare	Low	Nocturnal	Seydack, 1990; PMF, 2016
Birds (eagles, owls, corvids, gulls)	Sheep, goats		Rare	Low	Diurnal or nocturnal (owls)	Davies 1999; Botha, 2012; Lutchminarayan, 2014; Visagie & Botha, 2015; PMF, 2016
Python	Calves, goats, dogs	Strong	Rare	Rare	Diurnal	Hodkinson *et al*., 2007
Crocodiles	Sheep, goats, donkeys, dogs	Strong	Rare and localised	Low but can be severe for poor communities		Guggisberg, 1972; Fergusson, 2000

Strong = *supported by recognised peer reviewed publications or reviews by credible sources,*
Weak = *not supported by peer reviewed publications or reviews by credible sources, some anecdotes*
Common = *published data showing frequent reports as indicated in publications or expert opinion.*
Rare = *no data showing frequent occurrences of predation. Evidence through anecdotes.*

Activity patterns of predators and how this affects livestock predation

Predator activity patterns vary with species and have evolved through a diverse range of selection forces. Activity patterns of predators are potentially influenced by a number of aspects such as direct or indirect competition with other predators (e.g. Saleni *et al.*, 2007; Hayward & Slotow, 2009; Edwards, Gange & Wiesel, 2015; Swanson, Arnold, Kosmala, Foster & Packer, 2016; Dröge, Creel, Becker & M'soka, 2017), or the activity patterns of their prey (e.g. Hayward & Slotow, 2009). Not all predators are nocturnal or active at the same time. Some such as African wild dogs, chacma baboons, crocodiles, and raptors (besides owls) are diurnal, and therefore pose a risk during the day. Wild ungulates' perceived risk of predation (i.e. the landscape of fear) can affect resource use and activity budgets (Brown, Laundre & Gurung, 1999). Livestock, however, although able to perceive the risk of predation (Shrader, Brown, Kerley & Kotler, 2008) cannot do much to reduce it. They are managed and can only avoid predation if managed appropriately (see Chapter 6). To avoid or reduce predation on livestock it is, therefore, crucial to understanding the activity patterns of local predators (See Figure 9.1, Table 9.2). Putting livestock indoors, or in protected kraals at night may protect them against nocturnal predators, while having herdsmen or guard animals may help during the day (see Chapter 6). Although most animal species have a "baseline" activity pattern, a deviation in behaviour from the baseline occurs due to the interaction with their environment (Snowdon, 2015). Large carnivores have different abilities to adapt. Those with high behavioural plasticity and flexible ecological traits are those that recover quickly from depletion and which are more inclined to live close to humans (Cardillo *et al.*, 2004). For example, spotted hyenas change their demographic structure, social behaviour, daily activity rhythm, and space use in response to increased livestock grazing (Boydston, Kapheim, Watts, Szykman & Holekamp, 2003).

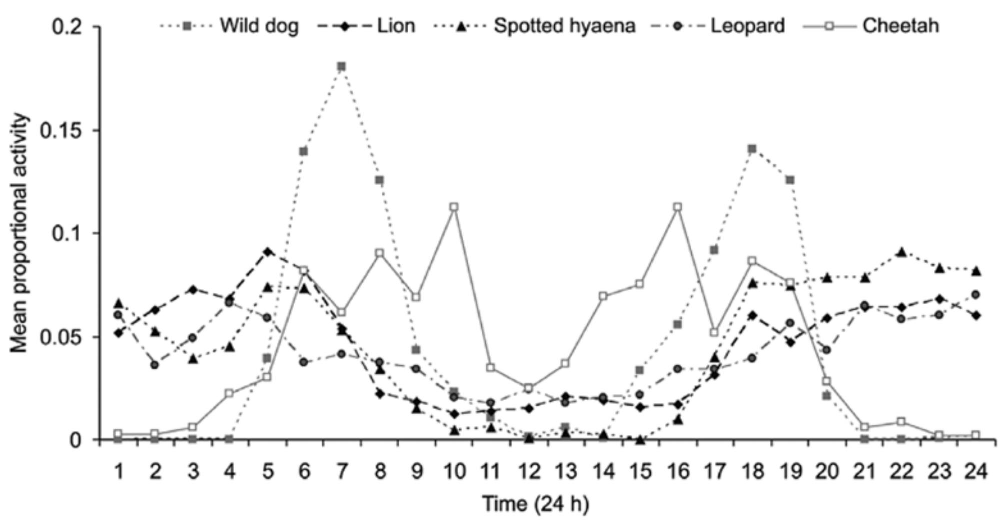

Figure. 9.1. Daily mean activity pattern (proportion an animal's daily activity that occurs in each hour) of all five members of Africa's large predator guild. (From Hayward & Slotow, 2009; Reproduced with permission of SAWMA).

Social structure of predators and its influence on livestock predation

The influence of home range size and territoriality on predation

An animal's home range is defined as "the area about its established home which is traversed by the animal in its normal activities of food gathering, mating and caring for young" (Burt, 1943). Predators have large home ranges; this often draws them into conflict with people (Treves & Karanth, 2003; Graham, Beckerman & Thirgood, 2005). For predators, home range size is influenced by several factors, including the spatial distribution of available prey (Hayward, Hayward, Druce & Kerley, 2009), metabolic needs, and diet (Gittleman & Harvey, 1982). For example, obligate vertebrate carnivores (in other words, those most likely to come into conflict with livestock farmers) tend to have the largest home ranges (Gittleman & Harvey, 1982), which complicates their management.

The spatial ecology of predators is based on their need to fulfil physiological, ecological and social requirements (Owen-Smith & Mills, 2008). These requirements are met with a combination of habitat suitability (Ogutu & Dublin, 2002), resource availability (Owen-Smith & Mills, 2008) and social dynamics (Packer *et al.*, 2005; Loveridge *et al.*, 2009). Home ranges need to be sufficiently large to ensure access to resources such as food, water, shelter and access to breeding mates (De Boer *et al.*, 2010). Animals usually adjust their location in space until their requirements have been met (Abade, Macdonald & Dickman, 2014). Consequently, environmental disruptions can alter home range selection and subsequently, negatively affect the requirements of an individual or even a population (Packer *et al.*, 2005). Similarly, social disruptions (e.g. caused by the excess removal of males) can alter the social organisation of predator species, which can potentially increase the roaming behaviour of individuals, or lead to an influx of new animals (Balme, Slotow & Hunter, 2009). Both these scenarios can inadvertently cause greater movement of predators, both from within a protected area to the outside or from outside in, which can potentially increase conflicts with livestock.

Home range sizes vary between animals of the same species, and this can be considerable, demonstrating the individuals' ability to adjust resource use in response to local conditions (Moorcroft & Lewis, 2013). The availability of prey influences a predator's movement within its home range: for example, when prey are scarce, African wild dog packs traverse their entire home range every 2-3 days, whereas during periods of greater prey availability, foraging efforts are much more restricted (Frame, Malcom, Frame & van Lawick, 1979). Similarly, home ranges of lion prides in the dry areas such as the Kalahari – a prey-scarce ecosystem – are 6-10 times larger than in most other areas where prey are substantially more abundant (reviewed in Hayward *et al.*, 2009). These variations have an important bearing on predator-livestock conflict, especially where human activities, such as habitat alteration, or the exclusion or exploitation of natural herbivores, have led to reductions in the prey resource base for predators, resulting in the likelihood of attacks on livestock (Graham *et al.*, 2005).

Seasonal variation in the spatial organisation may also influence the degree and spatial scale of predation. For example, for about 3 months each year during the denning season (which, in South Africa, takes place in mid-winter); African wild dogs occupy only a portion (average 50–260 km^2) of their annual home range (average 150–2,460 km^2; Hunter & Barrett, 2011). During this time, it is assumed that local impacts on prey can be more pronounced. However, a study of this phenomenon in the Lowveld of Zimbabwe suggests that these concerns are unfounded in some situations (Mbizah, Joubert, Joubert & Groom, 2014).

In a global review of human-predator conflicts, Graham *et al.* (2005) found that a third of the variance in the percentage of livestock (and game) prey taken by predators was explained by a combination of net primary productivity and predator home range, where percentage of prey was inversely related to both productivity and home range. The influence of home range on predator density is the likely mechanism affecting this pattern (Graham *et al.*, 2005), where larger home ranges tend to belong to larger species occurring at lower densities.

Carnivore home ranges also vary greatly in their level of exclusivity, from loosely defended home ranges to heavily defended, mutually exclusive territories. A territory may be defined as "a fixed space from which an individual, or group of mutually tolerant individuals, actively excludes competitors" (Maher & Lott, 1995). These variations have important consequences for demography, and consequently for ecological relationships, including predator-prey dynamics and management strategies to influence these. For example, territorial animals such as female mustelids tend to have mutually exclusive ranges, limiting the overall population density and mobility across a landscape. Disruptions in population spatial structure (for example, removal of resident individuals) may have unpredictable effects on home range placement. Highly territorial species are excellent candidates for non-lethal methods of conflict management that allow for the presence of resident individuals that do not kill livestock themselves, but keep losses locally low by excluding conspecifics (Shivik, Treves & Callahan, 2003). Small home ranges may indicate high predator density and therefore high predation frequency; large home ranges may lead to regular contact with prey "patches" (Graham *et al.*, 2005), both these scenarios can exacerbate conflict.

Social organisation and its influence on predation

Predator social organisation has an important bearing on prey selection (Clements *et al.*, 2016) and hence livestock predation risk and, in turn, the mechanisms by which conflict can be mitigated. Predators can be broadly classified as group-living or solitary, where group-living species are those in which individuals regularly associate together and share a common home range, while solitary species forage alone (Gittleman & Harvey, 1982). A comparison between solitary leopards and social African wild dogs neatly exemplifies this point: leopards are spaced out individually, and predation incidents typically involve just one individual within a population – and not all individuals. Therefore, there may be a problem in one place and not another depending on an individual. In contrast, African wild dog packs hunt together, and therefore the entire pack would be responsible for predation. They, however, have large home ranges, so effects on predation are not localised.

Related to this is the fact that group-living predators tend to be more visible when they encounter humans and their livestock and are therefore less tolerated. Conversely, solitary predators tend to be more cryptic. Consequently, human perceptions of the predation impact of group living predators may be exaggerated (Kruuk, 2002).

Density of predators and how it affects livestock predation

Management, land use practices, previous land use, and activity in neighbouring properties influence habitat quality and can play a significant role in determining the local density of predators (Balme *et al.*, 2009; Rosenblatt *et al.*, 2016). Alterations in landscape features and land use are key drivers of habitat degradation and fragmentation leading to declines in predator populations. This is particularly true for South Africa, where there has been a significant shift from livestock farming to game farming (Carruthers, 2008; Taylor, Lindsey & Davies-Mostert, 2016). Furthermore, as the viable habitat and resources available for predators decline with increasing human populations, the need for predator conservation and wildlife management efforts increases (Friedmann & Daly, 2004). For example, lions require large expanses of land (Schaller, 1972). For lions to survive and thrive, the land use must be restricted and dedicated to wildlife (see Ferreira & Hofmeyr, 2014). This can be in the form of game farming or protected areas. Although lions can cross through ill-maintained fences, if the habitat quality and food resources within the game farm or protected area are adequate, the likelihood of transgression into neighbouring areas is low.

