Human-primate conflict: an interdisciplinary evaluation of wildlife crop raiding on commercial crop farms in Limpopo Province, South Africa

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Abstract

Understanding and addressing conflict between farmers and wildlife due to crop raiding is of increasing conservation concern. Raiding impacts farmers' livelihoods, reduces tolerance to wildlife and often results in lethal methods of retaliation. Although crop raiding occurs on commercial as well as subsistence farms, there are very few quantitative accounts of on-farm primate behaviour or techniques to deter primates from raiding commercial farms. Working in partnership with commercial crop farmers, this study was conducted in Blouberg Municipality, South Africa. Using systematic behavioural observations, camera trapping techniques, vegetation transects, interviews and a workshop, this research adopts an interdisciplinary approach to examine farmers' perceptions of nature, behaviour of primates, and crop damage by other wildlife to understand the nature and extent of crop raiding. This information was used to develop and evaluate effective and locally appropriate deterrents to wildlife crop raiding.

The farmer-baboon relationship is complicated and filled with ambiguity. Farmers are happy to see baboons in the wild, but on the farm baboons are not welcome. High population numbers and the inability to control baboons are particular concerns for commercial farmers. Baboons were the dominant raiders, whose rates of raiding were influenced most by natural food availability. Vervet monkey raiding was also frequent and was influenced by the presence of baboons on the farm. In addition to primates, 18 other wildlife species were observed within crop fields. Farmers' perceptions were influenced by duration of raiding, average group size and overlap between farmer activity and crop raiding. Farmers underestimated crop loss to wildlife, but were able to accurately estimate where most damage occurs. The use of bells as an alarm system was not effective at alerting field guards to the presence of vervet raiders. Motion-activated sounds were effective at reducing baboon raiding for a short time, but baboons soon habituated. Electric fencing was effective at keeping most wildlife out of crop fields. The information obtained throughout the thesis was used to provide recommendations to commercial crop farmers to reduce crop raiding by wildlife.

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List of Abbreviations

CI:	Confidence Interval
IUCN:	International Union for Conservation of Nature
NDVI:	Normalised Difference Vegetation Index
ZAR:	South African Rand

Statement of Copyright

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Dedication

For my Grandma, Jean Gray,

who I know would have been proud.

And for Liiza van den Heever-Swart,

for being the strongest, most inspiring person I know.

CHAPTER 1: INTRODUCTION

Biodiversity is the richness and variety of life on Earth and is of fundamental importance to the functioning of all natural and human-engineered ecosystems (Jeffries 2006). Despite this, there is currently abundant evidence that many ecosystems, at both regional and global levels, have become highly stressed and dysfunctional as a result of loss of biodiversity due to human activities (Rapport et al. 1998). Current degradation of the environment is driven by increasing human pressures, largely a consequence of increasing human numbers (Kellert 1997); human population growth is significantly related to agricultural expansion, in turn resulting in habitat loss (Allen & Barnes 1985). Climate change, overexploitation of species and natural resources, conflict with wildlife, problems with introduced species and pollution has followed. With a current rate of 15,000-30,000 species extinctions annually (Kellert 1997), extinctions are taking place 1,000 times faster than background rates that are typical of the planets history (Millennium Ecosystem Assessment 2005).

This thesis focuses on the conflict between agricultural crop farmers and the wildlife that share these peoples' landscape. In this introduction, I first discuss why it is important to conserve biodiversity and the reasons why humans value nature. I then discuss what 'human-wildlife conflict' is, the impacts it has on both people and wildlife, and why it is increasing. Concluding this introductory chapter, I talk specifically about crop raiding by wildlife and what can be done to prevent it.

1.1 Why Conserve Biodiversity?

The definition of 'nature conservation' in the Oxford English Dictionary is '*the preservation of wild fauna and flora and natural habitats and ecosystems, especially from the effects of human exploitation, industrialisation, etc.'*. Nature conservation has the capacity to significantly reduce the rate at which diversity is being destroyed. It is estimated to cost around US$14 billion per year to effectively manage the existing protected area network, which increases to US$45 billion per year if existing areas were expanded to encompass the 'ideal' global protected area network (which should cover 15% of land and 30% of marine areas). However, only US$7-10 billion is currently invested per year into biological conservation (IUCN 2010).

Besides the moral obligation driving humans towards a conservation ethic – humankind is simply not justified in forcing some species to extinction in order to improve the quality of human life (Longton & Hedderson 2000) – there are many other reasons why biological conservation is important. Perhaps most importantly are the ecosystem services that the natural environment provides. Processes such as water purification, formation of soils, and the growth of food, fuel and products are driven by the activities of wild species (Jeffries 2006). The benefits humans gain from ecosystem services have only recently been acknowledged and are still poorly understood. However, we do know that these services are not only vital to humans, they are also freely provided where ecosystems remain undisturbed. In 2011, the estimated value provided by global ecosystem services was worth US$125 trillion per year (Costanza et al. 2014). Compare this with the estimated cost of US$45 billion per year that humans are currently unwilling to spend on protecting these vital services (IUCN 2010).

It is vitally important to conserve all parts of biodiversity; we are becoming increasingly aware of how much we do not know about the processes of life on Earth. The outcome of a species extinction is rarely predictable (Soulé 1985); cases have already been documented on the unexpected consequences of species declines. For example, erosion of biodiversity was seen in the Greater Yellowstone Ecosystem when grizzly bears and wolves were extirpated. The disappearance of these top predators led to an eruption of moose (*Alces alces*) populations, which in turn altered riparian structure and density to an extent that subsequently reduced the diversity of avian neotropical migrants (Berger et al. 2001); the absence of vertebrate predators resulting in unexpected decreases in biodiversity are also seen elsewhere (Terborgh et al. 2001).

Marine environments are no different. Estes et al.(1998) revealed how a reduction in fish stocks, likely a result of human activities, sent seal (*Phoca vitulina*) populations into decline, this resulted in killer whales (*Orcinus orca*) – who normally feed upon seals – shifting their diet to include sea otters (*Enhydra lutris*). A decline in sea otters released sea urchins from the limiting influence of otter predation, which in turn led to overgrazing of kelp forests. These studies demonstrate that the cascade of extinction effects (or even just decline in species numbers) across ecosystems can be lengthy and unpredictable.

Ecosystem degradation also increases risks to human health. Firstly, environmental changes can alter the patterns of human contact with various infectious diseases. An increase in US white-tailed deer populations (*Odocoileus virginianus*), brought about by the elimination of natural predators, increased the potential for human exposure to Lyme disease through infected ticks, who spend part of their life-cycle on the deer (Rapport et al. 1998). Anthropogenic changes such as climate-induced warming of water and eutrophication through agricultural nitrate and phosphate runoff cause algal blooms and subsequently proliferation of zooplankton (Smith et al. 1998); zooplankton provide a natural reservoir for the cholera bacterium, and an increase in zooplankton could lead to an increase in the dissemination of cholera into human populations (Colwell 1996). Global warming is predicted to increase the transmission capacity of malaria through mosquitos by 100-fold in temperate zones, and to increase the area where transmission is possible from a size currently containing 45% of the human population to 60%; since 1990 malaria has already spread to many areas where it was previously eradicated (Epstein 2001).

Secondly, biological accumulation of toxic substances produced through human activity, such as mercury and lead, leads to increased toxicological risks to humans, while toxic degradation of the environment can affect the productivity of agroecosystems, especially in already food-insecure areas (Rapport et al. 1998). Thirdly, a multitude of studies have demonstrated how experiencing and interacting with nature improves mental and physical wellbeing – involving effects such as experiencing decreased levels of stress, frustration and sickness, lower levels of aggression, reductions in blood pressure, positive effects on cognitive functioning, including improved concentration, enthusiasm and the capacity to think, increased relaxation, better recovery from illnesses and pain control, and positive changes in mood (Pretty 2004; Fuller et al. 2007; Keniger et al. 2013;). Humans will not receive these benefits if all of nature is lost. These are just a few examples of how our use of the environment can affect our own health.

The environment also provides a huge variety of economic benefits that the human race profits from. Natural substances from plants are employed by a large number of industries and serve as sources of oils, resins, tannins, natural rubber, gums, waxes, dyes and fragrances. Most spices, condiments, teas and other beverages owe their individual flavours and aromas to the plant metabolites they contain. Plant extracts are also used as insecticides and plant growth agents. Perhaps most importantly is the use of plant products in pharmaceuticals. A few examples include anticancer agents, oral contraceptives, morphine and quinine. These substances can reach values of up to US$20,000 per gram. In 1980, US$8 billion was spent in America alone on prescription drugs derived solely from higher plants. Plants continue to be important sources of new drugs, and although many products are now artificially synthesised, it is often forgotten that natural products serve as chemical models for the design and synthesis of new drug entities (Balandrin et al. 1985).

1.2 Human Values of Nature

Values are the range of orientations towards an object that provide the foundation for an individual's attitudes, which in turn guides the interpretation and use of the object (Manfredo et al. 2003; Manfredo 2009). Essentially, human values of nature can be intrinsic or instrumental. Intrinsic value is the value of a species independent of its usefulness to people or any other species, or indeed to the ecosystem (Hunter & Gibbs 2007). Species have instrumental value when they provide the means for acquiring something else of value. These include economic values such as food, fuel, medicine, products such as clothing, recreation obtained from the natural environment and ecosystem services, as already discussed, as well as scientific, educational, and spiritual values (Hunter & Gibbs 2007). Potential value is also possible – that is, the potential future value of the environment that we have not even realised yet (Hunter & Gibbs 2007).

Not all values of nature are perceived by all people, and the reasons behind which values people hold, and therefore their perceptions of and attitudes towards nature, are shaped by a multivariate role of intrinsic – individual experience and evolutionary history – and extrinsic – economic, social and cultural – factors (Treves 2008). As such, attitudes and beliefs towards nature are complex and can change over time, in association with changing conditions and experiences (Hill 2002). They can also shift rapidly with any stressor, such as drought, famine, land disputes or local politics (Lee 2010). In order to understand which values are adopted and why different people adopt different values, we need to understand the beliefs and motivations behind these values.

1.2.1 What influences perceptions of and attitudes towards nature?

A number of studies have revealed that age, gender, ethnicity, level of education, political attitude, landholding size, period of residency and religion all influence attitudes towards wildlife (White 1967; Grieve & Staden 1985; Infield 1988; Heinen 1993; Newmark et al. 1993; Fiallo & Jacobson 1995; Kellert 1997; Naughton-Treves 1997; Hill 1998; Manfredo et al. 2003; Lindsey et al. 2005; Allendorf 2007; Dickman 2010; Kirksey & Helmreich 2010; Gifford & Nilsson 2014), but the same patterns are not always revealed. For example, around the Budongo Forest Reserve, Uganda, Hill (1998) reported that men were more likely to express positive attitudes towards conservation, while in the Netherlands, Gutteling & Wiegman (1993) report that women tended to have stronger environmental concerns than men. Furthermore, other studies reveal no relationship between these factors and environmental attitudes (De Boer & Baquete 1998; Hill 1998; Riley & Priston 2010).

Attitudes also exhibit regional differences (Kellert 1997; Conover 1998). It is often the distance a person resides from a wildlife area that most strongly influences attitudes, with most people living closer to wild areas holding more negative views towards wildlife (Fiallo & Jacobson 1995; Webber 2006; Nijman & Nekaris 2010). Once again, this pattern is not universal (Naughton-Treves 1997), while other studies reveal no patterns at all (Heinen 1993; De Boer & Baquete 1998).

Livelihoods affect attitudes towards wildlife. Those employed in wildlife-related fields display more positive attitudes towards wildlife (Fiallo & Jacobson 1995), while agriculturalists hold more negative perceptions (Kellert 1997; Messmer 2000; Lindsey et al. 2005). A producer's economic dependence on a commodity also affects their attitude towards conflict and tolerance of wildlife (Wywialowski 1994; Jonker et al. 1998; Wang et al. 2006; Kirksey & Helmreich 2010). Those dependent on a single livelihood strategy tend to be particularly antagonistic towards conflict animals, as lack of alternative income strategies intensifies the potential consequences of resource destruction (Dickman 2010). Certainly, crops that are considered to be vital to a person's subsistence are perceived to be most vulnerable to damage by wildlife (Hill 1997). Obtaining benefits from the conflict situation improves attitudes towards the animals that are involved (Strum 1994; Jonker et al. 1998), but this can cause conflict elsewhere. For example, wildlife belonging to a landowner, as is the case in southern Africa, places a high market value on game such as wild ungulates, but consequently reduces tolerance of loss to carnivores (Lindsey et al. 2005).

Affluence influences perceptions of wildlife, but it is often not clear how. The more affluent are able to afford existing forms of conservation, while the poor are in greater need of the resources denied to them by conservation, and therefore are less able to support it (McMillan & Hoban 1997; Infield 1988; Gifford & Nilsson 2014). However, the conversion of subsistence-only to cash-crop farming brought about by the colonial imperative for economic development and market sales can create or enhance conflict, where even relatively minor losses can assume major perceptual importance (Lee & Priston 2005). When market values of the commodities under conflict increase, tolerance for damage by wildlife decreases (Decker & Brown 1982; Messmer 2000; Hill 2004). Tolerance further declines with the increasing use of new technological inputs, such as the use of pesticides (Knight 2001); those who can afford such approaches have lower tolerance of damage to the crops in which they have made higher investments. Higher labour investments in cultivating crops increase farmer perceptions of crop vulnerability (Naughton-Treves 1997).

Prior experience, including childhood experiences and preconceived ideas about nature also influence attitudes (Lee & Priston 2005; Dickman 2010; Gifford & Nilsson 2014) and can alter perceptions of the extent of problems (Jonker et al. 1998; Hill 1998). Perceptions of risk can be strongly influenced by rare but extreme past events (Naughton-Treves 1997), and the perceptions of raiding species in particular can be affected by these episodes. Small animals can cause more damage over time, but they do not destroy an entire field in a single raid as larger animals can do (Naughton-Treves 1997). Under such circumstances the *potential* for total loss shapes perceptions more than frequent but small losses. Indeed, in the context of human-wildlife conflict, actual extent of damage is often less important than the belief that a species is responsible (Lee & Priston 2005). Lack of control over the conflict situation also encourages negative attitudes, and further increases the perceptions of risk (Starr 1969; Fiallo & Jacobson 1995; Sillero-Zubiri & Switzer 2001; Hill 2005).

Large and dangerous animals incur hostility from locals owing to disproportionate antagonism and threat of injury (Saberwal et al. 1994; Hill 1997, 1998; De Boer & Baquete 1998; Archabald & Naughton-Treves 2001; Hill 2005; Lee & Priston 2005; Nahallage et al. 2008; Dickman 2010; Goldman et al. 2010; McLennan & Hill 2010; Mackenzie & Ahabyona 2012). Animals with large group and population sizes are often disliked as they can give the impression of causing greater damage than they actually do (Hill 1997; Knight 1999; Hill 2000; Riley 2007; Nahallage et al. 2008; Warren 2008). The appearance of an animal further influences human perceptions, in particular the animal's human-likeness (Kellert 1985; Kellert 1997). Again this can influence attitudes in opposite ways. On the one hand a closeness to humans enables animals (and particularly primates) to violate social rules and traditions, while on the other it instils understanding and sympathy and increases moral concern (Hill & Webber 2010; Bastian et al. 2011).

1.2.2 Why should conservationists study peoples' perceptions of and attitudes towards nature?

Social and environmental conditions are deeply and inextricably linked (Adams & Hutton 2007). An important component of conservation, and the management of human-wildlife conflict, is therefore the examination of people's behaviour and perceptions regarding wildlife and the factors that influence these perceptions (Riley & Priston 2010). Conservation can no longer be considered in isolation from the economic and social interests of people, and human-wildlife conflict even more so: the problem of species preservation is woven into the fabric of modern society, implicitly demanding the need to examine fundamental social and perceptual forces (Kellert 1985).

Perceptions influence attitudes towards wildlife (Conover 1994; Conover 1998; Hill 2004), and attitudes can be useful indicators of behaviour[1] (Manfredo 2009; St John et al. 2012;). As such, people's perceptions and expectations underpin human-wildlife interactions and shape their responses to conflict with wildlife (Hill 2004; Hytten 2009). If local people attach a negative value to wildlife they will not support its continued existence in the region (Gillingham & Lee 2003), and conservation depends on local community support (Sekhar 1998).

[1] However, it has also been shown that self-reported environmental concern does not always translate into pro-environmental behaviour (see Gifford & Nilsson 2014), and the opposite may well also be true. Investigations into attitudes should therefore proceed with caution.

The level of hostility towards species has important consequences, either directly through persecution of the animal or indirectly by altering habitat to reduce suitability for the species (Dickman 2010). It is the loss that people perceive rather than actual loss that leads to hostility (Mishra 1997). If a problem is perceived to exist, then a problem exists: in order to effectively resolve conflict it is important to discover the origins of these perceptions (Wang et al. 2006). Effective resolution may lie in methods other than damage reduction, such as sharing information (Wywialowski 1994); alternative methods will not be obvious if perceptions are ignored. Conservation managers who acknowledge local perceptions of damage and take appropriate action to mitigate both real and perceived losses receive greater support for their activities (Wang et al. 2006).

People’s attitudes towards wildlife are complicated and as such conflict scenarios are rarely simple. Attitudes are certainly more complex and nuanced than simply being positive or negative – it is often difficult for people involved in conflict to say whether they like or dislike the wildlife involved (Goldman et al. 2010). Perceptions also vary within and between communities (Hill 1998; Bal et al. 2011; Gifford & Nilsson 2014), homogenous treatment of communities under a conservation context are therefore not appropriate. Beliefs may frequently be at odds with, or outweighed by, economic or biological needs (Hill 2002), while value orientations do not necessarily develop in parallel with economic activities as might be expected (White et al. 2009). Further complicating matters is the reality that attitudes are not culturally fixed – they can change over time in association with changing conditions and experiences, or they can shift rapidly with any stressor (Hill 2002; Lee 2010). Social change must therefore also be considered (Hockings et al. 2014).

In order to properly understand people’s perceptions, it is important to recognise exactly how human-wildlife conflict affects people. The impact of conflict extends beyond economic losses and can also result in substantial social costs. While quantifying the economic costs of damage, as many conflict studies have done, has a role in determining impacts on local communities, it does not provide an accurate representation of the full effects (Hill 2004). As a consequence, it is vital to examine any conflict issue within the context of people’s economic, social and cultural lives.

Conservation policy now recognises that people should not suffer impoverishment from wildlife preservation (Hill 2002); any conservation action should entail protection of people and their property from wild animals as well as providing wildlife with protection from human activities (Hill 1998). Understanding people’s motivations and behaviour provides an important step in implementing management to reduce conflict (White & Ward 2010), allowing mitigation to be more accurately directed and ensuring it is acceptable to the local community. Working with the local community also prevents worsening conflict scenarios through misunderstandings, disagreements and disappointments that can stem from unrealistic expectations of mitigation practises (Hill 2004).

Important assumptions that are often made in conflict interventions can be drastically wrong without investigation into the social aspects of human-wildlife conflict. For example, a common misconception of mitigation initiatives is that, as a consequence, people will automatically change their attitudes and behaviour towards wildlife. However, significant conflict can remain after damage has been reduced (Marker 2002), indicating that social determinants of conflict are influenced by more than just damage. For example, Naughton-Treves (1999) revealed that the conflict caused by wildlife crop raiding in Uganda was more to do with the wider issue of people's concern over their loss of wildlife 'ownership' to the government (when laws were passed banning hunting, a traditional deterrent method) than it was about crop damage. A further possible misconception is the assumption that reducing conflict will have a measurable conservation effect. This is rarely tested and there is a need for the examination of both direct and indirect consequences of the conservation effects of mitigation (Dickman 2010).

Furthermore, conflict studies generally assume that the human-wildlife relationship is one of conflict. However, this may not be the truth of the situation. In the Maasai Mara, the act of hunting lions is not a symptom of conflict, but a key component of Maasai culture which brings about feelings of joy and respect for lions (Goldman et al. 2010). Without having accessed this cultural knowledge, the resultant 'conflict' intervention strategy – a ban on lion hunting – has possibly led to a reduction in the positive associations between Masaai people and lions. As such, a thorough examination of people's values can reveal that greater support exists for species protection than is generally presumed (Kellert 1985), which can be of great value when implementing conflict mitigation.

For all these reasons, before any interventions are put into place it is vital to thoroughly examine and properly understand social constructions of wildlife and human-wildlife conflict, as well as being aware of their underlying contradictions (Hytten 2009; Dickman 2010). Understanding attitudes and beliefs provides valuable knowledge of stakeholders, management alternatives and how attitudes can be affected (Baruch-mordo et al. 2009). Focusing management on wildlife often provides temporary fixes, but changing human behaviour can provide long-term solutions (Baruch-mordo et al. 2009). Disciplinary approaches are no longer sufficient to provide a comprehensive approach to conflict analysis or an adequate basis for conflict management

(White et al. 2009). As such the importance of interdisciplinary approaches is becoming increasingly recognised (White et al. 2009).

1.3 What is Human-Wildlife Conflict?

Species that naturally occur in the same geographic area have typically evolved together over long periods of time, enabling them to coexist (Messmer 2000). While humans and wildlife have a long history of coexistence (Anthony et al. 2010), the changing needs of humans have endangered their ability to live alongside wildlife. In an attempt to grow economies and increase standards of living, humans reduce, alter and eliminate natural habitats, to such an extent that in many places humans and wildlife can no longer survive together (Goedeke & Herda-Rapp 2005).

Despite the benefits of shared territories (such as ecosystem services and natural pest control, Rapport et al. 1998; Bianchi et al. 2006) it is wildlife's proximity to human areas, mainly occurring through human colonisation of animal territories, that leads to conflict (Knight 2001). Once in close proximity to one another, competition over habitat and natural resources is the core reason for conflict between wildlife and people (Goedeke & Herda-Rapp 2005). Human behaviour, such as planting highly palatable crops near forest edges (Riley & Priston 2010), and animal behaviour, such as the ability to adapt well to human environments (Agetsuma 2007; Henzi et al. 2011), both promote the opportunities for conflicts to occur.

Human-wildlife conflict has been identified as one of the most critical threats to many wildlife species and is now recognised worldwide as an issue of high conservation concern (IUCN 2005). It is one of the most difficult problems that conservation managers face in Africa, and poses a significant threat to the success of African conservation initiatives (Hill et al. 2002). Human-wildlife conflict has been defined as a negative impact of the needs and behaviour of wildlife on the goals of humans, or a negative impact of the goals of humans on the needs of wildlife (IUCN 2005); as such human-wildlife conflict can have negative impacts on both the humans and wildlife involved.

This definition of human-wildlife conflict and the term itself can be problematic because it suggests that wildlife are conscious human antagonists (Redpath et al. 2013). The term 'conflict' suggests the interaction emerges out of the actors' interpretation of the situation, instead of simple competition for limited resources (Madden & McQuinn 2014). This precludes most wildlife species because few if any wild species could be construed as being aware of their own goals, human goals and purposefully seeking to undermine human goal-seeking capacity (Peterson et al. 2010). Similarly, 'crop raiding', a term used to describe when animals forage on human crops, suggests negative intent by the animal, since the definition of 'to raid' is to attack or to enter in a forceful way in order to steal something; it is however, widely recognised that when carrying out this behaviour there is no intent to convey an intentionally aggressive or anti-social action directed at the farmer (Hill 2015). More neutral terms such as 'human-wildlife interactions' or 'human-wildlife coexistence' would be better in place of 'human-wildlife conflict' (Hill 2015).

Furthermore, many human-wildlife conflicts appear to be about perceived species impacts, but their origins are often rooted in material differences between stakeholders which arise from a deeper cognitive level and are linked to power relations, changing attitudes, and values that are rooted in social and cultural history (Redpath et al. 2013). A better term in this instance would therefore be human-human conflict. Indeed, many studies that have focused on human-wildlife conflict have in fact been describing human-human conflict (Peterson et al. 2010).

Human-human conflict occurs when the interests of two or more parties towards some aspect of biodiversity compete, and when at least one of these parties is perceived to assert its interests at the expense of another party's interests (White et al. 2009). This is the conflict *among* people *over* wildlife. A current example is provided by the competing interests of two groups on how to deal with chacma baboons (*Papio ursinus*) in pine plantations. Bark stripping by baboons in pine plantations, which damages and destroys commercially important trees, imposes serious costs to timber industries in southern Africa (Katsvanga et al. 2006; Henzi et al. 2011). Commercial plantations respond to baboon bark stripping with population control, often involving some form of baboon culling (Bigalke & van Hensbergen 1990; Katsvanga et al. 2006). However, environmental groups such as the Baboon Matters Trust (Baboon Matters Trust 2016) advocate for non-lethal methods of controlling baboons in plantations, which has resulted in plantations being taken to court over their accreditation. This leads to a conflict between the two groups.

Within the study system of this thesis, the conflict situation is, however, one of a human-wildlife dimension and not a human-human interaction. The 'conflict' is directly brought about by wildlife 'crop raiding' and farmer retaliation to this foraging behaviour; there is no second human stakeholder party involved. For these reasons I continue to use the phrase human-wildlife conflict and crop raiding throughout this thesis.

Human-wildlife conflict is usually described in terms of how wildlife affects people, occurring in the form of damage to crops, predation on livestock and managed wildlife, residential damage, vehicle collisions, direct competition for natural resources, disease transmission between wildlife and people in close proximity and, least common but most emotive, attacks on human life (Thirgood et al. 2005). Damage by wildlife is often viewed as a rural or agricultural problem (Messmer 2000) and conflict peaks where wildlife directly deplete human livelihoods or food supplies by foraging in crop fields or taking livestock (Naughton-Treves et al. 1998; Treves & Karanth 2003; Marchal & Hill 2009). Conflict also occurs however in urban areas (Lamarque et al. 2008). People of course affect wildlife too, in the form of habitat destruction, introduction of non-native species, overexploitation, competition for and often exclusion from resources, disease transmission, and killing of wildlife (Brooks & Buss 1962; Mishra 1997; Messmer 2000; Treves & Karanth 2003). Human-wildlife conflict thus has negative impacts on both wildlife and humans, as well as the environment (Osborn & Hill 2005).

1.3.1 Impacts of human-wildlife conflict

Human-wildlife conflict is estimated to cost $22.3 billion in losses per year in the United States alone, of which $4.5 billion is agricultural losses (Manfredo 2009). The direct costs of conflict to humans are the loss of livelihood and in the most extreme cases loss of life (Rajpurohit & Krausman 2000; Anthony et al. 2010). Loss of livelihood can result in substantial social costs, such as reduced access to resources, education, health care, labour, land tenure and food availability, even famine in extreme cases (Webber 2006). Conflict can impede development and social equality (Woodroffe et al. 2005). Indirect costs include the investments made in attempting to prevent wildlife damage and the associated increased risk of injury from wildlife, as well as missed opportunity costs in terms of alternative income and disruption of schooling (Hill 2004; Thirgood et al. 2005).

Extinction of a species is the ultimate cost of conflict to wildlife (Woodroffe et al. 2005). Lethal control by shooting and poisoning was a leading factor in the extinction of the Guadelupe caracara (*Polyborus lutosus*), a raptor that was reported to prey upon juvenile goats, while sheep depredation and consequent lethal control led to the extinctions of the thylacine (*Thylacinus cynocephalus*) and the Falkland Island wolf (*Dusicyon australis*) (Woodroffe et al. 2005). Many species have also suffered serious population declines as a consequence of active persecution. Lions (*Panthera leo*) in Kenya are in decline due to killing by Maasai people, shaped by perceptions of livestock depredation (Hazzah et al. 2009).

Conflict can also cause displacement or range decreases of wild animal populations. Prairie dogs (*Cynomys ludovicianus*) remain in less than 2% of their former distribution in North America, after being subjected to a massive government sponsored poisoning campaign (Woodroffe et al. 2005). Wolves (*Canis lupus*) were displaced from areas of a wildlife sanctuary bordering local villages, after litters were destroyed by locals in response to perceptions of livestock depredation (Mishra 1997).

Different species have varying abilities to cope with human encroachment and the resulting conflict (Woodroffe et al. 2005). Many fare poorly when human-induced changes disrupt their surroundings, and as a result their populations frequently decline so drastically that they become rare, endangered or extinct. Some species however adapt well in an anthropogenic landscape and have flourished under these conditions. Species such as sika deer (*Cervus nippon*) and Japanese macaques (*Macaca fuscata*) are able to adapt various aspects of their ecology, including diet, range use and daily rhythm, to proactively explore novel environments (Agetsuma 2007). Yet overabundant species can pose similar problems as exotic or introduced species, reducing natural diversity by monopolising resources, changing species composition and can be devastating for the less adaptable, rarer species (Garrott et al. 1993). For example, extensive timber cutting boosted white-tailed deer populations, which in turn led to detrimental effects on plant communities (Alverson et al. 1988).

The impacts of human-wildlife conflict extend beyond negatively affecting human and wildlife populations and can affect entire ecosystems, the consequences of which are only just beginning to be recognised (Woodroffe et al. 2005). Many conflict species are keystone species, whose removal can cause unexpected effects on the structuring of ecosystems and may cause the extinction of other species. For example, the absence of predators has been shown to cause an increase in herbivore numbers, in turn causing a decrease in vegetation, and consequently leading to a reduction in biodiversity (Terborgh et al. 2001). Grizzly bear (*Ursus arctos*) and wolf extirpation has led to an increase in moose abundance, changes in habitat structure and ultimately a decrease in nesting bird migrants (Berger et al. 2001). Elephants (*Loxodonta africana*) are a keystone species with significant roles in ecological dynamics and have the ability to profoundly affect the structure of entire ecological communities; their persistence outside protected areas is therefore important for the conservation of biodiversity (Graham et al. 2009).

Human-wildlife conflict can also directly drive further habitat destruction, when people convert habitat in a deliberate attempt to reduce contact between themselves and wildlife; this perhaps is more common than is realised (Wang et al. 2006). Maasai people converted traditional wildebeest (*Connochaetes taurinus hecki*) calving grounds to wheat farms in an attempt to eliminate wildebeest from these areas and minimise transmission of a disease from wildebeest to their cattle; this resulted in an 81% reduction in the local wildebeest population (Ottichilo et al. 2001). Loss of yields via crop raiding can also result in the need for farmers to cultivate progressively larger areas (Woodroffe et al. 2005). Lastly, conflict can jeopardise species conservation and requires increased resources from conservation managers (Baruch-mordo et al. 2009).

1.3.2 Human-wildlife conflict is increasing

Human-wildlife conflict is not a new phenomenon, and has been occurring for centuries (Lamarque et al. 2008). Scientific data suggest that the annual frequency and severity of conflicts are rising (Manfredo 2009). For example, complaints from producers of black bear (*Ursus americanus*) depredation on agriculture in Massachusetts increased by 167% from 1980 to 1990 (Jonker et al. 1998); 93% of farmers interviewed around Budongo Forest Reserve, Uganda believe that wildlife crop raiding increased over the previous 10 years (Tweheyo et al. 2005); the killing of livestock by wild carnivores increased over five years in India (Mishra 1997).

The increase in human-wildlife conflict can be attributed to a number of factors. Human-wildlife conflict increases with the growth of human populations (Thouless & Sakwa 1995; Torres et al. 1996; Woodroffe 2000). The world's human population is now at 7.1 billion (World Bank 2015). Despite a decline in growth rate since the 1960s, absolute increments in population are still very large (Alexandratos 1999), and population numbers are expected to reach 9 billion within the next 35 years (Manfredo 2009).

Increased human populations lead to a variety of other circumstances which pave the way for increased levels of conflict. With more human mouths to feed, agriculture expands and intensifies (Allen & Barnes 1985; Tweheyo et al. 2005; Nahallage et al. 2008; Marchal & Hill 2009), despite the world already producing more food than people can consume (Alexandratos 1999). From 1700 to 1980 the world total of land under cultivation increased by 466%; current world agricultural production is likely to keep up with, or exceed, increase in demand as it has in the past (Meyer & Turner II 1992). 37.7% of the world's land cover is now under cultivation (World Bank 2013a) and the human population currently channels over 40% of terrestrial net primary productivity to their own ends (Robinson 2005); demand for food is predicted to grow by 50-60% by 2030 (Scherr & McNeely 2002).

The expansion of agriculture in connection with human population growth is significantly related to deforestation (Allen & Barnes 1985; Scherr & McNeely 2002). As more farms encroach into wildlife habitat – which not only decreases available space for wildlife and destroys natural food sources, but also positions crops within close range of those food-depleted animal populations – wildlife consequently begins to feed on these crops, becoming problem animals (Tchamba 1996; Hill 1997; Kushwaha & Hazarika 2004; Wang et al. 2006; Riley 2007). Furthermore, as new agriculture expands, the use of lands already cultivated intensifies (Meyer & Turner II 1992) and habitats are destroyed at increasingly rapid rates as small scale subsistence agriculture shifts to vast commercial monocultures (Lee 2010). With habitats quickly becoming human-dominated, more species are compelled to exploit human resources in order to survive (Strum 2010).

Success of conservation efforts can also cause increasing conflicts. In response to the application of wildlife management and protection from overexploitation, many wildlife populations have recovered over the last century (Garrott et al. 1993; Messmer 2000), while some extirpated populations have also been successfully reintroduced (Smith et al. 1991). As recovering wildlife populations expand, they are forced to do so into areas now inhabited by people. For example, in the wake of habitat recovery and legal protection, wolves and other carnivores have recovered in many areas of North America and Europe, but this has happened alongside human populations and as a result conflicts over livestock depredation have increased (Treves et al. 2002).

As with human population increase, an increase in wildlife populations leads to increased conflict over resources. Increased crop raiding by rhesus macaques (*Macaca mulatta*) was reported after the establishment of a National Park in Bhutan (Wang et al. 2006). An increase in chital (*Axis axis*) population numbers following protection resulted in an increase in the incidence of crop damage (Studsrød & Wegge 1995). Increased reports of crop raiding by elephants may reflect the recovery of population numbers following the CITES ban on ivory trade and subsequent decline in poaching (Sillero-Zubiri & Switzer 2001). Protection of wolves in Minnesota led to a threefold increase in their population numbers and consequently an increase in conflict with people (Mladenoff et al. 1997). Problems are exacerbated if these populations become overabundant, and the resulting negative experiences further heighten public concerns over these species (Messmer 2000).

A lack of conservation equally causes problems. Farmers in Bhutan attribute increases in their crop losses to the elimination of wild dogs (*Cuon alpinus*), as wild dogs previously limited numbers of wild pigs (*Sus scrofa*), the crop raiding culprits (Wang et al. 2006). In Japan, wolves are believed to modify the range use of deer and consequently relieve the intensity of deer feeding pressure on vegetation in particular locations; extinction of the wolves has led to vegetation destruction and crop raiding occurring unchecked (Agetsuma 2007). Destruction of predators has been attributed to the increase in raiding behaviour of hamadryas baboons (*Papio hamadryas*) in Saudi Arabia (Biquand et al. 1994).

Human behavioural changes can also result in conflict increases. Changes in agricultural practices and animal husbandry over recent decades have increased vulnerability of crops and livestock to wildlife (Conover & Decker 1991; Sillero-Zubiri & Switzer 2001). Growing interest in ecotourism and increasing access to nature reserves raises potential for conflicts. The presence of and feeding by tourists causes increased levels of aggression in Tibetan macaques (*Macaca thibetana*) (Matheson et al. 2006). Approximately 25% of manatee (*Trichechus manatus* *lairostris*) deaths are caused by collisions with boats (Aipanjiguly et al. 2003), while wild animals attack tourists in South African nature reserves (Durrheim & Leggat 1999). As city planners strive to meet desires for improved quality of life by increasing open spaces in residential areas, problems with urban animals such as deer will increase (Messmer et al. 1997). Improper disposal of waste encourages raiding of garbage sites by baboons (Biquand et al. 1994). Lastly, increased human-wildlife conflict may be in part due to increased awareness and reporting of the situation (Conover & Decker 1991; Dickman 2010).

1.4 Crop Raiding

One of the most common conflicts between people and wildlife takes the form of crop foraging, hereafter referred to as crop raiding (Conover & Decker 1991; Hill 1998; Naughton-Treves et al. 1998; Sillero-Zubiri & Switzer 2001). Crop raiding can be simply defined as wild animals moving from their natural habitat onto agricultural land to feed on the produce that humans grow for their own consumption (Sillero-Zubiri & Switzer 2001). This consumption of human foods regularly brings wildlife into conflict with people (McLennan & Hill 2010). Crop raiding is not a new phenomenon and is as old as agriculture itself (Asquith 1989; Naughton-Treves 1997; Hill 2000; Sillero-zubiri & Switzer 2001; Hill 2005; Lamarque et al 2008; Riley & Priston 2010; Nyirenda et al. 2011). It is now widespread and an issue throughout the world (Box 1991; Sillero-Zubiri & Switzer 2001; Priston & Underdown 2009; Nijman & Nekaris 2010).

Crop raiding is essentially a foraging strategy that can be explained through optimal foraging theory – that animals strive to maximise their energy intake (Pyke 1984). Raiding can be understood as a cost-benefit scenario. It is a high-risk behaviour – raiders suffer greater mortality and injuries than non-raiders (Lee & Priston 2005; Obanda et al. 2008; Chiyo et al. 2012). However, it is also a high-gain foraging strategy – successful raiders derive substantial nutritional benefits from crops and as a result are able to reduce their overall investment in foraging time and have more time for resting and socialising (Hill 2000; Lee & Priston 2005; Obanda et al. 2008; Strum 2010; Chiyo et al. 2012). As agriculture and wildlife have existed side by side for millennia, crop raiding has naturally become an essential part of many species' subsistence strategies (Strum 1994; Naughton-Treves et al. 1998; Lee 2010; Wallace 2010), although both Strum (1994, 2010) and Riley (2007) have demonstrated that crop raiding is not inevitable when wildlife and humans live side by side.

1.4.1 Factors influencing crop raiding

The most significant contributing factor to the development of raiding is the dramatic reduction in natural food available to wildlife because of agricultural settlement (Strum 1994). Farmers planting and growing patterns subsequently make food available to wildlife, especially during times of natural food scarcity (Lee & Priston 2005). Crop raiding certainly intensifies when natural forage is limited (Naughton-Treves et al. 1998; Sekhar 1998; Kagoro-Rugunda 2004; Admassu 2007; Hockings et al. 2009; McLennan & Hill 2010; Strum 2010; Nyirenda et al. 2011; Pahad 2011; Lemessa et al. 2013) and raiding intensity has also been linked to peaks in crop production – occasionally despite natural food availability (Jonker et al. 1998; Hill 2005; Tweheyo et al. 2005; Chakravarthy et al. 2008; Warren 2008; Marchal & Hill 2009; Zimmermann et al. 2009; Campbell-Smith et al. 2010). Crop raiding is therefore an adaptation by wildlife to both natural habitat loss and increased availability of alternative food resources (Hockings et al. 2009).

As well as natural food availability and peaks in crop production, a number of other factors affect the frequency, location, duration and type of crop raids, and therefore the extent of damage sustained. These include the species involved (Naughton-Treves 1997; Chhangani et al. 2008; Nijman & Nekaris 2010), farm location and size (Naughton-Treves 1997, 1998; Hill 2000; Saj et al. 2001; Linkie et al. 2007; Chhangani et al. 2008; Priston 2008), crop type (Maples et al. 1976; Naughton-Treves 1997, 1998; Naughton-Treves et al. 1998; Hill 2000; Priston 2005, 2008; Priston & Underdown 2009), number of neighbouring farms (Naughton-Treves 1998; Hill 2000), surrounding land use (Hill 2000), and mitigation methods employed by the farmers (Maples et al. 1976; Sekhar 1998; Lee & Priston 2005).

With all these factors shaping the nature of crop raiding, the intensity of wildlife damage is understandably not uniformly distributed among producers (Besser & Brady 1986; Wywialowski 1994; Naughton-Treves 1997). In a national assessment of perceived crop losses to wildlife in the U.S., less than 0.3% of produce was found to be lost to damage by wildlife, but 51% of this damage was sustained by 1% of producers (Wywialowski 1994). Similarly, while crop loss on subsistence farms in Uganda averaged less than 10%, 7% of the farmers lost over 50% of their crops to wildlife (Naughton-Treves 1997). While the total percentage of crops lost to wildlife may be small in comparison to their total value, losses may not be small for the individual farmers involved.

1.4.2 Impacts of crop raiding

Crop raiding has a number of effects on raiders' health and activity budgets. Representing a foraging strategy that provides increased foraging efficiency of nutritionally superior foods, crop raiding increases the growth and reproductive rates of wildlife (Strum 1994). While it results in raiders spending less time feeding and more time resting and socialising (Strum 1994), it also increases the rates of competition and aggression encountered by raiders (Warren 2008). Furthermore, crop raiding tends to increase stress levels (Ahlering et al. 2011) and affects the social organisation of group living species (Warren 2008). Loss of learned foraging is a possible consequence, which could lead to greater mortality during years of food shortages (Warren et al. 2010).

Foraging on human-derived foods leads to increased exposure to disease transmission. In 1983, half the males in a group of Kenyan baboons (*Papio anubis*) died from tuberculosis due to feeding on infected meat at a garbage dump (Sapolsky & Share 2004). Also increased is the risk of disease transmission between wildlife and humans (Strum 2010). However, foraging on higher quality foods does appear to boost raiders' immune systems and increase their ability to fight off parasites and disease (Warren et al. 2010). Raiders also face an increased risk of mortality from farmers killing wildlife in retaliation to losing crops (Boulton et al. 1996; Warren et al. 2010; Strum 2010). It is difficult to obtain data on just how many animals are killed as a result of farmers attempting to their protect crops (Strum 1994).

Increased risk of mortality, injury and disease does not only affect wildlife crop raiders, but also affects the people involved. When protecting crops against large animals such as elephants and chimpanzees (*Pan troglodytes*), farmers often fear for their lives and fatal attacks on people are not unheard of (Studsrød & Wegge 1995; Mackenzie & Ahabyona 2012). Disease transmission from wildlife to both humans and livestock is more prevalent where crop raiding occurs, and increased time spent outdoors protecting crops brings with it increased risks of contracting diseases such as malaria (Mackenzie & Ahabyona 2012). Additionally, crop raiding can result in a lack of food for people, especially subsistence farmers (Loudon et al. 2006).

Crop raiding leads to reduced income for farmers (Loudon et al. 2006; Riley 2007; Priston & Underdown 2009) and an increase in time and money spent protecting crops (Naughton-Treves 1998; Lee & Priston 2005; Fuentes 2006; Marchal & Hill 2009). It is also associated with missed opportunity costs. For example, many children forgo their education to stay at home and protect crops (Naughton-Treves 1998; Kagoro-Rugunda 2004; Marchal & Hill 2009; Mackenzie & Ahabyona 2012), while protection also places a considerable drain on farmers' time and may lead to reduced time to complete other work (Lee & Priston 2005). Fear of crop damage can prevent farmers from using arable land (Wang et al. 2006), while abandonment of crop fields has been reported in response to crop raiding (King & Lee 1987; Naughton-Treves 1998).

As well as reduced profits for farmers, crop damage leads to increased prices for consumers (Messmer 2000) and can affect development of local communities (Loudon et al. 2006). It can also affect a country's economy; for example, loss of sugar cane to wildlife in Ethiopia resulted in reduced gross product of sugar factories, in turn affecting the country's economy (Admassu 2007).

1.4.3 Crop raiding is increasing

Since the study of wildlife crop raiding began, most studies have reported an increase in the prevalence of raiding (Besser & Brady 1986; Boulton et al. 1996; Tchamba 1996; Naughton-Treves 1997; Sillero-Zubiri & Switzer 2001; Wang et al. 2006; Nahallage et al. 2008; McLennan & Hill 2010; Pahad 2011; Mackenzie & Ahabyona 2012;). Several reasons for the increase have been suggested. Degradation of natural areas and the increase in agricultural lands due to an expanding human population probably forces wildlife into crop raiding (Starin 1989), or opens up opportunities for raiding (Admassu 2007). Furthermore, the intensification of agriculture results in large monocultures that can be very attractive to animals (Admassu 2007). Conversely, Boulton et al. (1996) demonstrated that a substantial reduction in cultivated land in Barbados led to an increase in crop damage by vervet monkeys (*Cercopithecus aethiops sabaens*). Increased crop raiding activity has also been ascribed to increasing population numbers of the offending species (Besser & Brady 1986; Pahad 2011), and decreasing population numbers of predators of the offending species (Biquand et al. 1994; Woodroffe et al. 2005; Wang et al. 2006).

1.4.4 Crop raiding on commercial farms

The majority of research conducted on crop raiding has focused on the conflict between wildlife and subsistence agriculturalists (Strum 1994; Studsrød & Wegge 1995; Tchamba 1996; Hill 1997; Naughton-Treves 1997; Hill 1998; Naughton-Treves 1998; Naughton-Treves et al. 1998; Sekhar 1998; Siex & Struhsaker 1999; Hill 2000; Saj et al. 2001; Hill 2004; Kagoro-Rugunda 2004; Priston 2005; Tweheyo et al. 2005; Linkie et al. 2007; Nahallage et al. 2008; Priston 2008; Warren 2008; Marchal & Hill 2009; Hockings et al. 2009; Priston 2009; Priston & Underdown 2009; Riley & Priston 2010; Strum 2010; Ahlering et al. 2011; McLennan & Hill 2012; Waters 2015).

However, wildlife damage to large-scale commercial agriculture is also a major facet of human-wildlife conflict and presents conservation challenges of its own. A small number of studies have conducted research on the extent of wildlife damage to commercial farms (Decker & Brown 1982; Besser & Brady 1986; Conover & Decker 1991; Wywialowski 1994; Conover 1998; Jonker et al. 1998; Admassu 2007; Chakravarthy et al. 2008; Engeman et al. 2010; Bal et al. 2011). Engeman et al. (2010) estimated the economic costs of primate damage to commercial farms in Puerto Rico at a total of US$1.13-1.46 million per year, likely a conservative estimate, while Conover (1998) estimated that agricultural producers in the U.S. alone sustain an annual loss of US$2 billion to wildlife. Crop losses on commercial farms are thus substantial and are likely to increase without significant action, warranting further research into crop raiding on commercial farms.