There appear to be several mechanisms, not necessarily mutually exclusive, that drive predator densities. First, the conflict between landowners and carnivores is often reported in areas where land use is dedicated to consumptive wildlife utilisation or livestock production (Dickman, Hinks, Macdonald, Burnman & Macdonald, 2015). Such conflict often results in persecution that directly reduces carnivore densities, even when prey densities remains adequate to sustain high carnivore populations (Balme, Slotow & Hunter, 2010). For example, leopard densities in prey-rich game farming areas can be as low as 20% of potential densities (Balme *et al.*, 2010). In contrast, studies have highlighted that non-protected land can have equal or even higher carnivore densities than protected areas (Stein, Fuller, DeStefano & Marker, 2011; Chase-Grey, Bell & Hill, 2013; Swanepoel, Somers & Dalerum, 2015). Such high densities can be attributed to high prey biomass and or reduced intraspecific competition. For example, subordinate predators such as cheetahs maybe higher densities in non-protected areas as there are fewer dominant predators such as lions (Marker-Kraus, 1996). However, such high carnivore densities can also be due to temporary immigration into these areas due to high local removal rates (Williams, Williams, Lewis & Hill, 2017). Secondly, prey populations in non-protected areas can be depleted due to poaching, habitat modification and game-livestock competition that could limit the density of carnivores (Rosenblatt *et al*., 2016). Owing to the lack of density data for most species and all these variables affecting densities, we provide only general descriptive density estimates for each predator species (Table 9.2).

It can thus be concluded that predator density will most often be determined by prey density. As such, we can also speculate that high natural prey biomass would ultimately also facilitate high livestock biomass (at least if both could co-occur). Under such conditions, we can further hypothesise that predation on livestock can be low when natural prey is high, possibly mediated through facilitation (e.g. at high livestock and natural prey availability, predators will choose natural prey) (Suryawanshi *et al*., 2017). Alternatively, high natural prey (and hence high predator density) can induce high livestock predation, mediated through competition (Suryawanshi *et al*., 2017). While studies investigating the relationship between predator density and livestock predation are few in South Africa, the pattern from elsewhere is not clear. Several studies have shown that

Table 9.2. Characteristics of the social and spatial organisation of predator species implicated in livestock conflicts in South Africa (Skinner & Chimimba, 2005).

Predator species	Social organisation	Group size	Territorial	Home range sizes (km^2)		Density (ind./100 km^2)
				Minimum	Maximum	
Leopard	Solitary	1-2	Yes	14.8	2182	0.62-15.63
Cheetah	Solitary females / male coalitions	1-5	Yes, males	24	1848	0.25-1
Serval	Solitary	1 or 1 + young	Yes	2.2	38	7.6
African wild cat	Solitary	1 or 1 + young	Yes	3.4	9.8	10-70
Lion	Group	1-30	Yes	150	4532	Up to 15
African wild dog	Group	1-50	Yes	150	>2000	Up to 60
Side-striped jackal	Group	1-7	Yes	0.2	4	0.07-1
Cape fox	Solitary	1-2	Yes, around den	9.2	27.7	
Feral domestic dogs	Solitary; group	?	?	1	4.6	?
Spotted hyena	Group	3 to 90+	Yes	9	>1000	2-35
Brown hyena	Solitary foragers	1 – 2	Yes	49	480	1.8-19.00
Chacma baboon	Group	10 to 200+	Yes	?	?	?
Honey badger	Solitary	1 or 1 + young	Yes	85	698	3-10
Bushpig	Group	1-5	Yes	3.8	10.1	3-50
Crocodile	Solitary	1	Yes	0.5	0.8	?

high natural prey densities can sustain higher predator densities, but with an increased risk of livestock predation (and more conflict) (e.g. snow leopards, Suryawanshi *et al.*, 2017). In contrast, several studies have highlighted that increased natural prey decreased predation on livestock (Meriggi, Brangi, Sacchi & Matteucci, 1996; Meriggi, Brangi, Schenone, Signorelli & Milanesi, 2011). However, many of these studies do not report on predator densities, which can be the driving factor in a variation of livestock predation and prey densities.

Dispersal of predators in South Africa

Dispersal occurs for a number of reasons. A dispersing individual is often alone, hungry, young and relatively inexperienced, and can go a long way out of its normal familiar range. These are dispersers, typically sub-adults perhaps, who have left their natal prides or packs and looking for a new home. Alternatively, dispersers could be old, weak and hungry individuals who have been pushed out of prides, packs or territories. Dispersing individuals can be responsible for important predation on livestock.

Movement of predators through is influenced by several factors that include availability or quality of food resources, predator avoidance and other environmental conditions (van Moorter *et al.*, 2013; Kubiczek, Renner, Böhm, Kalko & Wells, 2014). The way animals move and use space influences interactions with resources, thus affecting ecosystem processes, e.g., predation (Böhm, Wells & Kalko, 2011). We, therefore, need to know the identity and location of populations of predators. From this, we can perhaps predict dispersal patterns and mitigate against them. For instance, African wild dogs disperse, often from protected areas, in a predictable manner to form new packs. Pre-empting this with community engagement programs is recommended (Gusset *et al.*, 2007).

Many predators can move over large distances, especially when dispersing. Some examples include African wild dogs, which have on been recorded dispersing over 80 km (Davies-Mostert *et al.*, 2012). These African wild dogs moved through protected areas, farmland, and communal living areas and along roads. All these situations, including private, protected areas, provide opportunities for conflict. Similarly, a sub-adult male leopard was recorded dispersing 352 km from his natal range (Fattebert, Dickerson, Balme, Slotow & Hunter, 2013). This highlights the vast distances carnivores can disperse, which could bring them into conflict with multiple land users.

Geographical distribution of livestock predation events in South Africa

There is no database, and few data, on the distribution of livestock predation events within South Africa (Minnie *et al.*, 2015). Even within individual provinces, there are no published data available. We can therefore only provide a brief overview for each province. The type of livestock farmed influences the type of predator most likely to attack; larger predators are known for taking large domestic species, whereas smaller predators take a greater proportion of small to medium-sized livestock, such as sheep and goats (Sangay & Vernes, 2008). This results in the trend that the southern provinces tend to be dominated by small predators, such as jackals, while large predators are an issue in the north.

In communal farmland areas in the Grassland, Savanna and Succulent Karoo biomes the main livestock predators are reported to be caracals, black-backed jackals, but also domestic dogs and leopards. Leopards were only seen as a threat in the Savanna. Other predators were perceived as much less of a threat (Hawkins & Muller, 2017).

In the Eastern Cape Province, there are some data on vegetation-type specific predation by leopards in the Baviaanskloof Mega-Reserve (Minnie *et al.*, 2015). Here leopards were reported to prey on sheep and goats. Banasiak (2017) reported that re-introduced lion, leopard, cheetah and brown and spotted haeyna were responsible for livestock attacks (predominantly sheep and cattle) in the Eastern Cape, these predators being escapees from local reserves. Verreaux's eagles *Aquila verreauxii* are also implicated in the killing of lambs, but direct evidence of this is often lacking (Visagie & Botha, 2015). During periods of extreme drought, Cape vultures *Gyps coprotheres* have been reported killing newborn lambs in a weak condition, particularly if ewes leave them alone, and African crowned eagles *Stephanoaetus coronatus* come into conflict with stock farmers (Hodkinson, Snow, Komen & Davies-Mostert, 2007).

Van Niekerk (2010) studied the economic losses attributed to small stock predators in the Western Cape

Province and concluded that although predation losses were relatively low for the whole province, areas such as the Central Karoo, where small stock farming is the main agricultural activity, experienced high losses due to predation by (besides black-backed jackals and caracals), leopards, chacma baboons, crows and vagrant dogs. Braczkowski *et al.* (2012a) studied the diet of caracal in the George and Vleesbaai regions, and reported that although no livestock were detected in the scats of this predator, the local conservation organisation (CapeNature) had issued approximately 60 hunting permits for caracal to farmers in the Vleesbaai regions, suggesting that caracal-livestock conflict existed, even though not formally recorded.

Chardonnet *et al.* (2010) reported that occupants of some villages bordering the Kruger National Park (Mpumalanga and Limpopo Provinces) were responsible for the killing of lions supposedly responsible for killing cattle. To rectify the matter, it sufficed that the villagers remove cattle from within 500m of the park fence. However, elsewhere in Mpumalanga, van Niekerk (2010) reported that farmers attributed livestock losses to predation by black-backed jackals and caracals.

Personal communications from officials within the Gauteng Department of Agriculture and Rural Development (GDARD) to L. Dumalisile revealed that very few predator-livestock conflict events were reported by farmers in the Gauteng Province; only through permit applications for hunting Damage Causing Animals (DCA's) are records of conflicts received. Because of this, there are no reliable data on predator-livestock conflicts, except for some unconfirmed complaints from some farmers received by the General Investigations Unit of the Department that reported unconfirmed leopard kills (L. Lotter. pers. com. 2017).

In North West Province, Thorn *et al.* (2012) reported that farmers attributed 20% of predation to caracals, 41% to jackals, 15% to leopards, 12% to brown hyenas, 7% to cheetahs, 3% to spotted hyenas, with one attack being attributed to servals.

Rowe-Rowe (1992) provided some information on predation in KwaZulu-Natal. He listed African wild dogs emanating from Hluhluwe-iMfolozi Park as an occasional source of livestock predation. Incidents of predation on sheep and calves by brown hyena have been reported from the northern KwaZulu-Natal Midlands. Predation on cattle calves and goats by spotted hyenas are common in northern KwaZulu-Natal around the Hluhluwe and Mkuze areas adjacent to major reserves such as Hluhluwe-iMfolozi Park, Mkuze Game Reserve, and Phinda Private Game Reserve. Retaliatory hunting of spotted hyenas through trophy hunting has increased dramatically in the last 9 years, potentially causing edge-effect related population declines within protected conservation areas (Hunnicutt, pers. obs. 2017). Lions that leave protected areas often kill livestock. Ezemvelo KZN Wildlife assists in destroying such problem lions if needed. Leopards occasionally kill livestock in KwaZulu-Natal (Ferguson, 2006).

In the Northern Cape Province, Jansen (2016) reported that leopards were the main predators of goats near Namaqualand National Park. Another study in the Namaqualand (Paulshoek) found that apart from black-backed jackals and caracals, Cape foxes, Verreaux's eagles, black crows *Corvus capensis*, leopards, chacma baboons, African wild cats *Felis silvestris*, peregrine falcons *Falco peregrinus*, spotted eagle-owls *Bubo bubo* and bat-eared foxes *Otocyon megalotis* were responsible for livestock losses (Lutchminarayan, 2014). Cape and lappet-faced vultures *Torgos tracheliotus* may sometimes kill new-born lambs, particularly if ewes leave these alone, and Verreaux's and martial eagles *Polemaetus bellicosus* sometimes come into conflict with stock farmers in the Northern Cape (Hodkinson *et al.*, 2007).