1.4.5 Primate crop raiding

Among vertebrates, rodents are by far the greatest agricultural pest, causing significant amounts of damage (Makundi et al. 1999; Stenseth et al. 2003). It is larger mammals however, that are often selected for attention as pests by the people involved (Knight 2001) and primates dominate amongst the larger mammals that damage crops (Naughton-Treves 1998; Naughton-Treves et al. 1998; Hill 2000). Naughton-Treves et al. (1998) reported that primates were responsible for 71% of crop damage events and 48% of the total area of damaged crops. Similarly, Priston (2005) reported crop losses to primates to be as much as 70% on individual farms, while Warren et al. (2007) reported instances when over 60% of a season's crops were lost to primates. Hill (2000) found baboons to crop raid more often than any other species and were responsible for 70% of all crop damage events. Within the primate order, almost all families have been identified as crop raiders (Lee & Priston 2005), but Cercopithecidae (baboons, macaques and to a lesser extent colobines) top the list of the crop raiding culprits (Nijman & Nekaris 2010). Within this family, *Papio* (baboons) are among the most frequently cited primate crop raiding species (Naughton-Treves 1998; Hill 2000).

People and primates have lived in close association in most primate ranges for thousands of years (Hill 2002), but because human and primate niches overlap extensively the possibility for competition between the two is much higher than for other species (Priston & Underdown 2009). Furthermore, despite the increasing threat to primates from human-primate conflict, some primates are able to cope with some degree of human encroachment (Hill 2002); some species are even able to thrive in human-modified habitats (Kaplan et al. 2011).

The adaptability, intelligence, opportunism and agility of primates allows many species to easily exploit human food sources (Nijman & Nekaris 2010). Traits held by some species within the primate order that further enable successful exploitation of agricultural resources include being primarily terrestrial with an ability to exploit arboreal habitats, opportunistic omnivores and possession of cheek pouches to store food and therefore maximise food acquisition while reducing processing time (Priston 2009). The fact that primates are able to cross fences with ease (Hill 2002) and often wait for farmers to leave before raiding (Maples et al. 1976) only lends to their success. As such primates are the most challenging of all the larger mammals to control (Conover 2002; Wang et al. 2006) and are frequently conceived of as 'pests' (Goedeke & Herda-Rapp 2005), posing major management and conservation challenges (Strum 2010).

1.5 Crop Raiding Prevention

If people and wildlife are to coexist outside of protected areas, then ways must be found to resolve conflict. Identifying successful methods will provide major enhancements to conflict resolution and wildlife conservation in general (Sillero-Zubiri & Switzer 2001); current threats to wildlife stemming from conflict require strategies to manage and contain conflict if populations are to persist (Lee & Priston 2005). Conflict resolution is also important in reducing the vulnerability of people that come into conflict with wildlife, by reducing the magnitude of wildlife damage sustained (Dickman 2010). If problems are allowed to persist losses will only get worse and difficulties in management magnified (Engeman et al. 2010). Furthermore, providing solutions helps encourage positive attitudes towards wildlife so that peaceful people-wildlife coexistence can be maintained (Strum 2010).

There are a number of deterrent methods that are currently implemented by agriculturalists that suffer from damage by wildlife. These include: guarding, chasing, beating drums, throwing stones, slingshots, spears, bear bangers, ultrasound, dogs, scarecrows, chilli bombs, translocation, culling, a range of fencing including electric, fladry, buffer crops, and many more (King & Lee 1987; Naughton-Treves 1997; Mason 1998; Knight 1999; Hill 2000; Hill et al. 2002; Strum 2005; Katsvanga et al. 2006a; Wang et al. 2006; Nahallage et al. 2008; Warren 2008; King et al. 2009; Arlet & Molleman 2010; Nyirenda et al. 2011; Kaplan 2013). However, most of these methods are employed with limited effectiveness and could be significantly improved. For example, fencing was not found to be effective at keeping nilgai (*Boselaphus tragocamelus*) or wild pigs out of crops in India, because nilgai can easily cross fences over 1.5m in height and pigs can dig beneath fences.

Mitigative techniques will only be successful if the risk to animals of crop raiding is increased to outweigh its benefits; techniques need to be developed that artificially enhance the perceptions of risk by reducing the accessibility or palatability of crops (Strum 1994; Lee & Priston 2005; Strum 2010). Furthermore, because crop raiders save foraging time they are able to ‘sit and wait’ for opportunities to raid. Control techniques therefore need to use up much of the raiders’ time (Strum 2010). To be effective mitigation must also meet the following criteria. First and foremost, the value of the resource to be protected, in this case the crops, must exceed the cost of a deterrent (Kaplan 2013). Second, any strategy must be appropriate to the site concerned and acceptable to those living there (Hill 2000). Last, the technique must meet the needs of both the people and the wildlife involved.

The first step in developing a strategy for controlling the impact of crop raiding is a general understanding of the ecology and behaviour of the target species, site-specific spatial and temporal determinants of conflict and the human socio-political and economic environment (Woodroffe et al. 2005; Bal et al. 2011). Solutions must be driven by both biological and social scientific data, and not solely by fears and prejudices (Treves & Karanth 2003). The success or failure of any mitigation technique is thus likely to be site and species specific; what to do depends on the species, location, and timing, as well as the historical and ecological context involved (Osborn & Hill 2005; Strum 2010). For example, species activity patterns and ranging behaviour, which influence daily and seasonal patterns of damage as well as the types of crops targeted, can have significant impacts on mitigation effectiveness (Osborn & Hill 2005). There is likely to be a strategic location and timing for the implementation of mitigation that will provide the best outcome; the scientific data collected should provide this information (Osborn & Rasmussen 1995; Tweheyo et al. 2005; Strum 2010). No solution will work without site-specific knowledge of what is possible, practical and acceptable in any particular area (Hill et al. 2002). Most control strategies will require some form of investment in either manual labour or capital (Wang et al. 2006), so an important consideration is that any management strategy is appropriate and affordable to the community concerned (Hill 2000). It is therefore extremely important to gather knowledge of the context of crop raiding at any study site, both from an ecological and social stand point, before implementing mitigation strategies.

It is unlikely that a single management strategy will prevent all crop damage by all problem animals (Wang et al. 2006), and therefore a combination of techniques should be used. Mitigation will work best when deployed simultaneously in a combination of methods and when used in random rotations (Mason 1998; Naughton-Treves 1998; Sekhar 1998; O'Connell-Rodwell et al. 2000; Sillero-Zubiri & Switzer 2001; Treves & Karanth 2003; Wang et al. 2006; Zimmermann et al. 2009). The mix of strategies used will often involve modification of raider behaviour, a change in human behaviour, spatial separation and increasing tolerance (Treves & Karanth 2003; Bal et al. 2011). In many cases, highly technical interventions are not practical and so are unlikely to solve the problem (Treves & Karanth 2003; Bal et al. 2011). Despite commercial farmers being in a better position to use technical interventions, the large size of the farms often precludes this from being an option. Furthermore, because many animals habituate to deterrents, the most effective strategies are likely to be adaptive and inexpensive rather than complex (Osborn & Hill 2005). It is more likely therefore that successful techniques will be developed from the improvements of traditional deterrent methods (Strum 1994; Sekhar 1998; Sillero-Zubiri & Switzer 2001).

Finally, developing and implementing effective mitigation strategies is challenging and can cause unexpected consequences. Effective mitigation may only displace the conflict (Tchamba 1996; O'Connell-Rodwell et al. 2000; Wang et al. 2006; Dickman 2010). For example, chasing primates from one field may simply move them to the next field. Furthermore, the removal of one problem species may allow another to move in. When cardamom farmers removed problem squirrels (*Funambulus palmarum*) from their plantations in south India depredation by birds increased significantly (Chakravarthy et al. 2008). These consequences need to be considered and monitored for mitigation methods to be effective in the long-term.

1.6 Thesis Outline and Objectives

Crop raiding is a serious problem for agriculturalists and has been occurring for centuries (Sillero-Zubiri & Switzer 2001; Lamarque et al. 2008). Despite recently having received considerable attention from conservation biologists (Maples et al. 1976; Strum 1994; Naughton-Treves 1997; Naughton-Treves 1998; Naughton-Treves et al. 1998; Siex & Struhsaker 1999; Hill 2000; Saj et al. 2001; Sillero-Zubiri & Switzer 2001; Hill 2005; Thirgood et al. 2005; Riley 2007; Priston 2008; Warren 2008; Priston 2009; Priston & Underdown 2009; Nijman & Nekaris 2010; Strum 2010; Bal et al. 2011), very few studies occur on commercial crop farms (Conover & Decker 1991; Agetsuma 2007). Even fewer focus their research on primate crop raiding on commercial farms (Engeman et al. 2010), or investigate techniques to deter primate raiders from commercial farms.

The thesis presented here will attempt to address this lack of research through an interdisciplinary study of a commercial crop farming community in the Limpopo Province of South Africa, and this community's relationship with baboons, the primary crop raiding species in the area. Given the importance of South Africa as a crop exporter and the fact that agriculture is an important sector in South Africa (Trade and Industry Policy Secretariat 2003), the issue of crop raiding on commercial farms needs to be addressed. The farmers involved in the research are white Afrikaners, also a relatively understudied group (Gordon & Spiegel 1993). Furthermore, within South Africa there are no legal restrictions on the number of problem animals that can be killed in attempts to protect crops, and commercial farmers often retaliate with lethal methods of control (LEMA 2003). Given that these farmers are permitted to deal with problem baboons as they please, there is no record of how many baboons are killed under these circumstances (Lyle Wiggins, personal communication).

In this thesis I adopt an interdisciplinary approach to provide an integrated understanding of the factors that influence crop raiding on commercial crop farms in South Africa, and the mismatch between farmer perceptions of and measured crop raiding. I use this information to inform mitigation decisions and attempt to develop effective non-lethal mitigation strategies against primates on these farms.

In Chapter 2 I provide an introduction to the study site and an overview of my interdisciplinary research methods. In Chapter 3 I use information gathered from commercial crop farmers to describe and explore their attitudes towards nature and perceptions of baboons. I explore how and why these farmers value nature and examine the ambiguous nature of their relationship with baboons. In Chapter 4 I continue with this anthropological approach to explore the problems that farmers must overcome to successfully harvest crops in the study area, and their perceptions of wildlife crop raiding. I explore what concerns farmers most about the difficulties they face in growing crops, and examine the way they perceive baboons when they inflict damage to their crops. These two chapters provide an understanding of how farmers perceive human-wildlife conflict, and which aspects of the conflict they are involved in affect them most.

In Chapter 5 I investigate the conflict from the primates' perspective, by gaining an understanding of primate behavioural ecology whilst on crop farms. I do this through behavioural observations on primates when they are on the farm. I also record field guard behaviour when responding to primate crop raids.

In Chapters 6 and 7 I then use biological and social data to examine farmer perceptions of crop raiding alongside independent assessments of crop raiding. In Chapter 6 I determine which wildlife species are involved in crop raiding within the study area, and which species are perceived to cause crop damage by commercial farmers. I integrate the data to examine which species are blamed for crop raiding and why, and identify which species receive more or less blame from farmers than perhaps they should. While determining which species are responsible for crop damage is important for correctly directing mitigation, it is also important to understand the reasons behind why certain species are blamed in order to effectively address farmer concerns. In Chapter 7 I use data on farmers' perceptions of crop loss and systematic estimates of loss to determine whether commercial crop farmers in my study area overestimate damage and whether farmers are able to accurately locate where damage occurs. I also examine the locations of damage to investigate spatial factors that may influence amounts of damage sustained in each field. Lastly in this chapter, I present a method of rapid damage assessment that may be useful for farmers to gain a better understanding of the amounts of damage they sustain.

The final two empirical chapters, 8 and 9, examine mitigation techniques. In Chapter 8 I review several deterrent methods, using farmers' opinions, my biological data, and information from the literature. In Chapter 9 I assess the effectiveness of three of these techniques – bells used as an alarm system, a motion-activated sound repellent, and the use of an electric fence. In the final chapter (Chapter 10) I provide a summary of my findings and make recommendations for mitigating primate crop raiding on commercial crop farms in South Africa.

CHAPTER 2: METHODS

2.1 Study Area

2.1.1 South Africa

South Africa is the southernmost country in Africa, situated approximately 2,400 km south of the equator. It is bordered by neighbouring countries Namibia, Botswana, Zimbabwe, Mozambique and Swaziland. It also surrounds the kingdom of Lesotho. On the south it is bounded by 2,798 km of coastline. South Africa has a total land area of 1,220,813 km^2 (Statistics South Africa 2015). The interior of South Africa is mostly flat, with altitudes of between 1,000-2,100 m, surrounded by the Great Escarpment whose highest peak at 3,450 m is in the Drakensberg. South Africa is well known for its biodiversity. Ranking as one of the most biologically diverse countries in the world it contains eight major terrestrial biomes: fynbos, grassland, savanna, Nama karoo, succulent karoo, thicket, forest and desert (Turpie 2003; Sandwith et al. 2005).

South Africa is ranked as an upper middle income economy and has a gross national income of US$6,800 per capita (World Bank 2014a). With close to 53 million people, it has an average life expectancy of 57-64 years (WHO 2013). The majority of the adult population (93.7%) are literate (World Bank 2012). However, there remains a 25.1% unemployment rate (World Bank 2014b) and 53.8% of the population live in poverty (World Bank 2010).

South Africa is a multi-ethnic society encompassing a wide variety of cultures and religions, along with 11 official languages (Adams et al. 2014; Chidester 2014; Mesthrie 2002). There are four major ethnic groups in South Africa: Black, Coloured, White and Indian; each group's identity is rooted in cultural aspects that long predate the establishment of apartheid (Adams et al. 2012). The Black (African) group constitutes the largest portion of South Africa's population (80.5%, Statistics South Africa 2015), and is composed of nine indigenous groups that are distinguished by language (Adams et al. 2012). The Coloured group (8.8% of the population, Statistics South Africa 2015) comprise people of mixed descent, primarily Black, Malay, Khoisan, Indian and European, and speak mainly Afrikaans (Adams et al. 2014). The White group (8.3% of the population, Statistics South Africa 2015) consists of descendants of the Dutch and English settlers who migrated to South Africa in the 1600s and 1800s respectively, and speak Afrikaans and English (Adams et al. 2014). Lastly, the Indian group, constituting the smallest portion of the population (2.5%, Statistics South Africa 2015), comprises the descendants of labourers and traders who came to South Africa from the Indian subcontinent in the 1800s with the prospect of building a better life, and speak mainly English (Adams et al. 2014).

Since the beginning of Western colonisation of South Africa in 1652, the White group have systematically discriminated against indigenous peoples (Adams et al. 2014). In 1948, the apartheid regime began, formalising the discrimination in policies and laws (Adams et al. 2014). Apartheid insisted the population be segregated into bounded culture-groups, and pitted groups against one another in the competition for resources made scarce by the state (Gordon & Spiegel 1993). The Black group was heavily discriminated against during the colonial and apartheid periods and resulted in Africans being dispossessed of land on a large scale (Benjaminsen et al. 2008). They were stripped of their citizenship and their movement was heavily legislated and restricted (Adams et al. 2012). The Coloured and Indian groups experienced less severe legal discrimination during apartheid than the Black group (Adams et al. 2012). Both groups received limited political and economic opportunities, while the Indian group's movements were heavily restricted, and even prohibited in some areas, but were nevertheless allowed more freedom than the Black group and were permitted to become relatively well educated (Adams et al. 2012). The White group were politically and economically dominant, with access to education and employment opportunities, ensuring economic affluence (Adams et al. 2012).

In 1994 apartheid was abolished, which has been described as one of the most extraordinary events in world history (Adams et al. 2012). Since the end of apartheid, South Africa has initiated rapid reform of many of its governance institutions, although reform has not been uniformly effective (Anthony et al. 2010). Unemployment and poverty remain rampant amongst the Black group, despite the changes made when apartheid ended; most are currently employed as unskilled or semi-skilled labourers or are unemployed due to lack of quality education (Adams et al. 2012). Most Coloured individuals still work as semi-skilled labourers or in the service industry, while the White group may be somewhat disadvantaged because current affirmative action provides challenges for employment and promotional opportunities, particularly for White males (Adams et al. 2012). However, despite Black identity being most common, the Western values of the White group remain dominant, particularly in the economic and business sectors (Adams et al. 2014). South Africa continues to face big challenges regarding poverty and racial inequality (Benjaminsen et al. 2008), while the segregation that characterised apartheid has not yet disappeared (Adams et al. 2014).

2.1.2 Blouberg Local Municipality

Field work was conducted primarily in wards 18 and 21 of Blouberg District Municipality, which is situated in the far north of the Limpopo Province, bordering Zimbabwe and Botswana (Figure 2.1).

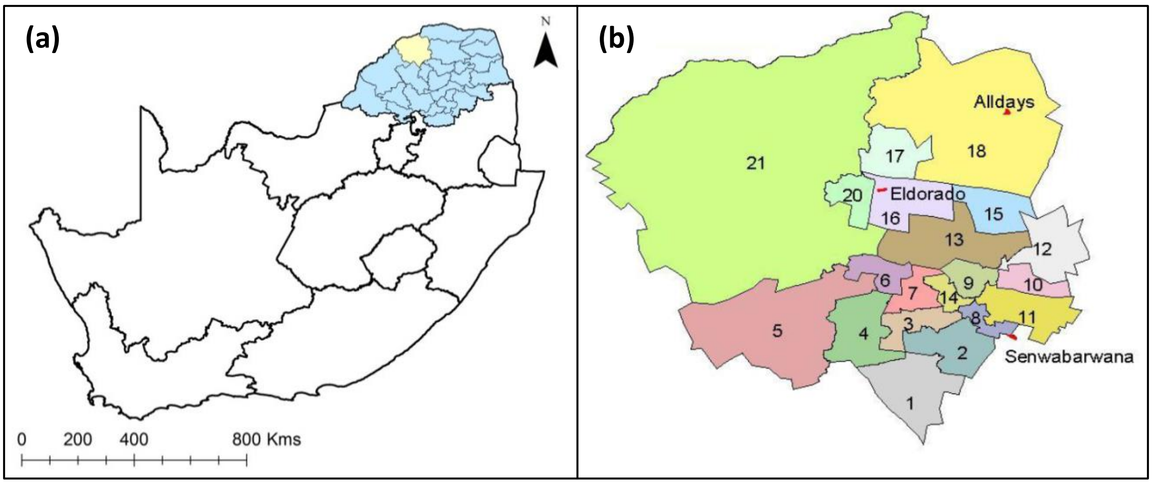

Figure 2.1: (a) Map of South Africa showing the location of Limpopo Province (blue) and Blouberg Local Municipality (yellow) within Limpopo Province. (b) Map of Blouberg Local Municipality showing ward locations; obtained from http://www.demarcation.org.za.

2.1.2.1 Climate

Blouberg has a semi-arid climate with warm, dry summers (October-March) and cooler dry winters (April-September). Temperatures range from an average daily minimum of 7^{o}C in June and July, with a minimum of -4^{o}C recorded, to an average daily maximum of 34^{o}C in January, with a maximum of 44^{o}C recorded (Limpopo DFED 2004). Annual rainfall varies within Blouberg between 380-550 mm, most of which falls during the summer months; the area is prone to frequent drought and the Mogalakwena River is the only perennial river (Grwambi et al. 2006).

2.1.2.2 Vegetation

The terrestrial biome of Blouberg Municipality is savanna (commonly referred to as bushveld), consisting of 11 vegetation types. All study farms where biological methods occurred and almost all farms where interviews occurred lie within the Limpopo sweet bushveld vegetation type. The remaining farms enter into areas of Roodeberg bushveld, Limpopo ridge bushveld and Musina Mopane bushveld (Figure 2.2). These vegetation types are defined by Mucina & Rutherford (2006) as follows:

- **Limpopo Sweet Bushveld:** Plains, sometimes undulating or irregular, traversed by several tributaries and comprised of short open woodland in distributed thickets of blue thorn (*Acacia erubescens*), black thorn (*A. Mellifera*) and sicklebush (*Dichrostachys cinerea*).
- **Roodeberg Bushveld:** Plains and slightly undulating plains, including some low hills, with short closed woodland to tall open woodland and a poorly developed grass layer.
- **Limpopo Ridge Bushveld:** Irregular plains, with ridges and hills, moderate open savannah, with a poorly developed ground layer. The presence of white seringa (*Kirkia acuminate*) on ridge skylines, baobabs (*Adansonia digitata*) on calcareous gravel and the trumpet thorn (*Catophracates alexandri*) on calc-silcate soils is characteristic of this vegetation type.
- **Musina Mopane Bushveld:** Undulating to irregular plains with some hills. Depending on the geographical location, these types of habitats can include open woodland to moderate closed scrubland, moderate closed to open scrubland on basalt areas and moderate open savannah on deep sandy soils.

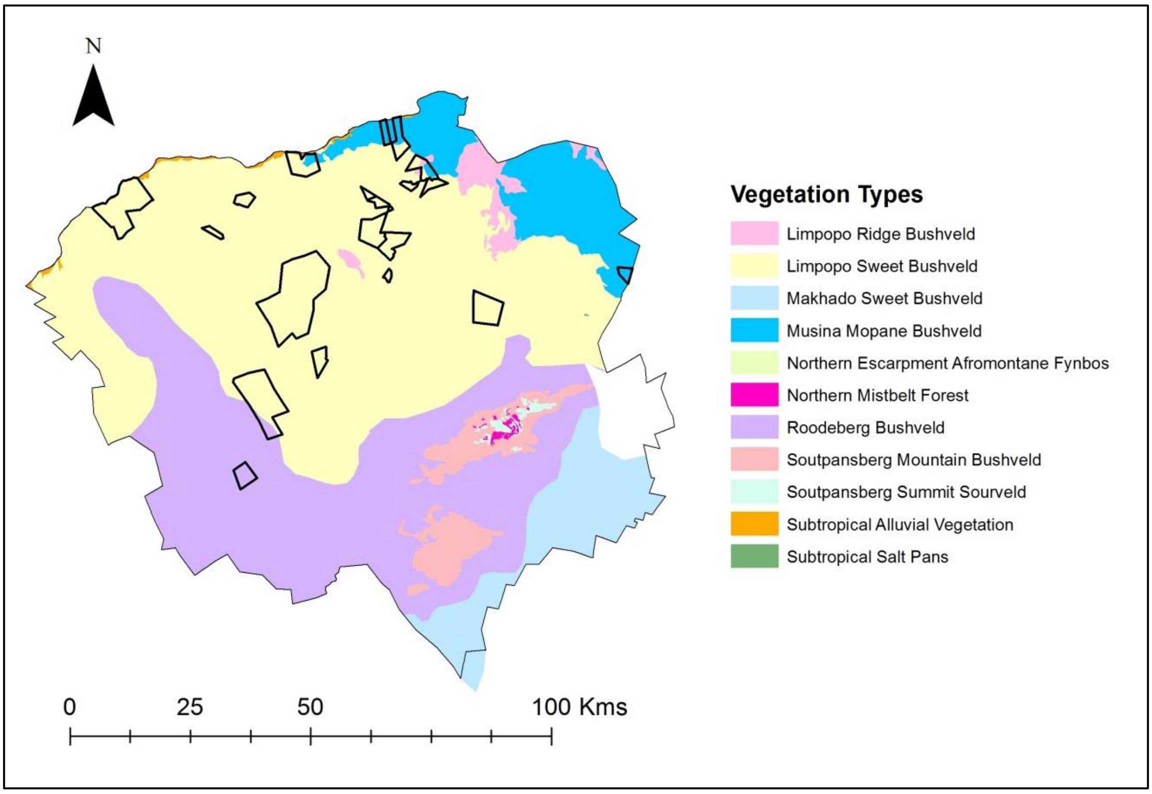

Figure 2.2: Locations of the study farms and the vegetation types of Blouberg Local Municipality.

2.1.2.3 Fauna and flora

The Limpopo Province has a high diversity of fauna and flora, which can be attributed to its diversity in landscape, terrain and vegetation types. The province supports 168 species of mammals (68% of the total number in South Africa), over 600 species of birds, 46 species of amphibian (40% of the number in South Africa), 148 species of reptile, 54 indigenous species of fish and a rich diversity of invertebrate species in all habitat niches (Limpopo DFED 2004). Included in these categories are a number of species endemic to Limpopo. Floral diversity is also high and within the provincial boundaries are three regions of floristic endemism. At least 170 species of plants are identified as rare and threatened, many of which are used as medicinal plants by local communties (Limpopo DFED 2004).

Present within the Blouberg study area are a variety of game species, including eland (*Tragelaphus oryx*), kudu (*Tragelaphus strepsicero*), blue wildebeest (*Connochaetes taurinus*), waterbuck (*Kobus ellipsiprymnus*), red hartebeest (*Alcelaphus caama*), gemsbok (*Oryx gazella*), sable (*Martes zibellina*), impala (*Aepyceros melampus*), mountain reedbuck (*Redunca fulvorufula*), nyala (*Tragelaphus angasii*), bushbuck (*Tragelaphus sylvaticus*), klipspringer (Oreotragus oreotragus), common duiker (*Sylvicapra grimmia*), steenbok (*Raphicerus campestri*), Cape buffalo (*Syncerus caffer*), Burchell's zebra (*Equus quagga burchellii*), giraffe (*Giraffa camelopardalis*), warthog (*Phacochoerus africanus*) and bushpig (*Potamochoerus larvatu*).

Carnivore species present include leopard (*Panthera pardus*), cheetah (*Acinonyx jubatus*), brown hyaena (*Hyaena brunnea*), spotted hyaena (*Crocuta crocuta*), caracal (*Caracal caracal*), serval (*Leptailurus serval*), aardwolf (*Proteles cristatus*), black-backed jackal (*Canis mesomelas*), bat-eared fox (*Otocyon megalotis*), honey badger (*Mellivora capensis*), African civet (*Civettictis civetta*), African wild cat (*Felis silvestris*), Cape clawless otter (*Aonyx capensis*), small-spotted genet (*Genetta genetta*), slender mongoose (*Galerella sanguinea*), banded mongoose (*Mungos mungo*), and dwarf mongoose (*Helogale parvula*).

Other species present include aardvark (*Orycteropus afer*), South African porcupine (*Hystrix africaeaustralis*) and scrub hare (*Lepus saxatilis*). A number of bird species that visit crop fields are also present in Blouberg, including helmeted guineafowl (*Numida meleagris*), Egyptian goose (*Alopochen aegyptiacus*), kori bustard (*Ardeotis kori*) and Abdim's stork (*Ciconia abdimii*). Various species of francolin are also present including Natal (*Pternistes natalensis*), Swainson's (*Pternistes swainsonii*), crested (*Peliperdix sephaena*) and Coqui francolin (*Peliperdix coqui*). Four of the five South African primate species are present in the area, the chacma baboon (*Papio ursinus*), vervet monkey (*Chlorocebus pygerythrus*), thick-tailed bush baby (*Otolemur crassicaudatus*) and lesser bush baby (*Galago moholi*).

2.1.2.4 People of Blouberg

Blouberg Municipality has a population of 162,629, 98% of whom are Black Africans (Capricorn District Municipality 2014-2015). The remaining 2% consists of Coloureds, Indians, Whites and 'others'. There are high levels of unemployment, poverty, dependency and illiteracy within the Blouberg area (Blouberg Municipality 2014-2015). Blouberg has the lowest level of education

(Grwambi et al. 2006) and the highest level of unemployment (Capricorn District Municipality 2014-2015) within the Capricorn District. The White group is mainly of Afrikaner descent and constitute 0.62% of Blouberg's population (Blouberg Municipality 2014-2015). Drawing on her own research, and the scholarly work of authors including Worden (2000, 2007), Bienart (2008) and Keegan (1996), Constant (2014) carefully details the history of the people of Blouberg. I use her extensive review to provide a brief summary on the history of this small group of Whites in Blouberg.

The modern day Afrikaners of the Blouberg region are descended from Europeans of Dutch and German descent who first colonised South Africa in 1652, when the Dutch East India Company established a settlement in Cape Town, and subsequently became known as the Voortrekkers. When the British settled in the Cape in 1772 they introduced conflict with the Voortrekkers, and consequently in 1835 the Voortrekkers set out from the Cape and began a long trek east towards the Orange River and north into the Transvaal.

During Voortrekker wanderings and the first years of their settlement, these people perceived it as their task to clear the land of wild animals to protect their pastures and make the country habitable. At this time, European perceptions of land and its wildlife were based on the view of the white conqueror. On arriving in the Blouberg area, the Voortrekkers entered into brief hunting partnerships with the indigenous peoples. These hunting partnerships enabled the settlers to develop intimate knowledge of their environment, including the tracking of wild animals, hunting and horsemanship, and herding, which necessitated knowledge of predators, plants, water, disease, drought and climate. However, this cooperation eventually deteriorated with expanding numbers of settlers. The settlers then began to clear indigenous peoples from their ancestral lands, who were enslaved or co-opted into enforced labour.

British encroachment into Blouberg territory culminated in the first Anglo-Boer War, commencing in 1879 in a fight for the Voortrekkers to become independent from the British Empire. After the conclusion of the second Anglo-Boer in 1902, large tracts of land were made available to overseas British investors and were subsequently sold to Afrikaans farmers during the late 1930s.

2.1.2.5 Agriculture

79.4% of South Africa's land is under agricultural cultivation (World Bank 2013b). The agricultural sector, along with mining, forms the backbone of the Limpopo economy and is the second biggest employment sector within the province, providing almost 120,000 jobs (Limpopo DFED 2004). There are two agricultural economies within Blouberg – the established and commercial white farming community and the less established and subsistence black farming community

(Blouberg Municipality 2014-2015). The commercial agricultural sector in Blouberg is large and mainly formed of Afrikaans speaking commercial farmers, whose properties incorporate a range of crop, cattle and game farming (Constant et al. 2015). Most commercial farmers engage to some extent with game farming, acquiring income in the forms of game capture, hunting and eco-tourism (Constant et al. 2015). Commercial farms vary in size between 320-10,000 hectares, with an average size of 2,694 hectares (Constant et al. 2015). Although a commercial farming area, extensive areas of Blouberg are populated by the Pedi tribe who make use of the communal lands (Grwambi et al. 2006).

Blouberg is well known for the production of tomato and potato products, as well as tobacco cultivation and pumpkins. Crops are mainly sold to national and international markets (Blouberg Municipality 2014-2015). Within the hot, dry climate of the Blouberg region, vegetable crops are mainly planted during the cooler winter season to avoid overly warm temperatures (Agricultural Reseach Council 2013).

2.2 General Methods

The data collection methods I use in this thesis have two key components – biological and anthropological – and produce a range of data sets. The range of methods are carried out on a number of different farms within Blouberg Municipality. The locations of all study farms are shown in Figure 2.3 and the characteristics of each farm are presented in Table 2.1, along with which methods were used on each farm. As different chapters draw on multiple data sets throughout the thesis the general methods are outlined here. Specific detailed methods are provided in relevant chapters. Due to its interdisciplinary nature, I have chosen to write in the present tense throughout this thesis, as is the norm with anthropological works.

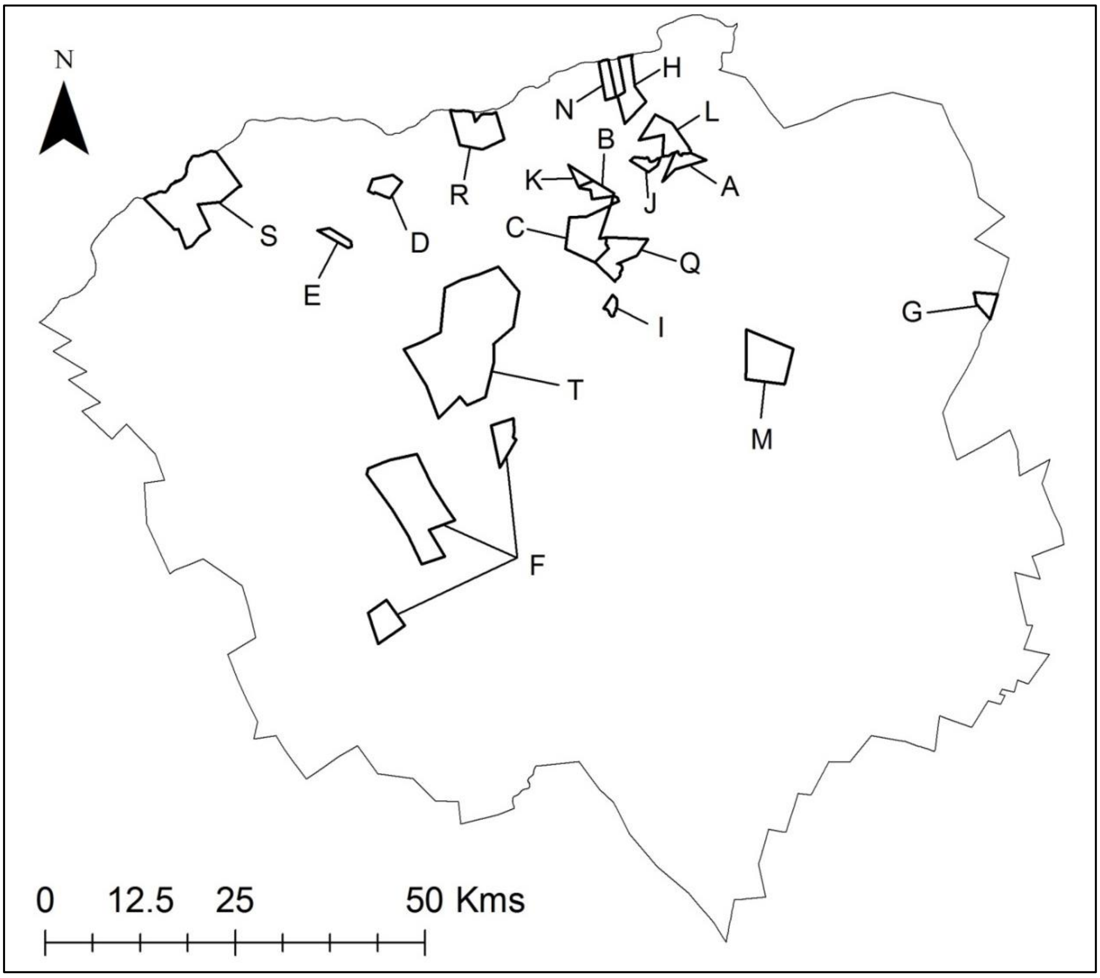

Figure 2.3: Location of all study farms within Blouberg Municipality. Letters indicate each farm, as identified in Table 2.1.

Table 2.1: Information regarding each study farm and methods carried out on these farms (Int: interviews; Beh: primate behaviour observations; Cam: camera traps surveys; Tra: vegetation transects; Mit: mitigation trials).

Farm	No. of farmers	Farm size (ha)	Crops size (ha)	Crops planted	Mitigation used	# Int	Beh	Cam	Tra	Mit
A	2	675	72	Baby marrow, butternut, tobacco	Day guards, fence, scarecrows	1	×	×	×	✓
B	4	564	80	Butternut, tobacco, tomato, pepper, watermelon, melon	Day guards, stones under fence, shooting, night patrols	4	✓	✓	✓	✓✓
C	3	2,500	60	Tomato, watermelon, butternut	Day guards, gas gun, shooting, scarecrows, electric fence	1	×	✓	×	✓
D	1	800	20	Potato, butternut	Day guards	1	×	×	×	×
E	1	400	55	Potato, butternut	Day guards	1	×	×	×	×
F	1	6,000	160	Potato	Day and night guards, electric fence, scarecrows	1	×	×	×	×
G	1	580	25-30	Zucchini, pattipan, baby gems, butternut, squash, tomato, watermelon, melon	Day and night guards	1	×	×	×	×
H	1	1,500	?	Lucerne	Day and night guards, fence, stones under fence	1	×	×	×	×
I	1	250	?	Tomato, lucerne, pumpkin	Day guards	1	×	✓	×	×
J	2	440	40	Tobacco, pattipan, maize, Herbert squash	Day and night guards, fence, shooting, hanging baboons on fence	1	×	×	×	×
K	1	300	?	Pattipan, baby marrow	Tin cans, shooting, scarecrows	1	×	×	×	×
L	2	1,680	20	Lucerne, mango	Day guards, electric fence	1	×	×	×	×
M	1	3,000	?	Onion, potato	Day guards, shooting	1	×	×	×	×
N	1	7,000[1]	110	Lucerne, maize	Day guards, electric fence	1	×	×	×	×
Q	0[2]	1,300	NA	NA	NA	1	×	×	×	×
R	0[2]	2,500	NA	NA	NA	1	×	×	×	×
S	0[2]	6,500	NA	NA	NA	1	×	×	×	×
T	0[2]	20,000	NA	NA	NA	1	×	×	×	×

[1] Includes a number of other farms not shown on the map
[2] Non-crop farming properties

2.2.1 Anthropological methods

To better understand the human-wildlife conflict present in the study area I used a mixed-methods approach to socio-cultural data collection. During two field trips I carried out a range of semi-structured interviews, focus groups and participant observation.

During March-April 2012, I made a pilot field visit to Lajuma Research Centre, South Africa – a research centre already well established with Durham University. During this time I used the research centre's owner and staff as gatekeepers to establish communication with surrounding land holders. It was during this period that I established contact with Mogalakwena Research Centre, a research centre located in northern Blouberg. Through members of this research centre I was able to make contact with local commercial farmers in the surrounding area. I then followed a snowball sampling strategy, where I used the social networks of people with the desired characteristics to gain access to further participants, those respondents then recruiting others themselves (Sadler et al. 2010). Desired characteristics were primarily commercial crop farming as an occupation and having had negative interactions with baboons.

2.2.1.1 Semi-structured interviews

During August 2012 to December 2013, I used purposive sampling to select interview subjects, appropriate given that the object of anthropological data collection was to identify and describe cases of human-wildlife conflict (Bernard 2006). Furthermore, the geographic location of the field site exposed me to the participants I wished to gain information from. I did not set out to conduct a specific number of interviews, but took available opportunities to interview participants whenever they arose. Given that qualitative research typically focuses on relatively small samples (Bell et al. 2008), this was considered appropriate. As such I approached farmers and asked if they would be willing to answer my questions whenever contact was made, and I deemed it appropriate to ask. I also used farmers known to me as gatekeepers to reach farming contacts of theirs.

Semi-structured interviews are the most common method of interviewing and allow a clear set of questions to be followed while the interviewer maintains discretion to follow any leads (Bernard 2006). The meaning and significance people give to their actions, which are necessary to understand why people act the way they do, can be better understood through semi-structured interviews (Seale 2004). This type of interview works well with busy people who require efficient use of their time, such as commercial farmers, and when more than one chance to interview someone is not possible – as was the case with many of the farmers I encountered (Bernard 2006).

Interviews were conducted later in the field season (from April 2013 onwards), at which point I felt I was well known and trusted within the community. This allowed interviewees to feel more comfortable answering the questions posed to them and allowed me time to learn what I wanted to know and how to phrase questions appropriately (Bernard 2006). Interviews were conducted in the participants' homes or farms whenever possible – a non-threatening, relaxing environment that was unlikely to be affected by other people (Gillham 2000). Prior to the interview commencing, I explained the nature of my project, the enquiries I was making and the ethical considerations around them. I made it clear that all responses were voluntary, confidential and anonymous, and that participants could withdraw from the study at any time, in which case all records of their participation would be erased. An information sheet was provided and a consent form was signed by all who took part (see Appendix 1 and 2). All interviews were conducted in English, voice recorded and later transcribed and entered into QSR NVivo 9. Each interview lasted between 30-60 minutes, depending on the participant's willingness to talk and how in depth their answers were.

An interview guide (Appendix 3) was formulated and used during each interview, which allowed me to remain focussed on the research questions and use the same standard questions throughout (Bernard 2006). The interview guide was split into five distinct sections, each section concerning the following:

- The participant's farming activities
- Perceptions of and attitudes towards baboons
- Experiences of conflict with wildlife
- Mitigation techniques used to prevent conflict with wildlife
- Perceptions of and attitudes towards nature and conservation.

The interview was given in this order so that, for example, interviewees' perceptions of baboons were gained before asking about problems with baboons. The last question allowed the participant to provide any further information they wished. The interview guide was modified slightly for use with non-crop farming participants, such that crop related questions were removed.

Lastly, a brief questionnaire was left with each participant to complete at their convenience, which allowed me to gather demographic information. Information requested included age, religion, ethnicity, education level, property size, sources of income, percentage of income from crops and crop types grown (see Appendix 4).

2.2.1.2 Participant observation and ethnography

During my field work I also conducted participant observation. It is argued that being a participant of what one observes is the only way to understand and interpret the meanings of people's actions and experiences (Cole 2005). It involves getting close to people and making them feel comfortable enough with the researcher's presence so that information about participants' lives can be observed and recorded (Bernard 2006). I immersed myself into the daily lives of the local people and built trustful relationships. As a result I was invited to attend numerous social events, including a funeral, and was also taken to a number of community agricultural meetings.

I recorded information from my observations in an ethnographic diary. I wrote an entry as soon as possible after every occasion that I had contact with participants, and gave specific attention to discourse I thought relevant to my research. I also asked my research assistants (see biological methods) to record any conversation they had with participants involving any aspect of the research. I transferred all material to NVivo 9 and coded its contents.

2.2.1.3 Farmer workshop

In November 2013 I carried out a mitigation workshop with local farmers. This involved presenting the attendees with a number of mitigation techniques – any that I had heard about, seen or read in the literature. After each method was presented discussion was opened up amongst the farmers so that they could share any prior experience with the method and their perceptions of whether they believe the method to be effective and appropriate for use on commercial farms in the study area.

A conference room was hired for the workshop in a local establishment that was well-known within the community and not too far for most farmers in the study area to travel (located on Farm Q in Figure 2.3). Dinner was provided for participants after the workshop in an attempt to encourage participants to attend. Invitations were made, printed in both English and Afrikaans, and personally handed out to farmers that I had contact with (Appendix 5). Posters were also made (Appendix 6), printed in English and Afrikaans, and put up around the local town to promote the workshop and encourage participants that I had no previous contact with. Thirty participants attended the workshop. The workshop was essentially a 'group interview' that allowed me to present participants with an idea, and the participants to respond to each other as the idea was evaluated (Frey & Fontana 1991). The workshop was video-recorded with permission from the participants and was later transcribed.

2.2.1.4 Data analysis

I used a grounded theory approach to identify the major themes within my social data – that is, I discovered ideas from the data, rather than trying to fit ideas to the data (Glaser & Scott 2006). I coded all data in NVivo 9, using an inductive coding approach – that is, codes evolved from the data (Bernard 2006). I was then able to organise codes into major themes. Drawing on those which occurred with high frequency and included intense responses from the participants I was able to create a thematic framework from which I analyse and discuss the results.

2.2.2 Biological methods

Field work was carried during two field trips, the first from August 2012 to December 2013, the second from July 2014 to November 2014. As well as the methods conducted below, group counts were conducted on baboon groups on an ad-hoc basis if the opportunity arose. This involved video-recording baboon groups crossing roads, and subsequently counting the number of individuals recorded.

2.2.2.1 Main study species

Chacma baboons live in a variety of habitats, ranging from sub-desert steppe, through savannahs to moist forest; as such they are common throughout much of southern Africa (Altmann & Altmann 1970; Estes 1991). They are a terrestrial primate (Byrne et al. 2009), with recorded home range sizes of up to 15 km^2 (Altmann & Altmann 1970; Henzi et al. 2011). Home ranges overlap with other groups, with baboons generally being non-territorial (Anderson 1981). Their social groups typically consist of a number of adult males, a greater number of adult females and many juveniles of all ages (Bolwig 1959). Chacma baboon group sizes have been recorded from four individuals (Henzi et al. 1997) to up to 198 individuals (Altmann & Altmann 1970). Average group size of chacmas in the nearby Blouberg Nature Reserve is 50 animals (Noser & Byrne 2007a). Females stay with their natal group while adult males disperse (Altmann & Altmann 1970). Baboons are opportunistic omnivores, feeding on a variety of food matter; if available, animal matter is most preferred, followed by fruits and seeds and then leafy vegetation (Hamilton III et al. 1978). They are listed as Least Concern on the IUCN Red List (Hoffman & Hilton-Taylor 2008).

Next to baboons, vervet monkeys are the most widespread and abundant of all African monkeys, ranging across much of sub-Saharan Africa (Struhsaker 1967). Vervets are present in savanna, open woodland and forest-grassland mosaic, especially close to rivers (Kingdon & Butynski 2008), and live a semi-terrestrial, semi-arboreal lifestyle. They occupy stable home ranges of between 0.18 km^2 and 6 km^2, which may overlap with neighbouring groups (Lee & Hauser 1998). They typically live in multi-male, multi-female groups of around 20-30 individuals (Struhsaker

1967). Females stay with the natal group while males emigrate as they near maturity. Vervet monkeys are a medium sized primate, males average 5.5 kg in weight and females 4.1 kg (Estes 1991). They are opportunistic omnivores taking what is most abundant and available. Vervet monkeys are listed as Least Concern on the IUCN Red List (Kingdon & Butynski 2008).

2.2.2.2 Crop raiding behaviour observations

Location

To maximise the quality of data collected a single focal farm was selected for behavioural observations. This behavioural study farm (B, see Figure 2.3) was chosen based on farmer cooperation, being within a practical travelling distance from base camp and having high levels of reported raiding. The four farmers living on this farm were informed of exactly what would occur on the farm and consent was obtained. With all farms in the area being different in size and crops grown, it was impossible to select a 'typical' farm in these respects (see Table 2.1). The study farm was however typical of the area in the crop protection methods being employed: field guarding. A focal field from this farm was selected based on farmer reports of being the worst field affected by crop raiding (Figure 2.4). An observation site was chosen to allow an unobstructed view of this field's crop-bushveld edge, as well as having optimum views of wildlife and human activity within the field. A hide was erected at the site to conceal observer presence from wildlife, or at least make them as inconspicuous as possible.

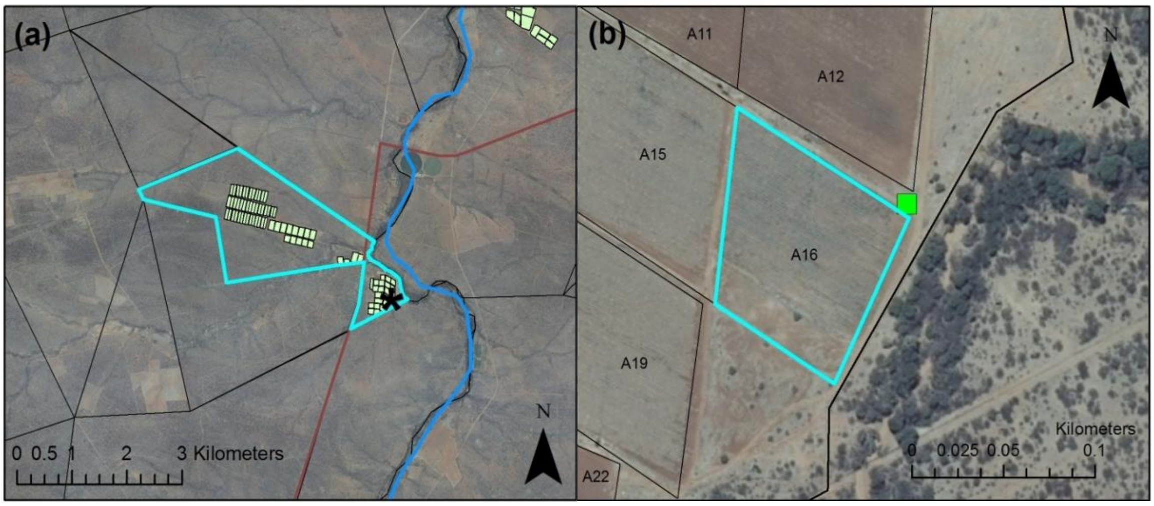

Figure 2.4: (a) Location of behavioural observations. The black star indicates the location of the crop field where behavioural observations took place; black lines demarcate farm boundaries, Farm B is highlighted in light blue, red line shows the main road, dark blue line indicates the river. (b) Location of the crop field observed, highlighted in light blue. The green box indicates the location of the observer hide; black lines demarcate crop fields and fence; bushveld can be seen on the other side of the crop fence.