In Limpopo Province, leopards remain the most important predator in livestock and game farming conflict (Pitman *et al.*, 2017). For example, leopards accounted for 68% of permits issued to nuisance wildlife in Limpopo Province during 2003-2012 (Pitman *et al.*, 2017). Permits issued for other nuisance carnivores during 2003-2012 include brown hyenas (3%), black-backed jackals (2%), caracals (2%), cheetahs (0.5%), and spotted hyenas (0.5%) (Pitman *et al.*, 2017). The majority of leopard mortality events due to problem animal removal were often in prime leopard habitat (Pitman, Swanepoel, Hunter, Slotow & Blame, 2015), which poses a conservation concern to leopard population persistence and connectivity (Swanepoel, Lindsey, Somers, van Hoven & Dalerum, 2014; Pitman *et al.*, 2017).

Most predator-livestock conflicts recorded for the Free State involve predation by black-backed jackals and caracals (e.g. van Niekerk, 2010).

A survey of 277 communal livestock farmers found that small stock experienced greater predation compared to large stock. However, predation did not differ between the three biomes within four provinces (Northern Cape, Eastern Cape, Limpopo and Mpumalanga; Hawkins & Muller, 2017). Losses to predation within this sample over the last 5 years ranged from extremely low (0 to 4% losses of cattle, 2% for sheep and goats) to moderate (10 to 20% for sheep and goats) based on both records and estimates of herd counts. The moderate losses of sheep and goats were comparable with those reported by van Niekerk (2010) for commercial farmers. For n communal farmers, no biotic and abiotic variables (rainfall, biome, vegetation type) or management strategies (type and number of non-lethal livestock protection method, distance to nature reserve or water body) emerged as clear drivers of livestock loss (Hawkins & Muller, 2017).

SELECTED SPECIES ACCOUNTS

While lion, African wild dog and spotted hyena livestock predation may be restricted to the areas adjacent to protected areas and therefore remain relatively limited in South Africa, species like leopards, cheetahs, brown hyenas and chacma baboons can contribute locally to livestock losses. Here, we review the ecology of those predators in the context of livestock predation. Because only anecdotal evidence exists for the other species incriminated by South African farmers, they will only be briefly reviewed here and are summarised further in Table 9.1.

Lion

The dominant prey species of lions are generally divided into three categories based on body weight: small, ≤ 100 kg – warthog *Phacochoerus africanus* and impala *Aepyceros melampus*; medium, 100-230 kg for example blue wildebeest *Connochaetes taurinus*, greater kudu *Tragelaphus strepsiceros* and plains zebra *Equus quagga*; and large, ≥ 230 kg, for example buffalo *Syncerus caffer* and eland *Tragelaphus oryx* (Clements *et al.*, 2014). Water-dependent grazers, such as wildebeests and plains zebras, tend to remain near open surface water during the dry season (Smit, Grant & Devereux, 2007). Rainfall patterns in savanna systems have a direct impact not only on the available surface water but also on vegetation growth (du Toit, 2010). Thus, when rainfall patterns alter, the distribution of plains zebras and wildebeests will be affected by available graze (Owen-Smith, 1996). Browsers obtain most moisture from their diet, thus making them less water dependent. Consequently, due to the feeding behaviour of browsers in savanna woodlands, the rate of encounter with lions is reduced.

In South Africa, the rate of livestock offtake by lions is relatively low in comparison to other African countries (Kissui, 2008). This, in part, is due to the fencing policies in South Africa. Natural populations of lions are found in the Kgalagadi Transfrontier Park and Kruger National Park, where incidences of lion and livestock interactions are reported adjacent to the park boundaries (e.g. Funston, 2011). This is often a consequence of dispersal, with movement out of the protected area towards areas with livestock.

Lions are nocturnal with peak activity periods at dusk and dawn. During daylight, lions rest. Other predators adjust their activity to avoid competition with this apex predator. Similarly, prey species adapt their behavioural patterns according to lion peak activity time (Saleni *et al.*, 2007, Tambling *et al.*, 2015). In regards to livestock practices, having animals in corrals between dusk and dawn reduces the likelihood of predation by lions.

In addition to ecological factors, social dynamics also influences lion home range metrics to varying degrees (Heinsohn & Packer, 1995). The home ranges of large prides in optimal patches may be smaller than expected, and the converse may be true for smaller prides in less productive areas. Thus, the number of adult females within a pride seems to influence the quality of the territory and may influence its relative size. Finally, anthropogenic influences could influence the movements and thus

Lion *Panthera leo*. Photo: Eugen Tullleken.

home ranges of lions. For example, mortalities due to human-lion conflict (Packer *et al.,* 2005), trophy hunting (Davidson, Valeix, Loveridge, Madzikanda & Macdonald, 2011) and bushmeat snaring (Lindsey & Bento, 2012) all influence home range size.

Movement over the landscape by predators varies according to the social structure and interactions with other members of the same species (Heinsohn & Packer, 1995). With regards to lions, both male and female sub-adults leave or are chased out of the pride due to social pressures. Young sub-adult females disperse from a territory when the pride social structure becomes unstable, such as when resources are constrained. Sub-adult males, however, disperse or are driven out of the pride for reproductive reasons. Although this behaviour is natural, this can become challenging to management on small reserves or areas that are surrounded by human communities and livestock activity. For this reason, it is critical for reserve management to practice good reproductive management in the form of contraceptive implants and relocating sub-adults (Miller *et al.*, 2013).

Spotted hyena

Spotted hyena clans live in a "fission-fusion" society in which members often travel and hunt alone or in smaller groups, joining a clan only to defend the territory and at a communal den site, or to hunt larger prey species (Smith, Memenis & Holekamp, 2007). The core of a spotted hyena clan is composed of a matrilineal group composed of closely related females and their offspring (Kruuk, 1972a). Males disperse from the clan at sexual maturity, between the ages of 2 and 6 years and will try to join non-natal clans (Boydston *et al.*, 2005).

Spotted hyenas are territorial, using vocal displays, scent marking, latrine sites, and border patrols to establish and defend territories (Kruuk, 1972a; East & Hofer, 1993; Mills & Hofer, 1998). Territory size can vary based on prey densities, from 40 km^2 in the Ngorongoro Crater in Tanzania (Kruuk, 1972a) to 1000 km^2 in parts of the Kalahari (Mills, 1990). Individuals are not limited to their clan's territory and often make long-distance foraging trips to find food (East & Hofer, 1993).

Spotted hyenas are efficient hunters, able to kill animals several times their size, with a success rate of 25-35% (Kruuk, 1972a; Mills, 1990). In ecosystems with high prey densities, such as the Maasai Mara in

Spotted hyenas *Crocuta crocuta*. Photo: Colin Grenfell.

Kenya, hyenas kill as much as 95% of the food they eat (Cooper, Holekamp & Smale, 1999). They mostly consume medium to large ungulates weighing up to 350 kg (Hayward, 2006). However, they are also capable of effectively hunting sizeable animals such as giraffe *Giraffa camelopardalis giraffa* and buffalo (Kruuk, 1972a; Cooper, 1990; East & Hofer, 1993; Holekamp, Smale, Berg & Cooper, 1997).

As opportunistic hunters, spotted hyenas tend to hunt the most abundant prey species and do so either solo or in groups (Kruuk, 1972a; Cooper, 1990; Höner, Wachter, East, Runyoro & Hofer, 2005). In addition to hunting, spotted hyenas readily scavenge (Kruuk, 1972a; Cooper, 1990; Mills, 1990; East & Hofer, 1993). In areas where prey densities are much higher, the cost of carrion consumption outweighs the benefits, and spotted hyenas underutilise this feeding strategy compared to other areas with lower prey densities where livestock predation is more likely (Cooper *et al.*, 1999). However, in areas where native prey species have largely been extirpated or displaced by extensive human settlements, such as northern Ethiopia, spotted hyenas can exclusively utilise anthropogenic food leftovers (Yirga *et al.*, 2012).

Limited work has been done to quantify livestock conflict with spotted hyenas in South Africa. However, much like leopards, they are commonly found outside of protected areas in some areas such as Mkuze, KwaZulu-Natal. Spotted hyenas utilise livestock such as cattle and goats in areas adjacent to parks with spotted hyena populations in KwaZulu-Natal (Mills & Hofer, 1998).

Though spotted hyenas do kill livestock, they are also often wrongly accused and persecuted due to their nature of scavenging on carcasses of livestock that either died of natural causes or were killed by other carnivores. This leads to the common persecution of spotted hyenas by poisoning carcasses of livestock (Mills & Hofer, 1998; Holekamp & Dloniak, 2010).

Despite the lack of work done in South Africa on livestock conflict, many studies in East Africa have investigated spotted hyena interactions with domestic animals. In the Maasai Steppe in Tanzania spotted hyenas and leopards favoured smaller livestock such as goats, sheep, and calves (also dogs), whereas lions select cattle and donkeys (Kissui, 2008). Temporal patterns of attacks showed that lions were more likely to attack grazing animals during daylight, whereas spotted hyenas and leopards were almost exclusively predating at night. Slight seasonal variations were exhibited by lions and spotted hyenas, where attacks on livestock from both species increased during the wet season (Kissui, 2008).

Leopard

Leopards have the widest geographic distribution of all felids and achieve this by their adaptability (Boitani *et al.*, 1999) and varied diet (Hayward *et al.*, 2006a). They are solitary and associated with rocky hills, mountains, forests, and savannas, but they also occur in deserts where they are restricted to the watercourses (Nowell & Jackson, 1996). Leopards are widespread outside formal conservation areas in South Africa (Swanepoel, 2008). Conflict with leopards is common in livestock and game ranching areas. This is made worse by their large home ranges, (159 to 354 km^2 or larger) (Swanepoel, 2008). Negative attitudes towards leopards, caused by this conflict, are normally the reason for leopard persecution (Swanepoel, 2008; Swanepoel, Lindsey, Somers, van Hoven & Dalerum, 2013).

The leopard is the most widespread large carnivore in South Africa and is often found on non-protected areas, and so several studies have investigated leopard diet (Balme, Lindsey, Swanepoel & Hunter, 2014). Historically leopards were believed to be a major predator of livestock, especially in the Cape Province. For example, the Ceres Hunting Club attributed between 44% (1979) and 16% (1980) of sheep losses to leopard (Conradie, 2012). Similarly, Norton, Lawson, Henley & Avery (1986) reported a 1.5% occurrence of domestic stock in leopard scats. These predation events translated to an average of 620 small stock that were believed to be killed by leopards in the Western Cape, resulting in the removal of 26 leopards per year on average (1977-1985; Chief Directorate Nature and Environmental Conservation, 1987). In areas where small ruminants dominate livestock (e.g. goats and sheep; Western Cape), leopards appear to incorporate livestock more often into their diet, especially in areas where native prey animals are depleted (Mann, 2014; Jansen, 2016). For example in the Little Karoo (Western Cape) livestock (mainly goats, cattle and feral donkeys) contributed to 10% of prey biomass consumed by leopards (Mann, 2014). In the Namaqualand, there was a stark contrast between leopard diet in protected areas (livestock 3.5%) of biomass consumed, mainly goats) compared to farmland (livestock 40.4% biomass consumed with 22.8% goats and 14.8% sheep) (Jansen, 2016). In the Cederberg area livestock comprised around 3.5% to 3.8% of leopard diet (Martins, 2010; Martins, Horsnell, Titus, Rautenbach & Harris, 2011), while in the Baviaanskloof Provincial Nature Reserve livestock comprised around 5% of leopard diet (goats and sheep; Ott, Kerley & Boshoff, 2007). Similarly, livestock (cattle) compromised around 5.3% of the biomass consumed by leopards in the southwestern Cape (Braczkowski, Watson, Coulson & Randall, 2012b).

In the Soutpansberg area (Vhembe Biosphere, northern South Africa) several studies have found no livestock in leopard diet (Stuart & Stuart, 1993; Schwarz & Fischer, 2006; Chase-Grey *et al.*, 2017), despite the fact that livestock are abundant in these areas (Chase-Grey, 2011). In contrast, some studies from the Waterberg area, have found that livestock (largely cattle) contributed to between 2.5% and 3.9% of leopard diet (Grimbeek, 1992), while others studies failed to detect any livestock in the diet of leopards in this area (Swanepoel, 2008; Jooste, Pitman, van Hoven & Swanepoel, 2012; Pitman, Kilian, Ramsay & Swanepoel, 2013).

African wild dog

African wild dogs are endangered, with a global population estimate of 6600 (Woodroffe & Sillero-Zubiri, 2012). Populations have declined markedly over the past several decades, with limited populations surviving in South Africa (Davies-Mostert, Mills, Macdonald, Hayward & Somers, 2009). African wild dogs are limited by competition with larger, more abundant carnivores in protected areas, but are still at low densities outside protected areas owing to direct human persecution.

Livestock predation by African wild dogs is low. However, it can be locally severe with surplus killing. For example, in Kenya in areas with abundant livestock, African wild dog predation was low (*ca* one attack per 1000 km^2 per year), and the costs of tolerating the African wild dogs were low (US $3.40/African wild dog/year). This occurred even where there were low densities of wild prey (Woodroffe, Lindsey, Romañach, Stein & ole Ranah, 2005). The same has been found in mixed farmland, private reserves and game farms in the Waterberg Biosphere Reserve in South Africa, where the diet of African wild dogs was determined through scat analysis. No livestock remains were found in the scats, despite the fact that dogs roamed over some livestock farms (Ramnanan, Swanepoel & Somers, 2013). In Botswana, Gusset *et al.* (2009), using questionnaires, found African wild dogs responsible for 2% of reported cases of predation. Despite this, ranchers interviewed in South Africa and Zimbabwe ranked African wild dogs as the least-liked predator, disliked even more than spotted hyenas, jackals, lions and leopards (Lindsey *et al.*, 2005b). Although African wild dogs kill livestock at lower levels than some other predators, they are still killed in retaliation for incidents of predation (Fraser-Celin, Hovorka, Hovork & Maude, 2017).

Chacma baboons

Baboons are large, widely distributed primates that are capable of living in a variety of habitats, even those heavily encroached or transformed by human activities (Altmann & Altmann, 1970; Swedell, 2011). The adaptability of baboons is mostly a function of their generalist diet, dexterity and scope of social learning (Swedell, 2011). While baboons' diet is composed predominantly of plant matter (Altmann & Altmann, 1970; Swedell, 2011), predatory behaviour has been described in most baboon species and is best known in olive baboons *Papio anubis* in central and western Africa (Dart, 1963; Strum, 1975; Hausfater, 1976; Hamilton & Busse, 1978; Strum, 1981; Davies & Cowlishaw, 1996). Potential wild prey species include various small ungulates, such as Thomson's gazelles *Gazella thomsoni*, Grant's gazelles *Gazella granti*, dik-diks *Rhyncotragus kirki*, steenboks *Raphicerus campestris*, impalas, other primates (e.g. vervet monkeys, *Cercopithecus aethiops*), small mammals (African hares, *Lepus capensis*, and several rodent species), birds, reptiles and amphibians. Prey are opportunistically encountered while foraging on plants. There are, however, a few documented cases of systematic hunting, with adult males actively seeking and chasing prey (Harding, 1973; Strum, 1975; Strum, 1981). Strum (1981) found that the number of prey killed by a single olive baboon troop varied from 16 to 100 per year over a seven-year period in Kenya.

Chacma baboon *Papio ursinus*. Photo: Cath Shutte.

Baboon predation on livestock is seldom documented in scientific literature. According to farmers' surveys in Tanzania and Benin, olive baboons were responsible for, respectively, 0.8% (during a 12-month period, Holmern, Nyahongo & Roskaft, 2007), and 24.8% (between 2000 and 2007, Sogbohossou, de Longh, Sinsin, de Snoo & Funston, 2011) of all small-livestock losses recorded. Butler (2000) surveyed Gokwe communal farmers in Zimbabwe, who reported that chacma baboons killed more livestock than lions and leopards (52% losses attributed to chacma baboons representing about 125 kills over 3.5 years) but only targeted small livestock, thereby having less impact on farmers' livelihoods than larger carnivores. In South Africa, farmers also report that chacma baboons mainly target the young of small livestock including sheep and goats (Dart, 1963; Stoltz & Saayman, 1970). A recent survey on Central Karoo farms in South Africa reveals that since the year 2000 a small but an increasing number of farmers rank chacma baboons as the top predator of small livestock on their farms, ahead of the two traditional carnivore species in the area viz. jackals and caracals (Tafani *et al. in prep*). Farmers reported mostly lamb losses, often with their abdomens having been ripped open and the skin rolled up to gain access to the stomach content (Tafani & O'Riain, 2017). However, despite these reported losses, Tafani *et al.* (*in prep*) reveal very low overall level of carnivory (wild or domestic) in the yearly diet of most troop members living on small livestock farms. Isotopic signatures of individuals show that only select adult males exhibit higher nitrogen levels that may reflect a higher proportion of animal protein in their diet (Tafani *et al.*, *in prep*). This result requires further investigation to clarify the food sources (Tafani *et al.*, *in prep*).

Predatory behaviour is highly variable between individuals and between troops. In various studies, mainly adult males (Strum, 1975; Hausfater, 1976; Hamilton & Busse, 1978; Strum, 1981; Davies & Cowlishaw, 1996; Butler, 2000) were involved in predation of wild or domestic prey; males were also the only ones recorded initiating complex hunting techniques (Strum, 1981). Additionally, prey sharing is limited and often an involuntary result of agonistic interactions (Hausfater, 1976). Behaviour acquisition through observational learning is thought to happen between individuals of the same troop. Strum (1981) observed this trend in the Gilgil troop, in which the proportion of all individuals engaging in predation increased with time. However, it generally remains a small contribution to their diet.

Baboons can learn quickly about the availability of new resources (Strum, 2010) and modify their daily routes (Hoffman & O'Riain, 2012) and foraging tactics (Strum, 2010; Fehlmann *et al.*, 2017a) accordingly. In the Karoo and Zimbabwe, farmers reported increased predation rates by baboons during drought periods (Butler, 2000; Tafani *et al., in prep*), suggesting that food scarcity may drive the behaviour. Most South African small-livestock farms are susceptible to droughts and rely on the provision of artificial water points (farm boreholes) where supplementary feed for livestock is also often provided when needed. It is likely that these resources attract baboons and bring them into close and regular contact with livestock – thus promoting opportunistic predation on lambs in particular (Tafani & O'Riain, 2017). Potential solutions to livestock predation by baboons have yet to be researched and remain a challenge at the scale of extensive camps, and given baboons' ability to habituate to many management techniques (Kaplan & O'Riain, 2015; Fehlmann, O'Riain, Kerr-Smith & King, 2017b). Currently, due to a lack of management advice specific to baboons, most farmers use lethal methods, in particular, cage capture with whole troops often being targeted in areas where losses are high (Tafani & O'Riain, 2017). Tafani *et al.* (*in prep*) suggest that culling whole troops is not appropriate, humane nor it is likely to be sustainable as new troops may move into vacated home ranges (Hoffman & O'Riain, 2012). While more research on livestock predation by chacma baboons is needed, identifying raiders (Strum, 2010) and improving the protection of livestock during critical periods of low biomass and lambing peaks, could reduce baboon's opportunities of predation and allow for case-specific management (see Box 6.2, Chapter 6 for non-lethal management methods used in the urban areas of Cape Town).

Birds of prey and vultures

Some raptors occasionally predate on livestock (with a low conflict potential); lappet-faced- and Cape vultures may kill new-born lambs, particularly if the lambs are left alone (Hodkinson *et al.*, 2007).

Verreaux's Eagles, especially immature birds, are known to take the lambs of smaller livestock (e.g. sheep and goats) and antelope as food (Hodkinson *et al.*, 2007). Boshoff, Palmer, Avery, Davies & Jarvis (1991) reported that juvenile domestic livestock comprised

Martial eagle *Polemaetus bellicosus*. Photo: Colin Grenfell.

3.4% of the diet of Verreaux's Eagles in the then Cape Province. This can lead to conflict with farmers. Verreaux's eagles regularly take carrion and are consequently often wrongly accused of killing livestock that were, in fact, killed by other predators or had died of natural causes (Botha, 2012).

In addition to Verreaux's Eagles, other species such as martial and African crowned eagles have been reported killing livestock and certainly can do so. Boshoff & Palmer (1979) reported that 8% of prey remains of adult martial eagles comprised of domestic livestock, particularly young livestock. Similar to the abovementioned scenario with Verreaux's eagle, these birds readily scavenge and can be wrongly accused of killing livestock when they are observed scavenging from a carcass (Visagie & Botha, 2015). This may also apply to species such as the tawny eagle *Aquila rapax*, African fish eagle *Haliaeetus vocifer*, jackal buzzard *Buteo rufofuscus* and yellow-billed kite *Milvus aegyptius* who all readily scavenge from carcasses.

Box 9.1 Information gaps

There is a lack of a coherent predator conflict monitoring program across all provinces. We found few published data on predator conflict as recorded by the relevant provincial authorities. It is, therefore, difficult to quantify temporal and spatial trends in predator conflict. We suggest that possible avenues to address these are for provincial authorities to liaise with local academic institutions to develop and maintain relevant monitoring programs.