Data collection preparations

The farm owners were encouraged to continue their usual farming practices and activity patterns, including responses to crop raiding and deterrent behaviours. They were advised that observers would take an unobtrusive role on the farm, recording activities but not responding to any raiding animals. Observers did not disclose any raiding activity to people on the farm. All arrangements for data collection were agreed with farmers in advance to ensure that they were aware of how and when their farm and behaviour were being observed. Myself and two assistants carried out behaviour observations.

A farm map of the view from the observation site was created and divided into sections. Sections were assigned logical codes which allowed locations of activity to be described quickly, consistently, and reliably across observers during data collection. From east to west the map was divided into six sections, representing two halves of the study crop field, farm roads and two other crop fields. From south to north the map was divided into seven sections, representing changes in land use and/or vicinity to the crops; including: bushveld far from the crops (D), bushveld just outside the crop fence (O), crop fence (F), inside the farm – between the fence and the crops (I), edge of the crops (E), crop field (C) and farm roads surrounding the crops (R). Additionally the crop field was split into three sections from south to north – the first 30m from the bushveld edge, 30-50m from this edge, and the rest of the field. Other crop fields within view, as well as a selection of specific locations, where either animals or humans spent higher amounts of time, were also given their own unique codes (Figure 2.5). Section boundaries coincided with readily viewable and relatively permanent features, such as roads, trees and wooden stakes. The diagrammatic map was used in the hide during each observation session.

Data collection techniques

A two week habituation period (23 April to 6 May 2013) was carried out before any data were collected to enable crop raiding wildlife to become accustomed to observer presence in the hide. During this time observer training on how to collect behavioural data was carried out. Behavioural data collection was conducted from 7 May to 20 August 2013, coinciding with the primary crop growing season and driest months of the year. Standard systematic behavioural observation techniques (Altmann 1974) were used to collect data on primate crop raiding behaviour as well as human on-farm behaviour. A combination of sampling techniques was used to ensure that enough data were collected to allow for the analysis of number and duration of visits, raiding party sizes, and estimates of crop damage.

Figure 2.5: (a) Diagrammatic farm map of locations used in behavioural data collection. (b) Aerial view of behavioural data collection area showing actual scales. Black circles represent locations given individual identities due to regular use by primates or people, not shown in (a). White square indicates location of observation hide.

The study farm was observed a maximum of five days per week, with observation days running from dawn (between 06:00 and 06:15) until dusk (between 17:45 and 18:00). Observation sessions were limited to a maximum of six hours per day per observer, to minimise researcher fatigue and maximise reliable data collection. Each day was therefore split into two approximately six-hour sessions, scheduled to run from dawn until 12:00 (AM sessions) or 12:00 until dusk (PM sessions). Observers worked alone at the observation site, swapping over at midday. Sampling schedules were prepared in advance to include rotations of sessions over days of the week and AM and PM shifts. Vehicles used for transportation to the site were parked over 200m from the observation hide in an attempt to minimise disturbance caused by observer change-over. Observers walked the remaining distance.

Observation sessions were conducted across all weeks of the study season to avoid seasonal bias, and over all days of the week and across all hours of daylight to ensure that sampling was representative across variations in human activity on the farm (Altmann 1974; Wallace 2010). Table 2.2 summarises the number of observation sessions that occurred each day of the week over the study period.

Table 2.2: Number of morning and afternoon observation sessions across each day of the week.

Day	am	pm
Monday	8	8
Tuesday	11	11
Wednesday	8	8
Thursday	11	11
Friday	13	13
Saturday	8	8
Sunday	10	10

Instantaneous scan sampling

Instantaneous scan sampling was used at five-minute intervals to record all presence on the farm: species or person type, location, activity and any vehicle used was logged. Date, time of scan, weather, observer, and any supplementary notes were also recorded. Scanning occurred across the farm from left to right, which included an area of bushveld just beyond the boundary of the farm. Any noticeable events (entry or exit into observer's field of view, or loud noises including baboon calls) that occurred outside the five-minute scans were also recorded, along with the time of occurrence. Information was entered directly onto a handheld PDA (PalmOne Zire 21), using Pendragon forms. Binoculars were used to aid observation when required.

Frequency of scans increased to one-minute intervals as soon as primates were observed, to facilitate fine-scale analysis of raiding-related behaviour and interactions with humans. During one-minute scans, all individuals – primate and person – were recorded. For primates, species, age, sex, location, height above ground, behaviour (in two categories, relating to movement and behaviour), as well as any foraging activity including foraging behaviour, food item and number of items, were recorded. For people, person type, location, any vehicle in use, and behaviour (two categories) were recorded. Time of scan, weather, observer and any supplementary notes were also logged. One-minute scans continued until at least two consecutive scans had occurred without any primate sightings being recorded. Five-minute scans were then resumed, occurring on the same time schedule as prior to the primate sighting. Information for one-minute scans was dictated into a voice recorder and entered into a spreadsheet at the end of the observation session. During data entry, the five-minute scan data not taken during primate sightings were extracted from the appropriate one-minute scans (maintaining the same five-minute time schedule) and inserted into the five-minute scan data sheets, to maintain continuity of sampling.

All-occurrence continuous sampling

Crop raiding events were also video recorded and videos were coded to provide details of both animal and human behaviour. Recordings were focused on the crop field-bushveld edge, with the frame remaining in a static position to capture all entries and exits to and from the crops, rather than following animals into the field. The video recorder field of view encompassed the entire field boundary through which raiding animals entered the field; animals rarely used the other field boundaries to gain access to the crops.

Video footage was used to record the following information for each crop raiding event: (1) species, (2) time when first animal entered the crops, (3) time when each additional individual entered the crops, (4) crop entry point for each individual, (5) age and sex class of each individual (if possible), (6) detection of raiding animals by humans, (7) every change in behaviour and location of humans, including the time of onset of chasing, (8) responses of animals to humans, including latency of primate response to being chased, (9) time each individual animal exited the crops, (10) time when the last individual exited the crops, (11) crop exit points for each individual and (12) number of crop items each individual removed. From these data the duration of each raid, number of individuals involved in a raid, the number of items removed during the raid and whether or not the raid was chased was extracted.

The amount of crop damage was estimated from observations of individuals carrying items out of the crop field during raiding events. Estimates derived in this manner are likely to be conservative because damage probably also occurs within the field during raids, which was not directly observable. It is therefore only items that are removed that are counted, and not those that are damaged and left behind in the field. Further assessment of crop damage immediately following raids was not possible because observers were to stay hidden from animals that often remained near the farm after raiding. Furthermore, observers were not to indicate to farm personnel that raiding had occurred.

Definitions

Primate sightings from the hide are distinguished between farm visits and crop raiding events. **Farm visits** are calculated from the time when a primate was first seen or heard within the vicinity of the farm (close enough to be detected by the observer) until the last individual was seen or heard for that visit. More than one hour had to pass with no sightings or vocalisations heard for a further sighting to be classed as a new farm visit (Tobler et al. 2008). It is assumed that after a period of one hour with no detection of a primate the group has moved away. If primates were only detected audibly with a duration of less than 30 minutes, it was not counted as a farm visit; in this instance the group is assumed to be passing by the farm rather than making a visit to it. **Crop raiding events (raids)** started when the first individual primate entered the crop field and ended when the last individual exited the crop field, and only if no other individuals were moving towards the crops between the farm fence and the crop field. If an individual exited the field but re-entered the crops within one minute without crossing the farm fence, the raid is considered to continue, but the time spent outside the crops was subtracted from the total time spent within crops (if there are no other individuals within the crops during this time). Each raid comprises only a single species entering the crops; instances of simultaneous raiding by more than one species are recorded as separate crop raiding events. Thus a farm visit can contain any number of raids, including none at all, and several farm visits can occur on the same day.

A response by a human to crop raiding activity is indicated by the onset of a behaviour that is directed towards the animals, such as chasing or shouting. Guard response time was measured from the first animal entry to the onset of guarding behaviour. No response was recorded if either (i) detection seemed to occur (awareness of the presence of crop raiding activity) but was followed by behaviour that indicated a decision not to respond to animal presence, such as resuming previous behaviour, or (ii) no detection seemed to occur. These latter two states were not differentiated as it was often difficult to determine whether detection had occurred if it was not followed by a response.

Data analysis

A total of 144 observation sessions were conducted across 83 days, from 23 April to 20 August 2013. The first 12 days of observation were excluded from analyses because this period was allocated to primate habituation to observer presence. A further two days were excluded from analyses, during which time baboon trapping occurred, since trapping in close proximity to the farm was considered a possible influence on raiding behaviour. Two afternoon sessions have been removed for baboons as well as one morning session for vervets, due to observer error which led to incomplete raiding behaviour data during those sessions. Logistical problems (e.g. difficulties with vehicles) resulted in some sessions being shorter than six hours. Total observation hours used for analysis was 699 hours 58 minutes for baboons and 713 hours 50 minutes for vervets, across 69 days.

On a number of observation days an observer was not present for an hour between morning and afternoon sessions, due to vehicle problems and logistical issues. If a farm visit was occurring when the morning observer left, and continued within one hour of the afternoon observer arriving, it was not clear whether the afternoon occurrence was a new visit or a continuation of a previously recorded visit. For the purpose of analysing number of visits, these afternoon sessions were excluded when this occurred and the corresponding amount of observer time was also removed from the analysis. Data for baboons and vervets were analysed separately.

From behavioural data the number of successful raids (when at least one individual entered into the crops, irrespective of whether or not crop items were removed), total duration of raids, total number of individuals involved in raiding and amount of damage were calculated per day, per farm visit and per raid. Minimum values are stated where data are missing, for example, it is not always possible to see whether a primate leaves the crop field with a food item, the item is therefore not counted and a minimum count is stated. The number of items that were removed from the field is used as a proxy for damage. I use NDVI (Normalised Difference Vegetation Index, downloaded from Global Land Cover Facility, (2015) as a measure of natural food availability, which in turn is used as a measure of 'season'. NDVI is one of the most commonly used vegetation indices (Jiang et al. 2006) and is an index of plant photosynthetic activity – the higher the NDVI (a value between -1 and 1), the more plant vegetation is present and available as natural forage. NDVI decreases in the study area as the dry season progresses (May to October). Time of day is measured as either morning (between 6am to 12pm) or afternoon (12pm to 6pm).

All data analyses is carried out in the statistical package 'R' (R Core Team 2014). I use non-parametric data analyses because the data sets do not have normal distributions and often contain many zeros. I use Wilcoxon rank sum tests to determine if there is a significant difference between primate species in the amount of crop damage they cause, for the whole observational period and by month, using day as my sample unit. I use linear regression analyses (function 'lm') to estimate which parameter of crop raiding is the best indicator of crop damage. A multiple regression incorporating all three parameters was not used as all are highly correlated with one another; parameters were therefore modelled separately to assess the proportion of variance explained by each. I used further linear regression analyses to determine which parameter – number of raids or duration – explained a higher proportion of variance in the number of individuals involved in raiding.

I use multiple regression (function 'glmmADMB') to analyse if season or time of day have an effect on a number of raiding measurements: duration of farm visits, duration of raids, and crop damage. The model glmmADMB was used to account for overdispersion within the data sets, caused by the presence of many zeros. Given that vervets appeared to leave the farm when baboons arrived, I also include duration of baboon farm visits as a predictor in vervet models, to assess the influence of this variable. I include day as a random variable and hours of observation as an offset term to control for different efforts in observation times (McCullagh & Nelder 1989). I use chi-square tests to determine which species is more likely to raid and how often they are involved in multi-raid or single-raid visits, and Spearman's rank correlation rho to test the relationships between visit durations and number of crop raids. I use multiple regression (function 'glmer' with poisson distributions) to determine the effects of species, NDVI and session on whether guards respond to raids and the effect of guard response on damage, raid duration and number of individuals. In this instance, NDVI is used as a proxy for temperature – as NDVI decreases temperature increases. The 'lmer' function was used to assess the effect of guard response and primate response time to guarding on damage and number of individuals involved, with NDVI and session as controls.

Prior to all regression analyses I inspected the distributions of predictors and responses and log-transformed data where necessary, to achieve a roughly normal distribution. Variables were also z-transformed when necessary. Where appropriate I checked various diagnostics of model validity and stability for each model (Cook's distance, DFBetas, DFFits and leverage; distribution of residuals, residuals plotted against fitted values, Field 2000; Quinn & Keough 2002). Variance Inflation Factors (VIF, Field 2005) were derived using the function 'vif' of the R-package 'car' (Fox & Weisberg 2011) and overdispersion was checked. To establish the significance of the full models (Forstmeier & Schielzeth 2011) I use likelihood ratio tests (Dobson 2002) comparing model deviances with that of the null models.

2.2.2.3 Camera trap surveys

Location

Camera traps were used to survey one crop field each on three different farms (B, C and I, see Figure 2.3). Five Bushnell 2010 Trophy Cameras were positioned along each crop-bushveld edge; spaced 20 m apart to cover a length of 100 m (due to logistical reasons only three cameras were used on Farm I, covering a length of 60 m). Camera traps were tested and spacing of 20 m was deemed sufficient to catch every movement between one camera and the next; all entries and exits from the field along these edges should therefore be caught on camera. Crop types, dates and camera survey periods are shown in Table 2.3. Number of trap-days were calculated for each field, during which time at least one of the cameras had to be fully functional.

Table 2.3: Locations of camera surveys with crop type, crop dates, camera dates and number of trap-days.

Farm	Field	Crop	Crop Planted	Cameras In	Last Harvest	Cameras out	Trap days
B	16A	Butternut	29/01/2013	09/03/2013	20/08/2013	02/10/2013	206
C	14-13	Tomato	Date unknown*[1]	16/10/2012	14/05/2013	26/06/2013	215*[2]
I	09	Tomato	Date unknown*[3]	16/03/2013	28/05/2013	01/07/2013	102

*[1] Plants just starting to fruit when cameras put in.

*[2] Cameras were not present on this farm from 07/01-28/01/2013.

*[3] Plants not yet fruiting when cameras put in.

Data collection

Cameras operated 24 hours a day, collecting frequency and duration data on both diurnal and nocturnal raiders, as well as human activity within each field. Batteries and SD cards were checked regularly. Photographs were sorted and coded using Windows Live Photo Gallery. Each photo was identified with species or person type (farmer, worker, researcher etc.), and date and time were recorded. Picture data were then downloaded to an excel spreadsheet using ExifTool and subsequently organised into independent field visits. For the purpose of analysis, a 'field visit' occurred each time one or more animals were captured on any camera trap, anywhere within the photograph. A visit started when the first individual was photographed and ended when the last individual was photographed – durations of visits were calculated accordingly. To avoid problems with independence, at least 30 minutes had to pass before a subsequent photograph of the same species was recorded as an independent field visit, (following O'Brien et al. 2003, Ridout & Linkie 2009 and Seufert et al. 2009). Individuals of different species visiting at the same time were counted as separate field visits.

Neither small mammals (those as small as or smaller than rats and mice) nor birds (with a few exceptions) were included in the analyses when caught on camera traps. Identifying the nature and extent of crop raiding by these species was not an objective of the study, nor would camera traps be the best method to record these animals. A few larger birds (helmeted guineafowl, francolin[2], Egyptian goose, kori bustard and Abdim's stork) were included in analyses, as these species are mostly ground-dwelling and large enough to be successfully and consistently caught on camera traps. Guineafowl, francolin and Egyptian goose have also been mentioned by farmers as crop raiders during interviews and/or participant observation. Species that were caught on camera traps but were unlikely to contribute to crop damage because their diets do not include fruit were removed from analyses: aardvark, Abdim's stork, African wild cat and bat-eared fox.

Data analysis

Due to the varying number of trap days between farm surveys, the average number of visits and average duration of visits per seven days were calculated for each species on each farm. A seven day period was used as average daily values were very small for some species. Durations of visits were calculated from the time the first individual of a species was photographed until the last animal of the same species was photographed, and 30 minutes passed without photographing another individual of that species. I used a chi-square test to check for differences between baboons and vervets, both in the frequency with which they visit the crops and the average duration they spend within the crops. I use Pearson's product-moment correlations to check for relationships between farms in the composition of raiding species. Average group sizes were calculated from behaviour data for primates (see Chapter 5, section 5.3) and from a sample of camera images for the remaining species. Where species were not caught on camera average group size was obtained from the literature.

2.3 Ethics and Research Permission

The Research Ethics and Data Protection Committee of the Department of Anthropology, Durham University approved this project (Appendix 7). The Durham Life Sciences Ethical Review Process Committee, Durham University, approved work with animals (Appendix 8). A research visa was obtained from the Republic of South Africa (Appendix 9).

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[2] The term 'francolin' is used here as a collective that includes any of the following species: Natal francolin (*Pternistes natalensis*), Swainson's francolin (*Pternistes swainsonii*), Crested francolin (*Peliperdix sephaena*) and Coqui francolin (*Peliperdix coqui*), which are all commonly resident in the area and similar in appearance, not being easily distinguishable on camera traps.

Anthropology ethics guidelines of the Association of Social Anthropologists of the UK and Commonwealth (Fairhead et al. 2011) were adhered to throughout the study. Individuals were always asked if they wished to participate in the study before interviews were conducted and all data were kept anonymous and confidential. The identity of individuals is concealed throughout the thesis, unless prior permission was granted to allow identification.

CHAPTER 3: PERCEPTIONS OF NATURE

3.1 Introduction

The following two chapters present my anthropological research findings, using information obtained through semi-structured interviews and participant observation (see Chapter 2, section 2.2.1 for methods). The results and discussions will be presented simultaneously, as is customary in qualitative research where theory emerges from the data (Curtin 2010). In this chapter, I will first present data profiling participants using a range of demographic information. This information applies to both chapters. I will then discuss several themes that emerge from the interviews, which give rise to a number of sub-themes. From this I develop a thematic framework – the framework being derived from the *a priori* research questions and emergent themes from the data. I use these themes to describe and explore crop farmers' opinions of nature and constructions of baboons in the first chapter, and then the problems they must overcome to successfully harvest crops in the study area, and their perceptions of wildlife crop raiding in the second chapter. Many local wildlife species raid crops, but I focus my study on baboons in particular, as these cause the most crop damage, and only briefly touch on other problematic species. I conclude both chapters with a discussion of the findings in terms of crop raiding deterrent implications. The information obtained is used to inform the remaining chapters of this thesis.

3.2 Who Are the Crop Farmers?

The focus of my anthropological data collection is on crop farmers, therefore most interviewees (n = 16) were of this occupation. The contribution of crops to each farmer's total income ranges between 2% to 100% (see Chapter 2, section 2.2.1.1 on how participants were selected). I also interviewed a small number (n = 4) of local people within the community belonging to other occupations, and I include some of their statements in the analysis. Interviewees' profiles are outlined in Table 3.1.

All crop farmers interviewed are male, Christian, and of Afrikaner descent. Their age range is 20 to 68 years, with a mean of 38.2 years. All are educated to at least secondary school level, with a small number educated to university level. Just under half the respondents (43.8%) have farmed crops all their adult lives (average 12.1 years, range 2 to 24 years). Those who had a previous occupation have been crop farming for an average of 12.3 years (range 5 months to 21 years). The majority (81.3%) own the farm they work; farm ownership extends from 11 years up to four generations. Three respondents manage farms on behalf of the owner. Farmer households range from 2 to 5 people, with 0 to 3 dependents.

Table 3.1: Interviewee profiles. Cells are shaded where information was not obtained.

Participant Code	Farm	Gender	Age	Education Level	Farm Type	Activity on Farm: CROPS	CATTLE	GAME	TOURISM	Position on Farm	Income from crops
F05	C	Male		Secondary	Agricultural	✓	✓	✓	×	Owner	40%
F06	D,E	Male	35	Secondary	Agricultural	✓	×	×	×	Owner	93%
F07	F	Male	39	University	Agricultural	✓	✓	×	×	Manager	100%
F08	G	Male			Agricultural	✓					
F01	B	Male	32	Secondary	Agricultural	✓	×	✓	×	Owner	95%
F04	B	Male	28	Secondary	Agricultural	✓	×	✓	×	Owner	95%
F02	B	Male	63	University	Agricultural	✓	×	✓	×	Owner	95%
F03	B	Male	39	Secondary	Agricultural	✓	×	✓	×	Owner	95%
F09	H	Male			Agricultural	✓*	✓	✓		Owner	
F10	I	Male			Agricultural	✓	×	×		Owner	
F15	M	Male			Agricultural	✓	✓	×			
F16	N	Male	42	Secondary	Agricultural	✓**	×	✓	×	Manager	2%
F12	J	Male	20	Secondary	Agricultural	✓	✓	×	×	Manager	95%
F13	K	Male	31	University	Agricultural	✓	✓	✓	×	Owner	100%
F11	A	Male	23	University	Agricultural	✓	✓	×	×	Manager	80%
F14	L	Male	68	Secondary	Agricultural	✓	✓	✓	×	Owner	50%
A01	S	Male	67	University	Game Reserve	×	×	✓	✓	Owner	0%
A02	T	Male	37	University	Volunteer Project	×	×	✓	×	Project Owner	0%
A03	Q	Female	38	Diploma	Tourist Lodge	×	×	✓	✓	Lodge Manager	0%
A04	R	Male	34	University	Predator Park	×	×	✓	✓	Manager	0%

* Crops grown for game and cattle only

** Crops mainly grown for game, sold if surplus to needs

3.3 Analysis and Discussion of Interviews: Emergent Themes

Four major themes emerged from interviewing crop farmers: attitudes towards nature, perceptions of baboons, risks to crop yields, and the nature of crop raiding. I will discuss the first two in this chapter (Figure 3.1).

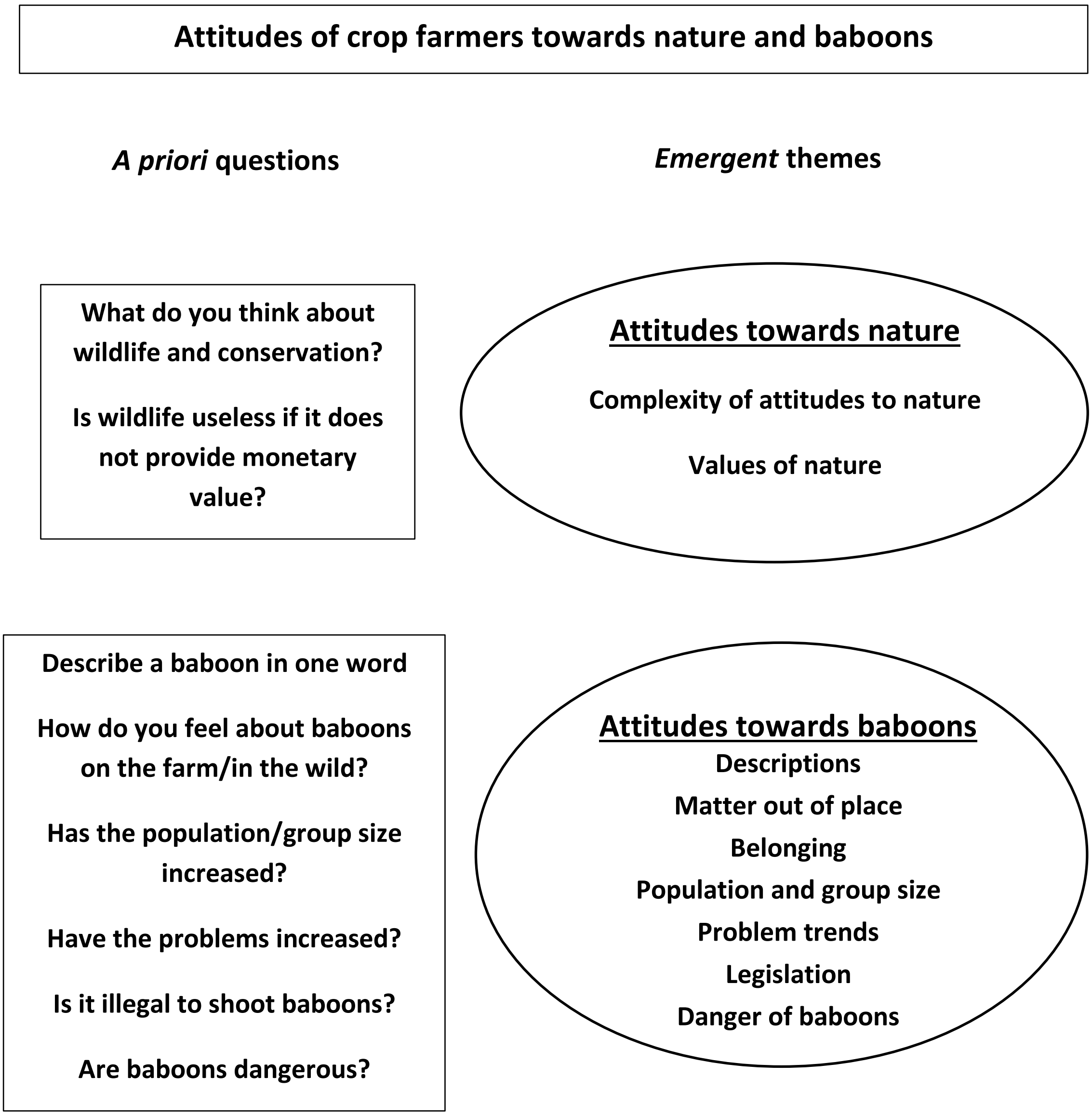

Figure 3.1: Thematic framework of major emergent themes arising from interviews. Headings in each bubble are provided in the text; sub-themes guide the subject-flow of the analysis.

3.3.1 Attitudes towards nature

Attitudes are defined as the evaluation of a particular object with some degree of favour or disfavour (Allendorf 2007), attitudes towards nature however cannot simply be described as positive or negative. People's relationships with nature are far more complicated and emotional than such a simple 'black-and-white' perspective. For example, Indonesian farmers face a dilemma with orangutans (*Pongo abelii*) – they enjoy the pleasure of seeing orangutans and hope their grandchildren will have the same experience, but this comes at the expense of their livelihoods when orangutans raid crops (Campbell-Smith et al. 2010). Similarly, in the Maasai Mara, Kenya it is often difficult for individuals to say whether they like or dislike lions, because lions provoke both feelings of awe and admiration as well as fear and resentment (Goldman et al. 2010). These variable attitudes towards nature are quite typical and are prevalent in a number of studies (for example see also Dietz et al. 2005; Hurn 2005; Loudon et al. 2006). As such, attitudes towards nature are often ambiguous and uncertain.

When asked what they think about nature in their area, every interviewee responded positively with statements such as 'I love it', 'it's wonderful' and 'that's why we stay here'.

> *We are very blessed to be able to live in this area with all the wildlife, it's nice to wake up in the morning and hear the birds outside and the zebra making a bunch of noise, I won't change it for anything, or ruin the wildlife.* (F12)

> *It's a wonderful place to stay and I'm very fond of nature… I've battled for 36 years to buy me this little piece of land, and I'll protect it with my life.* (F02)

This community thus appears to hold positive views towards nature. However, alongside these positive statements farmers also express negative sentiments towards the same wildlife. One farmer voices his concern about people-wildlife conflict, directing this opinion at any species that cause a problem.

> *You can conserve all species, but once a species causes a problem, it's numbers are picking up and it puts a financial burden on the people in the specific areas, then you must reconsider it and first solve the problem [before you conserve it].* (F09)

In order to mitigate human-wildlife conflict, it is important for conflict managers to understand where attitudes lie and when they 'cross over' from being supportive of a specie's survival to wanting to persecute it. There are a variety of explanations for such 'crossing over'. For example, diminishing support for conservation can occur: (1) in opposition to the pursuit of basic needs (Dietz et al. 2005); (2) with want of access to additional land (Newmark et al. 1993); or (3) with the want to eliminate conflict with wild animals (Lindsey et al. 2005). As discussed later, animals crossing moral or geographical boundaries can also cause people's attitudes towards these animals to change and take on ambiguity (Section 3.3.2). Given the diverse nature of attitudes across and within communities (see Hill 1998; Bal et al. 2011; Gifford & Nilsson 2014), it is important not to generalise explanations, but rather assess each community on its own merits. Given the focus of this thesis on baboons, I have attempted to explain farmer ambiguities towards baboons in the next section.

Despite being in conflict with wildlife through crop loss (and livestock/game depredation for some), study farmers nevertheless do not wish to see any animals become extinct, including baboons.

> *You can't let anything go extinct.* (F10)

> *Even the baboons you have to protect.* (F16)

> *They've got their place in the wildlife.* (F04)

> *Sometimes I do feel like it [wanting baboons to disappear], but no, I won't like any species to disappear.* (F03)

A high level of support for conservation despite a belief that conservation areas cause many problems for local people is not unusual (Infield 1988; Newmark et al. 1993; Studsrød & Wegge 1995), and can prove extremely useful if increasing farmer tolerance is to be used as a method of reducing conflict.

<u>Valuing nature</u>

Values are the range of orientations towards an object that provide the foundation for an individual's attitudes, which in turn guides the interpretation and use of the object (Manfredo et al. 2003; Manfredo 2009). Changes in values are assumed to lead to changes in decisions and consequently behaviour (Dietz et al. 2005); shifts in nature values can therefore result in changes in human behaviour towards wildlife. For example, economic development in post-industrialised nations has led to affluent societies placing increasing emphasis on higher-order psychological values, such as quality of life and environmental protection, over materialist values such as those required for basic human needs – security, shelter and food (Manfredo et al. 2003). Human history of whaling provides another example; over time human values of whales have changed from viewing the whale as a resource to be exploited, to whales being the subjects of recreational interest, admiration and protective concern. These values began to change with the acquisition of knowledge about the whale, which evoked feelings of admiration and awe, the whale being at the apex of their food chain and having successfully mastered the challenge of survival in the great oceans (Kellert 1997). If a person's values are understood, a conflict manager can anticipate their reactions to a variety of issues and will have insight into what can be done to change their behaviour towards wildlife.

However, describing human values of nature can be difficult because they are influenced by so many factors. These include aspects such as culture, gender, age, income, education and so on, and by the fact that values change dependent on circumstances. For example, values change when a person who was hungry has eaten (Hunter & Gibbs 2007). Essentially, human values of nature can be intrinsic or instrumental (extrinsic). An object with intrinsic value has a value independent of its usefulness to people or any other species – many conservationists believe that every species has value without reference to anything but its own existence (Justus et al. 2009). An instrumental value is valuing a species because it provides a means for acquiring something else of value. For example, art is instrumentally valuable because its value derives from the responses, such as pleasure, it produces in humans. Materialistic uses are the core of instrumental values, but spiritual, aesthetic, scientific and educational values, as well as ecosystem service provision, are also included here (Hunter & Gibbs 2007).

The core human values of nature within the study community are instrumental, under which all farmers appreciate nature for a variety of reasons. These include economic: "*a lot of people do live off the wildlife by hunting or whatever*" (F06), *"It's our country's main income [through ecotourism]"* (F08); recreational: "*I enjoy watching the animals, that's the main thing*" (F03); aesthetic: *"it's beautiful"* (F01); health and well-being: "*If something happens with you, you get overwhelmed with something and then you go to the nature and sit in the blind and look at the animals… and you're back on track again*" (F15); religious: "*Because it's God's creation, and that's the closest way to get to God*" (F15); and scientific: "*It gives everybody the opportunity to develop, to discover, to see, to read, to come out with new ideas*" (F05).

Just one farmer expressed appreciating nature for its intrinsic value, stating the reason to value nature is because it is available for everyone, rich and poor.

> *Everything with humans, we want to make money, for what, we already have everything. The richest, the poorest – that's why nature is so beautiful, it's there for everyone, for these people there, for me, everybody. You must just appreciate it, you must look in your eyes, you must see it.* (F07)

It is clear that communities value nature in a myriad of ways. Each value can be utilised when attempting to reduce human-wildlife conflict. The enjoyment of nature is important to people all around the world; more Americans visit zoos annually than attend all professional football, baseball and basketball games combined (Kellert 1997). Ecotourism is widely recognised as a method of directing income to local stakeholders to promote more positive and tolerant attitudes towards wildlife (Archabald & Naughton-Treves 2001; Rosie Woodroffe et al. 2005). Interaction with nature helps recovery from and prevention of stress, reduces sickness and blood pressure, increases relaxation and enthusiasm, aids recovery from illness, helps pain control and creates positive changes in mood (Pretty 2004). Health benefits can be promoted as a reason to conserve wild habitats and species. A number of religions are already responsible for people's generally tolerant behaviours towards wildlife in the face of conflict (Sekhar 1998; Nahallage et al. 2008). Without the knowledge of how a community values their natural environment, conflict managers will be unable to utilise these values when attempting to reduce environmentally harmful human behaviours.

Prevailing values should be drawn on and used when designing and implementing mitigation strategies; understanding why people value nature therefore proves extremely useful when investigating how to relieve human-wildlife conflict.

3.3.2 Attitudes towards baboons

Descriptions of baboons

Primates engender a range of different, and often conflicting, perceptions among people. While some cultures worship primates for their spiritual importance (Richard et al. 1989), others view primates as portents of evil (Simons & Meyers 2001). Even within cultures primates evoke contrasting opinions. In Thailand, long-tailed macaques (*Macaca fascicularis*) are tolerated within temple confines, but may be shot if they venture into surrounding rice fields (Eudey 1994). It is important to investigate the opinions held towards these animals if attempting to alleviate human-primate conflict.

Prior to any topic regarding problems with baboons being raised, study farmers were asked to describe the baboon using a single word (Figure 3.2).

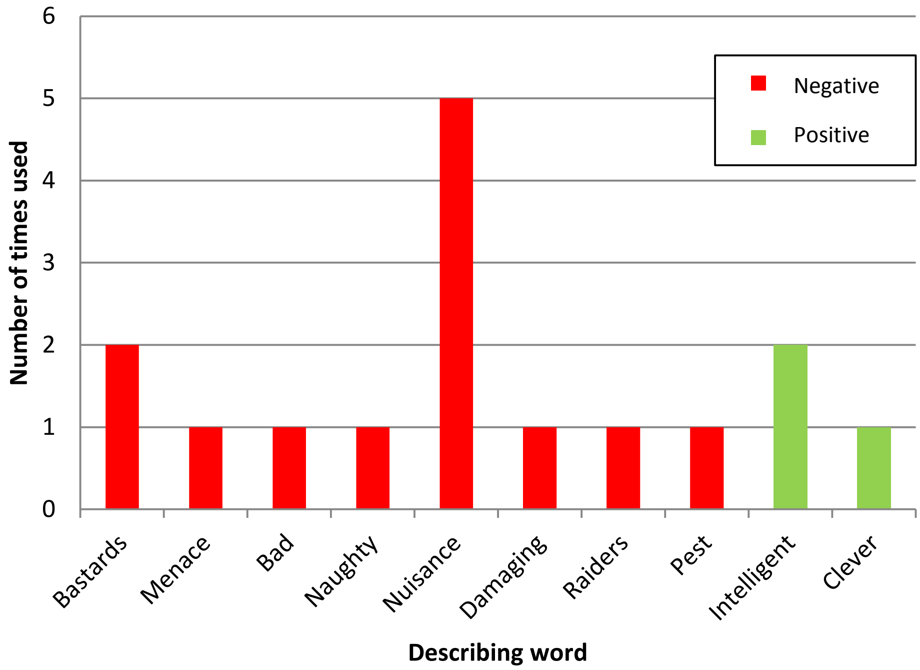

Figure 3.2: Number of times crop farmers used various single word descriptions of baboons

Even at this point in the interview, most words used (81.3%) have negative connotations. Most frequently used is the word 'nuisance' – not as negative as others such as 'bastards' and 'menace'. A number of words clearly reflect the baboons' status as a crop raider, such as 'damaging', 'raiders' and 'pest'. Words with positive connotations always refer to the baboon's intelligence. Although these words appear to positively describe baboons, taking a deeper look into farmers' beliefs that baboons are clever reveals that this is not necessarily an attribute that farmers view in a positive light.

If we do have a problem, one that's too clever for us, we will trap him and kill it. (F02)

The problem is that they are intelligent. (F05)

They're really clever, I think that is why they are a pest. (F01)

Within the crop raiding literature, perceptions of baboons as 'intelligent' are often recognised alongside descriptions such as 'calculating' 'malicious' and 'vindictive' (Hill 1997, 2000). This is also true with these study farmers.

In the fields it's as if they know they're not supposed to be there and they're doing something wrong. (F15)

If nobody is around, like on Sunday they know the staff don't come in, but when you wake up suddenly the whole lawn is just covered in bloody baboons, you know. So they *definitely keep a calendar somewhere and watch. They know exactly what is going on. They are very clever.* (A01)

Anthropologically speaking, there is a strictly drawn theoretical and moral boundary that exists between humans and animals, whereby animals are accepted as lower beings and can therefore be put to work and utilised by humans (Corbey 2005). However, their perceived intelligence shifts baboons across this human-animal boundary into a realm where they are considered able to understand moral obligations such as trespassing and stealing; the deliberate disobedience of these moral obligations is just not acceptable. This concept is amplified given baboons' apparent similarity to humans. Human-likeness creates expectations that are founded within human morality about how animals should interact with people – when animals transgress these social rules, as they do when they 'steal' crops, they are measured against the same moral framework as humans (Hill & Webber 2010). A number of farmers in this study talk about baboons being like humans.

They are just like you and me. (F06)

They're a lot like humans. (F15)

The idea of an animal's intelligence and human-likeness being perceived negatively is present elsewhere within the literature. Local farmers in Uganda claim "Baboons are a problem because of their skills, which are like those of humans" (Hill 2000, p130), while Costa et al. (2013) reveal that participants who rank baboons as 'similar to people' hold the most negative attitudes towards them. It is clear then that baboons' human-likeness further pits them against people.

However, another set of research suggests that an animal's human-likeness, instead of eliciting negative attitudes, raises concerns about the extension of moral rights enjoyed by humans to these animals (Bastian et al. 2011). It is argued that if animals are similar to humans in characteristics that define humans, then these animals should receive protection equivalent to the protection of humans (Bryant 2007). This perception is not just held by animal rights advocates, but also by the general public. For example, Knight (2003) describes how there is considerable reluctance among rural Japanese farmers to harm Japanese macaques, despite the macaque being recognised as a significant crop pest, because of macaques' physical resemblance to humans. Bell et al. (2008) detail how in Finland, fishermen have affection towards the Saimaa ringed seal (*Phoca hispida saimensis nordq*) because it shares various attributes with humans, such as intelligence, intentionality and social bonding. Kellert (1985) describes how phylogenetic and mental similarities to people, as well as a 'humanoid appearance', play a role in humans' species preferences. Animal intelligence can of course also be viewed in a positive light, such as the Maasai respect shown towards lions because they are accorded with a degree of intelligence (Goldman et al. 2010). Affinity for the baboon because of its human-likeness is also demonstrated within the current study.

> *I like them, they're really funny, to look at, and they're really nice. They've got a nice structure, and they cough like humans, I've watched them a lot, at other people's farms.* (F01)

> *If I find them in another place I don't mind them at all, they're very interesting and they're a lot like humans, I don't mind them.* (F15) [3]

These statements already illustrate the uncertainty felt towards baboons amongst this community of farmers – baboons are perceived both in a negative (they are too intelligent and know they are not supposed to be in the crops) and in a positive way (they are interesting and entertaining), because of their similarities to humans. This ambiguity surrounding perceptions of baboons is a common theme within the farmer-baboon relationship.

'Matter out of place'

One possible explanation for the ambiguous relationship between farmers and baboons is that a species (i.e. the baboon) is not always in conflict with people in every situation. For example, animals assume a completely different identity – sometimes both legally and discursively – within national parks than they do within private land (Hytten 2009). Among the constructions of baboons given by study farmers, a key criterion eliciting negative perceptions is baboons being in the 'wrong' place.

> *…if I see them in the wild it's OK, they're quite nice, but in the [crop] fields they create so much havoc and destroy so much crops that, I hate them in the fields, but in general I quite like them.* (F04)

This perception is shared by every crop farmer interviewed. Within the crop fields baboons elicit emotions such as 'angry', 'cross' and 'nervous'. When talking about baboons outside of the farm, emotions such as 'enjoyment' and 'interest' are familiar to the farmers.

> *I enjoy them, no they don't bother me at all.* (F05)

> *If you visit Kruger then it's nice to watch them… you can see they play and they are interesting, yes, then I like to watch them.* (F08)

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[3] Note that in both these quotes the reference to liking baboons is made only if they are found in another place, not the farmers' own farms.

> *Actually I enjoy baboons, watching them… it's fun to watch them.* (F16)

The idea of baboons 'being in the wrong place' resonates with Mary Douglas' theory of 'matter out of place' (Douglas 1966). Douglas states that dirt is matter out of place and therefore a product of the social understanding of environmental order: *"shoes are not dirty in themselves, but it is dirty to place them on the dining table"* (page 37). Specialists within the field of mammalian pest control also use this approach to define pests: "*much as we may define a weed as a plant in the wrong place… so some animal pests too are only pests when in inappropriate numbers or in the wrong context*" (Putman 1989, page 2). Just as Knight (2001) points out, when these animals are 'out of place' they become 'pests' within the social understanding of farmers – that is, the baboon is only seen as a pest when it is causing problems on the farm.

This 'love-hate' relationship between people and wildlife is not uncommon when conflict is present. Maasai people express joy and admiration for the lion when observing them in parks or pictures, but the sight of lion near their livestock or homes evokes fear and hatred (Goldman et al. 2010). Dingoes (*Canis lupus dingo*) are similarly perceived in Australia: "we don't mind the dingo in its *rightful* place… we just don't want it on *our* private land" (emphasis added, Hytten 2009, p22). Indonesian farmers inform researchers that long-tailed macaques are protected on a conditional basis – they are protected on temple grounds, but some farmers admit to attacking those that raid their farms (Loudon et al. 2006). Even species that people value for economic reasons, such as white-tailed deer, are viewed as a nuisance if they are abundant and habitually found in the wrong place at the wrong time (Goedeke & Herda-Rapp 2005).

The pestilence discourse that study farmers use for baboons supports this idea. When asked if farmers considered baboons as a pest or game animal, often the answer depended on *where* the baboon is found.

> *Where I'm sitting here now [on the farm] it's a pest, but when I go to Kruger National Park in July for a holiday, it's game. That's how I see it… If they are on that side of the fence, sitting there, not coming into the crops… I don't have a problem. But yes, now they are a pest.* (F06)

> *When you harvest crop then it's a pest, but in nature it is game.* (F07)

> *It's a difficult question that because if I see them in a game farm they are not a pest so, then they can't be a pest, but when they give you problems then they become a pest.* (F15)

Again, this outlook of an animal being a pest in one location but not in another is found within the literature (Naughton-Treves et al. 1998). It is not only baboons, however, that have earnt themselves the status of 'pest' under these circumstances, there are many other species currently classified as pests in this way (King & Lee 1987; Destefano & Deblinger 2005; Nahallage et al. 2008; Warren 2008). As Knight (2001) sums up, wild animals in human space are deemed unnatural and something to be removed, which leads to a preference for lethal means of control (Hurn 2005; Hill & Webber 2010). Unfortunately, the effect of pestilence discourses is to legitimise the use of lethal methods of control and make the animal the problem, obscuring the circumstances that have led to or exacerbated the conflict in the first place (Knight 2001). Fortunately, within this study community, farmers recognise their own place in creating conflict, reflected in statements such as:

> *Obviously we are in their turf and before we started farming there was bush and they could eat you know, so I think there has to be a balance between human and baboons, and you have to understand that they are doing it because of human pressure.* (F01)

These attitudes form an important part of the crop raiding discourse, and will be key if attempting to increase farmer tolerance to raiding species such as baboons.

Baboons 'belong' in the environment

Despite being in conflict with animals, it is not unusual to find people in these situations respecting and even appreciating the animals they struggle to deal with. The idea that baboons 'belong' was an unexpected theme that emerged from the interviews. Nothing within the interview questions mentioned the idea of belonging, yet 69% of crop farmers brought it up in response to a number of different questions. Some farmers talked about 'us' being in 'their' environment, and recognised that it is humans that have 'pressured' baboons into raiding crops.

> *We are in their environment, we have to cope with it.* (F05)

Others specifically mentioned roles that baboons play within the environment, even acknowledging the benefits they provide to humans.

> *They belong in nature, there's a place for them… it's part of the food chain in nature.* (F07)

> *They are in the food chain for leopards and stuff, so they must be there.* (F16)

> *They have a role in the environment, I mean they eat a lot of scorpions and insects… they were here long before us.* (F04)

Others simply stated that baboons '*have their place in the world*' (F03).

> *It's their place, so you can't say they must disappear.* (F08)

> *You can't kill everything that walks, I mean everything has its place.* (F06)

Respect for animals by the people they are in conflict with is also observed among other communities. Maasai communities perceive the lion to be a 'neighbour' despite experiencing attacks on livestock and people by this animal (Goldman et al. 2010). Scandinavian fishermen believe seals 'belong here the same as we do', although they are in competition with the seals for fish stocks (Bell et al. 2008). 94% of game ranchers interviewed in South Africa and Zimbabwe agree that wild dogs are 'a natural component of a healthy ecosystem' regardless of losing game to them (Lindsey et al. 2005). Once again it is clear, that within the context of human-wildlife conflict, negative perceptions of wildlife are not the only attitudes present, as many conflict managers often assume.

Given the number of conflicting opinions held towards baboons - such as their intelligence being perceived at once a negative and positive attribute - and that baboons are not wholly pesticised within the study community, it makes sense that farmers view baboons as 'belonging' at the same time as complaining about their conflict with them. It is extremely important to be aware of the positive views that people in conflict with wildlife hold towards these animals, especially as these ideas can be used to increase tolerance towards the species in question.