1. Predator research is still predominantly carried out in protected areas. For predator research to be relevant, it will have to be framed in the broader conservation issues faced by predators. Since the majority of predators in South Africa require large tracts of land and the majority of suitable habitat is often in private hands, it is essential to increase research in these non-protected landscapes. Furthermore, the main determinant of predator survival in non-protected areas is human wildlife conflict and tolerance; it is essential that research address these issues.
2. Controlled treatment studies investigating the effectiveness of mitigation actions is needed. There is a general lack of research investigating the effectiveness of mitigation actions. These controlled treatment studies will be fundamental in advancing conservation actions in non-protected areas.
3. Basic empirical data needs to be collected on predation events. The location, size, sex and species of prey and predator are required. Along with this, the density of predators needs to be determined. There are limited density data available for African wild dogs, cheetahs and leopards in some areas to accurately determine livestock predation risk. Some livestock predation data may be available through permit offices, which should be analysed and published. A risk model of livestock predation by predators based on environmental and livestock management variables (or any other variables that can be identified), which allows for identification of high-risk zones to define mitigation strategies (e.g. Zarco-González, Monroy-Vilchi & Alaníz, 2013; Zingaro & Boitani, 2017) could be generated.
4. Basic biological and ecological knowledge (including movements, range, behaviour, prey availability) is needed for most species, especially outside protected areas, where they encounter people and livestock.

REFERENCES

Abade, L., Macdonald, D. W. & Dickman, A. J. (2014). Using landscape and bioclimatic features to predict the distribution of lions, leopards and spotted hyaenas in Tanzania's Ruaha landscape. *PloS ONE,* 9, e96261.

Altmann, S. A. & Altmann, J. (1970). *Baboon ecology – African field research*. Chicago: University of Chicago Press.

Anderson, M. D. (2013). *Proteles cristatus*. In: J. Kingdon, J. & M. Hoffmann (Eds), *The Mammals of Africa. Volume V: Carnivores, Pangolins, Equids, Rhinoceroses* (pp. 560). London: Bloomsbury Publishing.

Badenhorst, C. G. (2014). *The economic cost of large stock predation in the North West Province of South Africa*. (Unpublished M.Sc. thesis). Bloemfontein, South Africa: University of the Free State.

Balme, G., Hunter, L. & Slotow, R. (2007). Feeding habitat selection by hunting leopards *Panthera pardus* in a woodland savanna: prey catchability versus abundance. *Animal Behaviour,* 74, 589–598.

Balme, G. A., Slotow, R. & Hunter, L. T. B. (2009). Impact of conservation interventions on the dynamics and persistence of a persecuted leopard (*Panthera pardus*) population. *Biological Conservation,* 142, 2681–2690.

Balme, G. A., Slotow, R. & Hunter, L. T. B. (2010). Edge effects and the impact of non-protected areas in carnivore conservation: leopards in the Phinda-Mkhuze Complex, South Africa. *Animal Conservation,* 13, 315–323.

Banasiak, N. (2017). *Assessing the outcomes and consequences of large carnivore reintroductions to the Eastern Cape, South Africa*. (Unpublished M.Sc. thesis). Port Elizabeth, South Africa: Nelson Mandela Metropolitan University.

Balme, G. A., Lindsey, P. A., Swanepoel, L. H. & Hunter, L. T. B. (2014). Failure of research to address the rangewide conservation needs of large carnivores: leopards in South Africa as a case study. *Conservation Letters,* 7, 3–11.

Begg, C. M., Begg, K. S., Power, R. J., van der Merwe, D., Camacho, G., Cowell, C. & Do Linh San, E. (2016). A conservation assessment of *Mellivora capensis*. In Child, M. F., Roxburgh, L., Do Linh San, E., Raimondo, D., Davies-Mostert, H.T., editors. *The Red List of Mammals of South Africa, Swaziland and Lesotho*. Johannesburg: South African National Biodiversity Institute and Endangered Wildlife Trust.

Beschta, R. L. & Ripple, W. J. (2006). River channel dynamics following extirpation of wolves in northwestern Yellowstone National Park, USA. *Earth Surface Processes and Landforms,* 31, 1525–1539.

Böhm, S. M., Wells, K. & Kalko, E. K. V. (2011). Top-down control of herbivory by birds and bats in the canopy of temperate broad-leaved oaks (*Quercus robur*). *PloS ONE,* 6(4), e17857.

Boitani, L., Corsi, F., De Biase, A., Carranza, I. D., Ravagli, M., Reggiani, G., Sinibaldi, I. & Trapanese, P. (1999). *A databank for the conservation and management of the African mammals*. Rome: Instituto di Ecolgia Applicata.

Bolwig, N. (1959). A study of the behaviour of the chacma baboon, *Papio ursinus*. *Behaviour*, 14, 136–162.

Boshoff, A.F. & Palmer, N.G. (1979). Macro-analysis of prey remains from martial eagle nests in the Cape Province. *Ostrich* 51, 7-13.

Boshoff, A.F., Landman, M. & Kerley, G.I.H. (2016). Filling the gaps on the maps: historical distribution patterns of some larger mammals in part of southern Africa. *Transactions Royal Society of South Africa*. 71, 23-87.

Boshoff, A.F., Palmer, N.G., Avery, G., Davies, R.A.G. & Jarvis, M.J.F. (1991). Biogeographical and topographical variation in the prey of the black eagle in the Cape Province, South Africa. *Ostrich*, 62, 59-72.

Botha, A. J. (2012). Verreaux's Eagle (*Aquila verreauxii*). In: Whittington-Jones, C. (Ed.) *Humans & birds: a guide to problem resolution and mitigation*. Johannesburg: Endangered Wildlife Trust.

Boydston, E. E., Kapheim, K. M., Watts, H. E., Szykman, M. & Holekamp, K. E. (2003). Altered behaviour in spotted hyenas associated with increased human activity. *Animal Conservation,* 6, 207–219.

Braczkowski, A., Watson, L., Coulson, D., Lucas, J., Peiser, B. & Rossi, M. (2012a). The Diet of caracal, *Caracal caracal*, in Two Areas of the Southern Cape, South Africa as Determined by Scat Analysis. *South African Journal of Wildlife Research,* 42, 111–116.

Braczkowski, A., Watson, L., Coulson, D. & Randall, R. (2012b). Diet of leopards in the southern Cape, South Africa. *African Journal of Ecology,* 50, 377-380.

Brown, J. S., Laundre, J. W. & Gurung, M. (1999). The ecology of fear: optimal foraging, game theory, and trophic interactions. *Journal of Mammalogy,* 80, 385–399.

Burt, W. H. (1943). Territoriality and home range concepts as applied to mammals. *Journal of Mammalogy,* 24, 346–352.

Butler, J. R. A. (2000). The economic costs of wildlife predation on livestock in Gokwe communal land, Zimbabwe. *African Journal of Ecology,* 38, 23–30.

Butler, J. & Toit, J. T. (2002). Diet of free-ranging domestic dogs (*Canis familiaris*) in rural Zimbabwe: implications for wild scavengers on the periphery of wildlife reserves. *Animal Conservation,* 5, 29–37.

Carbone, C., Mace, G. M., Roberts, S. C. & Macdonald, D. W. (1999). Energetic constraints on the diet of terrestrial carnivores. *Nature,* 402, 286–288.

Cardillo, M., Purvis, A., Bielby, J., Mace, G. M., Sechrest, W. & Gittleman, J. L. (2004). Human population density and extinction risk in the world's carnivores. *PloS Biology,* 2(7), e197.

Carruthers, J. (2008). Wilding the farm or farming the wild? The evolution of scientific game ranching in South Africa from the 1960s to the present. *Transactions of the Royal Society of South Africa*, 63, 160–181.

Chardonnet, P., Soto, B., Fritz, H., Crosmary, W., Drouet-Hoguet, N., Mesochina, P., Pellerin, M., Mallon, D., Bakker, L., Boulet, H. & Lamarque, F. (2010). *Managing the conflicts between people and lion: review and insights from the literature and field experience*. Wildlife Management Working Paper 13. Rome: Food and Agriculture Organization of the United Nations.

Chase-Grey, J. N. (2011). *Leopard population dynamics, trophy hunting and conservation in the Soutpansberg Mountains, South Africa*. (Unpublished Ph.D. thesis). Durham, U.K.: Durham University.

Chase Grey, J. N., Kent, V. T. & Hill, R. A. (2013). Evidence of a High Density Population of Harvested Leopards in a Montane Environment. *PloS ONE,* 8, e82832.

Chase Grey, J. N., Bell, S. & Hill, R. A. (2017). Leopard diets and landowner perceptions of human wildlife conflict in the Soutpansberg Mountains, South Africa. *Journal for Nature Conservation,* 37, 56–65.

Chief Directorate Nature and Environmental Conservation (1987). *Leopard conservation in the Cape Province*, Jonkershoek.

Clements, H.S., Tambling, C.J., Hayward, M.W. & Kerley, G.I.H. (2014). An objective approach to determining the weight ranges of prey preferred by and accessible to the five large African carnivores. *PLoS One* 9(7): e101054.

Clements, H.S., Tambling, C.J. & Kerley, G.I.H. (2016). Prey morphology and predator sociality drive predator prey preferences. *Journal of Mammalogy,* 97, 919-927

Conradie, B. (2012). Are hunting clubs the solution to small stock depredation? The case of Ceres, 1979 and 1980. *Agrekon,* 51, 96-113.

Cooper, S. M. (1990). The hunting behaviour of spotted hyaenas *Crocuta crocuta* in a region containing both sedentary and migratory populations of herbivores. *Africa Journal of Ecology*, 29, 131–141.

Cooper, S. M., Holekamp, K. E. & Smale, L. (1999). A seasonal feast: long‐term analysis of feeding behaviour in the spotted hyaena *Crocuta crocuta*. *African Journal of Ecology,* 37, 149–160.

Dart, R. A. (1963). The carnivorous propensity of baboons. *Symposia of the Zoological Society of London,* 10, 49–56.

Davidson, Z., Valeix, M., Loveridge, A. J., Madzikanda, H. & Macdonald, D. W. (2011). Socio-spatial behaviour of an African lion population following perturbation by sport hunting. *Biological Conservation,* 144, 114–121.

Davies, R. A. G. (1999). The extent, cost and control of livestock predation. *The Journal of Raptor Research*, 33(1), 67–72.

Davies, H. T. & du Toit, J. T. (2004). Anthropogenic factors affecting wild dog *Lycaon pictus* reintroductions: a case study in Zimbabwe. *Oryx*, 38, 32–39.

Davies, J.G. & Cowlishaw, G. (1996). Baboon carnivory and raptor interspecific competition in the Namib Desert. *Journal of Arid Environments*, 34, 247–249.

Davies-Mostert, H. T., Mills, M. G. L., Macdonald, D. W., Hayward, M. W. & Somers, M. J. (2009). *A critical assessment of South Africa's managed metapopulation recovery strategy for African wild dogs*. In M.W. Hayward & M.J. Somers (Eds), Reintroduction of Top-Order Predators (pp 10–42). London: Wiley-Blackwell.

Davies-Mostert, H. T., Kamler, J. F., Mills, M. G. L., Jackson, G.R., Rasmussen, G. S. A., Groom, R. J. & Macdonald, D. W. (2012). Long-Distance Transboundary Dispersal of African Wild Dogs among Protected Areas in Southern Africa. *African Journal of Ecology,* 50(4), 500–506.

De Boer, W. F., Vis, M. J. P., De Knegt, H. J., Rowles, C., Kohi, E. M., Van Langevelde, F., Peel, M., Pretorius, Y., Skidmore, A. K., Slotow, R., Van Wieren, S.E. & Prins, H. H. T. (2010). Spatial distribution of lion kills determined by the water dependency of prey species. *Journal of Mammalogy*, 91, 1280–1286.