Baboon population size

As previously discussed, animals are viewed as pests when in the wrong context or in inappropriate numbers (Knight 2001). Although not true for all conflict scenarios, in many instances pest problems are characteristic of populations which have, for one reason or another, reached excessively high densities (Putman 1989). When discussing baboon problems with farmers, a topic often raised was that there are too many baboons in the area. When asked whether they thought the number of baboons in the area was high, average or low, almost all crop farmers (92%) felt that the baboon population in the study area is high. Furthermore, 69% believe baboon numbers are increasing.

> *Ten years ago we didn't have so many baboons, you saw one or two groups, and now you see one on each farm… you used to just get them on the river bed… but now all of a sudden more into this area, more inland you get more.* (F06)

> *I started here with a few baboons, but now I think we've got two groups… with more than one hundred in a troop.* (F08)

I think they've got a role to play in the whole aspect of the ecosystem, but I really think their numbers are getting out of hand. (F09)

Perceptions of a large baboon population in the area, seen as one that is getting out of hand, have consequences for farmers' attitudes towards baboons. At present baboons are considered a pest only within the context of the crop farm; in other areas they are not perceived as a problem. However, if population numbers expand, or are perceived to expand, to a level that is not sustainable within the natural environment, then their pest status will grow; large population numbers already compound the baboons' pest status (Warren 2008). This is already seen in comments such as:

The baboons just harvest all the guineafowl nests, all the francolin nests – if they [the birds] breed they kill all the chicks and eat them, I mean they just like hoover the place, you know, and I've tried baboon control but it was a waste of time… I could shoot a hundred, it would make no difference. (A01)

It is important to note that this comment was not from a crop farmer, but came from the owner of a private nature reserve with a Ph.D in wildlife management. Like crop farmers, this informant also believes baboon numbers are too high and expressed a desire to see a decrease in the population; it is not only crop farmers who think there are too many baboons.

Animal populations have been known to increase within conflict areas (Jonker et al. 1998; Sekhar 1998), and overabundant wildlife can certainly cause problems for conservation and wildlife managers, so these opinions should not be overlooked. For example, high numbers of elephants can change species-rich woodlands into species-poorer grasslands (Cumming et al. 1997); while high deer densities can represent significant threats to plant communities (Alverson et al. 1988) Unfortunately, it was not possible to gather data on the population size of baboons in the area, past or present, so it is unknown whether the population is large, or indeed whether it is increasing.

Crop raiding is essentially a form of provisioning (the offering[4] of food beyond the natural supply and/or quality of the animal's environment, Asquith 1989), and provisioned populations generally increase in size (Fa & Southwick 1988). When asked why participants thought the baboon population was increasing, the most popular reason given was the increase in crops produced in the area – that is, people are providing more food for the baboons to consume.

[4] Although in this case the offer is not made willingly.

I think the more food, the more the small ones. I think they breed more because of the food. (F10)

Fifty years ago… there wasn't crops they could raid so in drought a lot of them died. (F01)

Ten to fifteen years ago no one planted potatoes or pumpkins on this farm, we planted more tobacco than potatoes… there's just in this whole area there is more people producing pumpkins, potatoes. (F06)

If we stop planting here, and producing food, yes you will see the numbers, they will go away. (F09)

Knight (2001) suggests that the effect of pestilence discourses is to make the wild animal the problem, and to obscure the circumstances in human society that have led to or exacerbated the conflict with wildlife. It is interesting to see here that, despite the crop farmers having their own pestilence discourse for baboons, they are partially taking responsibility for the situation. Indeed, when asked why he thought baboon numbers had increased, one farmer simply replied:

Us. That is easy for them if there are crops on the field. (F07)

Provisioning has been shown to result in higher reproductive rates, which, coupled with increased infant survivorship often results in rapid population growth (Altmann & Muruthi 1988). Indeed, when interviewees complained about high baboon population numbers, they often commented on how many infants they see. However, population processes are not as simple as an increase in food resulting in an increase in numbers; food availability is not the only, nor perhaps the most, important limiting factor in population growth – in some cases long-term provisioned primate populations have not shown sustained population growth (Asquith 1989). It is important then to consider other factors as to why the population may be increasing.

Other explanations for the perceived increase in baboon population numbers suggested by participants include an increased abundance of water in the area, a decrease in predation due to a decrease in predator numbers, and a decrease in persecution of baboons, with new legislation being held responsible for this decrease. However, one participant explained that he believes persecution of baboons has reduced because there has in fact been a *decrease* in crop farmers in the study area.

There used to be a lot of crop farmers, and wherever the baboons went, they got shot you know. So they (a) stayed away from the houses and (b) the numbers were kept low *the whole time. Now… there is no baboon control so to speak and there are no crops, so people have no reason to control the baboons on the majority of the game farms.*

(A01)

This opinion contradicts what many crop farmers believe, that the amount of crops grown in the area, and therefore food available to baboons, has increased over the past decade. Another contradictory statement was made when a farmer suggested that an *increase* in persecution is the reason he believes the baboon population is in fact *decreasing* (although he was the only farmer to express this belief):

With the new technology… they're shooting them more… more intensive farmers and there are more crops than ever before here… So obviously the more crops there are, the more shooting. (F05)

Persecution of wildlife suffering conflict with humans has indeed caused population decreases in other circumstances (Anthony et al. 2010). Within this community, there are certainly a number of different, and sometimes contradicting, discourses about the number of baboons in the study area. However, there are unfortunately no statistics on the size of the baboon population in the area, and although attempts were made, it was not possible to carry out a census during the field study. Without data on baboon population numbers, it is not surprising that there are many different opinions on the size of the local baboon population.

People that suffer conflict with wildlife are more likely to desire lower wildlife populations, and as such may take whatever actions necessary to try to bring that about (Wywialowski 1994). Preferences for a decline in numbers of conflict species has been demonstrated in several communities (Decker & Brown 1982; Jonker et al. 1998). When questioned whether participants would prefer the baboon population size to change, most farmers (63%) expressed the wish for the population to decrease. Unsurprisingly, the most common reason given for this desire was that baboons 'do too much damage' (F02) and 'it costs us a lot of money' (F07). Doing too much damage is not an uncommon reason given for why people want problem animals to be eradicated (Webber 2006), however only two farmers stated that they would like baboons to completely disappear.

Four farmers stated that they were happy for baboon numbers to remain the same, though two of these farmers believe that the population is decreasing or has not changed. The two that believe the population is increasing expressed their concern for the environment and the role baboons play within it.

Anything that decreases is not good... if they can stay the same it'll be fine. (F01)

Because they've got a role to play, so I'm happy with the quantities. (F04)

It is helpful for conservation goals that farmers show conservation orientated attitudes and express concern about environmental roles. However, the discourse of 'matter out of place' endures amongst these opinions:

If they can stay the same then just get out of the fields, I'll be happy... it's just keeping them out of the fields, that's the only problem I have with them. (F04)

Despite an appreciation of baboons in the wild, and the recognition of the farmer's own influences on population numbers, there remains a desire amongst the majority of crop farmers to reduce the number of baboons in their farming area. This is an important finding that needs to be addressed when attempting to mitigate conflict between farmers and baboons.

Baboon group size

The group size of a species is known to affect perceptions of wildlife crop damage; those coming in large numbers are considered to be very destructive (Hill 1997, 2000). When asked what participants thought the average group size of baboons in the study area is, perceptions ranged from 20-30 to 400-500 (mean 77.5, Figure 3.3). Participants were also asked whether they thought these sizes are larger than the average group size for baboons. Around half the farmers (56%) believe local groups are larger than average; the remainder believe group size is average, with no one believing group size is below average. However, the idea of what constitutes an 'average' or 'large' group varied among farmers, with perceptions of large groups ranging from 32-38 to 200 per group (mean 92.1), and perceptions of average groups ranging from 20-30 to 80-90 individuals (mean 41.6, Figure 3.3).

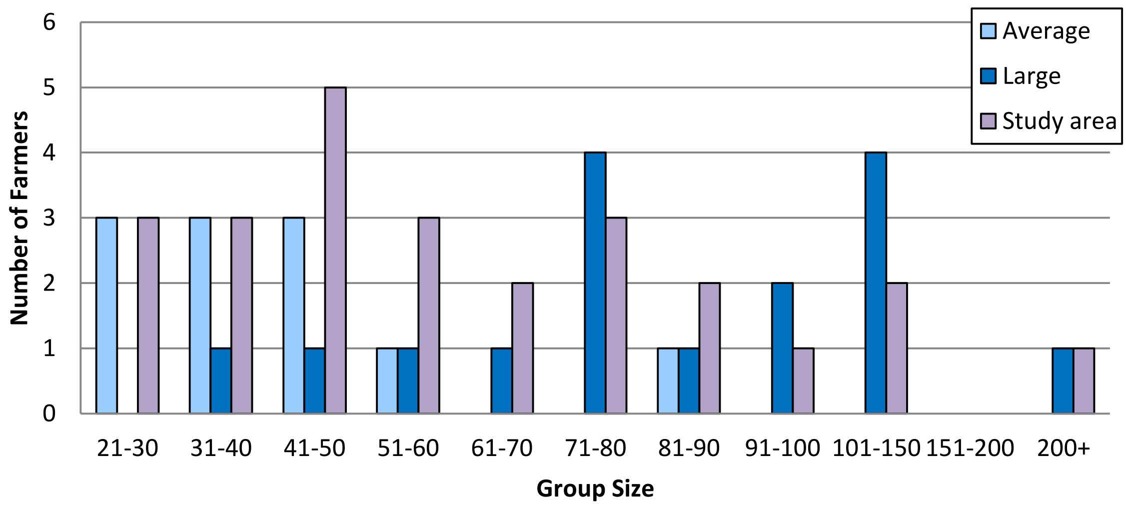


Figure 3.3: Farmer perceptions of what is considered average and large baboon groups and the size of groups in the study area. Total number of farmers in each category varies as some could not provide an answer while others provided more than one answer.

Perceptions of baboon group sizes in the local area span from as little as 20 individuals to as many as 500. Such disagreement could be accounted for by the actual variation in the size of baboon groups. Group sizes are highly variable in baboons, and fluctuate dramatically across habitats and subpopulations (Byrne et al. 2009; Warren et al. 2010). Chacma baboon group counts within South Africa vary from four in the Drakensberg (Henzi et al. 1997) to 115 in the Western Cape (Pebsworth et al. 2012). In nearby Blouberg Nature Reserve, counts vary from 25 to 50 individuals per group (Noser & Byrne 2007a, 2007b).Two group counts conducted in the study area revealed one group of 35 individuals and a nearby group of 123. As group size does vary, it is only expected that perceptions of group size should also vary. However, the perception of a baboon group consisting of more than 200 individuals does seem to be a large overestimation.

It is clear that there is no 'average' group size for chacma baboons, but a group of over 100 individuals does seem to reach the upper size limit of groups that have been studied, suggesting that a group of 123 individuals is indeed a 'large' group. Food availability has been shown to influence primate group size – where food is scarce a larger group has more difficulty accommodating the nutritional needs of all its members, and therefore an upper limit to group size is reached; increased availability of food therefore results in larger groups (Wrangham et al. 1993). It has also been suggested that when visibility is good, which influences coordination of group movements when searching for food, group sizes can become larger (Altmann & Altmann 1970). The nature of agricultural crops – a vastly clumped resource which is highly visible – meets both these criteria for facilitating larger groups. Furthermore, high predation pressure encourages larger groups (Dunbar 1992); the increased risk from humans when foraging within an agricultural environment possibly mimics an increase in predation pressure (Frid & Dill 2002), therefore favouring larger group sizes. These environmental factors may explain how baboon groups in the study area reach such large sizez, but they do not however explain the presence of two possibly neighbouring groups of such different sizes.

The group counts conducted in the study area suggest that farmers may actually be underestimating baboon group size. Two farmers residing on the farm where the group of 123 baboons spent most of their time were asked to speculate on the size of this particular group. One farmer believes the group consists of 50-60 individuals (half its actual size) while the other suggests over 80 individuals (two thirds its actual size). If baboons are considered pests because they come in such large number (Hill 2000; Warren 2008), then the knowledge that groups are larger than is currently thought will surely worsen the problem. However, having a more accurate representation of the problem will allow farmers to better direct their mitigation attempts. For example, using one field guard to protect crops from a group of 30 baboons may be appropriate, but may not be very effective with a group of over 120.

Trends in baboon crop raiding

Crop raiding is a growing problem in many areas (McLennan & Hill 2010; Nahallage et al. 2008; Wang et al. 2006; Tchamba 1996; Besser & Brady 1986; Pahad 2011; Sillero-Zubiri & Switzer 2001; Naughton-Treves 1997b; Boulton et al. 1996). In accordance with this, most farmers (64.3%) in the study area judge their problems with baboons to have increased over time. The remaining farmers (38%) believe problems have not changed; no farmer perceives a decrease. It is not surprising to report that farmers believe their problems with baboons crop raiding is increasing, as most crop raiding studies report the same (but see Mackenzie & Ahabyona 2012; Webber 2006).

The most common opinion for the perceived increase in problems with baboons is the presumed rise in the local baboon population, whether through an increase in the number of groups in the area, or an increase in the numbers per group. Farmers' concern about rising baboon population numbers naturally leads to an increased concern about crop raiding.

> *Obviously if there's more baboons the problems are getting bigger.* (F02)

> *The amount of the baboons in the troops is getting bigger and bigger, and that also makes the problem bigger.* (F07)

It is reasonable to believe that higher numbers of baboons will cause more damage to crops, others also suggest that as primate populations increase crop losses are likely to grow (Engeman et al. 2010), while elsewhere in South Africa there are concerns over baboon populations becoming too large (Pahad 2011).

However, other research reports that an increase in crop damage does not appear to be caused by an increase in wildlife populations (Besser & Brady 1986). An alternative explanation was given by two farmers, who suggest that problems with baboons have increased because more crops are available for them to raid.

> *There's definitely more fields so there is a bigger increase [in problems].* (F05)

Under these circumstances, farmers once again take on responsibility for the conflict – they acknowledge that if they were not in the area planting crops, there would be no source of conflict. Indeed, agricultural expansion has been reported as a cause of increased crop raiding at other study sites (Starin 1989; Admassu 2007).

It is likely that a combination of both factors – an increase in baboon numbers and an increase in crop availability – may cause an increase in crop raiding by baboons: more cultivated land represents a greater interface between farmers and baboons, while increasing population numbers – brought about through the provision of a year-round available food source – results in more baboons to raid farms.

One farmer however detaches himself from this sense of responsibility by suggesting that baboons have become more of a problem since they learned where crops are located.

> *It's worse than what it was in the beginning… [In the] beginning it was by luck they passed and saw something, but now they know there is a constant supply of food.*
>
> (F03)

In their study on the travel routes taken by chacma baboons, Noser & Byrne (2007b) demonstrate baboons have a complex spatial mental representation of several important locations and are able to actively choose between alternative resource places before they are in sight; the baboons knew not only where to visit, but also when to visit different locations. The suggestion that once baboons learn where crops are planted they can use this knowledge to exploit the resource is therefore not implausible.

It is difficult to know whether baboon problems have in reality increased in the study area over the last few years. As the law permits a landowner to act against crop raiding baboons, reports or complaints are seldom made to the governmental offices; there are therefore no records to offer this kind of information (Lyle Wiggins, personal communication). Nevertheless, the fact that farmers perceive an increase in crop raiding will likely reduce their tolerance of baboons and increase their likelihood of persecuting the animals involved – as previously discussed, where a problem is perceived to exist, a problem exists.

Baboon legislation

In 2003, baboons were removed from the South African problem animal list (which allowed any person to shoot a baboon, any time of year, at any location) and subsequently became listed as a game species. South African environmental law now permits a landowner on their land to act against a problem baboon without being issued a permit from Nature Conservation (LEMA 2003). Despite this legislation allowing farmers to legally deal with problem baboons, most study farmers (63%) would like to see the official status of baboons changed from 'game' back to 'problem animal'. One explanation for this desired change may be the misunderstanding by many farmers of the current legislation – more than half (62.5%) believe it is illegal to shoot a baboon without a permit, even as a landowner.

You can buy a permit… or how many you want to buy, so you can shoot baboons. (F01)

You've got to have a permit… to shoot a baboon. (F10)

Even those who indicated they are aware that it is not illegal to shoot problem causing baboons were not absolutely sure about their statements.

It's not illegal, I as a farmer can shoot it, but it's not legal to hunt it without a permit I think. That's the last I know, but I think that. (F08)

Most farmers who do not desire the baboons' status to be changed back to a problem animal are aware that it is not illegal for themselves as landowners to shoot problem baboons. This perceived lack of control over baboons – that farmers believe they cannot legally 'deal with' the problem – may be prompting a desire to see baboons back on the problem animal list.

…if they are giving me problems at a certain time then I must be able to do something about it. (F15)

This farming community does not stand alone when it comes to being unsure about the rules and regulations surrounding wildlife. Hill (2005) reveal that there is great confusion among farmers in Uganda as to whether they are able to kill 'pests' or not, while participants in Fairet's (2012) study in Loango National Park, Gabon have little knowledge of the legislation framing conservation practices in the park in which they live. These patterns highlight the need for the general public to be educated on environmental laws, particularly people that come into conflict with wildlife on a regular basis.

Responses to this part of the interview also provided insight into how the study farmers perceive those who are responsible for the legislation. One farmer stated the following:

I don't think there is a big difference between a problem animal and a game animal, its wording and it makes it a little bit, if it's a pest animal it makes it a little easier to shoot it or get rid of it than a game animal, but in these days you just can't go and shoot anything, you have to have a permit for everything you shoot. (F01)

Rather than any particular desire to see the baboon on or off the problem animal list, this opinion appears to reflect indifference because either way the legislation does not help the farmer. A number of farmers also expressed their dissatisfaction with the authorities, for making this change to the baboons' status in the first place.

I think that the people that changed that wasn't properly informed. (F06)

> *I don't think they should have made that change… They are still a problem, even in the Cape you can see the baboons there are also a problem. Stealing and breaking off everything, so, it's not only here.* (F08)

> *I don't agree with them… taking it off the problem animal list but I do understand that there's some regions in the area that has much less damage from the baboons than we have here so it will be difficult to pass a law for each area.* (F03)

> *…if they want it to be illegal to shoot a baboon they must come and take them away… I'll shoot it or they must come and guard my fields.* (F02)

Indeed, one farmer even states that the change in the law has led to an increase in baboon numbers, because they are no longer being kept under control by shooting.

> *That's why it's getting out of hand, but nobody wants to shoot it because you can be jailed or fined for that.* (F08)

These farmers are not in agreement with the authorities: they suggest the authorities are not properly informed about the decisions they make, and they expect the authorities to do something about problem animals if the farmers themselves cannot. This finding is in accordance with literature detailing many of the same problems found among farming communities situated near protected areas. Indonesian farmers who experience crop raiding by orangutans, a species protected by law, believe that local Forestry Department officials should handle problem individuals (Campbell-Smith et al. 2010). Locals living next to Ugandan wildlife parks believe the government – who behave as the owner of wildlife by making laws against people killing them – does not behave as a responsible owner when it comes to crop damage (Hill 2005). Under these circumstances there is little difference between crop raiding on commercial and subsistence farms – in both situations people have to live alongside damaging wildlife that they are not able to legally take action against.

Lastly, there are farmers who know they are legally within their rights to shoot a problem baboon, but still want to see them back on the problem animal list: either they do not perceive shooting as an effective method of control (see Chapter 8, section 8.3.2.2), or there is something more to the pestilence discourse than solely a feeling of lack of control.

Feelings of a lack of control and the unfulfilled expectations farmers have of the people that are trying to protect the species play an important part in the conflict discourse. Both a lack of control and unfulfilled expectations have been shown to reduce farmer tolerance towards wildlife and increase perceptions of risk (De Boer & Baquete 1998; Costa et al. 2013; Hill 2005). It is therefore critical to assess these issues when trying to mitigate human-wildlife conflict.

Are baboons a danger to people?

Animals that are considered dangerous because they pose a risk to human safety are more likely to be viewed negatively or as pests than those that are not dangerous (De Boer & Baquete 1998; Lee & Priston 2005; Woodroffe et al. 2005; Campbell-Smith et al. 2010; Goldman et al. 2010). Locals who did not support elephant conservation in Uganda commonly explained that this was because elephants are very dangerous to humans; those who did not consider elephants to be dangerous were more likely to express a positive attitude towards elephant conservation (Hill 1998). Wild pigs (*Potamochoerus porcus*) are considered to be a major pest because they can injure or kill people (Hill 1997). The main reasons for disliking Asiatic lions (*Panthera leo persica*) included lions attacking people and fear of the lion (Saberwal et al. 1994). Chimpanzees have killed people in Uganda, which contributes to the negative view locals hold of them (Hill 2005).

Most study farmers (75.0%) do not consider baboons to be a danger to people when they enter the farm, and some consider this to be the result of human persecution towards the baboons.

> *No they will run away.* (F06)

> *They are cocky but no, they are not dangerous, they run away when you get out of the vehicle or point something at them.* (F12)

> *No, they've still got a little fright for humans.* (F16)

In this instance farmers are again not completely disengaging from baboons, and take some moral responsibility for baboons' behaviour. They believe that their behaviour towards baboons directly affects baboons' behaviour, through a decrease in aggression towards people. Their concern is that if they do not persecute baboons they will become aggressive.

> *[If] you don't chase them away – shoot them or something – they get like aggressive, as they, as with the baboons in Cape Town.* (F05)

These farmers are not alone in holding this attitude. Maasai declare that hunting lion keeps the lion afraid of people and believe that attacks have risen as a result of prohibitions on hunting (Goldman et al. 2010), while it is observed that human aggression towards vervet monkeys cause them to avoid humans (King & Lee 1987). However, despite most farmers in the study area believing that baboons are not dangerous to people, many – including some who do not consider baboons dangerous – explain that their field guards often feel threatened by baboons, particularly the women.

Especially the women they get afraid because they chase the women away, so I must put men there. (F07)

They [the workers] phoned me, they said this one is going to kill them, they were scared of this. (F08)

Sometimes the big males wanted to attack the people looking after the crops that chased them away, they were trying to bite them. (F01)

They are scared of us, but the workers, sometimes they do ask us or tell us that there is some of the baboons that is aggressive at least… the males they show you their teeth and so they are aggressive. (F04)

Especially the old males that's moving on their own… they do threaten the guards. (F02)

I've seen them being aggressive towards the ladies that's watching over them. (F03)

Baboons have been reported to be aggressive and dangerous to humans in other areas, including Uganda (Webber 2006), and Cape Town, South Africa (NCC Environmental Services 2015). Furthermore, it has been documented many times that baboons are not particularly afraid of women or children (Strum 1994, 2010; Hill 1997; Sillero-zubiri & Switzer 2001). Using women to guard fields against baboons may consequently not be very effective, However most guards employed in the study area are women, which is also true in other crop raiding areas (Hill 2000).

Although aggression towards field guards was mentioned by the study farmers a number of times, including farmers from the behavioural study farm, it was never observed during crop raiding observations. However, fear in itself is important in shaping attitudes towards these animals, as fear – and not necessarily actual attacks – may be sufficient to initiate negative perceptions and even result in pre-emptive killing (Rosie Woodroffe et al. 2005). Fear is possibly the hardest issue to overcome when trying to increase farmers tolerance to crop raiding wildlife (Campbell-Smith et al. 2010), and should therefore be carefully considered under mitigative circumstances. In the study area it is fortunate that those with the means and motivation to lethally respond to baboon crop raiding (i.e. the commercial farmers) are not the ones who fear baboons.

3.4 Conclusion and Conflict Resolution Implications

The rural farming community under study values nature for many reasons. Economic values are common within this community, which is unsurprising given the nature of farming – whether it is crops, livestock or game, without nature farmers would not be able to make their living. However, the study farmers also see the values of nature beyond economic means, and appreciate it for their own personal benefits – through recreational, aesthetic, health and religious values. Not a single participant wants to see the extinction of any wildlife species in the area, despite many of these species causing farmers economic loss.

However, despite highly valuing nature, it is evident that the study community also holds ambiguous attitudes towards nature. On the one hand these people live for nature, but on the other they must intervene when nature starts causing financial problems. These contradictory values create internal conflict within the farmers, presenting a dilemma for the farmers. For example, so many aspects of the baboon fill the farmers with conflicting emotions: their intelligence is both respected and criticised; their human-likeness makes them entertaining to watch but at the same time assigns them with moral obligations which they cannot keep; they belong in the environment, but elicit anger when found on the farm. The list is likely to go on. When taking responsibility for the conflict situation, farmers experience no less ambiguity: farmers acknowledge that they are in the baboons' environment, but at the same time expect baboons to stay away from their farms.

This research therefore reveals some important findings as to why it is so important to include the social dimensions of human-wildlife conflict when attempting mitigation. It is important to understand farmer attitudes towards nature, and where their boundaries lie across which nature becomes problematic enough for the farmer to retaliate with environmentally harmful behaviours. Given that human relationships with nature are complex, emotional and filled with uncertainties, this is not a simple task, and the farmer-baboon relationship is no exception.

Having established some of these uncertainties, it would be beneficial to provide farmers with the information that could resolve some of these ambiguities surrounding their conflict situation. For example, one of the most used and consistent discourses about baboons is that the local population is too big and increasing. If this is true then it would serve the farmers well to have this acknowledged and a solution to this problem provided. The fact that farmers take on some responsibility for the increase in numbers indicates that they should be willing to take part in the solution. If baboon numbers are not increasing, then it would also serve the farmers well to be aware of this. The belief that a wildlife population is overabundant only serves to increase (or indeed create) the pestilence discourse surrounding that species; if these beliefs are held incorrectly, negative discourses could be reduced or even eliminated.

Throughout the data collection it became apparent that many of the study farmers deal with wildlife conflict alone. Perhaps the reason for this is that their internal conflicts are too complicated to share, or perhaps the social geography of the area – farms are fairly isolated given their size – prevents sharing. Either way this is not a good framework for seeking solutions. As such, bringing the community together to share information, problems and ideas for solutions, as well as providing the community with scientific data, could go a long way in reducing conflict.

CHAPTER 4: PERCEPTIONS OF RISKS TO CROP YIELDS

4.1 Introduction

Following on from the previous chapter, where I documented the values that study farmers hold of the natural environment and the ambiguous nature of their relationship with baboons, I will now discuss the problems that farmers must overcome to successfully harvest crops in the study area, and their perceptions of wildlife crop raiding. I conclude the chapter with a discussion of the findings relating to crop raiding mitigation implications. See Chapter 2, section 2.2.1 for the methods used to obtain information and the previous chapter, section 3.2 for participant profiles.

4.2 Analysis and Discussion of Interviews: Emergent Themes

Four major themes emerged from interviewing crop farmers: attitudes towards nature, perceptions of baboons, risks to crop yields, and the nature of crop raiding. The first two were discussed in the previous chapter, revealing the complexity of farmer attitudes towards nature and baboons in particular. I will now discuss the latter two (Figure 4.1).

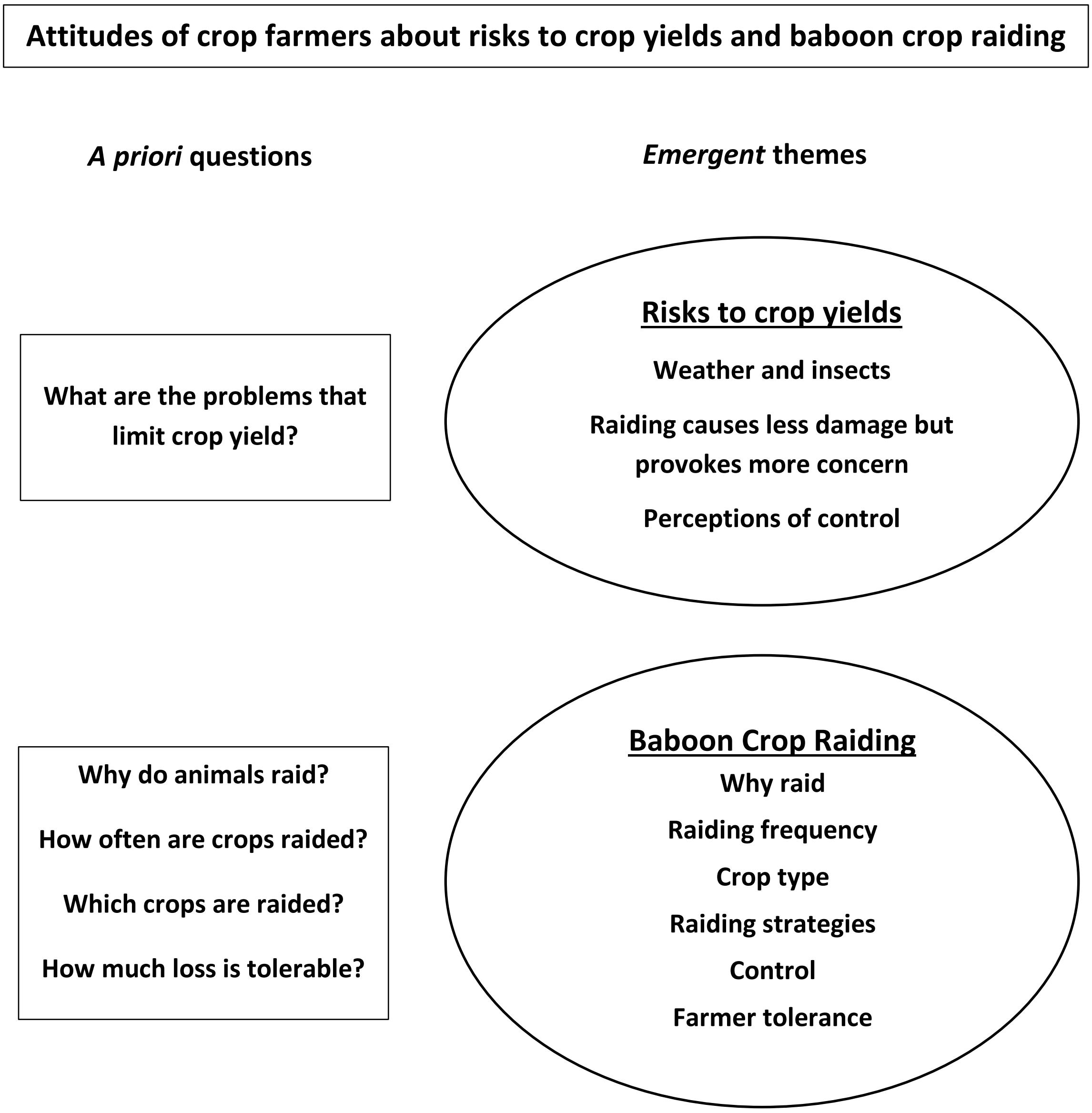


Figure 4.6: Thematic framework of major emergent themes arising from interviews. Headings in each bubble are provided in the text; sub-themes guide the subject-flow of the analysis.

4.2.1 Risks to crop yields

Damage by wildlife is not the only yield-limiting factor a crop farmer has to cope with; many other factors play a role. Not exhaustively, these include influences such as weather, fire, soil quality, water, access to land, crop diseases, illnesses and fungi, pests such as insects and weeds, costs of and access to labour and equipment such as pesticides and fertilisers, operational procedures and planting strategies, and human thieves (Tweheyo et al. 2005; Webber 2006; Linkie et al. 2007; Priston 2008; Arlet & Molleman 2010; Bal et al. 2011; Nyirenda et al. 2011).

Farmers were asked to freely talk about all the problems that limit their crop yields, without being offered a list of examples to discuss. Once they had finished providing this information they were asked to rank these factors in order of which cause the biggest limitation to crop yields (a rank of one representing the biggest problem). Table 4.1 displays the limitations on crop yields that farmers (n = 13 [5]) feel they experience on their farms. Overall ranks were calculated from all interviews. This was achieved using the equation below. A score was calculated by multiplying the ranks given by the number of times a crop yield problem receives this rank, and summing these multiplications. When a problem is not ranked at all by one or more farmers, a rank of six was assigned (the rank following the lowest rank that any problem received – five), which was multiplied by the number of times the problem was not ranked and included in the sum. The score was then converted to a rank, with the lowest score receiving the highest rank (one).

$$\sum (r \times n) + ((L+1) \times z) = \text{SCORE} \qquad \text{LOWEST SCORE = HIGHEST RANK (1)}$$

r = rank, n = number of times assigned each rank

z = number of times not assigned a rank, L = lowest rank in data set (in this case 5)

Table 4.4: The number of times each rank (from 1 to 5) was assigned by 13 crop farmers to each problem. An overall rank is calculated to determine which problems are perceived as most significant.

Crop Yield Problems	Number of times assigned each rank						Overall Rank
	1	2	3	4	5	Total	
Crop raiding	5	1	4	2	1	13	1
Weather	4	5	1	1	0	11	2
Insects	3	3	2	1	0	9	3
Disease/Fungus	1	2	0	0	0	3	4
Thieves	1	0	1	1	1	4	5
Government	1	1	0	0	0	2	6
Land size	1	0	0	0	0	1	7=
Harvesting	1	0	0	0	0	1	7=
Pesticide application	0	0	1	0	0	1	9

Crop raiding is perceived to be the biggest problem within the study area. Although less than half the farmers ranked wildlife raiding as the most significant problem affecting their yields, it is the only limiting factor that *every* farmer interviewed acknowledged and was labelled the top issue more times than any of the other problems mentioned. That farmers perceive wildlife raiding as their greatest concern is consistent with a number of other studies within the crop raiding literature (Wang et al. 2006; Webber 2006; Linkie et al. 2007; Marchal & Hill 2009; Fairet 2012).

[5] Three farmers were unable to give answers on this question.

Wildlife is closely followed by weather and damage caused by insects in farmers' perceptions of crop limiting problems. Interestingly, insects are not perceived as 'crop raiders' but instead are listed separately. This seems to be the general trend both among farmers (Tweheyo et al. 2005; Webber 2006) and within the literature. While biologists and ecologists take an ecosystem approach on the matter – that is, insects are wildlife – this concept is not followed among pest and problem animal management professionals: a number of written works on 'pest management' discuss only invertebrate wildlife (Altieri & Nicholls 2004; Horne & Page 2008), while works written on 'wildlife crop raiding' tend to discuss only vertebrate raiders – either not mentioning invertebrate life at all or categorising it as a separate issue from 'crop raiding' (Tweheyo et al. 2005; Wang et al. 2006; Webber 2006; Marchal & Hill 2009). However, despite following these categorisations and using the discourse of vertebrate 'crop raiders', vertebrates are often later labelled as pests themselves (Webber 2006; Priston 2008), suggesting there is a pestilence hierarchy when describing animal crop damagers.

Weather and insects have been ranked above vertebrate raiding as crop limiters in other farming communities (Tweheyo et al. 2005; Priston 2008) and while recognised as important sources of crop loss in these areas, other farmers make no mention of these concerns (Rao et al. 2002; Marchal & Hill 2009). Once again perceptions of control may be influencing these attitudes. The weather is impossible to control and is acknowledged by many farmers that 'you must just accept it'.

> *Frost is a big problem, but with nature you can do nothing.* (F07)

On the other hand, with current technology and the availability of many kinds of pesticides, insect pests are regarded by farmers as being controllable. This is also true of plant diseases and fungi.

> *You pick up a worm, you start spraying so you prevent that.* (F05)

> *I can control the insects, once I see one I can spray my crops and they will be away for a week, so I can control that.* (F06)

> *You can surely kill it by means of spraying pesticides or something like that.* (F09)

> *Every farmer has got diseases, but that we can spray and do something about so they are the ones we can keep out.* (F08)

> *There's stuff that we can do about the insects, but against the nature [weather], I mean that's in the hands of the Lord. You must just accept it.* (F02)

From a farmer's perspective, there is no point in worrying about what cannot be controlled (the weather), and certainly no point in worrying about something you already have control over (many species of insects). Wildlife crop raiding on the other hand falls ambiguously between the realms of something that can and cannot be controlled. The expectation seems to be that crop raiding is not a 'normal' problem for the farmer, and should be dealt with. However, the reality is that it is especially difficult to deal with, with very little evidence that it has been successfully controlled anywhere in the world. The frustration over believing wildlife raiding should be controlled but not being able to do so probably keeps it at the forefront of farmers' minds. Animals that are particularly hard to control are also perceived most negatively, as is discussed in the next section.

Indeed, every farmer mentions crop raiding as an issue, while weather and insects – which certainly affect all farmers in the study area – were not mentioned by everyone interviewed. Of the eleven farmers who state both crop raiding and either weather or insects to be yield limiters, eight actually rank weather and/or insects above crop raiding in terms of how much they limit yields. This suggests that weather and insects play a bigger role in limiting yields, but farmers are more frustrated and unsatisfied with the issue of crop raiding – although raiding does not destroy as much crop as weather or insects, farmers are more concerned about wildlife than anything else. Alternatively, this could be due to the farmers' knowledge that the focus of the study is wildlife crop raiding.

4.2.2 Baboon crop raiding

As discussed in the last section, the term 'crop raiding' is generally applied to vertebrate wildlife and does not include species such as invertebrate pests. A number of vertebrate species are included under the umbrella of 'wildlife crop raiders' and those implicated and engaged in crop raiding in the study area are discussed in detail in Chapter 6. The focus of the following section is limited to baboons specifically. Although I make a few comparisons of baboons with other species, these animals and the perceptions surrounding them are not discussed in any detail. The nature and patterns of perceived baboon crop raiding are discussed here.

Why do baboons raid?

Primates have interacted with human agriculture for millennia, and consequently crop raiding has become essential in many primates' subsistence strategies (Lee 2010). Crop raiding is essentially a foraging strategy that can be explained by optimal foraging theory – that is, that an animal will strive to maximise their energy intake (Pyke 1984). From an animal's perspective, fields of ripe crop may be analogous to the fruiting of forest trees, and just as humans integrated hunting and agriculture, so too have some primate species combined wild foods and crops (Naughton-Treves et al. 1998).

When asked why they thought baboons raided their crops, two main themes emerged from the study farmers. These are particularly interesting because they have opposite connotations attached to them. The first reason, stated by 13 (81.3%) of the farmers, is that baboons raid because when it is dry there is a lack of natural food in the veld and baboons get 'hungry'. This perspective accommodates baboons' needs for survival – living things need to eat and when there is no other or limited food sources, crop raiding is understandable.

> *They are hungry.* (F02, F05, F08, F10, F15, F16)

> *They're raiding the crops not because they want to, [but] because they are hungry… they don't have another choice, because they have to eat.* (F01)

> *Out there now it's winter, it's dry old stuff, they need to eat.* (F06)

> *If the only green things in the area is the crops, and it's food, so that's why.* (F04)

> *Now that's easy, you know it's dry here so it's the only green stuff, most of the dry season the crops are the only green stuff available, so it's food for them.* (F03)

> *There's less food in the bush so they come to the crops.* (F12)

An increased tolerance of crop raiding when hunger is the perceived cause is not unusual, as evident in statements such as: "*I abandoned my bean field in the forest because the tapir ate all the plants. She had a calf so she was hungry*" (Waters 2015, page 9), and "*no matter how bad the damage done during the summer, when winter comes, and people see the monkeys out there in the falling snow, they cannot help but give them apples*" (in Knight 1999, page 633).

This line of reasoning, that baboons are hungry, is reinforced by statements from study farmers such as:

> *In summer times they don't get into the field because there is enough fruit [in the bush], but we plant in winter and then the fields are dry, so they must come for the fields.* (F08)

Indeed, in response to being asked when baboons cause most damage, 12 (75.0%) farmers stated that this occurs during the dry season when there is little food available within the natural vegetation. Wild food scarcity is certainly a factor explaining wildlife use of crops; many other studies also demonstrate seasonal variation in intensity of crop raiding (Chapter 5, section 5.3.3;

Naughton-Treves et al. 1998; Sekhar 1998; Kagoro-Rugunda 2004; Hockings et al. 2009; Strum 2010; Lemessa et al. 2013). Lack of natural food is no longer only a consequence of season however, but also results from human modification and destruction of the natural environment. Crop raiding can therefore be viewed not as an 'assault' on human agriculture, but rather a reaction by wildlife to the human destruction of natural food sources (Knight 1999). The development of raiding behaviour has certainly been attributed to human habitat modification in some areas (Strum & Southwick 1986; Strum 1994).

In contrast however, some crop raiding studies demonstrate that natural food availability has no effect on raiding (Tweheyo et al. 2005; Riley & Priston 2010; Ahlering et al. 2011), while year-round crop raiding is reported in other areas (Marchal & Hill 2009; Hill 2000). The remaining responses from study farmers to when baboons cause most damage were all year round, whenever crops are growing, or when the crop plants get bigger.

> *The baboons are right through the year, whereas the pigs only as it starts getting dry are you getting problems.* (F04)

This implies that not all farmers believe raiding occurs only when it is dry and the baboons are hungry. Although raiding behaviour data from the current study shows that natural food availability is a significant factor in why and when baboons raid (Chapter 5, section 5.3.3), the circumstances under which farmers grow their crops may influence this. For example, if crop fields are near sleeping sites and therefore lie close to natural baboon routes, then a farmer may be troubled irrespective of natural food availability.

Another reason given to explain raiding, which holds a more negative perspective towards the baboon, and mentioned by six (37.5%) farmers is that baboons raid because crops are 'easy food'. This projects laziness onto baboons, who will take the easier option of harvesting crops rather than spending time and effort foraging for natural foods.

> *It's easy to find, there [in the bush] they have to go and work and look for scorpions and look for this and here they know it's there, they can run in and take it.* (F06)

> *It's easy for them. I mean to go and paw over rocks to get some insects for the whole day, just to get enough food for the whole day, rather sit and sleep the whole day and just in the morning and afternoon go and damage some crop, it's easier.* (F10)

> *In the potato field he can just sit at one place and eat a full stomach so I think it's just more available, just more and easy to find.* (F15)

Even when there's lots of [natural] food, because that's easy food, easy pickings. (F16)

Other primates are also considered 'lazy' because they opt for the easiest source of food and 'subsist off the industry of others' (Knight 2003). This laziness engenders negative perceptions of the perpetrator because it is not a characteristic that is held in high regard by people. Furthermore, these animals are not just being lazy, but they are doing it at the expense of others – farmers lose their crop and all the hard work put into growing it because baboons are too lazy to find their own food. However, feeding on crops – which is merely a good strategy that increases foraging efficiency – could be viewed as good sense rather than laziness. Human crops are certainly more palatable and nutritious than wild foods, and are a clumped resource that come in large package sizes (Strum 1994). Of course, the angry farmer who has lost his income and worked hard for nothing does not see the situation in this light.

These two perceptions of why baboons raid lead to very different outcomes for the baboons. The former opinion allows farmers to extend pity towards the baboon and perhaps some even understand that it is through the farmers' own actions that wildlife has to resort to subsisting on human-derived foods. This perception leads to increased tolerance of crop raiding and an apparently mutual understanding between the two players. However, the latter opinion results once more in farmers assigning moral boundaries to baboons; farmers are then affronted when baboons cross this boundary by being lazy (Hill & Webber 2010). As a consequence tolerance to crop raiding decreases and farmers feel vindicated in punishing the baboon. Interestingly, five farmers believe baboons raid both because they are hungry and because crops are easy food. This exposes the farmers' uncertainty about the baboons' nature, as is reflected in many of their attitudes towards baboons. Of course, the two explanations for why baboons raid are not mutually exclusive; they may raid during times of natural food scarcity because they are hungry and during times of plentiful natural food because crops are easier to harvest. Deciphering which individuals hold which perceptions of baboons is useful when trying to mitigate human-baboon conflict.

Frequency of baboon raiding

Frequency of raiding is not necessarily a good indicator of the level of crop damage sustained (Hill 2000), but nevertheless influences farmer perceptions and tolerance of wildlife. Many farmers consider baboons a problematic pest because they visit farms frequently (Hill 1997; Hill 2000; Warren 2008), and Webber (2006) demonstrates that as the number of raids increases, tolerance of primate incursions by farmers reduces. Farmer perceptions of raiding frequency could therefore provide insights into their perceptions of a species – the more frequent they perceive a species to raid the more likely they are to hold negative attitudes towards that species. When asked how frequently baboons raid crops, most study farmers expressed a quantity dependent on other aspects of the environment – predominantly the availability of natural food, whether crops are guarded and of course whether crops are available to raid.

> *How often? Oh it depends on the time of year. Summer time it's not even once a month, in winter time, in the dry, and the hotter it gets the worse it gets… it's four times a day.* (F01)
>
> *I think in the dry months it's often, maybe every day but then once it rains and there's marula fruit and stuff in the field, in the bush, then sometimes they can go a week or three without seeing a baboon.* (F03)
>
> *If we don't have workers [in the fields], they probably raid every day, but with the workers that keep them out of the fields, I'd say once, twice a week they do make damage.* (F04)
>
> *It's daily, especially if there's no guards, but sometimes it does happen even if there's guards.* (F02)
>
> *Once they know there is food they will come every day.* (F06)

When conditions are suitable for frequent raiding – that is, natural vegetation is dry, crops are growing and are not guarded – farmers most often state that raiding occurs daily, from once a day to up to four times a day. When guarding is in place – which occurs on most farms in the study area during the crop season and often intensifies during the dry season – farmers report raiding to occur 'sometimes', 'once or twice a week', or 'every day'. From the farmers' perspectives, it appears that natural food availability has a stronger influence on the frequency of baboon raiding than the effect of guarding, as during the wet season reported frequency decreases to once every one to three weeks or even less than once a month. Many crop raiding studies note considerable temporal variation in primate crop raiding (Naughton-Treves et al. 1998; Saj et al. 2001; Chhangani et al. 2008; Warren 2008; Hockings et al. 2009), so it is not surprising that farmers perceive raiding frequency to vary across time.

Availability of crops has been shown to be an important factor in determining crop raiding behaviour (Tweheyo et al. 2005), with many farmers reporting raiding as most severe during the peak of crop fruiting (Marchal & Hill 2009; Campbell-Smith et al. 2010). Wild food availability is also important in influencing raiding; several crop raiding studies demonstrate that raiding becomes more intense as natural food availability starts to decline (Sekhar 1998; Agetsuma 2007; Hockings et al. 2009). Given this information, it would make sense for farmers to manage planting strategies so that crops peaked during times of high natural food availability. However, for farmers in the study area this is not an option. Crops must be planted during the dry season – otherwise crops are damaged by the rains – but before it gets too cold. Farmers therefore do not have the flexibility to adjust their planting strategies. This demonstrates one of the many reasons why the social aspects of conflict must be included: if the outcome of this conflict research was to suggest that farmers plant their crops at different times of the year, this would obviously not be an acceptable solution.