Dickman, A. J. (2010). Complexities of conflict: the importance of considering social factors for effectively resolving human-wildlife conflict. *Animal Conservation,* 13, 458–466.

Dickman, A. J., Hinks, A. E., Macdonald, E. A., Burnham, D. & Macdonald, D. W. (2015). Priorities for global felid conservation. *Conservation Biology,* 29, 854–864.

Distefano, E. (2005). *Human-wildlife conflict worldwide: collection of case studies, analysis of management strategies and good practices.* SARD Initiative Report, FAO, Rome.

Do Linh San, E. & Somers, M. J. (2013). Editorial: African small carnivores: the 'forgotten Eden'. *Small carnivore conservation*, 48, 1–3.

Do Linh San, E., Begg, C., Begg, K. & Abramov, A.V. (2016). *Mellivora capensis*. The IUCN Red List of Threatened Species, e.T41629A45210107.

Dröge, E., Creel, S., Becker, M. S. & M'soka, J. (2017). Spatial and temporal avoidance of risk within a large carnivore guild. *Ecology and Evolution,* 7, 189–199.

du Toit, J. T. (2010). Considerations of scale in biodiversity conservation. *Animal Conservation*, 13(3), 229–236.

East, M. L. & Hofer, H. (1993). Loud calling in a female-dominated mammalian society. I: Structure and composition of whooping bouts of spotted hyaenas, *Crocuta crocuta*. *Animal Behaviour,* 42, 636–649.

Edwards, S., Gange, A. C. & Wiesel, I. (2015). Spatiotemporal resource partitioning of water sources by African carnivores on Namibian commercial farmlands. *Journal of Zoology*, 297, 22–31.

Fattebert, J., Dickerson, T., Balme, G., Slotow, R. & Hunter, L. (2013). Long-distance natal dispersal in leopard reveals potential for a three-country metapopulation. *South African Journal of Wildlife Research,* 43, 61-67.

Fehlmann, G., O'Riain, M. J., Kerr-Smith, C., Hailes, S., Luckman, A., Shepard, E. L. C. & King, A. J. (2017a). Extreme behavioural shifts by baboons exploiting risky, resource-rich, human-modified environments. *Scientific Reports*, 7, 15057.

Fehlmann, G., O'Riain, M. J., Kerr-Smith, C. & King, A. J. (2017b). Adaptive space use by baboons (*Papio ursinus*) in response to management interventions in a human‐changed landscape. *Animal Conservation*, 20, 101–109.

Ferguson, H. (2006). *Guidelines to managing damage-causing leopards and crocodiles in KwaZulu-Natal*. Pietermaritzburg: Ezemvelo KwaZulu-Natal Wildlife Working Document.

Fergusson, R. A. (2000). *An evaluation of reinforcement as a process in crocodile management in Zimbabwe*. (Unpublished Ph.D. thesis). Harare, Zimbabwe: University of Zimbabwe.

Ferreira, S. M. & Hofmeyr, M. (2014). Managing Charismatic Carnivores in Small Areas: Large Felids in South Africa. *South African Journal of Wildlife Research,* 44, 32–42.

Forbes, R. W. (2011). *The diet of black-backed jackal (*Canis mesomelas*) on two contrasting land-use types in the Eastern Cape Province, South Africa and the validation of a new analytical method of mammalian hair identification.* (Unpublished M.Sc. thesis). Grahamstown, South Africa: Rhodes University.

Frame, L. H., Malcolm, J. R., Frame, G. W. & van Lawick, H. (1979). Social organization of African wild dog. *Zeitschrift Für Säugetierkunde*, 50, 225–249.

Fraser-Celin, V. L., Hovorka, A. J., Hovork, M. & Maude, G. (2017). Farmer-African wild dog (*Lycaon pictus*) relations in the eastern Kalahari region of Botswana. *Koedoe,* 59, 1-10.

Friedmann, Y. & Daly, B. (2004). *Red data book of the mammals of South Africa: a conservation assessment.* Johannesburg: CBSG Southern Africa, Conservation Breeding Specialist Group (SSC/IUCN), Endangered Wildlife Trust.

Funston, P. J. (2011). Population characteristics of lions (*Panthera leo*) in the Kgalagadi Transfrontier Park. *South African Journal of Wildlife Research,* 41, 1–10.

Gittleman, J. L. & Harvey, P. H. (1982). Carnivore home-range size, metabolic needs and ecology. *Behavioral Ecology and Sociobiology,* 10, 57–63.

Graham, K., Beckerman, A. P. & Thirgood, S. (2005). Human-predator-prey conflicts: ecological correlates, prey losses and patterns of management. *Biological Conservation,* 122, 159–171.

Griffiths, C. (2015). *Activity patterns of serval at Sasol's Secunda plant*. (Unpublished B.Sc. Honours thesis). Pretoria, South Africa: University of Pretoria.

Grimbeek, A. M. (1992). *The ecology of the leopard in the Waterberg*. (Unpublished M.Sc. thesis). Pretoria, South Africa: University of Pretoria.

Guggisberg, C. A. W. (1972). *Crocodiles: their natural history, folklore and conservation*. Cape Town: Purnell.

Gusset, M., Maddock, A. H., Gunther, G.J., Szykman, M., Slotow, R., Walters, M. & Somers, M.J. (2007). Conflicting human interests over the re-introduction of endangered wild dogs in South Africa. *Biodiversity and Conservation,* 17, 83–101.

Gusset, M., Swarner, M. J., Mponwane, L., Keletile, K. & McNutt, J. W. (2009). Human-wildlife conflict in northern Botswana: livestock predation by endangered African wild dog *Lycaon pictus* and other carnivores. *Oryx*, 43, 67–72.

Hall, K. R. L. (1962). Numerical data, maintenance activities and locomotion of the wild Chacma baboon, *Papio ursinus*. *Proceedings of the Zoological Society of London*, 139, 181–220.

Hamilton, W. J. & Busse, C.D. (1978). Primate carnivory and its significance to human diets. *Bioscience*, 28, 761–766.

Harding, R. S. (1973). Predation by a troop of olive baboons (*Papio anubis*). *American Journal of Physical Anthropology,* 38(2), 587–91.

Hausfater, G. (1976). Predatory behavior of yellow baboons. *Behaviour*, 56, 44–68.

Hawkins, H-J. & Muller, H. (2017). *Experiences and perspectives of communal livestock farmers in relation to predation*. Unpublished report. Cape Town: Conservation South Africa.

Hayward, M. W. (2006). Prey preferences of the spotted hyaena (*Crocuta crocuta*) and degree of dietary overlap with the lion (*Panthera leo*). *Journal of Zoology,* 270, 606–614.

Hayward, M. W. & Kerley, G. I. H. (2005). Prey preferences of the lion *(Panthera leo*). *Journal of Zoology,* 267, 309–322.

Hayward, M. W. & Slotow, R. (2009). Temporal partitioning of activity in large African carnivores: tests of multiple hypotheses. *South African Journal of Wildlife Research,* 39, 109–125.

Hayward, M. W. & Somers, M. J. (2009). *Reintroduction of top-order predators*. London: John Wiley & Sons.

Hayward, M. W., Henschel, P., O'Brien, J., Hofmeyr, M., Balme, G. & Kerley, G. I. H. (2006a). Prey preferences of the leopard (*Panthera pardus*). *Journal of Zoology,* 270, 298-313.

Hayward, M. W., O'Brien, J., Hofmeyr, M. & Kerley, G. I. H. (2006b). Prey preferences of the African wild dog *Lycaon pictus* (Canidae: Carnivora): ecological requirements for conservation. *Journal of Mammalogy,* 87, 1122–1131.

Hayward, M. W., Hayward, G. J., Druce, D. J. & Kerley, G. I. H. (2009). Do fences constrain predator movements on an evolutionary scale? Home range, food intake and movement patterns of large predators reintroduced to Addo Elephant National Park, South Africa. *Biodiversity and Conservation*, 18, 887–904.

Heinsohn, R. & Packer, C. (1995). Complex cooperative strategies in group-territorial African lions. *Science*, 269, 1260-1262

Hemson, G. (2003). *The Ecology and Conservation of Lions: Human-Wildlife Conflict in semi-arid Botswana*. (Unpublished Ph.D. thesis). Oxford, U.K.: University of Oxford.

Hemson, G., Maclennan, S., Mills, G., Johnson, P. & Macdonald, D. (2009). Community, lions, livestock and money: A spatial and social analysis of attitudes to wildlife and the conservation value of tourism in a human–carnivore conflict in Botswana. *Biological Conservation*, 142, 2718–2725.

Hodkinson, C., Snow, T., Komen, H. & Davies-Mostert, H. T. (2007). Predators and farmers book. Johannesburg: Endangered Wildlife Trust.

Hoffman, T. S. & O'Riain, M. J. (2012). Troop size and human-modified habitat affect the ranging patterns of a chacma baboon population in the Cape peninsula, South Africa. *American Journal of Primatology*, 74, 853–863.

Holekamp, K. E. & Dloniak, S. M. (2010). Intraspecific variation in the behavioural ecology of a tropical carnivore, the spotted hyena. *Advances in the Study of Behavior*, 42, 189–229.

Holekamp, K. E., Smale, L., Berg, R. & Cooper, S. M. (1997). Hunting rates and hunting success in the spotted hyena (*Crocuta crocuta*). *Journal of Zoology*, 242, 1–15.

Holmern, T., Nyahongo, J. & Roskaft, E. (2007). Livestock loss caused by predators outside the Serengeti National Park, Tanzania. *Biological Conservation*, 135, 518–526.

Höner, O. P., Wachter, B., East, M. L., Runyoro, V. A. & Hofer, H. (2005). The effect of prey abundance and foraging tactics on the population dynamics of a social, territorial carnivore, the spotted hyena. *Oikos*, 108, 544–554.

Humphries, B. D., Tharmalingam, R. & Downs, C. T. (2016). Diet of black-backed jackals (*Canis mesomelas*) on farmlands in the KwaZulu-Natal Midlands, South Africa. *Mammalia,* 80(4), 405–12.

Hunter, L. & Barrett, P. (2011). *Carnivores of the world*. Princeton: Princeton University Press.

Jansen, C. (2016). Diet of key predators responsible for livestock conflict in Namaqualand South Africa. (Unpublished M.Sc. thesis). Stellenbosch, South Africa: University of Stellenbosch.

Jooste, E., Pitman, R. T., van Hoven, W. & Swanepoel, L. H. (2012). Unusually high predation on chacma baboons (*Papio ursinus*) by female leopards (*Panthera pardus*) in the Waterberg Mountains, South Africa. *Folia Primatologica,* 83, 353–360.

Kaplan, B. S. & O'Riain, M. J. (2015). Shedding light on reflective prisms as potential baboon (*Papio ursinus*) deterrents in the Cape Peninsula, South Africa. *South African Journal of Wildlife Research*, 45, 117–121.