If increased frequency of raiding invokes stronger negative perceptions of an animal, it would be interesting to investigate whether baboons are perceived by these farmers more negatively at particular times of the year compared to other periods. Baboons are perceived differently when in different locations, as discussed in the previous chapter (section 3.3.2.2), so may well be perceived differently at different times of the year.

Crops raided

A wide range of crops are reported to sustain wildlife crop damage (Naughton-Treves 1998; Wang et al. 2006; Linkie et al. 2007; Engeman et al. 2010). Farms in the study area grow a variety of crops (see Chapter 2, Section 2.2) and farmers reported a number of different scenarios when asked whether certain crops receive more crop damage than others. This seems to be dependent on which crops they grow.

One farmer, who grows tomatoes, butternut, watermelon and maize, stated baboons do not have a preference for consuming these fruits and vegetables:

> *They'll take whatever is there… what we were planting, that was all rated basically the same [by baboons], it's all good stuff.* (F05)

Another, who grows tobacco, butternuts, peppers and melons, explained that baboons take everything – including the tobacco and peppers, although he observes they have a preference for butternuts (F01). The other farmers on this particular farm concur that butternuts receive the worst damage by baboons, although one did add:

> *I think it's probably more on the ones they do eat [not tobacco], but if they get the wrong stage in the tobacco field they could ruin the crop in one go, so it's difficult. But they don't only raid the crops they can eat, they destroy everything.* (F03)

A different farmer, who grows a combination of butternuts, potatoes and tobacco, also considered baboons to have a preference for butternuts.

I think the butternuts because it's easier, it's on top of the ground, they can take it and run with it, potatoes they have to dig it open first… that side we just have potatoes and they will come every day. This side… when the potatoes are up and we have butternuts… the most damage we get is on butternuts. (F06)

Another farmer, growing zucchinis, pattipans, baby gems, butternuts and other squash, tomatoes, watermelon and melon, believes baboons have a preference for certain crops, but this preference wanes when they are particularly hungry.

They go for mealies [maize]… watermelons, tomatoes, pumpkins. But the small zucchinis not so much, but if they're hungry they will eat anything… (F08)

Within the crop raiding literature, baboons are indeed reported to raid a wide variety of crops (Box 1991; Naughton-Treves et al. 1998; Tweheyo et al. 2005; Webber 2006) and several studies reveal they do have preferred crops (Naughton-Treves 1997; Naughton-Treves 1998; Hill 2000; Kagoro-Rugunda 2004). In their study on the impact of invasive monkey species to commercial farms in Puerto Rico, Engeman et al. (2010) also report greatest losses to pumpkin crops, a group which includes butternut squash. Warren (2008) suggests preferences can be explained by the availability of the crop, harvesting rates and nutritional content.

A number of crops are reported as unattractive to animals, receiving no wildlife damage in crop raiding areas (Strum 1994; Naughton-Treves 1998; Riley 2007; Hiser 2012). Farmers in the study area made suggestions about crops that baboons might not raid; however, these suggestions were usually from those that had no experience growing the crop. For example, one farmer stated:

I think if you do onion, I think so I'm not sure, but if you do onion or beetroot or something like that, I don't think you're going to have a major problem. (F05)

Studies suggest that onion is less prone to raiding by wildlife (Nyangoma 2010), but is nevertheless subjected to raiding in the study area, as this farmer who has experience with onions stated:

The baboons they ate the onions a bit, but not as much as the potatoes. (F15)

Incidentally, later the same season farmer F05 tested growing onions on his farm and reported back that both baboons and vervet monkeys 'die for them'. This demonstrates how having access to farmers knowledge of crop raiding is invaluable – instead of testing whether a crop is unattractive to raiding wildlife, we can simply use the knowledge of other farmers in the area with the appropriate experience.

Tobacco provides another example of the benefits of procuring information from farmers. As well as being reported not to sustain wildlife damage (Hiser 2012; Nyangoma 2010), casual conversations with participants and peers reveal that many believe tobacco is not subjected to wildlife damage. However, interviewing farmers who grow tobacco reveals a different story:

> *It's only baboons that eat the tobacco, and then the bushbuck, steenbok and the duiker, they'll eat it when it's small.* (F01)

Other farmers also explain how tobacco is still damaged, even when it is not consumed:

> *The tobacco, they can't eat it they just break it.* (F03)

> *On the tobacco number one [crop raider] is baboon because baboons break off the plants.* (F12)

Although there are very few studies that report wild animals feeding on tobacco, a number of studies nevertheless reveal that tobacco does suffer wildlife damage. Chimpanzees damage tobacco by treading on seedlings (McLennan & Hill 2012) and have been seen removing tobacco leaves and 'laying them down as a kind of matting' (Hiser 2012); bushpig (*Potamochoerus porcus*) damage tobacco by trampling it, possibly because they use it to kill off body lice (Kagoro-Rugunda 2004); elephants damage small amounts of tobacco in Uganda, but it was not reported whether this was through trampling or feeding on the crop (Mackenzie & Ahabyona 2012). Whether wildlife damage crops by consuming them or for other reasons makes little difference to the outcome for farmers: the crop is damaged and cannot be sold. In fact, destroying a crop without consuming it elicits stronger negative perceptions from farmers, as this is often seen as malicious and vindictive rather than a hunger-driven action (discussed in the next section).

Chilli is often suggested as a crop that is unattractive to wildlife (Parker & Osborn 2006; Hedges & Gunaryadi 2010), and has been used in crop raiding deterrents, such as with chilli-rope fences and pepper sprays (Osborn & Rasmussen 1995; Chelliah et al. 2010). One study farmer, with experience of growing chillies, stated that baboons will not eat this crop even when they are hungry.

> *They go for everything, only the chillies they don't.* (F08)

However, while some studies suggest that chilli crops are not raided, others record chilli being damaged by wildlife (Wang et al. 2006). Furthermore, one farmer in the study area stated:

It's not an option because chillies – you can't make money out of chillies now. (F05)

Further investigation needs to be carried out to determine whether chilli is in fact a crop that is unpalatable to wildlife. Moreover, exploration into the farmers' situation and whether chilli is an appropriate crop to grow in this area or has the economic viability of being planted as a 'sacrifice' crop is required before any suggestion is made on either switching crops or using chilli as a buffer crop between the bushveld and more palatable crops.

Raiding strategies

The impression that baboons are well organised in their crop raiding strategies reinforces negative perceptions of baboons (Hill 1997); negative attitudes intensify when primates appear to be willingly deceiving farmers by conducting calculated assaults (Webber 2006). Information on baboon raiding strategies was not requested during interviews, but over half (53.8%) the farmers described the same raiding strategy in response to a number of different questions.

> *Other things will run away, but your baboon, if he sees that is the guard – they know them – and he's on this side of the field, they will move around to the other side and they will harvest on that side. When the guards get to that side, they move up to the top-side again.* (F05)

> *They come from every side, everywhere and if the one jumps over and she runs that side they'll come behind her and in front of her.* (F01)

> *They're also getting clever, they divide in two groups, they'll charge here and if the guard runs after them here the other group will enter the other side of the land.* (F02)

Baboons are not the only perpetrators of this raiding strategy; it was also described for vervet monkeys.

> *Last year we had a problem on this field because it's so big that the women will be on that side and the monkeys will come in there [opposite side]. And it happened two days ago, the group split up and there were monkeys on this side and on that side… so she doesn't know where to run to… I can't put two people, it's just too expensive.* (F06)

This particular strategy has been described in other studies (Maples et al. 1976; Sillero-Zubiri & Switzer 2001) and was observed during crop raiding behavioural observations. Whether this strategy of raiding is 'tactical deception' (that is, when one part of the group deliberately distracts the guard while the others silently raid another area of the farm, Lee & Priston 2005) or not is debated (Lee & Priston 2005) – while guards and farmers perceive this as very deceitful behaviour, it could merely be a result of the way baboon groups divide when foraging (Warren 2008). In their study of baboon raiding behaviour in Kenya, Maples et al. (1976) suggest there is no evidence that baboons exhibit conscious diversionary tactics, but rather are influenced by the geography of the farm-forest interface as the group spread along the forest margin; when guards leave parts of a farm unprotected to converge on raiding baboons, other baboons simply take advantage of the guard's departure. Nevertheless, baboons are perceived to be worse than other crop raiders because of their 'strategic' methods (Warren 2008).

Organised raiding strategies also contribute to the frustration farmers feel about the lack of control they have over baboons. Indeed, this strategy was given as a reason for why it is difficult to control baboons and was often talked about when describing why guarding fields was not 100% effective.

> *It's very difficult to… control it… they came in there, now she's [guard] concentrating there, they come around this side.* (F06)

Baboon raiding strategies lend to the negative perceptions that farmers hold of them. Their strategic methods make them difficult to control and their deceptive ways are not appreciated. The way in which they forage once they reach the crops further worsens the matter. When food is plentiful baboons will not finish eating one item before moving onto another, which in a field full of crops naturally leads to damage that is out of proportion to what is actually eaten (Bolwig 1959). This destructiveness particularly vexes the farmers, who often criticise baboons for their 'wasteful' ways of feeding.

> *They try it or give it a bite and then throw it down and take another one. They are not finishing a product with anything – potatoes, tomatoes, pumpkins, butternuts – give it maybe a bite or two and grab the new one… if they took one butternut that would be more than enough for a baboon, so just finish the whole thing, but they don't operate like that.* (F05)

> *The only thing that bothers me about a baboon is that if they come in and took one butternut and they leave and they eat it and then its finished, then it's fine, but now they come in and they'll take one, they'll take two bites out of it, throw it down, take another one, take a bite out of that one, throw it down, take another. So one baboon will cause damage to 10 or 11 different fruits, but they won't finish one.* (F01)

More than this, baboons are described as being 'spiteful' and 'malicious' when they are seen destroying crops they do not even eat.

> *The baboon is very spiteful, if it does raid your land or gets into the tobacco he would break your plants and if the pumpkin plant is still very small he would pull it out of the ground and if there was nothing for him to feed he would just throw it down… he's damaging the plants before there's any harvest.* (F02)

> *They don't only raid the crops they can eat, they destroy everything… even just natural feeding they'll damage stuff just because they can.* (F03)

This perception of baboons is not unique among these farmers. Baboons have previously been described as 'malicious', 'vindictive' and 'wasteful' because they cause wilful damage for the sake of it and not just to satisfy their hunger (Hill 1997; Hill & Webber 2010). This leads to suggestions that baboons are 'greedy', a perception that serves to displace any anxieties about killing what farmers view as 'vermin' (Knight 2001). Being greedy results in baboons once again crossing a moral boundary that has been assigned given their likeness to humans, rendering farmer retaliation justified because they therefore *should* be punished. Perhaps reducing conflict can be achieved through educating people about baboons and how they operate, in an attempt to dissipate the negative perceptions such as baboons being deceptive, malicious, greedy and wasteful.

Control

The inability to control an animal negatively influences people's attitudes towards them (Fiallo & Jacobson 1995). People are much more willing to accept risk when it is 'voluntary' rather than 'involuntary' – that is, when people have control over the situation (Starr 1969). While 'good' animals accept their subordinate roles and reinforce the concept of humans at the pinnacle of the animal kingdom, 'bad' animals are uncontrolled creatures capable of subverting this hierarchy – these animals do not fear humans, humans fear them, they have power over humans, humans do not have power over them (Costa et al. 2013). This is summed up neatly by the following quote from a local tourist lodge manager:

> *The problem is that they are very clever… so that's why there are problems because people think they are a challenge and people don't like being challenged – they like being the boss.* (A03)

Primates have been labelled as the most challenging of all the larger crop raiding mammals to control because they are so intelligent (Strum 2010). Baboons' intelligence is not only perceived by farmers to brand them as sinful rule breakers, it also makes them very difficult to control.

They are… much smarter than most of the other animals… so it's very difficult to keep them out. (F01)

Animals that are considered particularly difficult to deal with are disproportionately complained about and tolerance towards them reduces (De Boer & Baquete 1998; Hill 2004). For example, although weaver birds are common pests of grain crops throughout Africa, farmers claim they are not especially problematic because they are able to predict when the birds will enter fields and are thus able to take appropriate action against them; baboons on the other hand will come at any time and therefore cannot be controlled as easily (Hill 2005).

The inability to control a problem animal may also result in the animal being pesticised. One farmer sums up nicely his idea behind what constitutes a pest or not:

I think pests are more for, I think insects are a pest for me, something not controllable. And it's not like, it's something that's there. Game is something that will be in the wild and is running away, trying to ignore humans. Where the insect, kind of thing, is just there, it's in your face the whole time. (F05)

Perhaps this is the line that baboons cross to become pests – once they are deemed 'uncontrollable', which is a concern for many of the farmers, they move into the realm of being a pest animal. It has been seen before that when methods of control (such as killing a problem animal) are legally removed, but are not replaced with another, farmers become frustrated and tolerance of the animal in question decreases (Naughton-Treves 1998; Rosie Woodroffe et al. 2005). Increased frustration and reduced tolerance is likely to exacerbate the conflict situation and may lead to the increased use of retaliatory methods involving lethal, albeit illegal, control.

Tolerance to raiding

Tolerance to wildlife crop raiding exists at many different levels and is influenced by a number of factors. Tolerance towards a species is certainly affected by the amount of damage it causes (Malik & Johnson 1994; Conover 1998). It is not only wildlife attributes however that affect tolerance, the level of crop loss accepted as tolerable is also influenced by social factors. For example, increased investment into growing crops, through use of pesticides and other technological inputs, can lead to reduced tolerance to damage (Knight 2001), as does a person's dependence on agriculture and declining alternative employment opportunities (Hill 2005).

Study farmers were asked how much crop loss they are willing to tolerate from wildlife damage. Of the nine farmers that gave clear answers, such as providing a percentage loss that is toleraable, four of these implied that the losses they currently sustain are acceptable. However, three of these same farmers continue to use shooting as a method of control, suggesting that they are *not* accepting of current levels of damage. It is not clear in the data whether these levels are tolerable because they use shooting as a deterrent method or whether shooting is an outcome of intolerable damage – this would require further investigation. Furthermore, the answers given could also have been influenced by the farmers' knowledge of my position as the interviewer. Two of the remaining farmers offered a tolerance level which is less than the level of loss they currently perceive to sustain; both of whom also use shooting as a control method. The last three farmers stated that no loss is acceptable, with statements such as:

> *The damage they cause is straight out of your pocket, so every rand or every two rand that goes is two rand I could have had, so I would like it to be zero.* (F01)

> *No, I don't want them in my fields. Once I'm finished, then they can have whatever is left.* (F10)

Finding a deterrent that reduces wildlife crop damage to zero is unlikely; at least there have been no such successes reported in the literature up to now. This means that under such circumstances where farmers imply they will not tolerate any damages, it is likely that methods to increase farmer tolerance are required. Raising tolerance of damage can be as important as reducing damage itself (Woodroffe et al. 2005), and can be achieved through actions such as enhancing appreciation for wildlife and its non-tangible benefits (Messmer 2000), as well as its direct benefits (Naughton-Treves 1998). Fortunately those with a zero tolerance level are among the minority in the study area.

Tolerable levels of loss among study farmers ranged from zero to up to 10% of the crop, while suggestions such as the following were also made:

> *If the damage the wildlife cause amounts to more than what a guard will cost me to work there then I'll put a guard there, so if it's less than that then it's acceptable.* (F15)

> *If you don't make money off the crops, then I don't care at all, then they can come and do what they want but if we are very dependent on the crops like the tobacco and we know there's a potential income of half a million that's there in front of you and they damage those crops then you get angry and mad, so I can't tolerate that, so it depends on which crop it is and what the going rate at that stage for the crop.* (F12)

It is normal for those farming alongside wildlife to expect some level of crop damage (Knight 1999; Knight 2001), and in some areas high levels of tolerance are afforded to primates (Priston 2008; Riley & Priston 2010). However, there are also reports of agriculturalists expressing that losses exceed their tolerable level (Conover 1998). It is important therefore to determine levels of tolerance and work to reduce damage to this level, while perhaps increasing tolerance to realistic levels of damage once mitigation is in place.

4.3 Conclusion and Conflict Resolution Implications

Farmers suggest that the biggest problem they face to their crop yields is not wildlife crop raiding, yet this is the issue that most frustrates them, because it is very difficult to control. This suggests attention needs to be focused on bringing about a solution. In this area of commercial farming in South Africa there is currently no research being conducted on preventing crop damage by wildlife, other than what farmers attempt to do themselves, and, as discussed in the previous chapter, often do alone.

Having accurate knowledge of the conflict situation will allow farmers to better deal with the problem. Improving farmer knowledge however can only be achieved once current perceptions have been investigated. For example, one of the characteristics of baboon crop raiding that most vexes farmers is their destructive and wasteful way of feeding once in the crop field. This results in farmers experiencing anger and baboons being perceived of as spiteful – negative outcomes for both farmer and baboon. Provided with information on baboons and the ecosystem services they may provide, such as their potential role in seed dispersal (Kunz & Linsenmair 2008), then perhaps farmers would be more understanding and less frustrated with baboons' behaviour. Although this does nothing to reduce actual crop damage it could reduce some of the resentment felt by farmers towards baboons and thereby increase tolerance. If farmers' perceptions had not been investigated, we would not know that this issue needs addressing.

During my anthropological investigations, I received many other questions from crop farmers about baboons, some of which – being no expert on baboon behaviour – I could not answer. An educational programme on baboon behaviour that is specifically tailored towards the aspects of baboons that engender negative feelings amongst farmers, and could answer some of their other questions, could alleviate the conflict. As well as information on baboons, included in this programme should certainly be accurate information on current environmental legislation, and what farmers should expect from the authorities. The fact that farmers take on some of the responsibility for the conflict as well as the baboons' behaviour lends itself towards such a programme being able to influence farmer tolerance towards baboons.

As well as increasing farmer tolerance, it would also be beneficial to continue in the search for a deterrent method that could at least give farmers a higher level of control over baboons than they currently feel, if not total control. A theme which was present throughout conversations with farmers is that baboons are so difficult to control. This engenders a range of negative perceptions of baboons, leading to baboons being pesticised, viewed as deceptive and consequently lethal methods of retaliation being utilised. Chapter 8 discusses farmer perceptions of a number of deterrent techniques and will provide further information on this topic. Given that a 100% effective solution to baboon crop raiding seems unlikely, it is important to combine implementing new techniques with increasing farmer tolerance.

Despite a high level of conflict with this species, the level of support from farmers for the continued existence of the baboon is high – this, as well as farmer values of the environment, can be drawn upon to aid in the task of increasing tolerance. Given the knowledge obtained through these anthropological methods, the undertaking of both increasing farmer tolerance towards and feelings of control over baboons will be that much easier, more appropriate and more successful, and can be used to encourage a change away from lethal methods of control.

CHAPTER 5: PRIMATE CROP RAIDING BEHAVIOUR

5.1 Introduction

Knowledge of crop raiding patterns of wildlife is essential for planning, implementing and monitoring mitigation techniques, which should include a detailed understanding of the underlying factors, patterns and processes associated with crop raiding (Nyirenda et al. 2011). Effective management of crop raiding is hindered in the absence of reliable information (Naughton-Treves 1998; Sillero-Zubiri & Switzer 2001; Wang et al. 2006). Long-term management of conflict must therefore not only be based on an understanding of local perceptions from the affected human communities, but also an improved understanding of wildlife behavioural ecology (Treves & Karanth 2003; Anthony et al. 2010).

Crop raiding by wildlife is a problem for commercial crop farmers in the study area (Chapter 4, section 4.2.2), and primates rank amongst the most problematic of the species that forage on crops (Hill 2002; Tweheyo et al. 2005; Campbell-Smith et al. 2010, see also Chapter 6, section 6.3.2). Baboons are often cited as the most damaging of all primate crop raiding species (Hill 1997; Naughton-Treves 1997; Hill 2000; Tweheyo et al. 2005); I will determine whether baboons cause more damage than vervet monkeys within the study area. Primates are highly intelligent and adaptable (Conover 2002; Wang et al. 2006) and as a consequence are the most challenging of all the larger crop raiding mammals to control As a result, farmers often have little success preventing crop damage by primates (Mason 1998; Warren 2008; Pahad 2011; Mackenzie & Ahabyona 2012). Their intelligence is a reason given by many farmers for baboons being so good at crop raiding (Chapter 3, section 3.3.2) and is believed to be the reason that they are so difficult to control (Chapter 4, section 4.2.2). However, the lack of success in controlling primate raiding may partially stem from a lack of knowledge of how and why they raid.

5.1.1 Factors influencing primate crop raiding patterns

Data on crop raiding can be collected through behavioural observations and in this study I employ a technique of distinguishing between crop raids (actual raiding of crop fields) and farm visits (primate groups visiting the vicinity of the farm, which may include multiple raids, a single raid or no raids at all; see Chapter 2, section 2.2.2.1 for full definitions). Most research on crop raiding discusses crop raids only, rarely making reference to the amount of time wildlife spends nearby crop farms when they are not raiding. Wallace (2010) investigates multiple crop raiding events, which he defines as "*raids by the same species that occurred in a series during an observation session and were deemed to be temporally linked*" (page 162), but I felt it important to investigate all the parameters of farm visits, because crops are at risk of being raided all the time a farm visit is occurring. Mitigation methods may therefore be more effective if directed at deterring farm visits rather than just crop raids. To investigate this, I will determine how often farm visits do not involve crop raids, and when crop raids do occur how often single raids occur compared with multiple raids.

Gathering information on primate crop raiding is important because a number of raiding features affect the nature and intensity of crop damage caused by primates. The frequency of its occurrence, duration of raids, number of individuals involved, composition of the raiding party, distance travelled into crops and primate raiding strategies all affect the outcome of raiding (Maples et al. 1976; Hill 2000; Warren 2008; Wallace 2010). Many crop raiding studies have investigated the effects of raiding parameters on the amount of crop damage caused (Maples et al. 1976; Strum 1994; Naughton-Treves 1998; Hill 2000; Saj et al. 2001; Linkie et al. 2007; Warren 2008; Hockings et al. 2009; Wallace 2010), but all these studies take place within subsistence farms. There is very little data on crop raiding patterns within commercial crop farms (Agetsuma 2007; Bal et al. 2011) and these parameters need to be understood in this context to be able to implement effective mitigation on commercial farms.

Among subsistence farms, crop raiding occurs at different rates. Warren (2008) records a raiding rate of 0.08 raids per hour for olive baboons (*Papio anubis*) in Nigeria, while Maples et al. (1976) record a rate of 1.8 raids per hour for yellow baboons (*Papio cynocephalus cynocephalus*) in Kenya. Saj et al. (2001) received varying reports from households in Uganda that vervets (*C. a. pygerythrus*) raided daily, three to four times a week, or that raids were restricted to the rainy season, while Naughton-Treves et al. (1998) reveal that redtail monkeys (*Cercopithecus ascanius*) have lower inter-monthly variation in raiding rates in Uganda than olive baboons or chimpanzees. Duration of raids and the number of individuals involved in raiding also vary under different circumstances (Maples et al. 1976; Kavanagh 1980; Warren 2008; Wallace 2010).

Raid frequency, duration and the number of individuals involved in raiding have all been shown to be affected by a number of temporal and spatial influences, such as time of day, season and human interference when attempting to prevent raiding (Maples et al. 1976; Kavanagh 1980; Linkie et al. 2007; Warren 2008; Wallace 2010). Time of day may affect raiding for several reasons. Primate crop raiding has been reported to reflect general circadian activity patterns for primates (Altmann & Altmann 1970; Hill et al. 2004), with activity peaking early and late while reducing during the middle of the day (Saj et al. 1999; Priston 2005; Wallace 2010). However, this pattern is not universal; Campbell-Smith et al. (2011) reported Sumatran orangutans foraging on cultivated fruits mostly in the afternoons and evenings, when farmers had left the farms to return to their village for the night. As seasons change and natural food availability fluctuates so too does wildlife crop damage; usually a reduction in natural food availability leads to an increase in crop damage (Sekhar 1998; Kagoro-Rugunda 2004; Admassu 2007; Hockings et al. 2009; McLennan & Hill 2010; Strum 2010; Nyirenda et al. 2011; Pahad 2011). Again however, this pattern is not universal, with many reports of severe crop raiding taking place irrespective of surrounding natural food availability (Naughton-Treves et al. 1998; Tweheyo et al. 2005; Riley 2007; Riley & Priston 2010). I will use the behavioural observation data collected on primate crop raiding to determine whether farm visit and raid durations and levels of crop damage differ between morning and afternoon on commercial crop farms and whether these measurements increase as natural food availability decreases. Competitive or predator-prey interactions affect foraging patterns (Willems & Hill 2009), and therefore may also influence raiding activity; I will therefore also test whether the durations of vervet farm visits and raids shorten and crop damage decreases with the increased presence of baboons around the farm.

The level of farmer vigilance, or crop guarding, can also have a significant effect on crop raiding patterns; in many areas this method of crop protection is the most effective deterrent against raiding primates; with increased crop guarding, damage by wildlife to crops decreases (King & Lee 1987; Sekhar 1998; Sitati et al. 2005; Sitati & Walpole 2006; Riley 2007; Nijman & Nekaris 2010; Hill & Wallace 2012). . I will investigate how guarding affects primate crop raiding on commercial farms, by determining whether a guard's response decreases damage, raiding duration or the number of individuals involved in a raid. I will also test whether a delay in response time by guards leads to an increase in crop damage and number of individuals involved and will do the same for a delay in response time by primates to guard reactions.

Guarding clearly effects crop raiding, but crop raiding can also impact the effectiveness of guarding. For example, Wallace (2010) reveals a relationship between primate body size and farmer detection of crop raiding events – larger animals are more likely to be detected than smaller species. I will determine whether guards respond more frequently to baboons than they do to vervets. Since crop guarding is labour-intensive and requires a guard to be present all day, and all night if nocturnal species are a problem (Hill 2000), effectiveness of guarding is also likely to be affected by factors such as guard fatigue. To investigate this I will test whether guards respond to more raids in the morning than the afternoon, and whether guard response rate changes over the season.

5.1.2 Quantifying primate crop damage

Quantifying the extent of crop damage by wildlife is often difficult (Sekhar 1998; Sillero-Zubiri & Switzer 2001). It can be labour-intensive, very time consuming and difficult in itself to assess (Priston 2009). For example, the way fruit grows on a tomato plant makes it very difficult to count the number of damaged fruits on each plant. Furthermore, damage by wildlife is not the only source of crop loss for many farmers (Hill 2004), estimates can therefore be inflated if other damage is blamed on wildlife. Lastly, it can be difficult – if not impossible – to assign damage to a particular species. The difficulty in assessing wildlife crop damage probably contributes to there being relatively few studies that attempt to quantify actual crop damage caused by wildlife (for examples see Priston 2009; Wallace 2010; Hill 2000). It would therefore be useful to find an easier way to measure damage.

Damage could be estimated through data on different crop raiding parameters. It might be assumed that the relationship between crop damage and raiding parameters are fairly simple – that is, with increasing frequency of raids, raid duration and the number of animals involved in a raid there is an associated increase in damage. However, this is not necessarily true. For example, smaller groups may have an advantage when raiding because they are less conspicuous to farmers (Warren 2008; Wallace 2010) – if they are not chased away from crops they may create more damage than larger groups which are consequently chased sooner. Primates may well take advantage of this fact; raiding party sizes have been shown to be smaller than social group sizes in primates (Warren 2008; Wallace 2010). Neither is raiding frequency necessarily a good indicator of the level of sustained crop damage; although farms experiencing more frequent raiding tend to sustain proportionally greater losses, crops that are raided relatively infrequently can suffer considerable damage (Hill 2000). It is important to be able to collect information on damage estimates before implementing mitigation strategies; as such I will determine which raiding parameter – frequency of raids, raid duration or number of individuals involved in raiding – is the best estimator of crop damage on this commercial crop farm, using a count of crop items removed by primates as a proxy for damage.

In the previous two chapters I have investigated farmer perceptions of primate crop raiding , gaining an understanding of how farmers perceive human-primate conflict and what aspects of this conflict affects them most. In this chapter I investigate the conflict from the primates' perspective, gaining an understanding of primate behavioural ecology whilst on commercial crop farms. Having knowledge of both sides of the conflict situation will help me to identify and implement the most appropriate mitigation strategies. The chapter focuses solely on the two primate crop raiding species present within the study area – baboons and vervet monkeys, raiding a single crop type: butternut squash. As described, I will determine the influences of a number of factors on crop raiding by primates, which have not previously been conducted in a commercial farm setting where field guards are already permanently employed.

5.2 Methods

This chapter uses data from primate crop raiding behavioural observations, which were collected via instantaneous scan and all-occurrence continuous sampling. These data were collected on the main study farm (B) during May to August 2013 (see Chapter 2, section 2.2.2.1 for location, methods and data analyses).

5.3 Results

A total of 202 farm visits (baboon = 110, vervet = 92), involving 643 raid attempts (baboon = 344, vervet = 299) and 506 successful crop raids (baboon = 287, vervet = 219) were recorded across the observation period (total observation time: baboon = 699 hours 58 minutes, vervet = 713 hours 50 minutes). This amounted to a total of 353 hours 22 minutes of time primates spent around the farm (baboon = 249 hours 15 minutes, vervet = 104 hours 7 minutes; 35.6% and 14.6% of observation time, respectively) and 16 hours 3 minutes within the crops (baboon = 6 hours 54 minutes, vervet = 9 hours 9 minutes; 1.7% and 5.3% of their farm visit time, respectively). A minimum of 2,368 primate entries (baboons = 1,939, vervets = 429) were made into the crop field during the observed crop raids. Of these entries at least 102 (baboons = 64, vervets = 38) were the same individual entering the crops more than once in the same raid. Individual crop raids involved between 1 and 63 baboons (mean = 7.01) and 1 and 18 vervets (mean = 2.12).

5.3.1 Does amount of crop damage by primates differ between primates?

A minimum of 1,794 crop items were removed from the observation field (baboons = 1,526, vervets = 268). Using the market value of butternuts at the time of harvest (ZAR35-40 per bag) and extrapolating to include days when observations were not made, this equates to an economic loss of ZAR14,219-16,250 caused by primates (baboons = ZAR12,132-13,865, £763-872; vervets = ZAR2,087-2,385, £131-150) in this single butternut crop field over 106 days. Overall, baboons caused significantly more damage than vervets across the observational period, using crop items removed from the field as a proxy for damage (Figure 5.1a). However, when analysing damage monthly, this is only true for July and August – there is no significant difference in damage caused by baboons and vervets during May and June (Figure 5.1b-e).

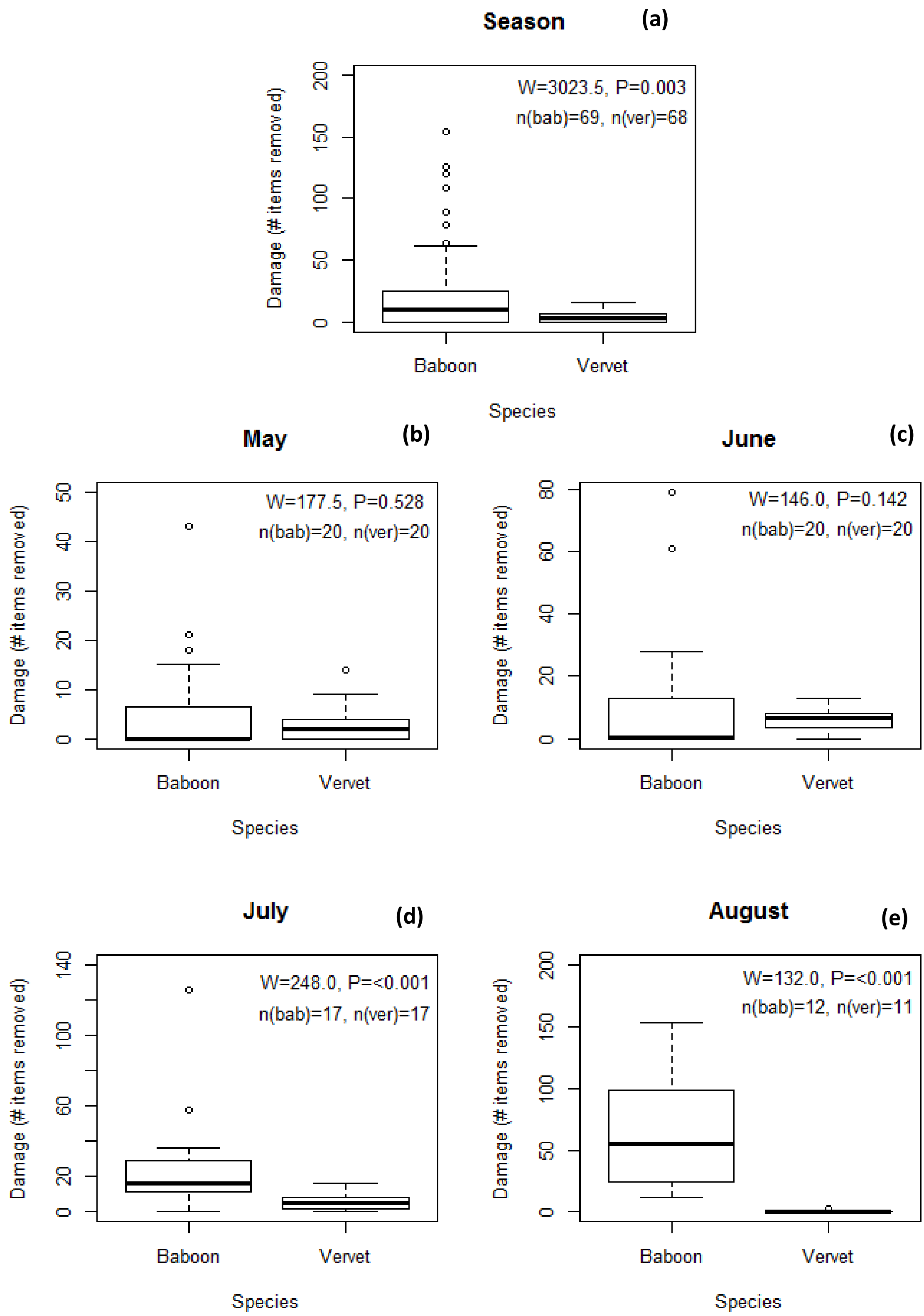


Figure 5.1: Amount of damage caused by two primate species throughout the crop season and during each month. The median is indicated by the bold line, edges of the box indicate the quartile values. Whiskers represent the distribution of spread and outlying points represent data more than 1.5 times the upper quartile value. Plots show Wilcoxon rank sum test scores and P values, indicating whether there is a significant difference between species in each graph, using day as the sample unit.

5.3.2 Which raiding parameter best estimates damage?

Number of individuals involved in raiding is the best predictor of damage (as measured by the number of crop items removed from the field) for both primate species (Table 5.1, Figure 5.2), accounting for over 96% and 79% of the variance in damage for baboons and vervets respectively. However, highly significant positive relationships also exist between both raiding frequency and raid duration and crop damage for both species. Raid duration correlates better with the number of individuals raiding than frequency of raids for both species (Table 5.2, Figure 5.3), suggesting that, if information on number of individuals raiding is not available, duration is the better estimate of number of individuals involved and therefore damage caused.

Table 5.1: Linear regression output assessing the influence of i) successful raid frequency, ii) raid duration and iii) number of individuals involved in raiding on the amount of crop damage sustained (number of items removed from the field). Bold values indicate significance.

	Parameter	R^2	Estimate	SE	t	df	P	Lower CI	Upper CI
Baboon	Frequency	0.525	0.965	0.137	7.043	**43**	**<0.001**	0.689	1.242
	Duration	0.733	0.617	0.056	11.022	**43**	**<0.001**	0.504	0.730
	Individuals	0.960	0.950	0.029	32.453	**43**	**<0.001**	0.891	1.010
Vervet	Frequency	0.365	0.150	0.029	5.238	**45**	**<0.001**	0.093	0.208
	Duration	0.396	0.439	0.080	5.519	**44**	**<0.001**	0.279	0.599
	Individuals	0.787	0.741	0.057	13.087	**45**	**<0.001**	0.627	0.855

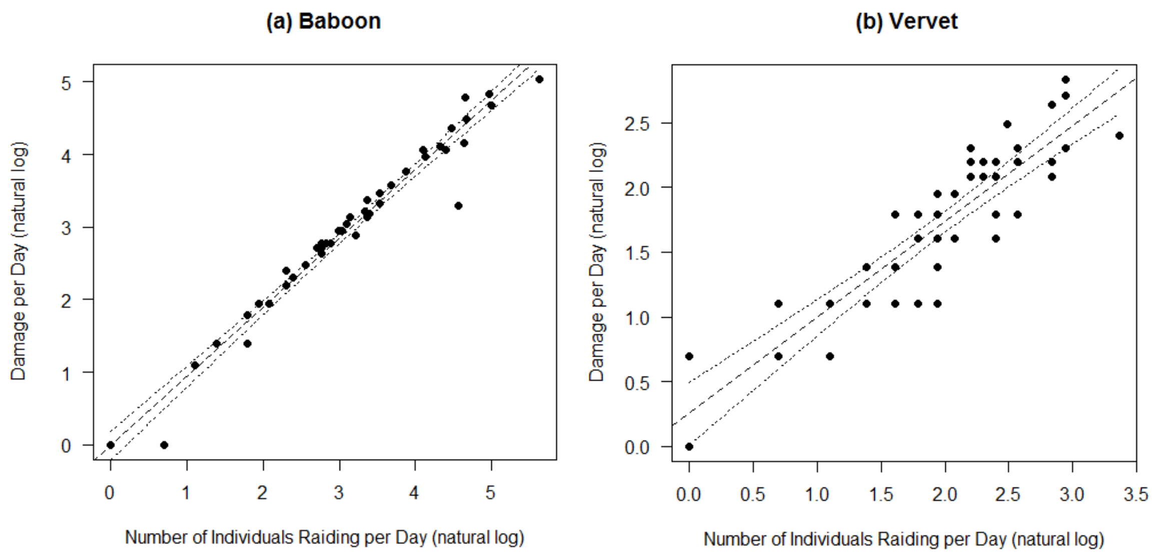


Figure 5.2: Relationship between the number of individuals involved in raiding and the damage caused per day by (a) baboons and (b) vervets. Both variables are logged. Dashed line shows the linear regression, dotted lines show the confidence intervals for the slope estimate.

Table 5.2: Linear regression output assessing the influence of i) frequency and ii) duration of successful raids on the number of individuals involved for baboons (B) and vervets (V), to determine which parameter is most closely associated with number of individuals raiding. Bold values indicate significance.

	Parameter	R^2	Estimate	SE	t	df	P	Lower CI	Upper CI
B	Frequency	0.568	0.965	0.1371	7.043	**43**	**<0.001**	0.763	1.306
	Duration	0.761	0.648	0.055	11.865	**43**	**<0.001**	0.538	0.758
V	Frequency	0.327	5.536	1.133	4.885	**46**	**<0.001**	3.255	7.817
	Duration	0.657	0.633	0.068	9.336	**44**	**<0.001**	0.496	0.770

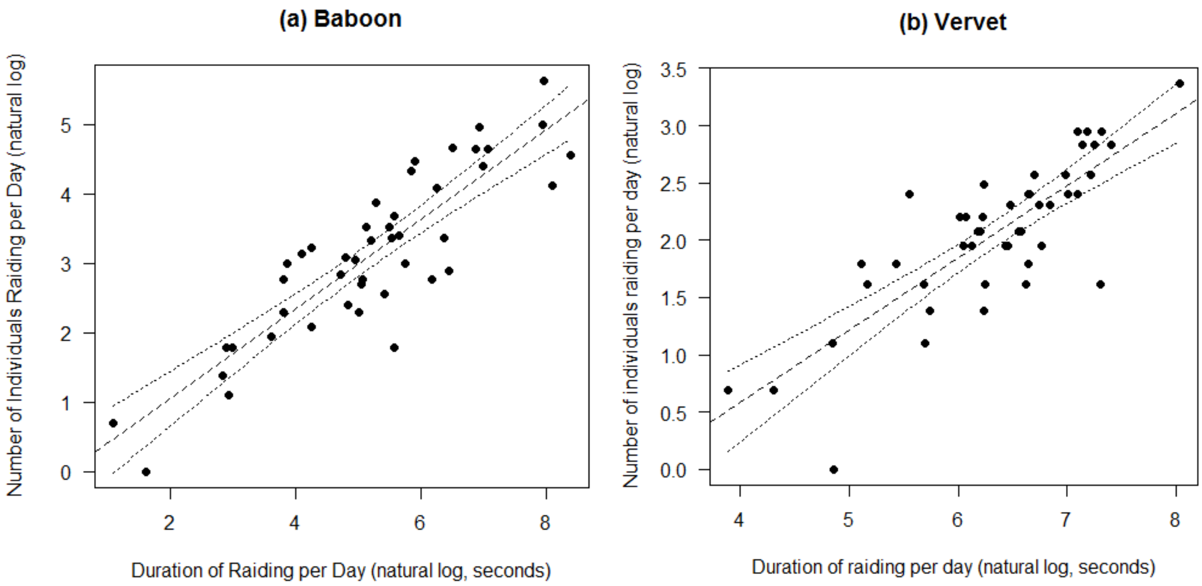


Figure 5.3: Relationship between the duration of raiding and the number of individuals involved in raiding per day for (a) baboons and (b) vervets. Dashed line shows the linear regression, dotted lines show the confidence intervals for the slope estimate.

5.3.3 Does raiding change with time: time of day and season?

Overall, NDVI and session clearly influence farm visit and raid durations and crop damaged caused by baboons (comparisons of full with null models: farm visit duration – log-likelihood (LogLik) = -1.096.4, P = 0.011; raid duration - LogLik = -542.5, P = <0.001; damage – LogLik = -359.3, P = <0.001). All baboon raiding parameters significantly increase as NDVI decreases (Figure 5.4 a-c, Table 5.3). However, only crop damage shows a significant difference based on time of day, with baboons causing more damage during morning sessions than afternoons (Figure 5.4 d, Table 5.3).

In contrast with baboons, the overall model for vervets shows that NDVI and session do not appear to influence any of the raiding parameters tested for vervets (comparisons of full with null models: farm visit duration – LogLik = -907.19, P = 0.138; raid duration – LogLik = -533.89, P

= 0.225; damage – LogLik = -228.97, P = 0.475, see Table 5.3 for multiple regression output for each predictor).

Table 5.3: Multiple regression output assessing the influence of NDVI and session (am or pm) on (a) farm visit duration, (b) raid duration and (c) amount of damage. Bold values indicate significance.

(a) FARM VISIT DURATION: Influence of NDVI and session on baboon (B) and vervet (V) farm visit duration.

	Predictor	Estimate	SE	Z	P	Lower CI	Upper CI
B	NDVI	-13.011	4.137	-3.15	**0.002**	-21.119	-4.903
	Session	-0.208	0.371	-0.56	0.574	-0.935	0.518
V	NDVI	3.975	5.833	0.68	0.496	-7.458	15.407
	Session	-0.825	0.469	-1.76	0.078	-1.744	0.094

(b) RAID DURATION: Influence of NDVI and session on baboon (B) and vervet (V) raid duration.

	Predictor	Estimate	SE	Z	P	Lower CI	Upper CI
B	NDVI	-27.038	4.119	-6.56	**<0.001**	-35.111	-18.965
	Session	-0.304	0.459	-0.66	0.508	-1.203	0.595
V	NDVI	10.150	7.548	1.34	0.179	-4.644	24.944
	Session	-0.513	0.592	-0.87	0.386	-1.673	0.646

(c) CROP DAMAGE: Influence of NDVI and session on baboon (B) and vervet (V) crop damage.

	Predictor	Estimate	SE	Z	P	Lower CI	Upper CI
B	NDVI	-20.382	6.154	-3.31	**0.001**	-32.443	-8.321
	Session	-1.067	0.355	-3.00	**0.003**	-1.763	-0.371
V	NDVI	4.021	4.255	0.95	0.340	-4.318	12.361
	Session	-0.199	0.331	-0.60	0.550	-0.848	0.449

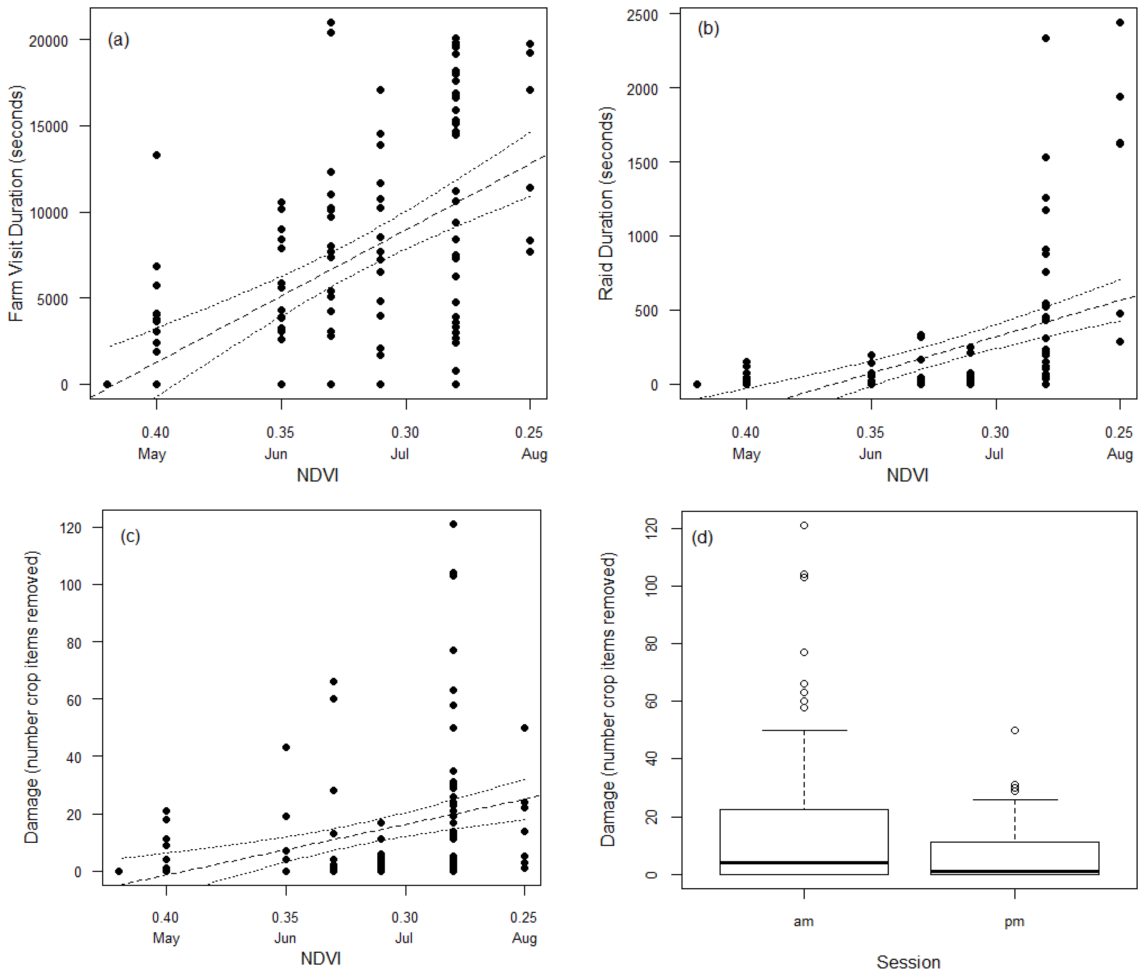


Figure 5.4: The relationship between baboon (a) farm visit duration and NDVI, (b) raid duration and NDVI, and (c) damage and NDVI. Dashed line shows the linear regression, dotted lines show the confidence intervals for the slope estimate. (d) Effect of session on baboon damage, using day as the sample unit. The median is indicated by the bold line, edges of the box indicate the quartile values. Whiskers represent the distribution of spread and outlying points represent data more than 1.5 times the upper quartile value.

Figure 5.5 shows the pattern of primate crop damage across NDVI values, using a smooth curve fitted to a scatter plot in R. Vervet damage starts to increase as NDVI decreases, until baboon damage increases significantly, at which point vervet damage starts to decline, suggesting that while NDVI appears to have no effect on vervet raiding, this may be due to the presence of baboons. I therefore tested the effect of baboon presence around the farm and session on vervet raiding.

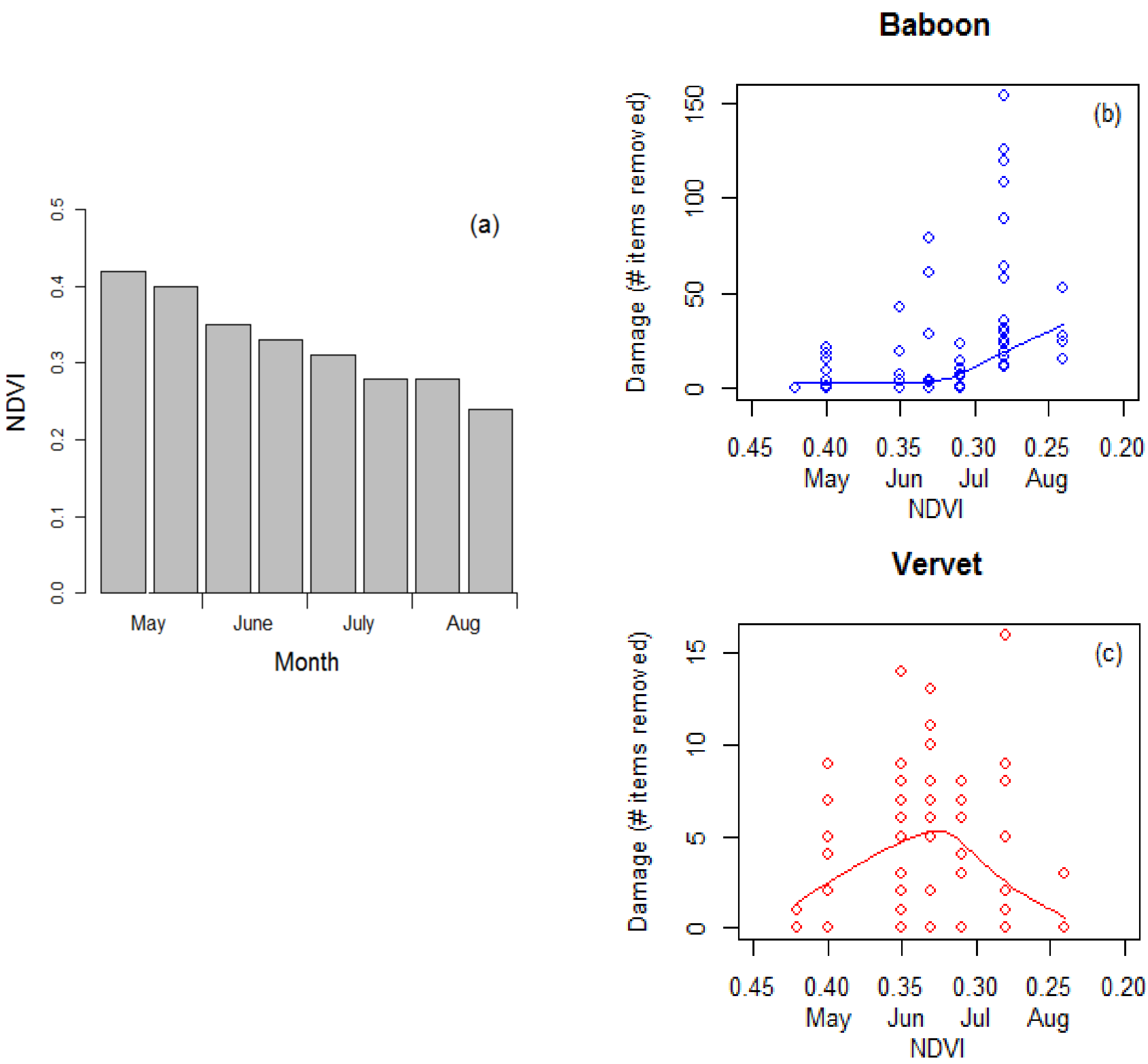


Figure 5.5: (a) NDVI values across each month of the observation period. Pattern of crop damage across NDVI values caused by (b) baboons and (c) vervets. Note that NDVI decreases over time so that the highest value lies to the left of the scale and the lowest value to the right on graphs (b) and (c).

The presence of baboons and session appear to influence only the amount of damage that vervets cause (comparisons of full with null models: farm visit duration – LogLik = -905.3, P = 0.085; raid duration – LogLik = -532.6, P = 0.121; damage – LogLik = -225.8, P = 0.034). Vervet damage is significantly reduced by the increase of baboon presence at the farm (Figure 5.6, Table 5.4), with each additional four hours of baboon presence decreasing vervet damage by one butternut. Raid and farm visit duration are not affected by the presence of baboons. In this model, session has no influence on any of the vervet raiding responses tested (Table 5.4).

Table 5.4: Multiple regression output assessing the influence of baboon presence and session on (a) farm visit duration, (b) raid duration and (c) amount of damage. Bold values indicate significance.

(a) Influence of baboon presence and session on vervet (V) farm visit duration.

	Predictor	Estimate	SE	Z	P	Lower CI	Upper CI
V	Baboon	-0.00005	0.00004	-1.28	0.202	-0.00013	0.000029
	Session	0.766	0.466	-1.64	0.101	-1.680	0.148

(b) Influence of baboon presence and session on vervet (V) raid duration.

	Predictor	Estimate	SE	Z	P	Lower CI	Upper CI
V	Baboon	-0.00009	0.00005	-1.87	0.062	-0.00019	0.000006
	Session	0.349	0.614	-0.57	0.570	-1.551	0.0854

(c) Influence of baboon presence and session on vervet (V) damage.

	Predictor	Estimate	SE	Z	P	Lower CI	Upper CI
V	Baboon	-0.00007	0.00002	-2.59	**0.010**	-0.00012	-0.00002
	Session	0.200	0.319	-0.63	0.529	-0.8246	0.0424

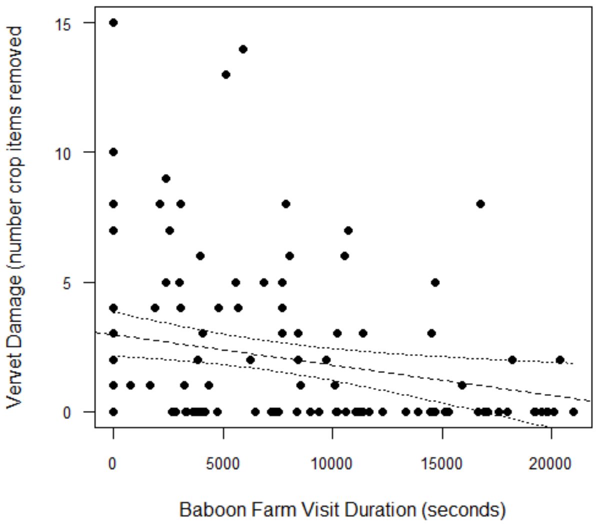


Figure 5.6: Simple linear regression to demonstrate the relationship between vervet damage and the presence of baboons at the farm (baboon farm visit duration), using day as the sample unit. Dashed line shows the linear regression, dotted lines show the confidence intervals for the slope estimate.

5.3.4 Farm Visit Parameters

42.5% of primate farm visits (baboons = 48.6%, vervets = 34.0%) did not involve raiding at all (Figure 5.7). Vervets are more likely to raid when they do visit than baboons (Chi-square: χ^2 = 4.490, df = 1, P = 0.034), reflected in the lower percentage of vervet farm visits without raids. Of the visits that involved raiding, significantly more visits involved multiple raids than a single raid for both species (Chi-square: baboon - χ^2 = 14.222, df = 1, P = <0.001; vervet - χ^2 = 17.515, df = 1, P = <0.001, Figure 5.8), and there was no significant difference between species in how often they were involved in single- or multi-raid farm visits (chi-square test, χ^2 = 0.078, *df* = 1, P = 0.781, Figure 5.8). There is a strong positive correlation between the duration of farm visits and the number of crop raids (r_s = 0.653, n = 240, P = <0.001), that is true for both species independently (baboon: r_s = 0.737, n = 140, P = <0.001; vervet: r_s = 0.635, n = 100, P = <0.001).

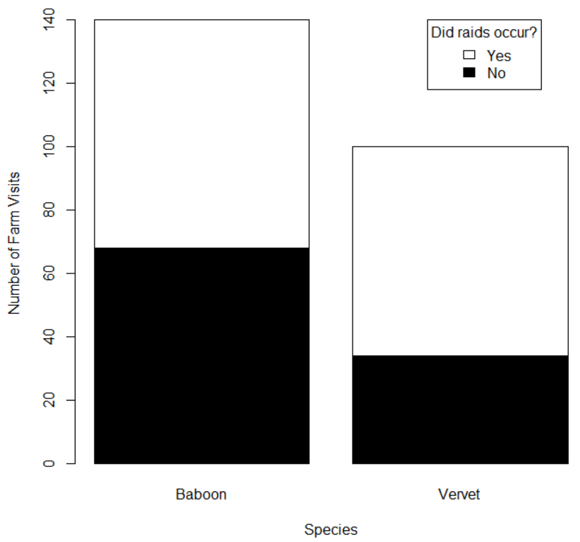


Figure 5.7: Number of farm visits for both primate species that did (white) and did not (black) involve crop raids.

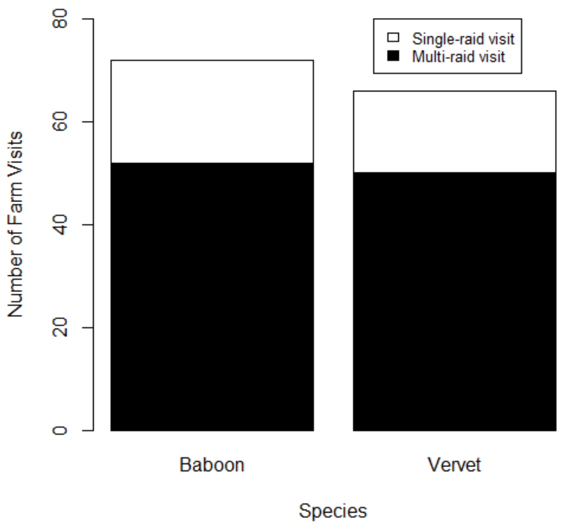


Figure 5.8: Number of farm visits for both primate species that involved single (white) and multiple (black) crop raids.

5.3.5 How do guards affect primate raiding?

Guards responded to 81.7% of baboon raids and 15.5% of vervet raids. Overall, species, NDVI (temperature) and session influence whether a guard responds to a raid (comparison of full with null model: χ^2 = 185.95, df = 3, P = <0.001). Both species and session had a significant effect on whether guards responded to raids – with guards more likely to respond to baboons than vervets, and during the morning than the afternoon; NDVI had no effect on whether guards responded (Table 5.5, Figure 5.9).

Table 5.5: Multiple regression output assessing the influence of species, NDVI and session on whether or not the guard responds to raids. Bold values indicate significance.

Predictor	Estimate	SE	z	P	Lower CI	Upper CI
Species	-3.741	0.408	-9.181	**<0.001**	-4.612	-3.000
NDVI	2.308	4.406	0.524	0.600	-6.491	11.191
Session	-1.136	0.330	-3.441	**<0.001**	-1.810	-0.508

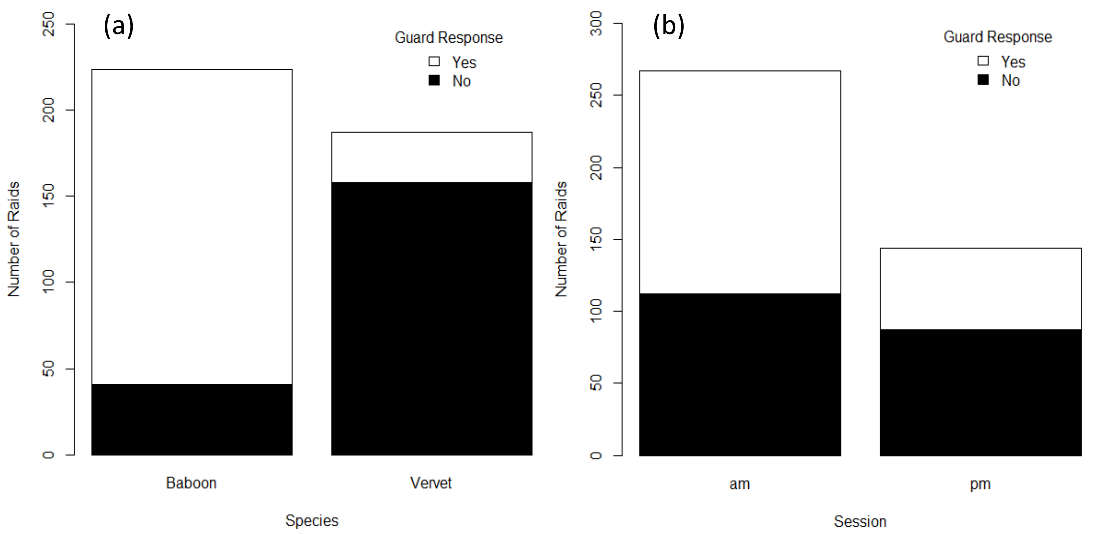


Figure 5.9: Number of raids that occurred (a) for both species and (b) during each session that guards did (white) and did not (black) respond to.

Whether or not a guard responds has an effect on baboon damage and the number of individuals involved in raiding, but not on raid duration (comparisons of full with null models: damage – χ^2 = 34.997, df = 1, P = <0.001; raid duration – χ^2 = 2.237, df = 1, P = 0.135; individuals – χ^2 = 47.515, df = 1, P = <0.001, Figure 5.10 a and b). Interestingly, damage and the number of individuals involved are higher when guards respond (Table 5.6), suggesting that in fact guards are more likely to respond because there are more individuals in the field. For vervets, there is an overall effect of guard response on number of individuals involved, but not damage or raid duration (comparisons of full with null models: damage – χ^2 = 1.651, df = 1, P = 0.200; raid duration – χ^2 = 3.177, df = 1, P = 0.075; individuals – χ^2 = 13.001, df = 1, P = <0.001, Figure 5.10 c). Again, the number of vervets involved in raids is higher when guards respond.

Table 5.6: Multiple regression output assessing the influence of whether or not the guard responds on i) damage sustained per raid, ii) duration of raid and iii) number of individuals involved. Bold values indicate significance.

	Response	Estimate	SE	Z/t	P	Lower CI	Upper CI
Baboon	Damage	0.572	0.101	5.643	**<0.001**	0.376	0.775
	Duration	0.327	0.212	1.543	0.134	-0.100	0.737
	Individuals	0.568	0.086	6.584	**<0.001**	0.376	0.775
Vervet	Damage	0.244	0.187	1.310	0.190	-0.132	0.606
	Duration	0.482	0.266	1.808	0.075	-0.047	0.994
	Individuals	0.561	0.151	3.712	**<0.001**	0.259	0.859

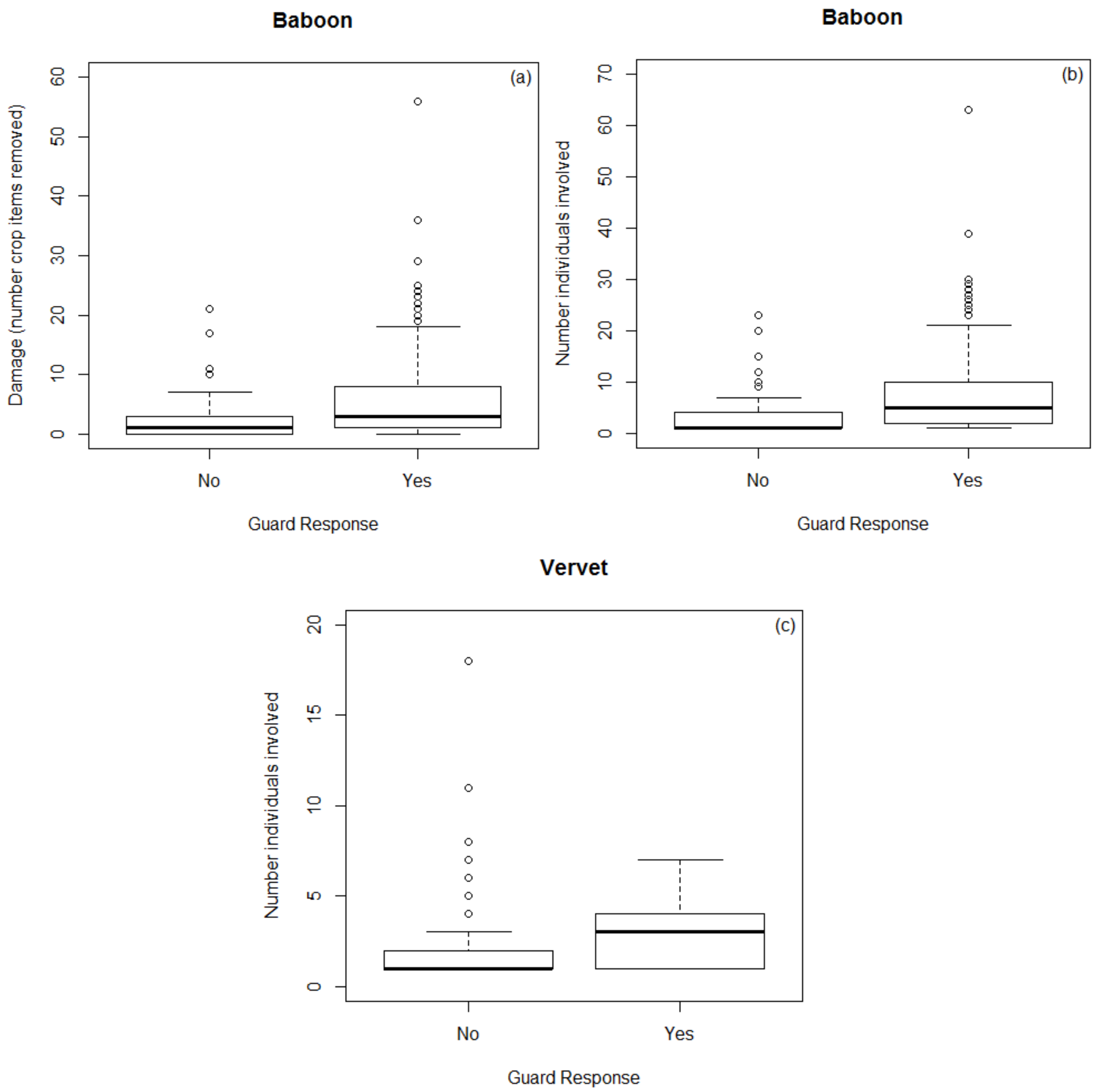


Figure 5.10: Plots showing the effect of guard response on baboon (a) damage and (b) number of individuals involved in raiding and (c) number of vervets involved in raiding, using day as the sample unit. Median values are indicated by bold lines, edges of boxes indicate quartile values. Whiskers represent distribution of spread and outlying points represent data greater than 1.5 times the upper quartile values.

Guard delay from the onset of raiding to the onset of chasing ranged from 0 to 7 minutes 50 seconds (mean 43 seconds) for baboons and 0 to 11 minutes 15 seconds (mean = 4 minutes 11 seconds) for vervets. Primate delay from the onset of chasing to the cessation of raiding ranged from 0 to 6 minutes 35 seconds (mean = 27 seconds) for baboons and 0 to 1 minute 9 seconds (mean = 25 seconds) for vervets.

Guard and primate delays clearly influence both damage caused and number of individuals involved in raiding for baboons (comparisons of full with null models: damage – χ^2 = 27.133, df = 2, P = <0.001; individuals involved – χ^2 = 24.835, df = 2, P = <0.001). Both damage and number of individuals significantly decrease with decreasing guard delay, but only number of individuals involved significantly decreases with decreasing primate delay (Table 5.7). For vervets, guard and primate delays have an overall influence on damage and number of individuals involved (comparisons of full with null models: damage – χ^2 = 9.299, df = 2, P = 0.010; individuals involved – χ^2 = 26.914, df = 2, P = <0.001). Both vervet measurements significantly decrease with decreasing guard delay; number of individuals involved significantly decreases with decreasing primate delay, but this pattern is not significant for vervet damage (Table 5.7).

Table 5.7: Multiple regression results assessing the influence of guard and primate delay on (a) amount of damage, and (b) number of individuals involved. Bold values indicate significance.

(a) Influence of guard and primate delay on damage sustained by baboons (B) and vervets (V).

	Predictor	Estimate	SE	t	P	Lower CI	Upper CI
B	Guard delay to raid	0.006	0.001	4.984	**<0.001**	0.004	0.009
	Primate delay to guard	0.004	0.002	1.982	0.051	0.00002	0.008
V	Guard delay to raid	0.001	0.0004	2.945	**0.002**	0.0005	0.002
	Primate delay to guard	0.006	0.005	1.209	0.166	-0.003	0.014

(b) Influence of guard and primate delay on number of individuals involved in raiding for baboons (B) and vervets (V).

	Predictor	Estimate	SE	t	P	Lower CI	Upper CI
B	Guard delay to raid	0.006	0.001	4.204	**<0.001**	0.003	0.009
	Primate delay to guard	0.005	0.002	2.397	**0.015**	0.001	0.010
V	Guard delay to raid	0.003	0.0004	7.082	**<0.001**	0.002	0.0005
	Primate delay to guard	0.007	0.004	1.745	**0.046**	0.0002	0.016

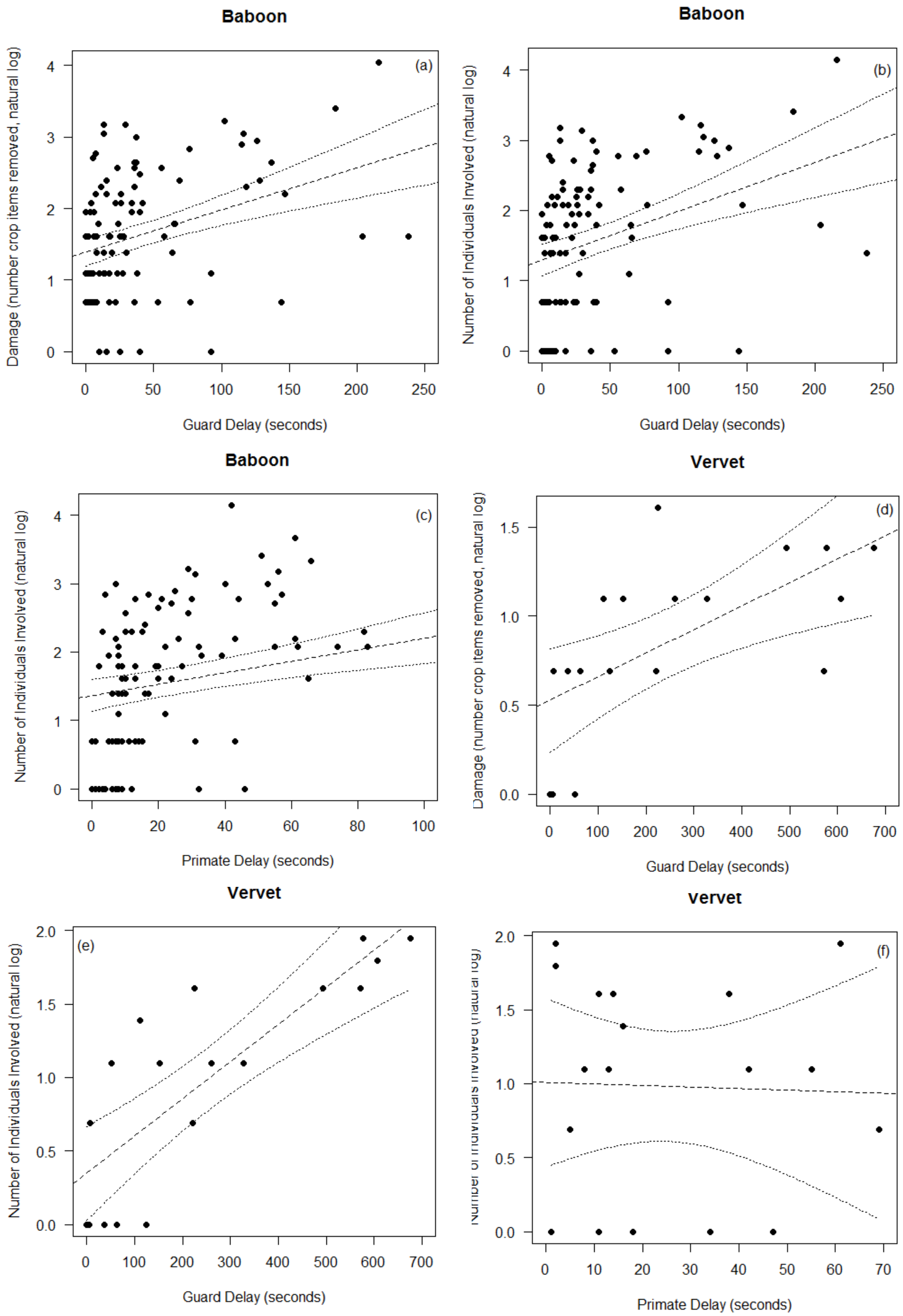


Figure 5.11: The relationship between (a) baboon damage and guard delay, (b) number of baboons involved in raiding and guard delay, (c) number of baboons raiding and primate delay, (d) vervet damage and guard delay, and the number of vervets involved in raiding and (e) guard delay and (f) primate delay, all using day as the sample unit. Dashed line shows the linear regression, dotted lines show the confidence intervals for the slope estimate.

5.4 Discussion

5.4.1 Baboons cause most crop damage

Baboons are habitually reported to cause more damage than other primates (Naughton-Treves 1997; Hill 1997, 2000; Kagoro-Rugunda 2004; Tweheyo et al. 2005; Webber 2006; Wallace 2010; Mackenzie & Ahabyona 2012). This is certainly true in the current study area, with baboons causing significantly more damage than vervets over the duration of the crop season. Chapter 4 reveals that baboons are perceived as the top crop damaging wildlife species in my study area – unsurprising since baboons are frequently reported as the worst primate crop raider, and primates are frequently reported as the most problematic wildlife crop raiders (Naughton-Treves et al. 1998; Tweheyo et al. 2005; Campbell-Smith et al. 2010; Wallace 2010). Primates, and baboons in particular, caused significant crop damage.

5.4.2 Best estimator of damage

Analysis shows that there is a significant increase in crop damage as all three parameters of raiding – frequency, duration and number of individuals involved – increase. However, number of individuals involved in raiding is clearly the best predictor of damage, accounting for over 96% and 79% of the variance for baboons and vervets respectively. The importance of the number of individuals in predicting the damage caused may relate to the definition used for damage – that is, the number of crop items removed; an item cannot be removed if there are no individuals to remove it. Such a high correlation does indicate however that most individuals that enter the field leave with an item, suggesting that taking into account the number of individuals involved in a raid is very important.

The number of individuals involved in raiding is, however, the most difficult parameter of crop raiding to measure. It is the most time-consuming measurement to obtain from video coding and, furthermore, where field guards are employed to watch for crop raiders they will not have the time to count the number of individuals involved in raiding when they are attempting to chase raiders away. Data collection from direct observations on the number of individual raiders is therefore unlikely to occur. Since duration of raiding correlates better with the number of individuals involved than frequency of raids, duration would be the next best estimate of damage if data collection on number of individuals is not possible. This is true of both baboons and vervets, which have different raiding styles, and therefore could be assumed to be true for other wildlife raiding species within the study area. Wallace (2010) found that the number of individuals raiding together with duration of raids best accounted for wildlife crop damage; if it was possible to obtain information on average raiding group sizes, duration of raiding multiplied by average group size could therefore provide a good proxy for crop damage.

5.4.3 Seasonal and daily patterns in primate crop raiding

5.4.3.1 Seasonal patterns

Although baboons cause more crop damage than vervets overall, this pattern is not constant throughout the season. During the first two months of behavioural observations (May and June) there were no significant differences between the species in extent of damage caused. It is only from July onwards that the two species start to show differences.

Baboon crop raiding increased as the NDVI value of the surrounding vegetation – used as a proxy for determining natural food availability (Willems et al. 2009) – decreased. NDVI values for dense vegetation generally range from 0.3 to 0.8, values lower than 0.3 indicate shrub and grassland, while less than 0.2 tend to denote bare soils (Earth Observatory 2000). While remaining fairly low over May and June, baboon damage starts to increase as NDVI approaches 0.3, and continues to do so for the rest of the crop season. The obvious change in raiding rate at this point – when there is very little outside the crop fields to consume – strongly suggests that natural food availability is the driving force behind increased baboon crop raiding. These results concur with many other studies on wildlife crop raiding that report crop damage by wildlife increases as natural food availability decreases (Naughton-Treves et al. 1998; Sekhar 1998; Kagoro-Rugunda 2004; Admassu 2007; Hockings et al. 2009; McLennan & Hill 2010; Strum 2010; Nyirenda et al. 2011; Pahad 2011).

Vervets do not follow the same pattern and generally show no significant change in raiding as natural food availability decreases. However, vervet damage does significantly decline with increasing baboon presence around the farm. As can be seen from Figure 5.2, vervet damage tends to increase over the first half of the season, but around mid-June damage starts to decline. This coincides exactly with the NDVI value at which baboon damage starts to increase. Furthermore, vervets were repeatedly seen leaving the farm in response to the arrival of baboons during behavioural observations. There is certainly literature describing predatory behaviour of baboons towards vervets (DeVore & Washburn 1963; Hausfater 1976; Altmann & Altmann 1970; Willems & Hill 2009), as well as vervets being spatially supplanted by baboons, especially in open habitats (Struhsaker 1967). It would therefore be logical for vervets to move away in response to the presence of baboons.

It is interesting that the amount of damage caused by vervets decreases in response to baboon presence, but their farm visit durations do not. This suggests that while vervets leave the crop field in response to baboon presence, they do not move away from the farm altogether. Instead they retreat to the farm edge where the bushveld provides cover and where they could continue to monitor their raiding opportunities. With the increase in the duration of baboon farm visits towards the end of the crop season however (throughout August baboons spent on average 71% of observation hours in farm visits), there may have been very few chances for vervets to raid, leading to the observed decrease in vervet damage.

The differences in distance travelled into farms between the two species may contribute to the effect that baboon raiding appears to have on vervet raiding. Vervets have been recorded to travel shorter distances into farms when raiding than baboons (Wallace 2010). The increase in baboon damage in the present study may have resulted in crops being depleted at the edge of the field, where most vervet raiding occurs. Furthermore, the field was harvested for the first time at the end of June; first harvests involve removing the larger mature butternuts and leaving the smaller ones on the plants to grow. Farmers are aware of the increased risk of crop damage by wildlife at the edges of fields and consequently harvest these areas first. These factors may have contributed towards the decline in vervet damage over the latter half of the crop season, when there was potentially less crop available in the area where vervets are comfortable travelling. Further analysis would be required to determine which of these factors – baboon presence, edge depletion or farmer harvesting – has the most influence on vervet crop raiding.

An alternative explanation for vervet raiding patterns could be that vervets raid earlier in the season when the butternut crop is smaller and less tough to eat. This was the rationale used by Wallace (2010) – vervets raided more frequently earlier in the season, before cobs of maize had fully matured and dried. Unripe butternut squash is certainly softer than mature squash, but when vervets were seen raiding later in the season during the present study, they had no trouble carrying off and biting into butternuts that were fully mature and almost as large as the vervets themselves. It would be interesting to find out how changing nutritional content of butternuts as they ripen might affect when vervets raid. However, such close timing between the onset of increased baboon damage and the reduction in vervet damage suggests that it is the presence of baboons, rather than the developmental stage of the crop, that affects vervet raiding.

Successful mitigation techniques that affect only baboons could therefore simply lead to an increase in vervet raiding. Vervets are often reported as a high crop damaging species (Sillero-Zubiri & Switzer 2001; Saj et al. 2001; Lee & Priston 2005), and were certainly criticised as crop raiders by many farmers in the study area (Chapter 6, section 6.3.1). Although baboons cause more crop damage than vervets in the study area, mitigation methods must nevertheless be directed towards vervets in addition to baboons.

5.4.3.2 Daily patterns

Baboons cause significantly more damage to crops in the morning than the afternoon, while the durations of their farm visits and raids do not differ between sessions. An increase in crop damage without a simultaneous increase in raid duration could be explained by a higher number of shorter raids involving a greater number of individuals occurring in the morning, resulting in more damage but similar total raid durations.

Both Priston (2005) and Wallace (2010) found primate raiding to be more frequent in the early morning and late afternoon. Within these two periods, Priston (2005) found primate raiding was more frequent in the mornings than afternoons, and suggested this was due to a need to find food on waking. Wallace (2010) however, found more raiding occured by primates between noon and sunset than between sunrise and noon. As a result of different studies finding different timing patterns for raiding by diurnal primates, Wallace (2010) suggests this indicates that the pattern of raiding over the hours of the day is tied to local factors. Baboons raiding the current study farm regularly use a sleeping site a few hundred metres from the crop fields; this could explain baboons causing more damage in the mornings – upon awakening they descend to the crops to feed without the need to travel any distance. Vervets do not follow the same daily pattern as baboons; there is no difference in vervet raiding between morning and afternoon sessions. This could suggest that vervet sleeping sites were further afield from the farm, unfortunately the location of vervet sleeping sites is unknown.

A higher frequency of raiding in the early mornings and late afternoons reflects the general circadian activity patterns for primates, where activity peaks early and late and reduces during the middle of the day (Altmann & Altmann 1970; Hill et al. 2004). Wallace (2010) suggests this indicates that primates merge crop raiding into their daily activity cycle instead of modifying their behaviour to raid crops. It would be interesting to further break down time of day and conduct additional analysis on data from this study site to reveal whether these primates also follow this pattern.

5.4.4 Farm visits

Baboons and vervets spent around 50% of the time that the farm was observed in farm visits, meaning that for almost half the daylight hours the farm is at risk of primate crop raiding. Although the time primates spend raiding crops is much less, there is a positive correlation between farm visit time and number of raids – the longer the farm visit continues the more raiding occurs. Furthermore, when primates raid, they are more likely to raid multiple times in a single farm visit rather than raiding just once. Preventing crop raiding may therefore be more effective if farmers attempted to deter farm visits, as well as crop raids.

Guarding methods currently involve chasing primates until they leave the immediate vicinity of the crop field, and then ceasing to chase. Despite the large difference in guard response rates to baboons compared with vervets, there is no difference between the species in whether they are involved in multiple- or single-raid visits. This suggests that as it is currently performed, chasing has no effect on whether primates return to the field to undertake subsequent raiding, and is therefore not increasing perceived risk of raiding to the primates. Increasing perceived risk of the guard to primate raiders may therefore decrease frequency of raiding through a reduction in subsequent raids.

When feeding on crops foraging efficiency is so much greater that baboons are able to sit and wait for hours for the opportunity to raid; guarding crops can therefore only be successful if guards use up all the baboons' extra time (Strum 1994). More persistent chasing – that moves primates away from the vicinity of the farm, rather than just the vicinity of the crop field – could further reduce raiding. However, with the nature of primate raiding, especially with baboons, this would likely require more than one person. Both the behavioural observations and reports from farmers (Chapter 4, section 4.2.2) documented many times, that when guards move to one side of the field to chase away raiding baboons, other individuals would take advantage of this and come in at the other side of the field. This raiding strategy is also reported many times in the literature (Maples et al. 1976; Sillero-Zubiri & Switzer 2001; Lee & Priston 2005; Warren 2008; Warren et al. 2010). If a guard was to move away from the crops in an attempt to chase primates away from the farm itself, then at least one other guard would need to stay on the farm to chase away those that would take advantage of an unprotected crop field. Furthermore, it would undoubtedly take more than one person to herd a large group of baboons. In all likelihood this would only work if again the perceived risk of chasing by the guard was increased.

Interestingly, almost half of observed farm visits did not involve any raiding at all. It is assumed that, given the risk of raiding, when primates enter a crop farm they do so to acquire food and for no other reason (Wallace 2010). However, farm visits do not pose the same risks as crop raids, and habitat surrounding the farm – given its location directly next to the river – may be favourable to primates for natural foraging as well as other activities and resources (such as sleeping sites).

When primates visit the farm, vervets are more likely to raid crops than baboons. Since guards chase baboons more often than vervets, this may reduce the proportion of baboon visits involving raids. However, as discussed above, chasing does not appear to increase primates' perceived risk of raiding and does not affect subsequent raiding. It is therefore unlikely that this is the cause for a higher proportion of baboon non-raid visits. Another, more likely, explanation is that baboon non-raid farm visits are easier to detect than vervet non-raid visits (baboons are vocal and highly visible at the farm edge whereas vervets are not), and therefore a higher number are recorded for baboons.

5.4.5 Efficiency of guarding could be improved

Within the context of this study, the term field guarding is used to describe the activity of guarding fields from wildlife and chasing away individuals that attempt to forage within the crops. In the study area, this activity is carried out by farm employees, occurring seven days a week from dawn until dusk. Field guards spend the daylight hours at small camps directly next to planted fields, and often care for more than one field at a time. When animals are not present, guards will often carry out activities at the camp such as cooking, washing and gardening. Patrols of the fields are not implemented.

The difference in the proportions of raids responded to by guards between the two primate species is substantial (81.7% for baboons and 15.5% for vervets). Since guard response is relatively high for baboons, the low response rate to vervet raids is unlikely to be through guard negligence. Instead, vervet raids may go unnoticed due to their small body size and behaviour. Baboons – larger in body size, raiding in higher numbers and more vocal – are much easier to spot whilst raiding. It is not surprising then, especially with more than one field to attend, that guards do not even notice the vast majority of vervet raids, despite this species also being a diurnal raider. For this reason, a deterrent method that involved an early warning system alerting guards to vervet raiding would likely reduce damage by increasing guard response rates to vervets.

Raids that guards responded to had higher crop damage and more individuals involved than raids to which guards did not respond, suggesting that guards are more likely to chase raids that involve more individuals. This is true of other studies, where farmers are more likely to detect raids involving relatively larger groups (Wallace 2010).

Guards are more likely to respond to crop raids in the morning than the afternoon, which could possibly be due to guard fatigue by the afternoon session. Guards are employed from sunrise (as early as 6am) to sunset (as late as 6.30pm) and remain at the fields all day. With such long shifts it is not surprising that more raids are chased earlier on in the day than later, as it has been shown that performance reduces with longer working hours (Spurgeon et al. 1997). This could be prevented by employing two guards for half day shifts, rather than one for the whole day.

Guard delay (that is, the time between the start of a raid and the start of chasing by the guard) has a significant effect on raiding of both primate species – as the guard delay decreases so too does damage caused and the number of individuals involved in raiding. These results imply that guarding is an efficient strategy at reducing crop raiding damage by primates. However, they also imply that guarding could be improved – if guards responded immediately to every primate raid, damage could be significantly reduced. Under current circumstances, where a guard has more than one field to protect, guard delays towards baboons could probably not be improved a great deal. However, average guard delay increases from 42 seconds for baboons to 4 minutes 12 seconds for vervets, providing further evidence (along with such a low guard response to vervets) that detecting vervet raids is difficult for guards. A mitigation technique that alerted the guard to the presence of vervet raiding could significantly decrease this reaction time and increase the number of raids responded to by guards, thereby reducing damage caused by vervets.

A reduction in primate delay (that is, the time between the onset of chasing and the end of the raid) has little effect on the amount of damage caused by vervets. This is probably because vervets generally respond immediately to the onset of chasing by guards (the longest delay between onset of chasing and termination of vervet raiding was little over a minute). Baboons on the other hand, were observed spending more than a further six minutes in crops after chasing began. This suggests that baboons are less fearful of guards and the risks of being chased. This delay in baboon reaction could certainly be reduced, by increasing their perception of fear towards the guards. Guards with weapons are perceived as more of a threat than guards without (King & Lee 1987; Strum 1994; Hill 1997; Strum 2010), therefore providing guards with some sort of 'scaring device' could improve their efficiency at protecting crops from baboons.

5.4.6 Conflict management implications

Baboons are the top crop damaging species in this area, and certainly warrant time, labour and money put into efforts to deter them from crop fields. The estimates of economic loss due to primate raiding are likely to be conservative given that all damaged crop items are not necessarily removed from the field. For primates, this suggests that any deterrent costing up to (at least) ZAR14,219-16,250 (£894-1022) per crop season would be worth investing in for this crop field alone. See Chapter 7 for further estimates on damage costs across the farm.

Deterrent techniques that cost more themselves than what they save in crop damages are not worth implementing, but if damages are higher than perceived by farmers it is worth spending more on superior deterrent methods. It is important then for farmers to have a method which they can easily use to estimate crop losses to wildlife. Raid durations combined with average number of individuals raiding appear to present a good estimate for damage, if actual number of individuals raiding is not available.

Possessing knowledge of wildlife crop raiding behaviour – such as knowing there is a higher occurrence of baboon damage in the morning and the percentage of guard responses decreases in the afternoon – can help farmers better target their mitigation. For example, farmers using field guards to protect crops could be encouraged to use extra guards during morning sessions, while removing them again in the afternoon, and replacing guards in the afternoon with a fresh member of staff. This would increase mitigation efficiency when needed, without wasting labour time when not. However, observations would need to continue to enable monitoring of whether primates change their raiding patterns in response to this change in focus of mitigation. Such knowledge also allows recommendations to be developed, such as increasing the perceived risk of guarding, attempting to herd primates away from the farm instead of just crop fields and implementing an early warning system that alerts guards to more inconspicuous raiders, such as vervets.

Finally, the results here suggest that there may well be unexpected consequences of implementing effective deterrent methods, and these should be considered. For example, successfully deterring baboon crop raiding could lead to a subsequent increase in vervet crop raiding – if this has not been considered, such deterrents – although being effective against baboons – may not be effective in reducing crop damage.

CHAPTER 6: CROP RAIDING SPECIES

6.1 Introduction

Across the globe a huge range of animals raid agricultural crops. Invertebrates of course belong within the animal kingdom, and cause such huge amounts of damage that, when compared, vertebrate damage becomes insignificant; estimates suggest that without invertebrate damage world food production could be increased by about a third – this estimate represents losses despite the current use of pesticides and control methods (Emden 1991).

However, as discussed in Chapter 4, section 4.2.2, invertebrate pests are generally not included when discussing 'wildlife crop raiding'. Among vertebrates, rodents are by far the greatest agricultural pest, causing significant amounts of damage (Makundi et al. 1999; Stenseth et al. 2003). It is larger mammals however, that are often selected for attention as pests by the people involved (Knight 2001). Highly visible species, such as elephants and primates, can give the impression of causing greater damage than more inconspicuous species (Siex & Struhsaker 1999; Linkie et al. 2007; Nahallage et al. 2008), especially those that cause highly visible damage. Large species are also more difficult to deal with and can be aggressive (De Boer & Baquete 1998; Hill 2005), which influences perceptions and intensifies negative feelings towards them (as discussed in Chapter 3, section 3.3.2). Diurnal species also receive more blame than nocturnal species, again due to visibility (Sekhar 1998), while species that damage staple crops come off worse in farmers' perceptions compared with those that forage on non-staple crops (Linkie et al. 2007). As a result, certain species often receive most blame for crop damage, while others go unnoticed (Hill 1997; Siex & Struhsaker 1999; Linkie et al. 2007; Riley 2007). In this chapter I will investigate commercial crop farmers' perceptions of crop raiding species within my study area, to determine which species are believed to cause the highest amounts of crop damage.

When attempting to mitigate against crop losses it is essential to know which species are actually responsible for damage, rather than relying on farmers' perceptions. For example, in Sumatra, farmers describe wild boar (*Sus scrofa*) as the worst crop pest when in fact pigtailed macaques (*Macaca nemestrina*) cause more damage (Linkie et al. 2007). As a consequence, there is little point in spending money on fencing crops to exclude pigs, if primates are the real problem. Similarly, in Kibber Wildlife Sanctuary, India, wolves (*Canis lupus*) are perceived negatively and are heavily persecuted for livestock depredation, but most livestock kills are actually made by the snow leopard (*Uncia uncia*); there have been no elimination attempts on the latter species (Mishra 1997). This results in a negative situation for both the people and wolves since people are spending time and effort attempting to reduce their losses, which will not occur since they are persecuting the wrong species. Wolves are being eliminated despite not actually being the problem animal (Mishra 1997). As such, I will use camera trap data to determine the frequency and duration of crop raiding by a number of wildlife species in the study area.

Whilst determining the species responsible for crop damage is important for correctly directing mitigation, it is also important to understand the reasons why certain species are blamed in order to effectively address farmer concerns. However, the reasons for inconsistencies between actual and perceived crop damagers are not always clear and can be influenced by a number of factors.

The frequency with which animals visit crops has been demonstrated to affect farmer perceptions, with tolerance towards animals decreasing as the frequency of raiding increases (Wallace 2010). For example, baboons are labelled a pest in Uganda because they are considered to come very frequently (Hill 1997, 2000). Similarly the duration of time which animals spend within crops could also influence farmer perceptions. The size of a species' social group can affect perceptions of the species and both baboons and pigs are considered pests in Uganda because they come in large numbers (Hill 1997). The presence of large groups increases perceptions of risk to crops (Lee & Priston 2005) and can be more difficult to control. Large group sizes can also cause farmers to overestimate the crop damage they cause (Nahallage et al. 2008), as well as give the impression that the species is proliferating (Knight 1999). Farmers in the study area believe the local baboon population has large group sizes, adding to their negative perceptions of baboons (Chapter 3, section 3.3.2).