Kerley, G.I.H., Behrens, K.G., Caruthers, J., Diemont, M., Du Plessis, J., Minnie, L., Richardson, P.K., Somers, M.J., Tambling, C.T., Turpie, J., Van Niekerk, H.N. & Balfour, D. (2017). Livestock predation in South Africa: The need for and value of a scientific assessment. *South African Journal of Science,* 113 (3/4),17-19.

Kissui, B. M. (2008). Livestock predation by lions, leopards, spotted hyenas, and their vulnerability to retaliatory killing in the Maasai steppe, Tanzania. *Animal Conservation* 11, 422–432.

Knowlton, F. F., Gese, E. M. & Jaeger, M. M. (1999). Coyote depredation control: an interface between biology and management. *Journal of Range Management,* 52, 398–412.

Kolowski, J. M. & Holekamp, K. E. (2006). Spatial, temporal, and physical characteristics of livestock depredations by large carnivores along a Kenyan reserve border. *Biological Conservation*, 128, 529–541.

Kruuk, H. (1972a). *The spotted hyena: a study of predation and social behaviour*. Chicago: University of Chicago Press.

Kruuk, H. (1972b). Surplus killing by carnivores. *Journal of Zoology*, 166, 233–244.

Kruuk, H. (1986). Dispersion of badgers *Meles meles* and their resources: a summary. *Lutra*, 29, 12–15.

Kruuk, H. (2002). *Hunter and hunted: relationships between carnivores and people*. Cambridge: Cambridge University Press.

Kubiczek, K., Renner, S. C., Böhm, S. M., Kalko, E. K. V. & Wells, K. (2014). Movement and ranging patterns of the common chaffinch in heterogenous forest landscapes. *PeerJ*, e368.

Lindsey, P. A., Alexander, R. R., du Toit, J. T. & Mills, M. G. L. (2005a). The potential contribution of ecotourism to African wild dog *Lycaon pictus* conservation in South Africa. *Biological Conservation*, 123, 339–348.

Lindsey, P. A., du Toit, J. T., Mills, M. G. L. (2005b). Attitudes of ranchers towards African wild dogs *Lycaon pictus*: Conservation implications on private land. *Biological Conservation*, 125, 113–121.

Lindsey, P. & Bento, C. (2012). Illegal hunting and the bushmeat trade in Central Mozambique: A case-study from Coutada 9, Manica Province. Harare: TRAFFIC East/Southern Africa, Zimbabwe.

Loveridge, A. J., Valeix, M., Davidson, Z., Murindagomo, F., Fritz, H. & Macdonald, D. W. (2009). Changes in home range size of African lions in relation to pride size and prey biomass in a semi-arid savanna. *Ecography*, 32, 953–962.

Lutchminarayan, K. (2014). *Predation impacts on livestock in a communal area of Namaqualand, Northern Cape, South Africa*. (Unpublished B.Sc. Honours thesis). Cape Town, South Africa: University of Cape Town.

Lyamuya, R. D., Masenga, E. H., Fyumagwa, R. D. & Røskaft, E. (2014). Human–carnivore conflict over livestock in the eastern part of the Serengeti ecosystem, with a particular focus on the African wild dog *Lycaon pictus*. *Oryx*, 48, 378–384.

Maher, C. R. & Lott, D. F. (1995). Definitions of territoriality used in the study of variation in vertebrate spacing systems. *Animal Behaviour*, 49, 1581–1597.

Mann, G. (2014). *Aspects of the ecology of leopards (*Panthera pardus*) in the Little Karoo, South Africa*. (Unpublished Ph.D. thesis). Grahamstown, South Africa: Rhodes University.

Marker-Kraus, L. (1996). *Cheetah survival on Namibian farmlands*. Windhoek: Cheetah Conservation Fund.

Martins, Q. (2010). The ecology of the leopard *Panthera pardus* in the Cederberg Mountains. (Unpublished Ph.D. thesis). Bristol, U.K.: University of Bristol.

Martins, Q., Horsnell, W. G. C., Titus, W., Rautenbach, T. & Harris, S. (2011). Diet determination of the Cape Mountain leopards using global positioning system location clusters and scat analysis. *Journal of Zoology*, 283, 81–87.

Mattisson, J., Odden, J., Nilsen, E. B., Linnell, J. D. C., Persson, J. & Andrén, H. (2011). Factors affecting Eurasian lynx kill rates on semi-domestic reindeer in northern Scandinavia: Can ecological research contribute to the development of a fair compensation system? *Biological Conservation*, 144, 3009–3017.

Mbizah, M. M., Joubert, C. J., Joubert, L. & Groom, R. J. (2014). Implications of African wild dog (*Lycaon pictus*) denning on the density and distribution of a key prey species: addressing myths and misperceptions. *Biodiversity and Conservation*, 23, 1441–1451.

Meriggi, A., Brangi, A. Sacchi, O. & Matteucci, C. (1996). The feeding habits of wolves in relation to large prey availability in northern Italy. *Ecography*, 19, 287–95.

Meriggi, A., Brangi, A., Schenone, L., Signorelli, D. &. Milanesi, P. (2011). Changes of wolf (*Canis lupus*) diet in Italy in relation to the increase of wild ungulate abundance. *Ethology Ecology & Evolution*, 23, 195–210.

Miller, S. M., Bissett, C., Burger, A., Courtenay, B. Dickerson, T., Druce, D. J., Ferreira, S. et al. (2013). Management of reintroduced lions in small, fenced reserves in South Africa: an assessment and guidelines. *South African Journal of Wildlife Research,* 43, 138–54.

Mills, M.G.L. (1990). *Kalahari hyenas: Comparative behavioral ecology of two species*. Caldwell: Blackburn press.

Mills, M.G.L. & Hofer, H. (1998). *Hyaenas: status survey and conservation action plan*. Gland: IUCN/SSC Hyaena Specialist Group.

Minnie, L., Boshoff, A. F. & Kerley, G. I. H. (2015). Vegetation type influences livestock predation by leopards: Implications for conservation in agro-ecosystems. *African Journal of Wildlife Research*, 45, 204–214.

Moorcroft, P. R. & Lewis, M. A. (2013). *Mechanistic home range analysis*. Princeton: Princeton University Press.

Norton, P. M., Lawson, A. B., Henley, S. R. & Avery, G. (1986). Prey of leopards in four mountainous areas of the south-western Cape Province. *South African Journal of Wildlife Research*, 16, 47–52.

Nowell, K. & Jackson, P. (1996). Wild cats – status survey and conservation action plan. Gland: IUCN.

Ogutu, J. O. & Dublin, H. T. (2002). Demography of lions in relation to prey and habitat in the Maasai Mara National Reserve, Kenya. *African Journal of Ecology,* 40, 120–129.

Ott, T., Kerley, G. I. H. & Boshoff, A. F. (2007). Preliminary observations on the diet of leopards (*Panthera pardus*) from a conservation area and adjacent rangelands in the Baviaanskloof region, South Africa. *African Zoology,* 42, 31-37.

Owen-Smith, N. (1996). Ecological guidelines for waterpoints in extensive protected areas. *South African Journal of Wildlife Research,* 26, 107-112.

Owen-Smith, N. & Mills, M. G. L. (2008). Predator-prey size relationships in an African large-mammal food web. *Journal of Animal Ecology,* 77, 173–183.

Packer, C., Hilborn, R., Mosser, A., Kissui, B., Borner, M., Hopcraft, G., Wilmshurst, J., Mduma, S. & Sinclair, A. R. E. (2005). Ecological change, group territoriality, and population dynamics in Serengeti lions. *Science*, 307(5708), 390–393.

Parker, D. M., Whittington-Jones, B. M., Bernard, R. T. F. & Davies-Mostert, H. T. (2014). Attitudes of rural communities toward dispersing African wild dogs in South Africa. *Human Dimensions of Wildlife*, 19, 512–522.

Pitman, R. T., Kilian, P. J., Ramsay, P. M. & Swanepoel, L. H. (2013). Foraging and Habitat Specialization by Female Leopards (*Panthera pardus*) in the Waterberg Mountains of South Africa. *South African Journal of Wildlife Research*, 43, 167–176.

Pitman, R. T., Swanepoel, L. H., Hunter, L., Slotow, R. & Balme, G. A. (2015). The importance of refugia, ecological traps and scale for large carnivore management. *Biodiversity and Conservation*, 24, 1975–1987.

Pitman, R. T., Fattebert, J., Williams, S. T., Williams, K. S., Hill, R. A., Hunter, L. T. B., Robinson, H., Power, J., Swanepoel, L., Slotow, R. et al. (2017). Cats, connectivity and conservation: incorporating datasets and integrating scales for wildlife management. *Journal of Applied Ecology*, 54, 1687–1698.

PMF (2016). *Predation management manual: the farmer's one-stop to identifying and managing predators*. Pretoria: Agri Connect.

Quinn, J. L. & Cresswell, W. (2004). Predator hunting behaviour and prey vulnerability. *Journal of Animal Ecology,* 73, 143–154.

Ramnanan, R., Swanepoel, L. H. & Somers, M. J. (2013). The diet and presence of African wild dogs (*Lycaon pictus*) on private land in the Waterberg region, South Africa. *South African Journal of Wildlife Research,* 43, 68–73.

Ripple, W. J. & Beschta, R. L. (2007). Restoring Yellowstone's aspen with wolves. *Biological Conservation*, 138, 514–519.

Rosenblatt, E., Creel, S., Becker, M. S., Merkle, J., Mwape, H., Schuette, P. & Simpamba, T. (2016). Effects of a protection gradient on carnivore density and survival: an example with leopards in the Luangwa Valley, Zambia. *Ecology and Evolution*, 6, 3772–3785.

Rowe-Rowe, D.T. (1992). *The carnivores of Natal.* Pietermaritzburg: Natal Parks Board.

Saleni, P., Gusset, M., Graf, J. A., Szykman, M., Walters, M. & Somers, M. J. (2007). Refuges in time: temporal avoidance of interference competition in endangered wild dogs *Lycaon pictus. Canid News*, 10.2, 1–5.

Sangay, T. & Vernes, K. (2008). Human-wildlife conflict in the Kingdom of Bhutan: patterns of livestock predation by large mammalian carnivores. *Biological Conservation*, 141, 1272–1282.

Schaller, G. B. (1972). *The Serengeti lion*. Chicago: University of Chicago Press.

Schwarz, S. & Fischer, F. (2006). Feeding ecology of leopards (*Panthera pardus*) in the western Soutpansberg, Republic of South Africa, as revealed by scat analysis. *Ecotropica*, 12, 35–42.

Schiess-Meier, M., Ramsauer, M., Gabanapelo, T. & Koenig, B. (2007). Livestock predation – insight from problem animal control registers in Botswana. *Journal of Wildlife Management,* 71(4), 1267–1274.

Seydack, A. (1990.). *The ecology of the bushpig (*Potamochoerus porcus *Linn. 1758) in the Cape Province*. (Unpublished Ph.D. thesis). Stellenbosch, South Africa: University of Stellenbosch.

Shivik, J. A., Treves, A. & Callahan, P. (2003). Nonlethal techniques for managing predation: primary and secondary repellents. *Conservation Biology*, 17, 1531–1537.