The frequency with which farmer on-farm activity overlaps with crop raiding activity may also affect farmer perceptions. Coefficients of overlap (Ridout & Linkie 2009) measure the similarity between two activity patterns and have been used to make comparisons of activity between, for example, predator and prey (Weckel et al. 2006) and the males and females of a species (Di Bitetti et al. 2006). This technique allows insights into the temporal interactions between two species or groups of animals (Linkie & Ridout 2011). Species that are more visible often receive a higher proportion of blame for crop raiding that those that are more inconspicuous (Hill 2004). Measuring overlap between farmer activity and species patterns within crop fields may therefore provide insight into farmer perceptions of crop raiding species.

I will attempt to explain farmer perceptions of which species cause most damage, using information on the species' frequency and duration of crop visits, average group size of the species, and the amount of overlap there is between farmer activity on the farm and species activity within the crop fields. This chapter therefore utilises both biological and social data to determine which species are actually involved in crop raiding, which species are blamed and why, and provide insights into what can be done to mitigate the conflict between commercial crop farmers and raiding wildlife.

6.2 Methods

6.2.1 Crop farmer interviews

During semi-structured interviews (see Chapter 2, section 2.2.1.1), 15 [6] commercial crop farmers were asked to list all species that damage their crops, and to rank these species in order of which cause most crop damage (see Figure 2.3, Chapter 2, section 2.2 for interview locations). Farmers were asked to free-list, and were not prompted with a pre-listed set of species or other farmers' perceptions. The only exception was for primates; if farmers did not mention either baboons or vervet monkeys, they were subsequently asked if either of these primates cause crop damage and where they ranked amongst the list already given. Farmers were able to list as many or as few species as they liked.

A rank of one indicates the species is perceived to cause the highest amount of crop damage. Farmers often graded two or more species with the same rank, indicating they believe these species to cause equal amounts of damage. In such cases, the same rank was given to the two species and the next animal listed was given the next rank in line with how many species (and not ranks) had been named. For example, if warthog and bushpig were both given a rank of two, the next species received a rank of four.

A relative rank was assigned to each species to account for the differing numbers of crop raiders mentioned between farmers. This was done using the equation:

$$\text{Relative Rank} = \frac{\sum \left(\frac{1}{L} \times (\text{rank} - 1) \right)}{N}$$

L = number of species listed by individual farmer

rank = rank assigned to species

N = number of farmers (i.e. 15)

[6] One of the 16 farmers interviewed could not provide a ranked list of crop raiding species.

Whenever a species was not ranked as a crop raider in an interview, the value inside the square bracket was set at 1.00 for that farmer. This enables instances when species were not mentioned to be accounted for; if not taken into account, a species that was listed as the top raider by only one farmer would rank very highly, despite not being labelled as a crop raider by 14 other farmers. Subtracting one from the rank allows 1.00 to be set for species that were not mentioned. If one was not subtracted the lowest ranking species would also receive a value of 1.00. A lower relative rank indicates the species is perceived to cause a higher amount of crop damage. Ranks were assigned to each species based on these relative ranks (the lowest relative rank receiving a rank of 1 and so on).

To test whether there is a relationship between relative rank and the number of ranks a species was assigned I calculated the Pearson product-moment correlation. To test for a relationship between the number of ranks assigned to a species and the number of times it was mentioned by farmers I used simple linear regression.

6.2.2 Camera trap surveys

To determine which species raid crops, I use data from the camera trap surveys on three farms (B, C and I). See Chapter 2, section 2.2.2.2 for the locations and methods for using camera traps.

6.2.3 Comparing and explaining farmer perceptions using camera trap data

Linear regressions were used to explore the relationships between relative ranks and frequency of visits, total duration of visits, species group size, frequency multiplied by group size, duration multiplied by group size, frequency multiplied by group size and overlap, and finally duration multiplied by group size and overlap (see Chapter 2, section 2.2.2.2 for data collection methods on each parameter). Overlap between farmer activity and each species' activity within crop fields were calculated from camera trap data using coefficients of overlap, using the 'overlap' package (Meredith & Ridout 2014) in R (R Core Team 2014). $\Delta 1$ was used for small sample sizes and $\Delta 4$ for large sample sizes (Ridout & Linkie 2009). Correlations included only species which farmers cited as crop raiders.

Chapter 5, section 5.4.2 suggests that in the absence of direct behavioural observations, the relative amount of crop damage a species causes can be estimated by multiplying the average group size of the species with its duration of raiding. I therefore used the linear regression of average group size multiplied by duration of raiding to examine the relationship between this proxy of damage and relative farmer ranks. Examination of confidence intervals around the relationship enabled species which were significantly over- or underestimated by farmers to be identified.

6.3 Results

6.3.1 Perceptions of crop raiding species

Farmers' perceptions of crop damage caused by wildlife vary across the sample of 15 farmers (Table 6.1 and 6.2). 19 species are listed as crop raiders; seven of these are ranked as the top crop raiding species by at least one farmer, while six are cited by only one farmer. The number of problem animals mentioned by each farmer varied, ranging from two to 12.

Table 6.1: Ranks assigned to crop raiding species by 15 crop farmers. Equals sign illustrates where more than one species was given the same rank.

Farm	**B**	**B**	**B**	**B**	**C**	**D**	**F**	**G**	**H**	**I**	**A**	**J**	**K**	**L**	**M**
Farmer	**F01**	**F02**	**F03**	**F04**	**F05**	**F06**	**F07**	**F08**	**F09**	**F10**	**F11**	**F12**	**F13**	**F14**	**F15**
Baboon	3	1	1	1	1	1	1	1	1=	1	1	1=	3	1=	3
Warthog	1=	3=	2=	2=	3=	5	3	3	1=	-	4	7	4	1=	-
Bushpig	1=	3=	2=	2=	3=	4	4	2	-	4	6	5=	-	-	2
Vervet	8	2	5	5	2	2	6	9	1=	3	3	3	-	-	-
Porcupine	4	5	6=	4	-	3	-	4	-	5	5	-	2	-	1
Bushbuck	5	8=	4	6=	-	-	-	-	-	-	2	1=	-	-	-
Common duiker	-	8=	6=	6=	5=	-	5	5	-	-	-	5=	-	-	-
Helmeted guineafowl	6	-	-	-	-	-	2	-	4	2	-	-	-	-	-
Steenbok	-	8=	8	6=	5=	-	-	-	-	-	-	4	-	-	-
Rats and mice	7	7	-	-	7=	-	-	8	-	-	-	8	-	-	-
Scrub Hare	-	-	-	-	-	-	-	6	-	-	-	-	1	-	-
African civet	9	6	-	-	-	-	-	-	-	-	-	-	-	-	-
Birds	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
Black-backed jackal	10	-	-	-	-	-	-	7	-	-	-	-	-	-	-
Impala	-	-	-	-	-	-	7=	-	-	-	-	-	-	-	-
Banded mongoose	-	-	-	-	7=	-	-	-	-	-	-	-	-	-	-
Kudu	-	-	-	-	-	-	7=	-	-	-	-	-	-	-	-
Francolin	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Waterbuck	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-
No. species cited	12	10	8	8	8	5	8	9	4	5	6	8	4	2	4

Table 6.2: The number of times each species received each rank. Table also shows species relative rank, its rank based on the relative rank, the number of times it was cited as a crop raider, the number of ranks it received (including not being mentioned as a raider = N), and the range of ranks.

Species	Rank													Relative Rank	Rank	Number of times cited	Number of ranks assigned	Range of Ranks
	1	2	3	4	5	6	7	8	9	10	11	12	N					
Baboon	12	0	3	0	0	0	0	0	0	0	0	0	0	0.078	1	15	2	1-3
Warthog	3	2	4	2	1	0	1	0	0	0	0	0	2	0.398	2	13	7	1-7
Bushpig	1	4	2	3	1	1	0	0	0	0	0	0	3	0.465	3	12	7	1-6
Vervet	1	3	3	0	2	1	0	1	1	0	0	0	3	0.500	4	12	8	1-9
Porcupine	1	1	1	3	3	1	0	0	0	0	0	0	5	0.607	5	10	7	1-6
Bushbuck	1	1	0	1	1	1	0	1	0	0	0	0	9	0.747	6	6	7	1-8
Common duiker	0	0	0	0	4	2	0	1	0	0	0	0	8	0.793	7	7	4	5-8
Helmeted guineafowl	0	2	0	1	0	1	0	0	0	0	0	0	11	0.833	8	4	4	2-4
Steenbok	0	0	0	1	1	1	0	2	0	0	0	0	10	0.872	9	5	5	4-8
Rats and mice	0	0	0	0	0	0	3	2	0	0	0	0	10	0.900	10	5	3	7-8
Scrub Hare	1	0	0	0	0	1	0	0	0	0	0	0	13	0.904	11	2	3	1-6
African civet	0	0	0	0	0	1	0	0	1	0	0	0	13	0.944	12	2	3	6-9
Black-backed jackal	0	0	0	0	0	0	1	0	0	1	0	0	13	0.961	13	2	3	7-10
"Birds"	0	0	0	1	0	0	0	0	0	0	0	0	14	0.983	14=	1	2	4
Impala	0	0	0	0	0	0	1	0	0	0	0	0	14	0.983	14=	1	2	7
Banded mongoose	0	0	0	0	0	0	1	0	0	0	0	0	14	0.983	14=	1	2	7
Kudu	0	0	0	0	0	0	1	0	0	0	0	0	14	0.983	14=	1	2	7
Francolin	0	0	0	0	0	0	0	0	0	0	1	0	14	0.989	18	1	2	11
Waterbuck	0	0	0	0	0	0	0	0	0	0	0	1	14	0.994	19	1	2	12

Baboons are consistently perceived as the worst crop raiders; 80% of farmers state that baboons cause more crop damage than any other wildlife. They were listed as a raider by every crop farmer interviewed and were never given a rank outside the top three. For other species, those that were mentioned by more than one farmer often received considerable variation in assigned ranks, demonstrating the lack of agreement between farmers on the degree to which other species pose crop raiding problems. Relative ranks show a significant negative correlation with number of ranks assigned to a species (Pearson's product-moment correlation: r = -0.533, P = 0.019), indicating that species perceived as more important raiders have less agreement among farmers on exactly how much damage they cause in relation to other species. Baboons are the obvious outlier, being consistently ranked an important raider (Figure 6.1).

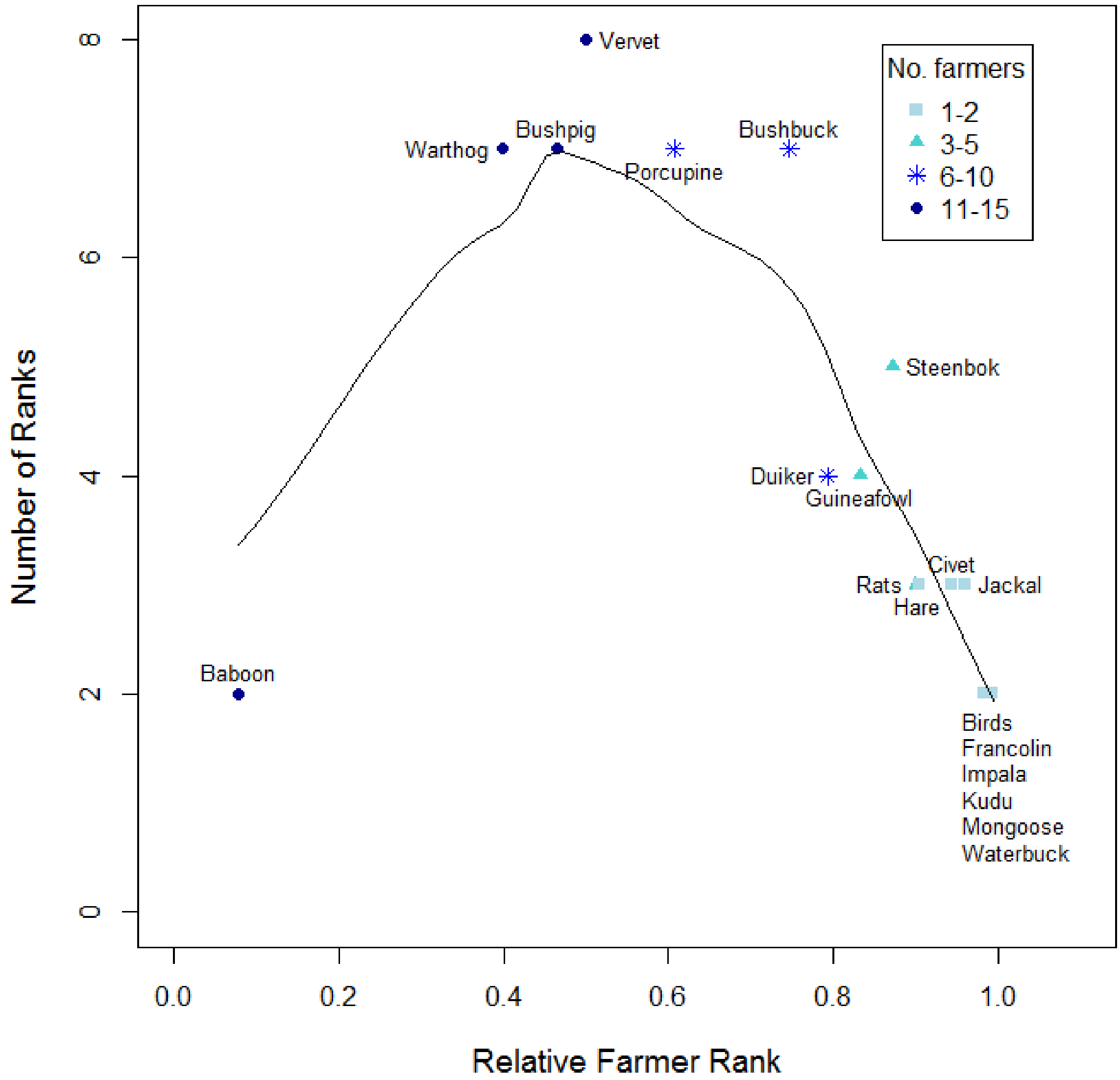


Figure 6.1: The number of ranks assigned to each species plotted against relative farmer ranks; symbols show the number of farmers that cited the species. Curved line shows the general pattern, plotted using scatter.smooth in R.

The number of farmers citing a species significantly correlates with the number of ranks it receives (estimate±SE: 2.440±0.196, t = 12.46, P = <0.001). Baboons are again an outlier, being cited by all 15 farmers but receiving only two ranks. Among other species, those that receive fewer ranks are perceived as the least important raiders because most farmers agree on their status as non-raiders, with only a minority labelling them crop raiders. Those that are commonly mentioned by farmers are given many different ranks, indicating large variation among farmers in perceptions of crop raiders (Figure 6.2).

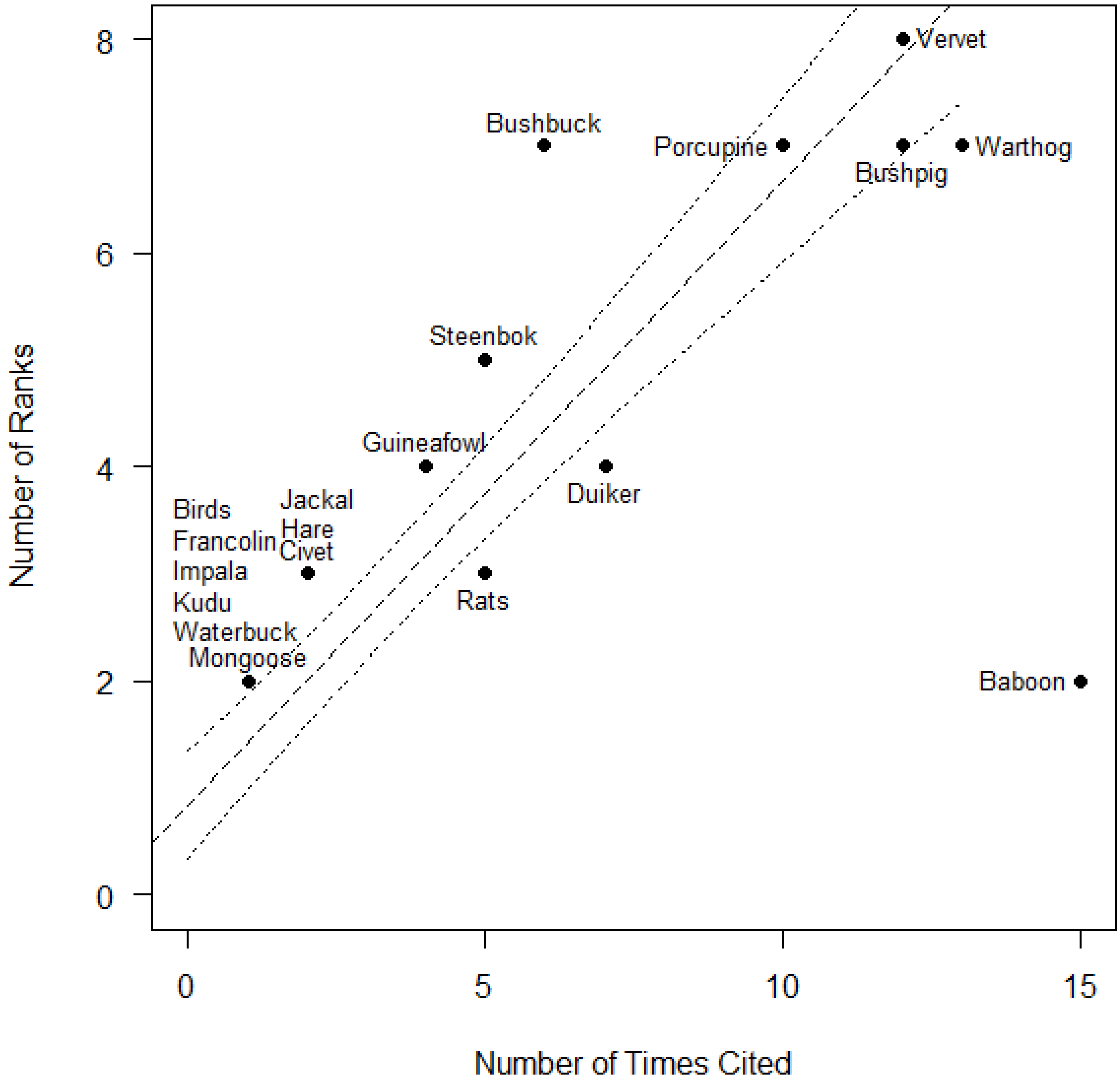


Figure 6.2: Number of farmers that cited the species against the number of ranks assigned to each species. Dashed line shows the linear regression with baboons removed as an outlier, dotted lines show the confidence intervals for the slope estimate.

Variation in farmer ranks is also seen within the same farm (Table 6.1). One study farm is owned by a family in which four farmers play an active and daily role on the farm. Between the four farmers, 14 species are labelled as crop raiders, with lists ranging from eight to 12 species. Only six of these species are mentioned by all four farmers, while four are mentioned by only one farmer. Despite variation amongst other species, baboons are again most often cited as the top raider, with only one farmer assigning the top rank to a different species (jointly between warthog and bushpig).

6.3.2 Camera detection of crop raiding species

Across all farms, a total of 1,947 field visits involving 24 animal species were captured on camera traps, amounting to 264 hours 12 minutes that wildlife spent within the crops surveyed (Table 6.3) from a total of 12,552 camera trap observation hours. Bushbuck visited considerably more often and with greater duration than any other species (Figure 6.3).

Table 6.3: Number of field visits and average duration of visits per seven days for each species in each survey crop field and the average for all fields. Red boxes highlight the most frequent or longest crop visitor for each field. Species in grey are those previously established as non-crop damaging visitors.

	Number of Field Visits per 7 days				Average Duration in Visits per 7 Days (hrs)			
Species	**AS09**	**LA16A**	**SH14-13**	**All**	**AS09**	**LA16A**	**SH14-13**	**All**
Bushbuck	0	21.10	0	8.31	0	03:12	0	01:15
Baboon	0	6.12	1.76	3.13	0	01:25	00:25	00:43
Vervet	0	5.00	2.12	2.84	0	00:45	00:32	00:31
Helmeted guineafowl	1.51	0.34	4.07	2.10	00:18	00:01	00:27	00:15
Warthog	0	0.37	3.81	1.71	0	<1min	00:44	00:18
Common duiker	3.02	0.03	1.92	1.39	00:05	<1min	00:13	00:06
Porcupine	0.69	2.00	1.11	1.38	00:03	00:07	00:02	00:04
Francolin	2.13	2.41	0.03	1.38	00:15	00:04	<1min	00:04
Black-backed jackal	0.07	0.03	1.86	0.79	<1min	<1min	00:05	00:02
Scrub Hare	2.88	0	0.36	0.71	00:11	0	00:01	00:02
African wild cat	0.14	1.22	0.36	0.66	<1min	00:02	<1min	00:01
Bushpig	0	0.10	1.01	0.46	0	<1min	<1min	<1min
African civet	0.48	0.14	0.33	0.28	<1min	<1min	<1min	<1min
Banded mongoose	0.07	0.37	0.29	0.28	<1min	<1min	<1min	<1min
Small-spotted genet	0	0.48	0	0.19	0	<1min	0	<1min
Waterbuck	0	0.37	0	0.15	0	00:07	0	00:02
Egyptian Goose	0	0	0.16	0.07	0	0	<1min	<1min
Slender mongoose	0	0	0.13	0.05	0	0	<1min	<1min
Steenbok	0	0.10	0	0.04	0	<1min	0	<1min
Aardvark	0	0.10	0	0.04	0	<1min	0	<1min
Kori Bustard	0	0	0.10	0.04	0	0	<1min	<1min
Bat-eared fox	0	0	0.10	0.04	0	0	<1min	<1min
Abdim's Stork	0	0	0.03	0.01	0	0	<1min	<1min
Honey badger	0	0.03	0	0.01	0	<1min	0	<1min

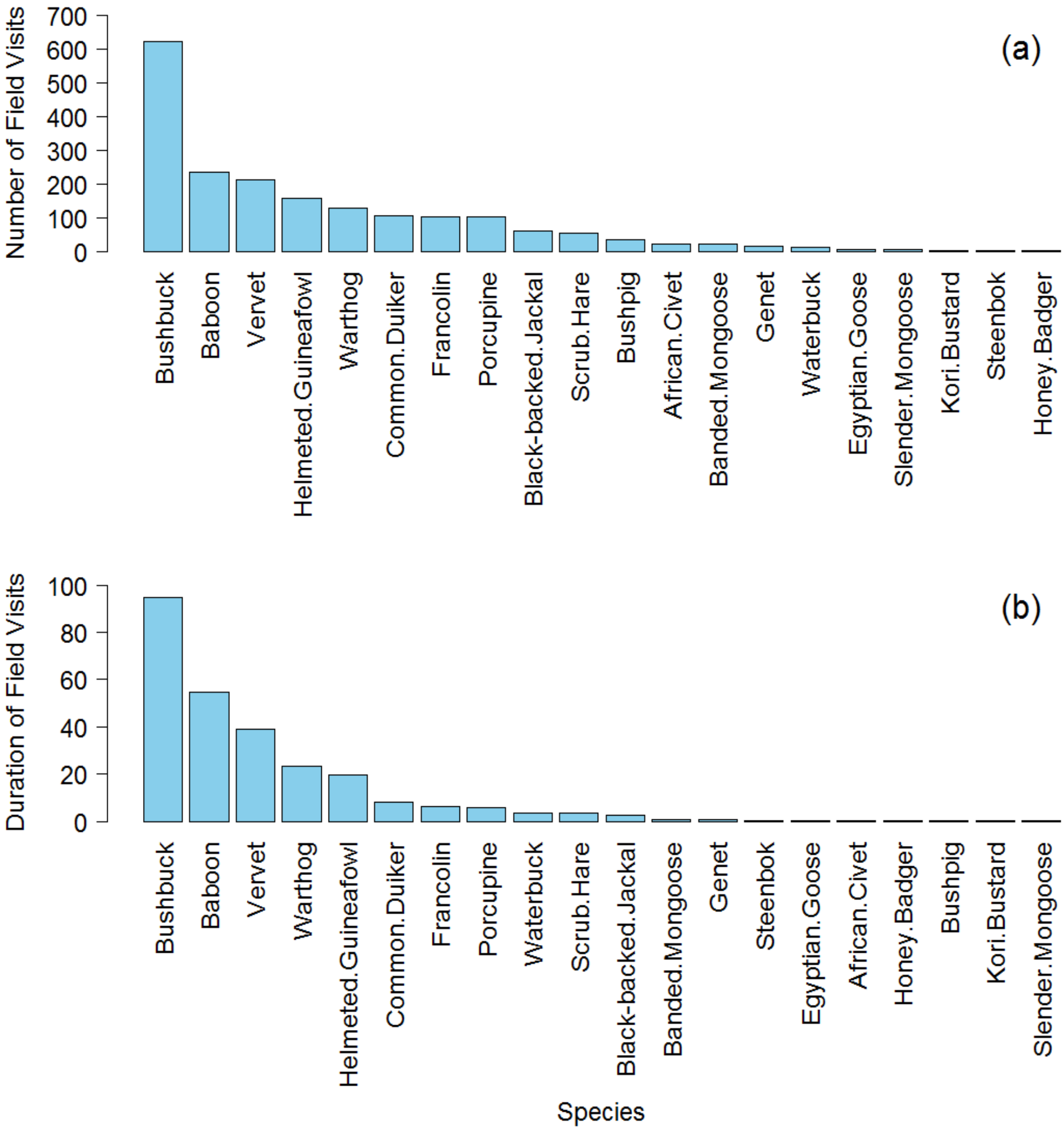


Figure 6.3: (a) Total number of field visits and (b) total duration (hours) of field visits caught on camera traps across all farms for each species.

There is no correlation between farms in frequency of crop visits (Pearson's product-moment correlation: AS09, LA16A $r = -0.15$, $n = 20$, $P = 0.52$; AS09, SH14-13 $r = 0.16$, $n = 20$, $P = 0.51$; LA16A, SH14-13 $r = -0.09$, $n = 20$, $P = 0.71$) or duration of crop visits (Pearson's product-moment correlation: AS09, LA16A $r = -0.17$, $n = 20$, $P = 0.48$; AS09, SH14-13 $r = 0.13$, $n = 20$, $P = 0.59$; LA16A, SH14-13 $r = 0.09$, $n = 20$, $P = 0.71$), suggesting that crop raiding by different species is variable between farms (Figure 6.4). Bushbuck, which visit more often than any other species, are actually only seen on one of the farms, while baboons and vervets only appear on two farms. Despite other species visiting all three farms, these three species remain the overall top visitors in terms of frequency and duration.

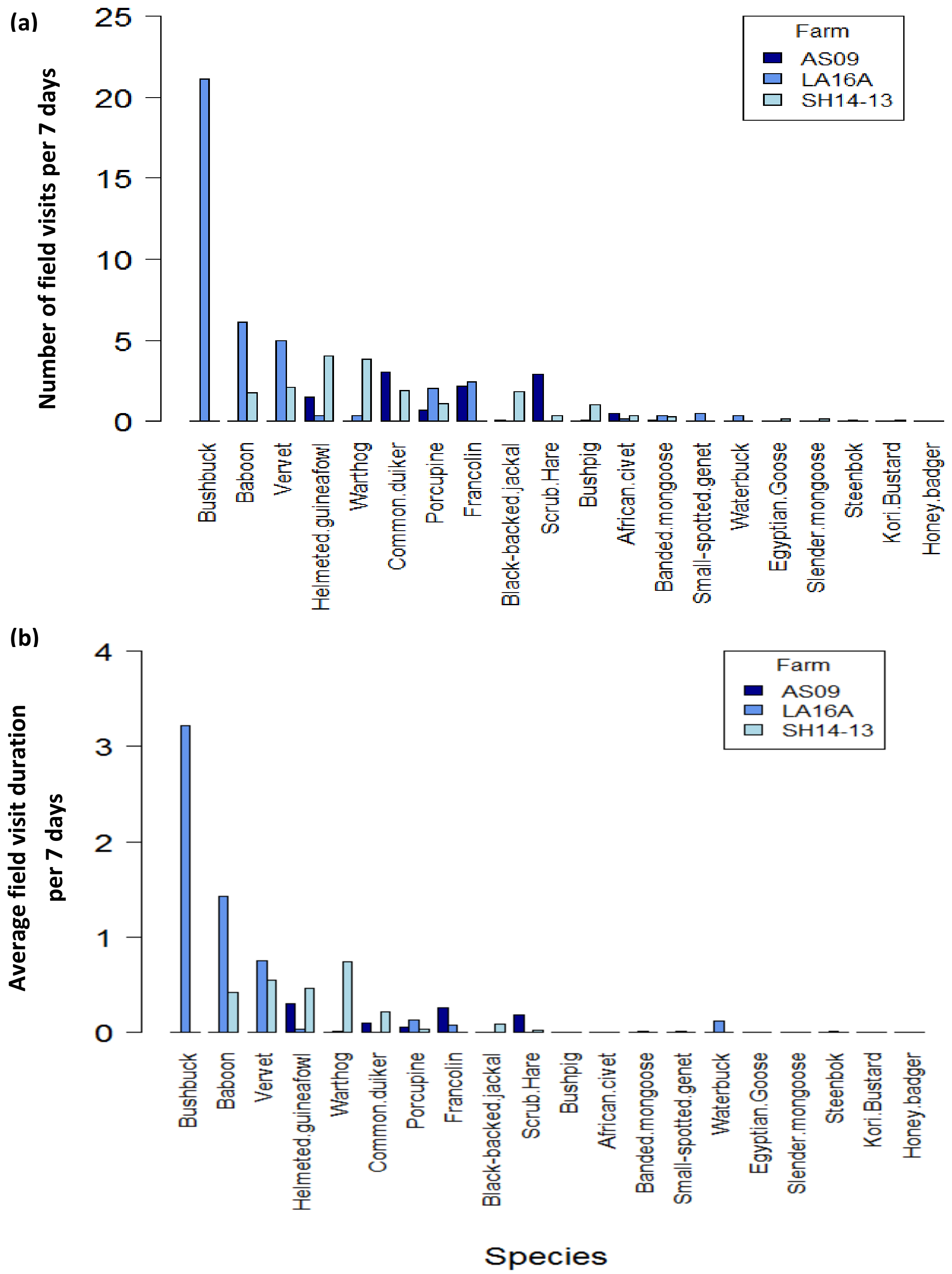


Figure 6.4: (a) Number of visits and (b) average duration of visits per 7 days for each species between the three farms surveyed. Where no bars are visible species were not recorded visiting the farm in question.

Table 6.4 displays information gathered from camera trap data that is used in the following section in attempting to explain farmer perceptions.

Table 6.4: Species information obtained from camera trap data.

Species	Number of visits	Total duration of visits (hr)	Average group size	Coefficient of Overlap[1]
Baboon	234	54.726	7.01	0.760
Vervet	212	38.846	2.12	0.842
Warthog	128	23.069	1.58	0.472
Bushpig	34	0.113	1.18	0.203
Porcupine	103	5.663	1.02	0.140
Scrub hare	53	3.444	1.02	0.199
Waterbuck	11	3.559	1.00	0.046
Bushbuck	621	94.571	1.14	0.158
Common duiker	104	8.158	1.07	0.213
Steenbok	3	0.418	1.00	0.168
Impala	0	0	10.50	0
Kudu	0	0	10.00	0
Helmeted guineafowl	157	19.640	6.01	0.399
Francolin	103	6.104	2.26	0.406
African civet	21	0.140	1.00	0.126
Black-backed jackal	59	2.758	1.11	0.204
Banded mongoose	21	0.531	6.14	0.622

[1] Overlap between farmer and species farm activity. Density plots displaying overlaps are provided in Appendix 10.

6.3.3 Comparing and explaining farmer perceptions using camera trap data

Neither frequency of visits nor group size show a significant correlation with farmer ranks (linear regression: frequency – estimate±SE: -0.0007±0.0004, t = -1.540, P = 0.144; group size – estimate±SE: 0.005±0.021, t = 0.259, P = 0.799). Duration of visits does however significantly correlate with farmer ranks (estimate±SE: -0.005±0.002, t = -2.218, P = 0.042, Figure 6.5). This suggests that farmers perceptions are influenced by the duration species spend in crop fields, but not the frequency with which they visit or the number of individuals that visit.

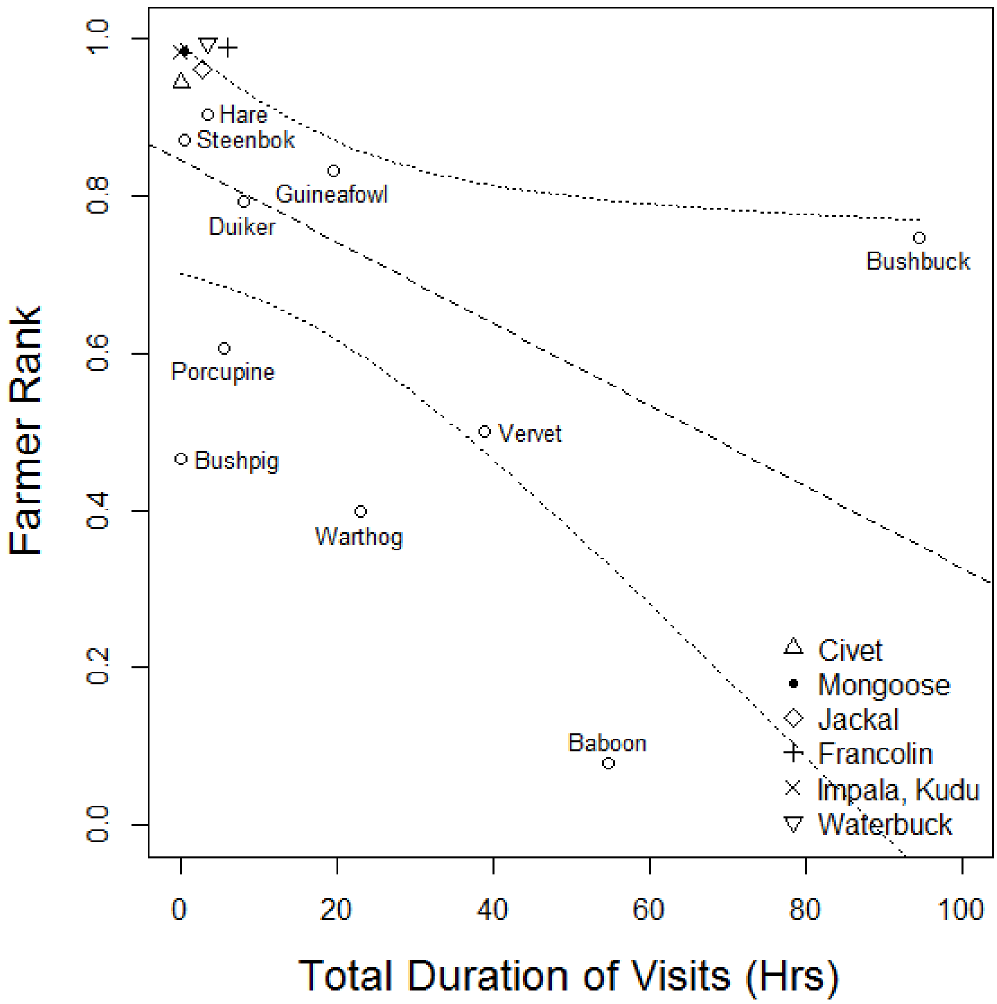


Figure 6.5: Relative farmer ranks against total duration of crop visits. Dashed line shows the linear regression and dotted lines display confidence intervals.

When combined with species group size both frequency and duration of crop visits significantly correlate with farmer rank (linear regression: frequency – estimate±SE: -0.0004±0.0001, t = -3.181, P = 0.006, Figure 6.6a; duration – estimate±SE: -0.002±0.0005, t = -3.863, P = 0.002, Figure 6.6b).

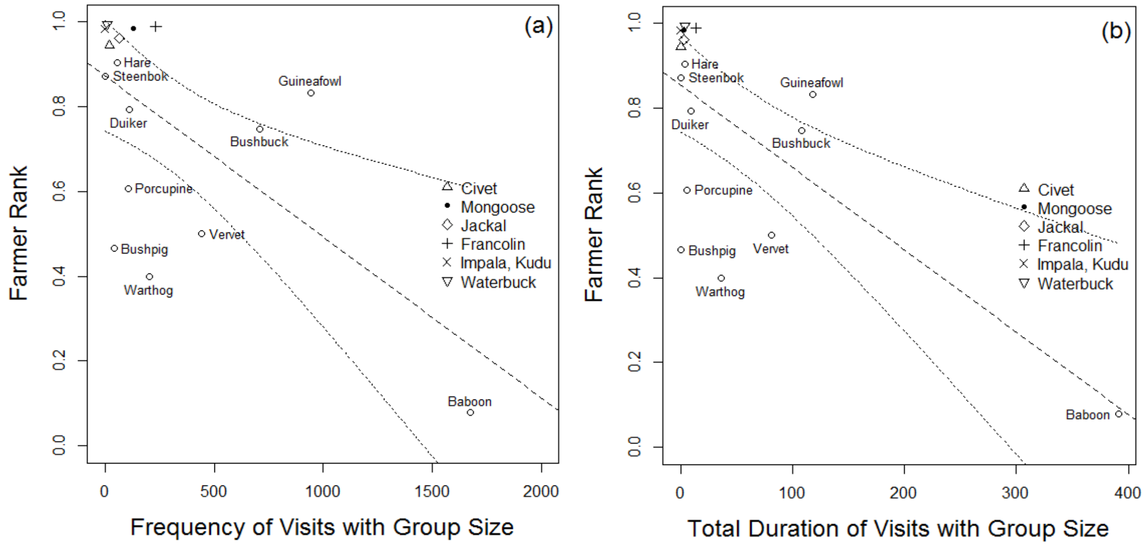


Figure 6.6: Relative farmer ranks against (a) frequency of crop visits and (b) total duration of crop visits when average species group size is taken into account in both instances. Dashed lines show the linear regression and dotted lines display confidence intervals.

Given the results from Chapter 5, section 5.4.2, average species group size multiplied by duration of raiding could be used as a proxy for the amount of damage caused by each raiding species. When using this measurement as a proxy for damage, it appears that farmers are fairly accurate in estimating which species cause most damage. There are however instances when farmers clearly over- or underestimate how much damage a species causes. Warthog, bushpig and porcupine appear to be overestimated in farmer perceptions of how much damage they cause, whilst bushbuck, guineafowl and baboons appear to be underestimated (Figure 6.7).

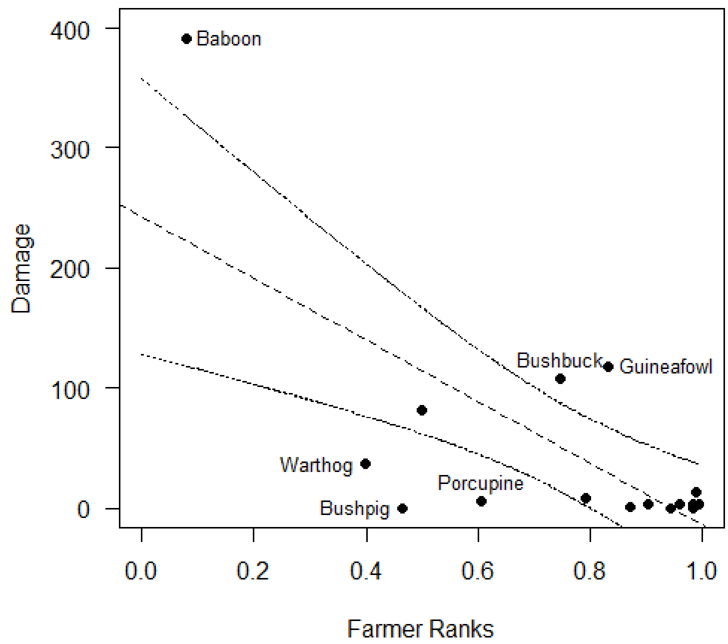


Figure 6.7: Relative farmer rank against damage estimate for each species. Dashed line shows linear regression model while dotted lines show confidence intervals. Species falling outside confidence intervals are interpreted as being under- (above CIs) or overestimated (below CIs) by farmers.

When combined with group size and overlap of farmer activity, both frequency and duration again correlate significantly with farmer rank (linear regression: frequency – estimate±SE: -0.0006±0.0002, t = -3.862, P = 0.002, Figure 6.8a, duration – estimate±SE: -0.003±0.0007, t = -4.091, P = <0.001, Figure 6.8b).

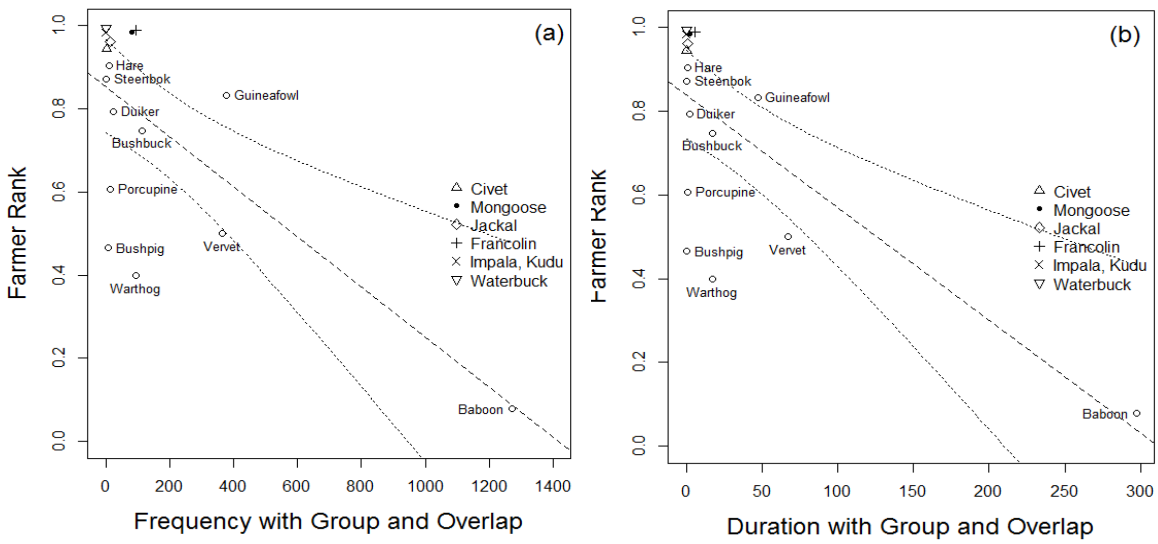


Figure 6.8: Relative farmer ranks against (a) frequency of crop visits and (b) total duration of crop visits when both average species group size and overlap with farmer activity are taken into account in both instances.

6.4 Discussion

6.4.1 Variations in farmer perceptions and raiding species on farms

Considerable variation exists among farmer perceptions of the number of species that crop raid, which species these are, and which of these causes the most damage in the Blouberg region of South Africa. This is in contrast to previous research on famer perceptions elsewhere, which report that farmer rankings of problem animals are similar across farmers (Marchal & Hill 2009; Wallace 2010). However, this variation may be explained by the considerable variation between farms in which species raided and how often.

A number of factors have been shown to affect whether and how often a farm is raided, including farm location and size (Naughton-Treves 1997, 1998; Hill 2000; Saj et al. 2001; Linkie et al. 2007; Chhangani et al. 2008; Priston 2008), number of neighbouring farms (Naughton-Treves 1998; Hill 2000), surrounding land use (Hill 2000), crop type (Maples et al. 1976; Naughton-Treves 1997, 1998; Naughton-Treves et al. 1998; Hill 2000; Priston 2005, 2008; Priston & Underdown 2009) and mitigation methods employed (Maples et al. 1976; Sekhar 1998; Lee & Priston 2005). The farms on which camera surveys took place varied from one another in most of these parameters – there was no 'average' farm in the area in terms of size, amount or type of crops planted, mitigation methods used, or even its location in relation to other geographical features, including the river, trust lands or other crop farms (see Chapter 2, section 2.2). These factors may lead to variation in raiding species between farms and so explain some of the variations in perceptions. However, if the spatial difference in raiding species across farms was the sole explanation for variable perceptions, farmers from the same farm would be expected to agree on ranks. When exploring the responses of four farmers working on one farm, rankings also differed between these farmers suggesting that there are other reasons for variations in farmer perceptions.

Despite farmer rankings of most crop raiders being highly variable, there is very little variation when discussing baboons. 80% of interviewed farmers state that baboons are the worst crop raiders, including three of the four farmers on the same farm. Although farmers were asked to list animals that they have problems with, even a farmer who did not suffer crop damage by baboons ranked them as the worst crop raiding species. This follows the pattern of many other crop raiding studies: wherever baboons are involved in raiding crops, they are consistently cited as the worst raiding species (Hill 1997, 2000; Naughton-Treves 1997; Tweheyo et al. 2005; Webber 2006; Wallace 2010; McLennan & Hill 2012). The reasoning behind this is often because baboons are in fact responsible for most damage (Naughton-Treves 1997; Hill 2000), but where they are not the worst culprits, perceptions of baboons are influenced by their perceived ability to harm or even kill humans, their reportedly strategic raiding behaviour and their destructiveness to crops, destroying more than they eat (Hill 1997; Hill & Webber 2010).

Camera trap surveys from this study reveal that while bushbuck visit more frequently and with longer duration than baboons, when taking into account the number of individuals raiding, baboons potentially cause higher amounts of damage than any other species (as shown in Figure 6.7). Under these circumstances, farmers accurately rank baboons as the most damaging crop raiding species. The fact that farmers who do not suffer baboon raiding still report them as the worst crop raiders suggests there is a rhetoric within this community on the extent of their raiding, leaving baboons with a notorious reputation. Baboons certainly have a reputation within the community, with many people, and not only crop farmers, expressing negative perceptions of this species.