Shrader, A.M, Brown, J.S., Kerley, G.I.H. & Kotler, B.P. 2008. Do free-ranging domestic goats show 'landscapes of fear'? Patch use in response to habitat features and predator cues. *Journal of Arid Environments* 72, 1811-1819.

Sinclair, A. R. E., Mduma, S. & Brashares, J. S. (2003). Patterns of predation in a diverse predator-prey system. *Nature,* 425, 288–290.

Skinner, J. D. (1976). Ecology of brown hyaena *Hyaena brunnea* in Transvaal with a distribution map for southern Africa. *South African Journal of Science,* 72, 262-269.

Skinner, J. D. & Chimimba, C. T. (2005). *The Mammals of the Southern African Sub-Region*. Cambridge: Cambridge University Press.

Smit, I. P. J., Grant, C. C. & Devereux, B. J. (2007). Do artificial waterholes influence the way herbivores use the landscape? Herbivore distribution patterns around rivers and artificial surface water sources in a large African savanna park. *Biological Conservation*, 136, 85–99.

Smith, J. E., Memenis, S. K. & Holekamp, K. E. (2007). Rank-related partner choice in the fission-fusion society of the spotted hyena (*Crocuta crocuta*). *Behavioral Ecology & Sociobiology*, 61, 753–765.

Smuts, B. (2008). *Predators on livestock farms: a practical farmers' manual for non-lethal, holistic, ecologically acceptable and ethical management*. George: Landmark Foundation.

Snowdon, C. (2015). Significance of animal behaviour research. Northridge: California State University. http://www.csun.edu/~vcpsy00h/valueofa.htm. Accessed 1 May 2017.

Sogbohossou, E. A., de Iongh, H. H., Sinsin, B., de Snoo, G. R. & Funston, P. J. (2011). Human-carnivore conflict around Pendjari Biosphere Reserve, northern Benin. *Oryx*, *45*, 569–578.

Somers, M. J. & Nel, J. A. J. (2004). Movement patterns and home range of Cape clawless otters (*Aonyx capensis*), affected by high food density patches. *Journal of Zoology,* 262, 91–98.

Stuart, C. T. & Stuart, T. D. (1993). Prey of leopards in the western Soutpansberg, South Africa. *Revue de Zoologie Africaine,* 107, 135–137.

Stein, A. B., Fuller, T. K., DeStefano, S. & Marker, L. L. (2011). Leopard population and home range estimates in north-central Namibia. *African Journal of Ecology,* 49, 383–387.

Strum, S. C. (1975). Primate predation: Interim report on the development of a tradition in a troop of olive baboons. *Science*, 187(4178), 755–757.

Strum, S. C. (1981). Processes and products of change: baboon predatory behavior at Gilgil, Kenya. In R.S.O. Harding & G. Teleki (Eds), *Omnivorous primates. Gathering and hunting in human evolution* (pp. 254–302) New York: Columbia University Press.

Strum, S. C. (2010). The development of primate raiding: implications for management and Conservation. *International Journal of Primatology*, 31, 133–156.

Stoltz, L.P. & Saayman, G.S. (1970). Ecology and behaviour of baboons in the Northern Transvaal. *Annals of the Transvaal Museum,* 26, 99-143.

Swanepoel, L. H. (2008). *Ecology and conservation of leopards Panthera pardus on selected game ranches in the Waterberg region, Limpopo, South Africa*. (Unpublished M.Sc. thesis). Pretoria, South Africa: University of Pretoria.

Swanepoel, L. H., Lindsey, P., Somers, M. J., van Hoven, W. & Dalerum, F. (2013). Extent and fragmentation of suitable leopard habitat in South Africa. *Animal Conservation,* 16, 41–50.

Swanepoel, L. H., Lindsey, P., Somers, M. J., Van Hoven, W. & Dalerum, F. (2014). The relative importance of trophy harvest and retaliatory killing of large carnivores: South African leopards as a case study. *South African Journal of Wildlife Research*, 44, 115–134.

Swanepoel, L. H., Somers, M. J. & Dalerum, F. (2015). Density of leopards *Panthera pardus* on protected and non-protected land in the Waterberg Biosphere, South Africa. *Wildlife Biology,* 21, 263–268.

Swanson, A., Arnold, T., Kosmala, M., Forester, J. & Packer, C. (2016). In the absence of a 'landscape of fear': How lions, hyenas, and cheetahs coexist. *Ecology and Evolution,* 6, 8534–8545.

Swedell, L. (2011). African Papionins: Diversity of Social Organization and Ecological Flexibility. In C.J. Campbell, A. Fuentes, K.C. MacKinnon, S.K. Bearder & R.M. Stumpf (Eds), P*rimates in Perspective, Second Edition* (*pp.*241–277). New York: Oxford University Press.

Suryawanshi, K. R., Redpath, S. M., Bhatnagar, Y. V. Ramakrishnan, U., Chaturvedi, V., Smout, S. C. & Mishra, C. (2017). Impact of wild prey availability on livestock predation by snow leopards. *Royal Society Open Science*, 4, 170026.

Tafani, M. & O'Riain, J. (2017). Sheep-eating baboons in the Karoo? Searching for evidence : management. *Red Meat/Rooivleis*, 8, 50–53.

Tambling, C.J., Minnie, L., Meyer, J. Freeman, E.W. Santymire, R.M., Adendorff, J. & Kerley, G.I.H. (2015). Temporal shifts in activity of prey following large predator reintroductions. *Behavour, Ecology & Sociobioliology,* 69, 1153-1161.

Taylor, A. A., Lindsey, P. & Davies-Mostert, H. (2016). An assessment of the economic, social and conservation value of the wildlife ranching industry and its potential to support the green economy in South Africa. Johannesburg: Endangered Wildlife Trust.

Thirgood, S., Woodroffe, R. & Rabinowitz, A. (2005). The impact of human-wildlife conflict on human lives and livelihoods. In R. Woodroffe, A. Rabinowitz & S. Thirgood (Eds). *People and Wildlife: Conflict or Coexistence*. (pp. 13–26). Cambridge: Cambridge University Press.

Thorn, M., Green, M., Dalerum, F., Bateman, P. W. & Scott, D. M. (2012). What drives human-carnivore conflict in the North West Province of South Africa? *Biological Conservation,* 150, 23–32.

Thorn, M., Green, M., Scott, D. & Marnewick, K. (2013). Characteristics and determinants of human-carnivore conflict in South African farmland. *Biodiversity and Conservation*, 22, 1715–1730.

Treves, A. & Karanth, K. U. (2003). Human-carnivore conflict and perspectives on carnivore management worldwide. *Conservation Biology,* 17, 1491–1499.

van Moorter, B., Bunnefield, N., Panzacchi, M., Rolandson, C. M., Solberg, E. J. & Saether, B. E. (2013). Understanding scale of movement: animal ride waves and ripples of environmental change. *Journal of Animal Ecology,* 82, 770–780.

van Niekerk, H.N. (2010). *The cost of predation on small livestock in South Africa by medium-sized predators*. (Unpublished M.Sc. thesis). Bloemfontein, South Africa: University of the Free State.

Visagie, R. & Botha, A. J. (2015). *Innocent until proven guilty.* Johannesburg: Endangered Wildlife Trust.

Wallach, A. D., Johnson, C. N., Ritchie, E. G. & O'Neill, A. J. (2010). Predator control promotes invasive dominated ecological states. *Ecology Letters,* 13, 1008–1018.

Williams, S. T., Williams, K. S., Lewis, B. P. & Hill, R. A. (2017). Population dynamics and threats to an apex predator outside protected areas: implications for carnivore management. *Royal Society Open Science,* 4, 161090.

Wilson, K. (2006). *Status and distribution of cheetahs* Acinonyx jubatus *outside conservation areas in the Thabazimbi district of the Limpopo Province.* (Unpublished M.Sc. thesis). Pretoria, South Africa: University of Pretoria.

Woodroffe, R. & Ginsberg, J. R. (1998). Edge effects and the extinction of populations inside protected areas. *Science,* 280, 2126–2128.

Woodroffe, R. & Sillero-Zubiri, C. (2012). *Lycaon pictus.* The IUCN Red List of Threatened Species, e–T12436A16711116.

Woodroffe, R., Lindsey, P., Romañach, S., Stein, A. & ole Ranah, S. M. K. (2005). Livestock predation by endangered African wild dogs (*Lycaon pictus*) in northern Kenya. *Biological Conservation,* 124, 225–234.

Woodroffe, R., Davies-Mostert, H., Ginsberg, J., Graf, J., Leigh, K., McCreery, K., Robbins, R., Mills, G., Pole, A., Rasmussen, G., Somers, M. & Szykman, M. (2007). Rates and causes of mortality in Endangered African wild dogs *Lycaon pictus*: Lessons for management and monitoring. *Oryx,* 41, 215–223.

Yirga, G., De Iongh, H. H., Leirs, H., Gebrihiwot, K., Deckers, J. & Bauer, H. (2012). Adaptability of large carnivores to changing anthropogenic food sources: diet change of spotted hyena (*Crocuta crocuta*) during Christian fasting period in northern Ethiopia. *Journal of Animal Ecology*, 81, 1052–1055.

Zarco-González, M. M., Monroy-Vilchi, O. & Alaníz, J. (2013). Spatial model of livestock predation by jaguar and puma in Mexico: conservation planning. *Biological Conservation*, 159, 80–87.

Zingaro, M. & Boitani, L. (2017). Assessing wild canid depredation risk using a new three steps method: the case of Grosseto Province (Tuscany, Italy). *Hystrix, the Italian Journal of Mammalogy,* 28, 1–7.

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Predators are valued as part of South Africa's natural heritage, but are also a source of human-wildlife conflict when they place livestock at risk. Managing this conflict ultimately falls to individual livestock farmers, but their actions need to be guided by policy and legislation where broader societal interests are at stake. The complexity of the issue together with differing societal perspectives and approaches to dealing with it, results in livestock predation management being challenging and potentially controversial.

Despite livestock predation having been a societal issue for millennia, and considerable recent research focussed on the matter, the information needed to guide evidence-based policy and legislation is scattered, often challenged and, to an unknown extent, incomplete. Recognising this, the South African Department of Environmental Affairs together with the Department of Agriculture, Forestry and Fisheries, and leading livestock industry role players, commissioned a scientific assessment on livestock predation management. The assessment followed a rigorous process and was overseen by an independent group to ensure fairness. Over 60 national and international experts contributed either by compiling the relevant information or reviewing these compilations. In addition an open stakeholder review process enabled interested parties to offer their insights into the outcomes. The findings of the scientific assessment are presented in this volume.

"Livestock Predation and its Management in South Africa" represents a global first in terms of undertaking a scientific assessment on this issue. The topics covered range from history to law and ethics to ecology. This book will thus be of interest to a broad range of readers, from the layperson managing livestock to those studying this form of human wildlife conflict. Principally, this book is aimed at helping agricultural and conservation policymakers and managers to arrive at improved approaches for reducing livestock predation, while at the same time contributing to the conservation of our natural predators.

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