6.4.2 What affects farmer perceptions of crop raiding species?

Frequency and group size alone do not significantly correlate with farmer perceptions, whereas duration alone explains 49.7% of farmer perceptions. When frequency of raids and raid duration are combined with group size, these combinations explain 63.5% and 70.6% of farmer perceptions respectively. The size of a raiding species group has been documented to affect farmer perceptions (Hill 1997, 2000; Knight 1999; Lee & Priston 2005; Nahallage et al. 2008;

Warren 2008; Hill & Webber 2010). In this study, farmer perceptions are influenced by group size, but only when taken into account alongside frequency or duration. When we add a further variable, overlap of activity, these percentages again increase to 70.6% and 72.6%, respectively. Overlap of farmer activity with raiding activity also plays an important role in constructing perceptions; it is reported that diurnal species receive more blame for crop damage than nocturnal species for this very reason (Hill 2004). This result also suggests that farmers base their opinions on their own knowledge of what they see on their farms, and not merely what is reported to them by field guards or other farm workers.

When taking into account all three variables (duration, group size and overlap) which appear to best explain farmer perceptions, there still remain outliers to this relationship. Many of these outliers are nocturnal raiders, which are overestimated in the ranks assigned to them by farmers based on predictions made from this combination of variables. This suggests there may be other influences on farmer perceptions which are not accounted for in this model.

It is worth discussing that baboons are a key driver of these analyses and have a significant effect on the explanations of farmer perceptions; if baboons were removed from the analyses, the relationships between farmer ranks and explanatory variables lose significance. Baboons are, however, undoubtedly the worst crop raiding species in this area, and it is therefore unsurprising that they have such an effect on farmer perceptions. Given farmer perceptions of baboons and the baboon's crop raiding status, it is expected that baboons should have such an influence on the results. Nevertheless, further work is needed to determine whether these results apply more broadly across other systems.

No matter the explanations for farmer perceptions, when using duration of raiding combined with average group size as a proxy for damage, farmers in the current study appear to be fairly accurate at estimating which species cause most damage; some of their perceptions are therefore likely to be grounded in actual crop loss. This is in concordance with other studies, which also reveal their own findings on crop raiding species to mirror farmer perceptions (Hill 2000; Priston 2009). However, there are a number of species which are over- or underestimated by farmers on the amount of crop damage they do, which are worth discussing in the current study.

6.4.3 Damage estimates compared with farmer ranks

6.4.3.1 Species underestimated by farmers

Although farmers appear to be correctly labelling baboons as the worst crop raiding culprits in the study area, they nevertheless still appear to be underestimating baboons. This results from three of the 15 farmers who did not rank baboons as the number one raiding species, usually because bushpig, warthog and porcupine were receiving the blame – all of which appear to be overestimated in farmer perceptions. Of course, given the variable nature of crop raiding species across the study area, these farmers could simply be ranking baboons lower because in fact they sustain less baboon damage on their farms. However, one of these farmers belonged to a study farm on which camera surveys were carried out, and the farm was indeed predicted to suffer most crop damage from baboons using the damage proxy (although these results applied to only one crop type on the farm). This highlights the importance of running systematic observations across the farm whilst exploring farmer perceptions – these farmers would benefit from the knowledge that baboons are likely causing most damage so that they can direct their mitigation attempts more appropriately.

Bushbuck is also slightly underestimated in farmer perceptions. Cited by six of 15 farmers with a range of ranks between one and eight, and appearing on one of the three cameras survey farms, bushbuck crop raiding is variable across the study area. However, on the farm in which they were recorded raiding, bushbuck was the highest ranked raider in both frequency and duration on this farm; farmers on this farm however ranked bushbuck from four to eight. Even with a small group size, this rate of visitation is still likely to be causing enough damage to be of concern to farmers. Bushbuck does however have a value to farmers in the study area as a trophy hunted species, which may contribute to the positive perception that farmers appear to hold towards bushbuck. It has been demonstrated that farmers have higher tolerance for crop damage by domestic and game species than they do for damage by wild species (Hill 1997; Rosie Woodroffe et al. 2005; Webber 2006). Value of a species to farmers may be a variable that we have not considered here that might help to explain farmer perceptions. Bushbuck is also unlikely to be perceived as a dangerous species – another factor which is known to encourage negative perceptions of a species (Chapter 3).

Guineafowl are the final species to which the study farmers assign less blame than perhaps they should. Whereas the larger mammals are likely to cause damage to most crop types in the study area, guineafowl are more variable in the crops they inflict damage on. For example, whilst causing severe damage to tomato crops they are rarely seen within butternut crops, probably because the butternut fruit is too hard for them to harvest. Whilst rarely visiting the butternut field on Farm B, they were the most frequent visitors to the tomato field on Farm C, whose farmer did not even mention them as a raiding species. Being a crepuscular species, overlap of activity between guineafowl and farmers is relatively high; this, together with their relatively large group sizes, suggests that farmers should be ranking them higher on the crop raiding list. Perhaps the explanation for this result is that guineafowl are also relatively small. As a consequence they can often be difficult to see when in crop fields, likely resulting in lower visibility. Despite a high overlap of activity patterns, farmers may actually not be seeing guineafowl within their crop fields. Body size may also be an explanatory variable of farmer perceptions that is not considered here. Larger bodied species are known to receive more blame for crop damage than their smaller counterparts (Naughton-Treves 1997; De Boer & Baquete 1998; Riley 2007).

6.4.3.2 Species overestimated by farmers

Warthog and bushpig are often labelled and ranked together as 'pigs' and are regularly given high crop raiding ranks. They were also repetitively criticised as crop raiders during participant observation. Overall farmer opinion suggests they rank as the second and third worst crop raiders after baboons, respectively. However, their damage proxy level was relatively low, and bushpig in particular featured very little on camera trap observations.

When compared with bushbuck, warthogs are predicted to cause much less damage but are ranked much higher by farmers. They also have a much higher level of activity overlap with farmers (0.472) than bushbuck (0.158); their visibility may be causing farmers to overestimate the warthog's contribution to crop damage. However, when using raid duration, group size and overlap of activity collectively as explanatory variables for farmer perceptions, farmers still overestimate warthog.

Similar to primates, pigs also have a notorious crop raiding reputation, often being stated as the worst crop damagers after primates, if not the worst (Starin 1989; Studsrød & Wegge 1995; Hill 1997; Naughton-Treves 1997; Sekhar 1998; Rao et al. 2002; Kagoro-Rugunda 2004; Tweheyo et al. 2005; Wang et al. 2006; Linkie et al. 2007; Priston 2009; Lemessa et al. 2013). Reasons for these perceptions include pigs being very destructive, notorious crop raiders capable of causing heavy crop damage, nocturnal and therefore difficult to control, coming in large groups and having potential to be dangerous to humans (Hill 1997; Sillero-Zubiri & Switzer 2001; Tweheyo et al. 2005). Farmers within the study area agreed that pigs were difficult to control because they come at night; a lack of control is certainly a factor encouraging negative perceptions of a species (Chapter 4, section 4.2.2). Farmers also report that pigs can break fences and are able to dig under fences, not only providing access for themselves, but also allowing other species to enter the crops. A species ability to enable raiding activity by other species, as well as causing damage outside the crop field, could be further explanatory variables for farmer perceptions.

Porcupine also appears to be overestimated in farmer perceptions of crop damage. Porcupine did not spend a particularly great amount of time within any of the observed crop fields, did not come into the fields in large numbers, and had a low overlap with farmer activity. Despite nocturnal activity resulting in low visibility of porcupine, farmers mentioned that porcupines are also difficult to control given their nocturnal nature. It appears that farmers may be over-reporting nocturnal species that already have a bad reputation. Perceptions of control may also be a factor that needs to be accounted for when attempting to explain farmer perceptions.

6.4.4 Conflict management implications

Baboons, and vervets to some extent, are widely recognised as crop raiders, and deterrent attempts have long been directed towards these species. However, the results here show that it is important not to ignore other wildlife species. There were cases of farmers either underestimating or overestimating certain species as crop raiders and this is problematic for two reasons: (1) underestimating species leads to other animals getting unduly blamed, any mitigation targeted at these animals will not necessarily be productive in reducing the problem; (2) overestimating species leads to these animals being targeted instead of the real perpetrators, which again will not be productive in reducing the problem (Mishra 1997). In both scenarios mitigation attempts are misdirected.

A number of study farmers do not enclose their crop fields with a fence designed to keep animals out. Perhaps the reason for this is that primates and pigs are perceived to be the major problems – primates can easily climb over fences and pigs can dig under fences (Hoare 1992; Hill 2002); fencing is therefore a waste of time and money. However, damage by bushbuck appears to be underestimated and may well constitute a major problem for the farmers. This species could easily be excluded from crop fields with appropriate fencing (Lindsey et al. 2011), but because farmers do not perceive bushbuck as a problem – for whatever reason – they have not considered fencing as a mitigation strategy. Fencing however would not keep guineafowl from the crops, a species whose raiding activity is also underestimated. Scarecrows are a mitigation method which many farmers deem ineffective (Chapter 8, section 8.3.4); perhaps because they are considering effectiveness against primates – for which they are indeed not effective (personal observation). However, scarecrows have been shown to have deterrent effects on birds (Marsh et al. 1992; Gilsdorf et al. 2002), and may well be effective at deterring guineafowl from crop fields. If farmers do not consider guineafowl as pests, they will not consider simpler techniques such as this for mitigation.

It is clear that a systematic survey to establish which species are causing damage is needed before any mitigation strategies are put into place, otherwise techniques will be misguided and misdirected and, at worst, simply a waste of time and effort.

CHAPTER 7: EXTENT AND LOCATION OF WIDLIFE CROP DAMAGE

7.1 Introduction

Wildlife crop raiding impacts people in many different ways, including through a loss of income, health risks, food insecurity, opportunity costs such as missing school to protect crops, and delays in community development (Hill 1997; Naughton-Treves 1998; Webber 2006; Mackenzie & Ahabyona 2012). One of the main impacts of raiding on farmers – especially commercial crop farmers – is the loss of income through damaged crops. Conover (1998) estimated that agricultural producers in the U.S. alone sustain an annual loss of US$2 billion to wildlife; in France, estimated annual losses total €22-23 million (in 2007, Lamarque et al. 2008); 25 villages around Kibale National Park, Uganda were estimated to lose US$109,600 in a single year to baboons alone (Mackenzie & Ahabyona 2012). The average percentage of crops lost across farms varies widely from location to location. Naughton et al. (1999) reviewed 16 studies quantifying crop damage by elephants and found average crop losses ranged from 0.2% to 61%. For individual farmers these losses can be substantial; 100% losses on individual farms have been recorded (Tchamba 1996; Naughton-Treves 1997; Kagoro-Rugunda 2004; Chhangani et al. 2008).

It is important for farmers to be accurately aware of their crop losses, so that they can apply crop protection appropriately and effectively. Many published accounts of crop raiding report damage valuations generated from farmer estimates (Decker & Brown 1982; Studsrød & Wegge 1995; Tweheyo et al. 2005; Linkie et al. 2007), but where studies combine farmer perceptions with independent assessments of crop loss it is revealed that farmer perceptions of damage often differ from measured levels of damage (Tchamba 1996; Naughton-Treves 1997; Rao et al. 2002; Mackenzie & Ahabyona 2012). Most often these studies show that farmers overestimate damage, by as much as 30-40% (Tchamba 1996); farmers are rarely recorded underestimating crop loss by wildlife (Conover 1988).

Farmers do not necessarily inflate estimates of loss intentionally; people's perceptions and memory can be influenced by a number of underlying factors (Hill et al. 2002). Conflict is often an emotional issue and, as a result, opinions can be biased, creating false impressions of the size of the problem (Anthony et al. 2010). Hyper-awareness or inflated perceptions of risk can lead to fears of what could happen outweighing the recognition of what generally happens (Knight

2001; Tweheyo et al. 2005). Similarly, a focus on extreme or worst-case events can strongly influence farmers' estimates (Naughton-Treves 1997; Treves 2008). Even minimal experience with animals as crop raiders can lead to estimates that outweigh actual extent of damage (Siex & Struhsaker 1999).

Social tensions can also inflate perceptions of conflict. For example, to natives of the Island of Ngeaur the long-tailed macaque (*Macaca fascicularis*) is a constant symbol of the foreigners who brought the monkey to the island, along with destruction of the native environment and the islanders' traditional way of life (Fuentes & Wolfe 2002). This negative attitude towards the macaque could explain why they perceive the crop damage it causes to be greater than it really is (Fuentes & Wolfe 2002). It is also difficult to retrospectively estimate losses, especially when particular events take on greater significance in people's minds (Hill et al. 2002). Of course, estimates can also be inflated deliberately, usually to maximise claims for compensation of losses (Tchamba 1996; Sekhar 1998; Siex & Struhsaker 1999).

Information obtained from farmers alone is not necessarily unreliable and inaccurate, but has to be handled and interpreted appropriately (Hill et al. 2002). Impacts of crop raiding extend beyond economic losses and these are often reflected in farmers' perceptions; perceptions therefore form an important part of understanding what the situation means to those involved, and ultimately how conflict impacts people's lives (Hill 2004). It is therefore important to understand how farmers perceive losses through comparison with real losses, and to investigate the factors that influence these estimates. In this chapter I use data on farmers' perceptions of crop loss and systematic estimates of loss to determine whether commercial crop farmers in my study area overestimate damage. I will also use this information to determine whether these farmers accurately locate where damage occurs.

It is difficult to quantify crop losses systematically (Sekhar 1998; Sillero-Zubiri & Switzer 2001; Wang et al. 2006), particularly in a way that is not overly labour-intensive (Priston 2009). Systematic crop damage estimates have been carried out in a variety of ways, including exclosure plots (Priston 2009), vegetation quadrats (Naughton-Treves et al. 1998; Sekhar 1998; Kagoro-Rugunda 2004) and line transects (Siex & Struhsaker 1999; Priston & Underdown 2009), as well as behavioural observations (Wallace 2010). These estimates are time consuming and labour intensive, methods which farmers do not have time to carry out themselves. If farmers are to be able to accurately estimate their own crop losses a more convenient method of estimating damage needs to be developed. I will determine whether a new method of rapid damage estimation provides accurate results.

The implementation of mitigation techniques requires knowledge of not just how much crop loss occurs, but also where damage occurs. Many studies reveal spatial patterning of crop raiding, with a number of factors impacting on this, including the species involved, farm location and size, number of neighbouring farms, surrounding land use, crop type and mitigation methods already employed (Maples et al. 1976; Naughton-Treves 1997, 1998; Naughton-Treves et al. 1998; Hill 2000; Priston & Underdown 2009). These studies examine patterns within the subsistence farming context, there are no descriptions of crop raiding patterns on commercial crop farms.

The distance from which crops are planted to the nearest natural habitat is one of the most influential factors determining the intensity of wildlife crop raiding; most studies report that crop losses decrease with increasing distance from wild areas (Anthony et al. 2010; Sekhar 1998; Wang et al. 2006; Hill 1997; Studsrød & Wegge 1995; Linkie et al. 2007; Agetsuma 2007; Rao et al. 2002; Chhangani et al. 2008; Kagoro-Rugunda 2004; Hill 2000; Naughton-Treves 1997b; Naughton-Treves 1998; Priston 2008; Saj et al. 2001; Prasad et al. 2011; Lemessa et al. 2013; Hill 2005; Priston 2009). Hill (2000) found that most farms suffering crop raiding are located within 100 m from the forest boundary, while no damage was recorded further than 450 m from the forest edge. Naughton-Treves (1997) reported almost all crop loss around Kibale National Park, Uganda was confined entirely within 200 m of the national park, with animals only occasionally damaging crops beyond 450 m.

The majority of recorded primate crop raids occur within 100 m of wild areas (Hill 1997; Saj et al. 2001; Tweheyo et al. 2005; Wallace 2010). Wallace (2010) states that when farms are at least 100 m in length a farm with another farm between itself and a natural area will probably experience little raiding compared to the farm next to the wild area. This same principal can be used on commercial farms for describing crop fields. Given that the smallest crop fields on commercial farms in the study area are at least 100 m x 100 m, then fields bordering natural areas are likely to receive more damage than those bordering other crop fields.

Distances that primates travel into farms when crop raiding varies between studies. Priston (2005) reported the vast majority of primate raids in Buton, Sulawesi occur within 10 m of forest areas. Later, Priston (2009) recorded primates in the same area to travel up to 30 m into farms from forest edges, while Wallace (2010) described over 75% of raids occurring up to 30 m into the farm and only 10% of raids involving animals travelling beyond 50 m in western Uganda. These results imply that while farms nearest the forest edge are most heavily raided, so too are the edges of those crop fields that are within 10-50 m of the forest-farm edge. I will test whether crop fields with exposed edges sustain more damage than those that are surrounded by other crop fields, and whether fields closer to the river sustain more damage than those further away.

In this chapter, I will use one crop type (butternut squash) on a single farm to compare farmer estimates of crop damage – both estimates of losses and patterns of damage – with independent systematic surveys of damage.

7.2 Methods

7.2.1 Crop farmer interview

One farmer from the main study farm B (see Chapter 2, section 2.2 for location and farm information) was asked to provide detailed estimates of wildlife crop damage, in the form of estimates in ZAR of the damage sustained to each crop field on his farm. Estimates were made once harvesting was complete and the requested information was for a single crop type (butternut squash) for one field season. A map of the farm was also given to the farmer, who was asked to illustrate on the map where most crop damage occurs on the farm.

7.2.2 Crop damage transects

Wildlife crop damage for each field planted with butternut squash was assessed through vegetation transects. A transect consisted of walking the length of a crop row – the length and direction of the transect was therefore determined by the field itself. Walking transects where strip width is defined by crop rows is less labour intensive than maintaining a fixed-width quadrat that crosses rows, and reduces potential crop damage caused by moving between rows (Engeman & Sterner 2002). Logistical reasons precluded using exclosure plots and behavioural observations as damage assessment measures. Transects are also an appropriate method to reveal patterns of crop damage throughout the field. For every plant along the row the number of damaged and undamaged butternuts were counted and recorded. Fourteen transects were carried out in each field. To ensure transects were not clumped, one row was selected at random from each tenth of the field (light grey rows, Figure 7.1); the outer two rows on either side of every field were also assessed (dark grey rows, Figure 7.1). Transects were walked as near to, but before, harvesting as possible to allow for maximum damage to be accounted for. 25 fields (34 hectares) were assessed on this farm during the winter (June-August) 2013 crop season.

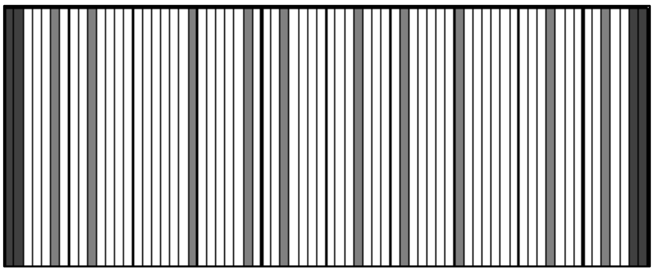


Figure 7.1: Diagrammatic representation of the selection of transects within a crop field. Outer two rows on either side of the field were always assessed (dark grey), while one row was selected at random from each tenth of the field (light grey).

7.2.3 Rapid damage assessment

In order to facilitate farmers making damage assessments, a new method of rapid damage estimation was developed and tested. Estimation was achieved by walking along the edges of each crop field, and counting the number of damaged butternuts located within the distance equivalent to the width of two rows. Care was taken not to count butternuts twice when walking around corners of the fields. Using this method, estimations took roughly 10-15 minutes per crop field.

7.2.4 Analyses

Transects were used to calculate estimated value in ZAR of crop damage per field. The total number of damaged butternuts were summed across the 10 centre transects and extrapolated to estimate the number of damaged butternuts in the whole field, excluding the four outer rows. The total number of damaged butternuts in the four outer rows was then added. This number was divided by eight to obtain the equivalent number of bags that had been lost per field; butternuts are sold by the bag, with an average of eight items per bag. Number of bags was converted to a value in ZAR by multiplying by ZAR35-40, the current value per bag at the time of harvesting (F01, personal communication). This provided an estimate of damage per field. It is important to note that this value does not account for crop items that were removed from the fields by wildlife crop raiders and is therefore a conservative estimate of damage. Matplotlib (Hunter 2007) was used to graphically display where damage occurred within fields and across the farm.

A Wilcoxon rank sum test was performed on the two sets of data (farmer reports and transect assessments) to check for differences between estimates of damage. Spearman's rank correlation was used to determine whether a positive relationship exists between farmer estimates of damage and transect estimate of damage , and was also conducted on the number of damaged butternuts and the total number of butternuts in each field. Due to data being counts, non-parametric tests were used.

I used multiple regression to analyse the factors (edge exposed to natural habitat, distance from the nearby river and farm block) affecting the amount of damage sustained within each field. I checked various diagnostics of model validity and stability for each model (Cook's distance, DFBetas, DFFits and leverage; distribution of residuals, residuals plotted against fitted values), and none of these indicated obvious influential cases, nor obvious deviations from the assumptions of normality and homogeneity of residuals (Quinn & Keough 2002; Field 2000). Variance Inflation Factors (VIF, Field 2000) were derived using the function 'vif' of the R-package 'car' (Fox & Weisberg 2011) and did not indicate collinearity to be an issue. Overdispersion was checked for and was not an issue. A linear regression was used to test whether rapid damage estimations could predict transect data.

7.3 Results

7.3.1 Estimates of damage

The farmer estimated wildlife crop damage per field to range from ZAR0 to ZAR2,500. Estimates obtained from transects ranged from ZAR116 to ZAR6,538. There is a significant difference between the estimates of damage obtained from the farmer and those calculated from transects (Wilcoxon Rank Sum: minimum W = 341, P = 0.002; maximum W = 343, P = 0.002, Figure 7.2), with the farmer underestimating damage. On average across all fields evaluated, the farmer underestimates economic losses by 59.5-64.6% (Table 7.1).

Table 7.1: Estimates of economic loss via crop damage per field obtained from farmer reports and field transects with percentage overestimated by farmers; estimates of the number of damaged butternuts per field obtained from transects and rapid damage assessments.

Field	Farmer Estimate of Damage	Transect Estimate of Damage	% Overestimate by Farmer	Transect Estimate of Number of Damaged Butternuts	Rapid Damage Estimate of Number of Damaged Butternuts
A6-5	R0	R311-355	-100%	-	-
A6	-	R116-132	-	26	0
A5	-	R195-223	-	45	8
A10-9	R1,500	R1,084-1,238	+21.2-38.4%	-	-
A10	-	R214-245	-	49	2
A9	-	R869-993	-	199	117
A12-11	R2,000	R5,721-6,538	-65.0-69.4%	-	-
A12	-	R5,175-5,914	-	1183	128
A11	-	R546-642	-	125	17
A13	R2,000	R2,553-2,918	-21.7-31.5%	584	56
A16-15	R2,000	R3,595-4,108	-44.4-51.3%	-	-
A16	-	R3,375-3,857	-	771	114
A15	-	R220-251	-	50	18
A17	R2,500	R4,696-5,367	-46.8-53.4%	1073	236
A19	R1,500	R869-993	+51.1-72.6%	199	24
A22	R2,500	R1,208-1,380	+81.2-107.0%	276	78
B03	R0	R351-401	-100%	80	18
B04	R0	R439-502	-100%	100	12
B05	R0	R707-808	-100%	162	87
B06	R0	R1,043-1,192	-100%	238	32
B07	R0	R235-269	-100%	54	48
B08	R0	R2,183-2,495	-100%	499	131
B09	R0	R2,559-2,924	-100%	585	84
B10	R0	R667-762	-100%	152	26
B11	R0	R349-399	-100%	80	13
B12	R0	R560-640	-100%	128	16
B13	R0	R1,289-1,473	-100%	295	59
C1	R100	R1,352-1,545	-92.6-93.5%	309	116
C2	R100	R3,366-3,847	-97.0-97.4%	769	268
Total	**ZAR14,200**	**ZAR35,134-40,153**	**-59.6-64.6%**	**8,031**	**1,708**

Table 7.2: Colour scale for Table 7.1.

Colour Scale
R5,000+
R4,000-4,999
R3,000-3,999
R2,000-2,999
R1,000-1,999
R0-999

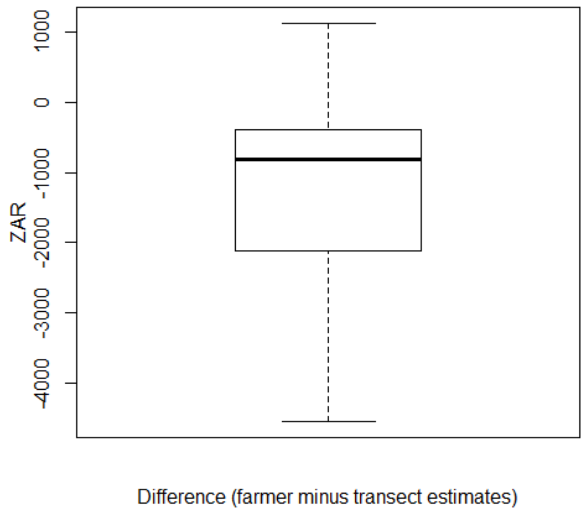


Figure 7.2: Difference between farmer and transect estimates of crop field damage (using minimum values at ZAR35 per crop bag). The median is indicated by the bold line, edges of the box indicate the quartile values. Whiskers represent the distribution of spread.

7.3.2 Patterns of damage

Patterns of crop damage across the farm and within fields are shown in Figure 7.3-7.5. There is a significant positive correlation between farmer and transect estimates (Spearman's rank correlation rho: $r = 0.646$, $n = 21$, $P = 0.002$), suggesting that the farmer accurately perceives where higher levels of damage occur within the farm. There is no significant correlation between damaged butternuts and the total number of butternuts in a field (Spearman's rank correlation rho: $r = 0.282$, $n = 18$, $P = 0.256$), which suggests that damage does not occur more in one field simply because there are more butternuts to be damaged; damage is therefore not influenced by field productivity.

More damage occurs on the south side of block B than the north side, and block A is certainly worse than block B, as articulated by the farmer (Figure 7.6). The farmer also conveys that damage is worse on the east side of A, which is true, but that the west side of A sustains damage if B is well protected. The lower damages in block B and the fact that the farmer believes no damage occurred here possibly suggests that during this crop season block B was well protected, hence the high levels of damage on the west side of A. It does appear however, that damages in block C are overlooked by the farmer.

Overall, the amount of edge exposed to natural habitat, distance from the river and the block in which the field is located have a significant effect on damage within each field (comparison of full with null model: $F = 4.274$, $df = 4$, $P = 0.012$). Specifically, the length of field edge exposed to natural habitat has a significant effect on amount of damage sustained within the field – the more edge exposed the more damage it sustains (estimate±SE = 0.012±0.003, $t = 3.788$, $P = 0.001$). That is, for every one meter increase in the amount of crop edge exposed to natural habitat the natural log of damage increases by 0.012. The distance with which the field is located from the river has no significant effect on damage (estimate±SE = -0.0001±0.001, t = -0.124, P = 0.903), nor does block (B estimate±SE = -1.049±1.333, t = -0.787, P = 0.441; C estimate±SE = -1.724±0.985, t = -1.750, P = 0.095).

Figure 7.7 shows patterns of damage using the rapid damage estimation method. There is a highly significant correlation between rapid damage estimations and estimates of damage obtained from transects (linear regression: intercept = 339.378±290.552, estimate = 18.542±2.999, t = 6.183, P = <0.001, Figure 7.8).

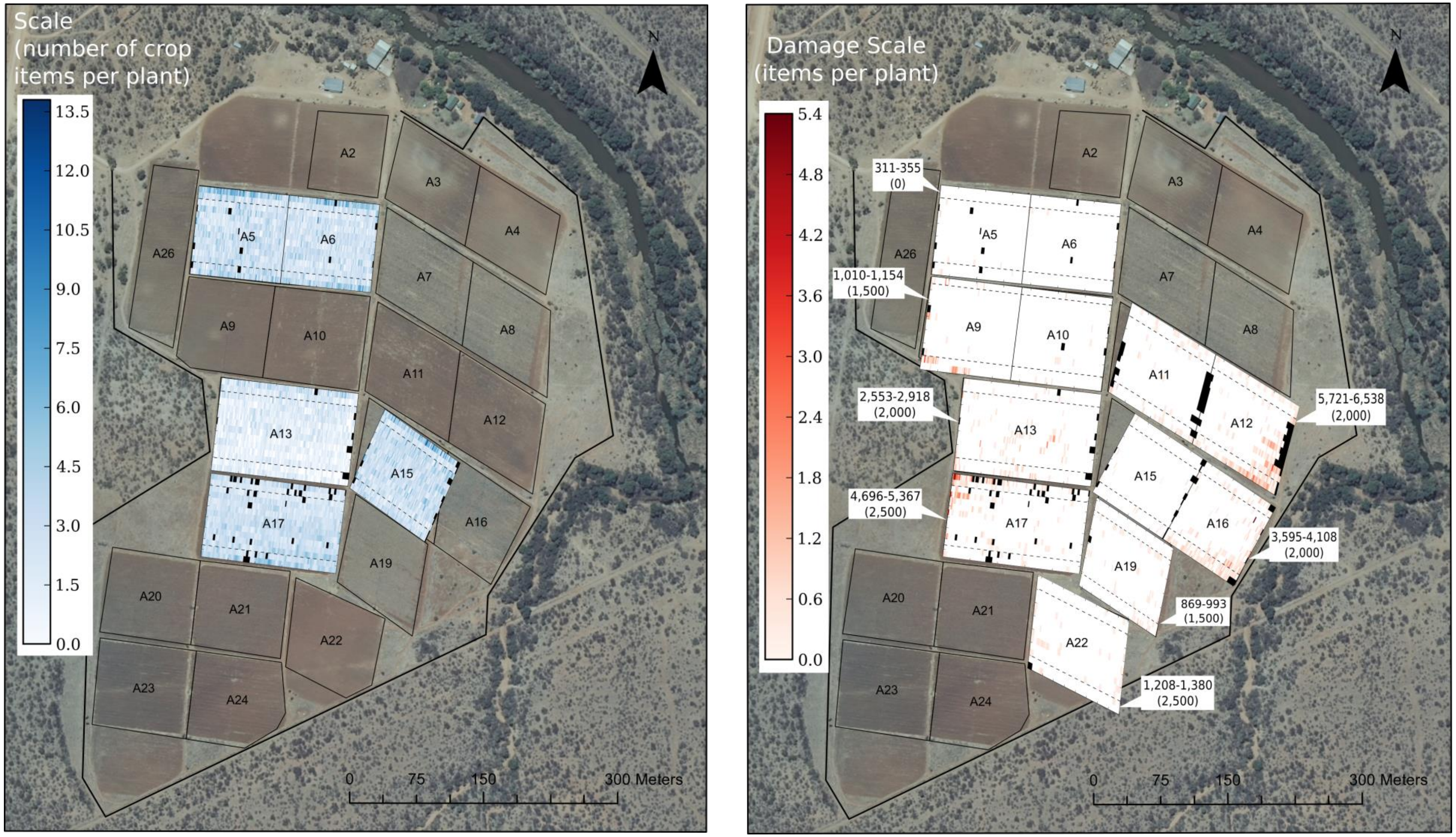


Figure 7.3: Diagram illustrating location of crop damage in block A. Left graphic shows the total number of butternuts (damaged and undamaged) remaining in each field just prior to harvesting. Lighter fields represent those with fewer butternuts remaining in the field, the assumption being because of a higher number of crop items removed by wildlife. Unfortunately it was not possible to collect these data for all fields, as some fields were harvested earlier than expected. Right graphic shows where crop damage occurs when items are not removed, darker red patches indicate higher levels of damage in these areas. Text bubbles show the economic cost of damage calculated from transect data for each field with the farmer estimate of loss in brackets.

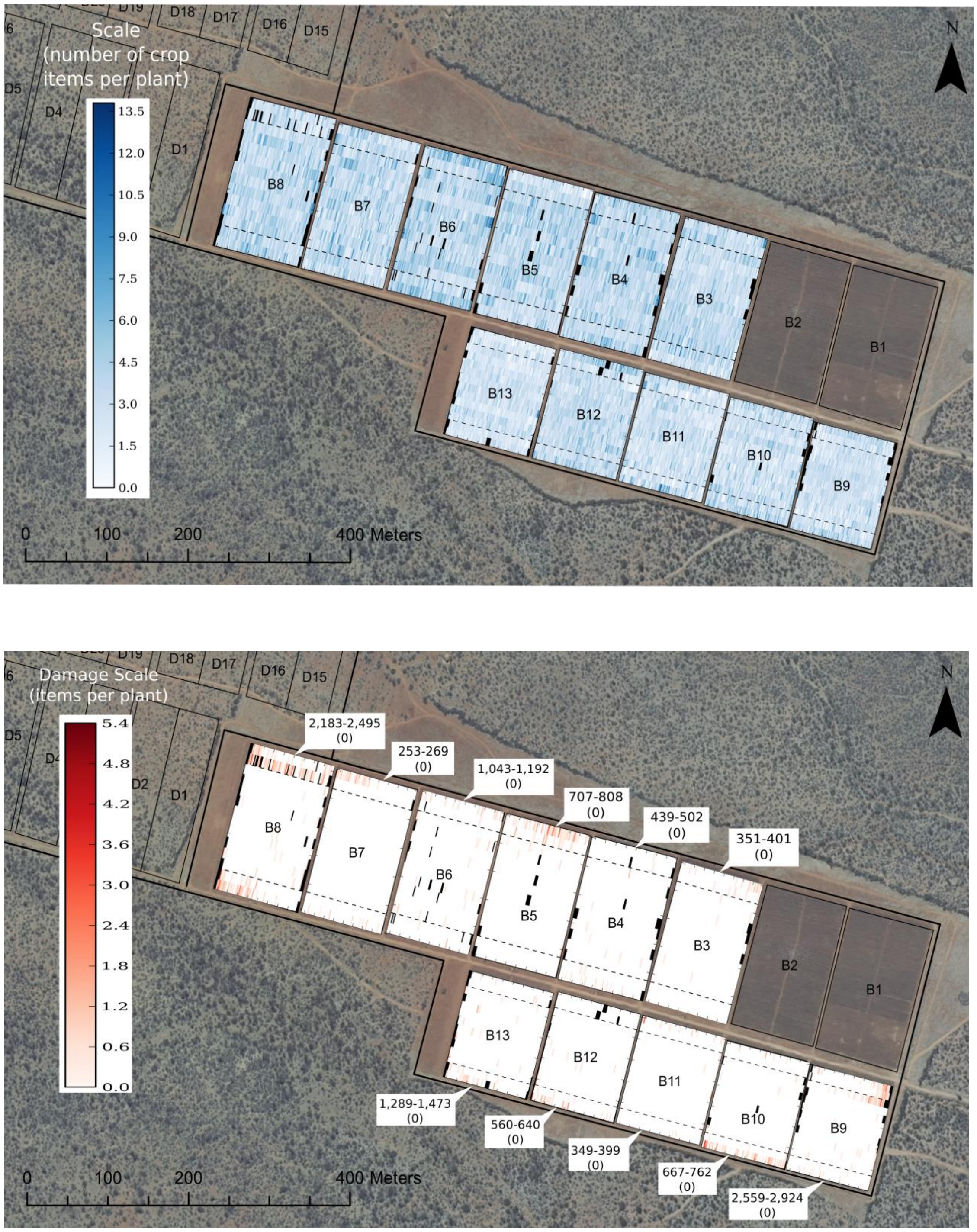


Figure 7.4: Diagram illustrating location of crop damage in block B. Top graphic shows the total number of butternuts (damaged and undamaged) remaining in each field just prior to harvesting. Lighter fields represent those with fewer butternuts remaining in the field, the assumption being because of a higher number of crop items removed by wildlife. Bottom graphic shows where crop damage occurs when items are not removed, darker red patches indicate higher levels of damage in these areas. Text bubbles show the economic cost of damage calculated from transect data for each field with the farmer estimate of loss in brackets.

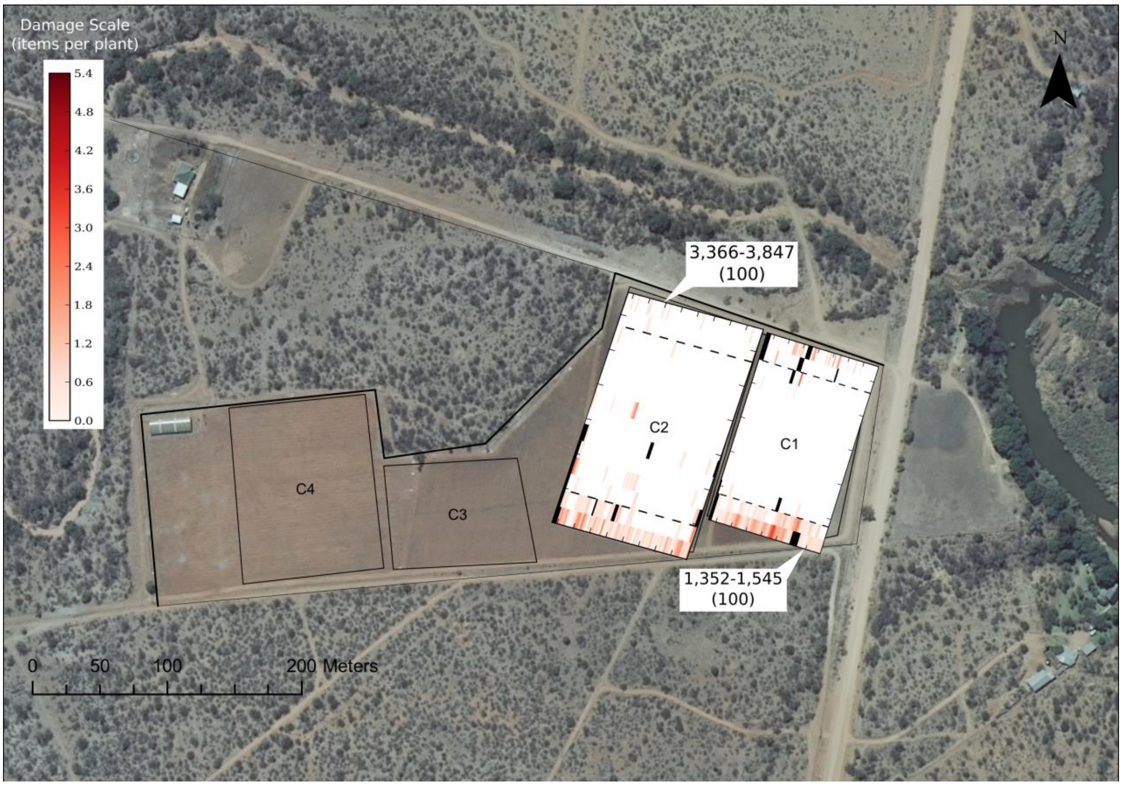
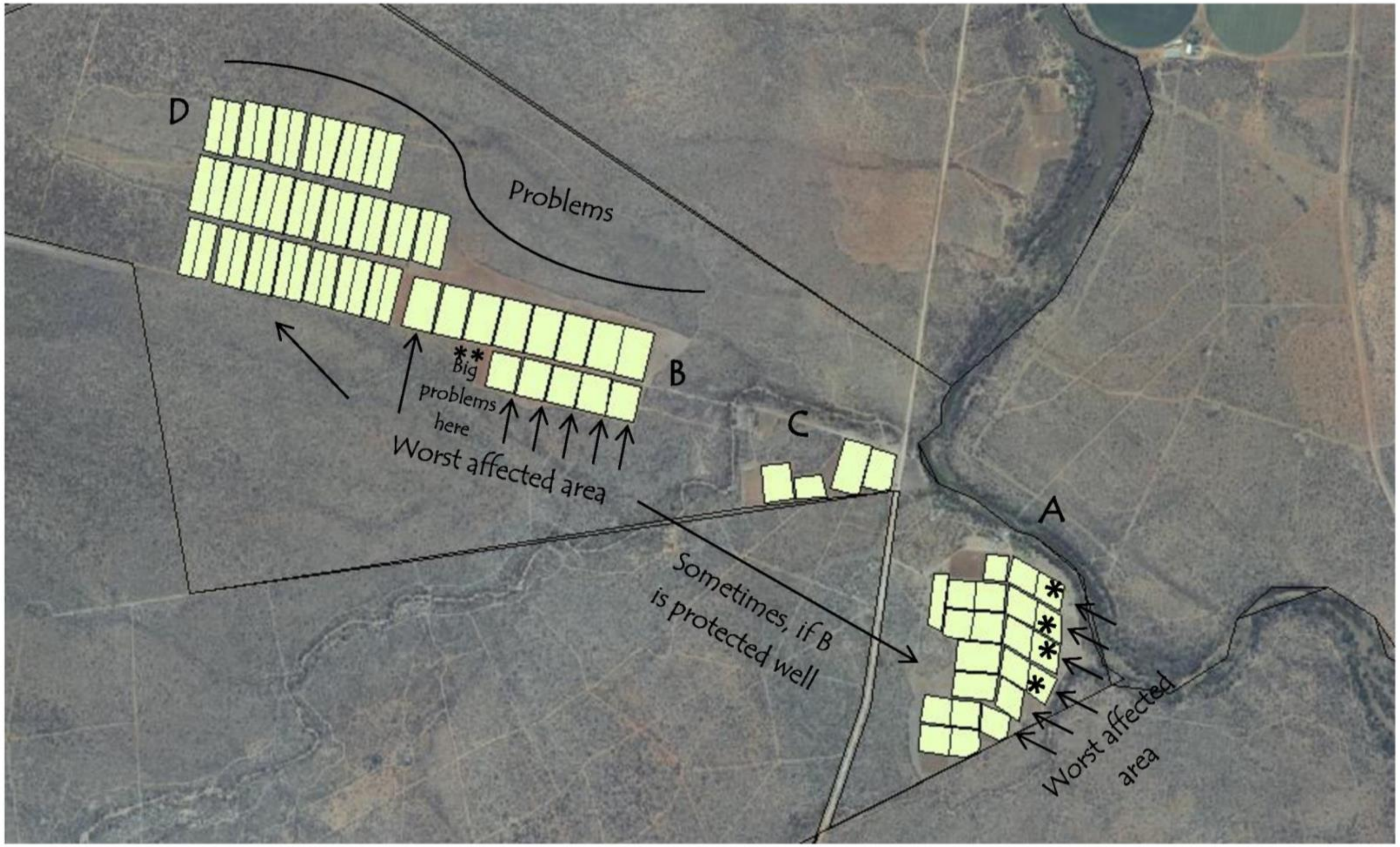


Figure 7.5: Diagram illustrating location of crop damage in block C. Top graphic shows the total number of butternuts (damaged and undamaged) remaining in each field just prior to harvesting. Lighter fields represent those with fewer butternuts remaining in the field, the assumption being because of a higher number of crop items removed by wildlife. Bottom graphic shows where crop damage occurs when items are not removed, darker red patches indicate higher levels of damage in these areas. Text bubbles show the economic cost of damage calculated from transect data for each field with the farmer estimate of loss in brackets.



Most damage occur in block A

** Try not to put butternuts here, or harvest them before it gets really dry

Figure 7.6: Participatory map of the study farm. A farmer's interpretation of where the highest level of damage occurs on the farm.

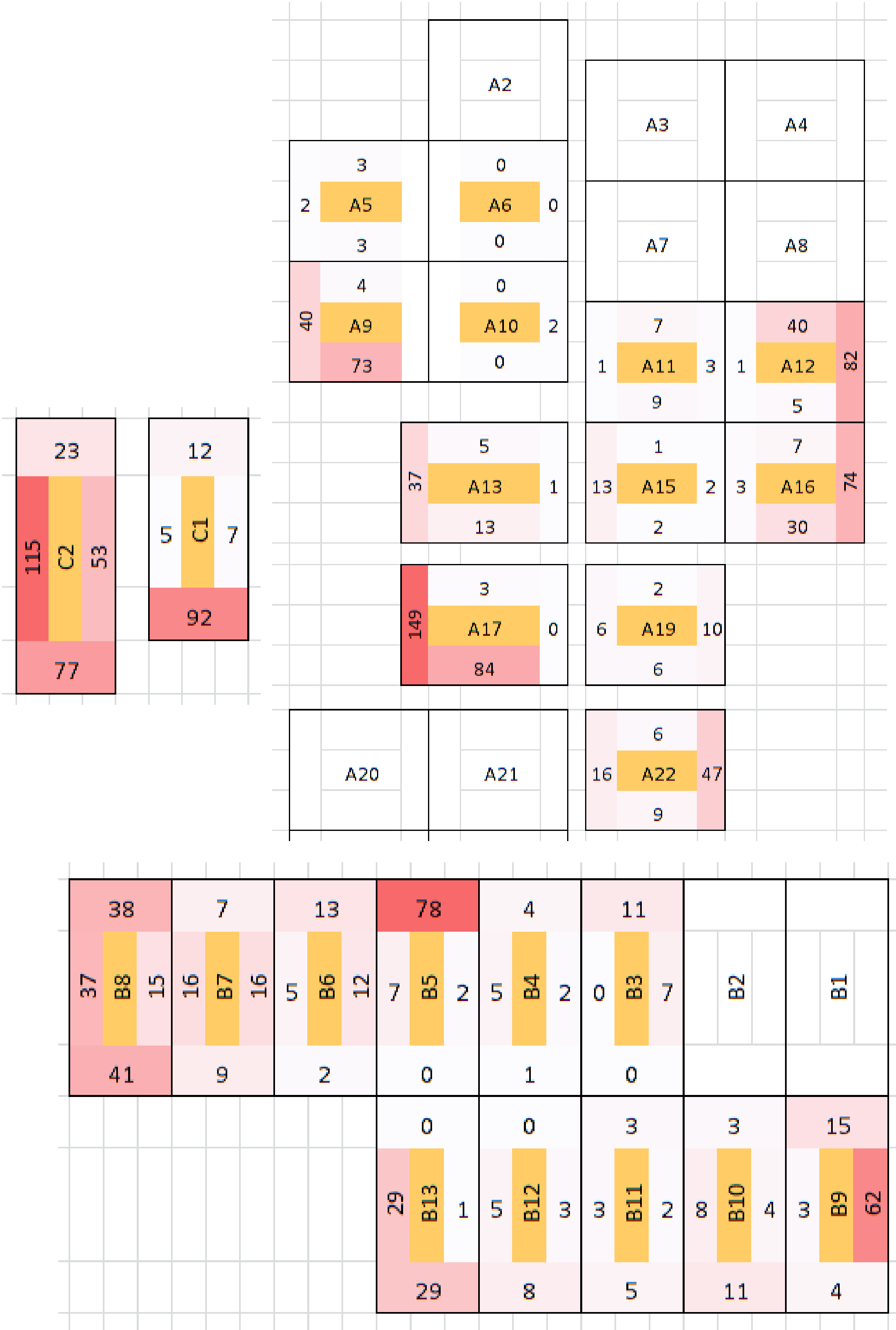


Figure 7.7: Diagrammatic display of crop damage as assessed by the rapid damage estimation method.

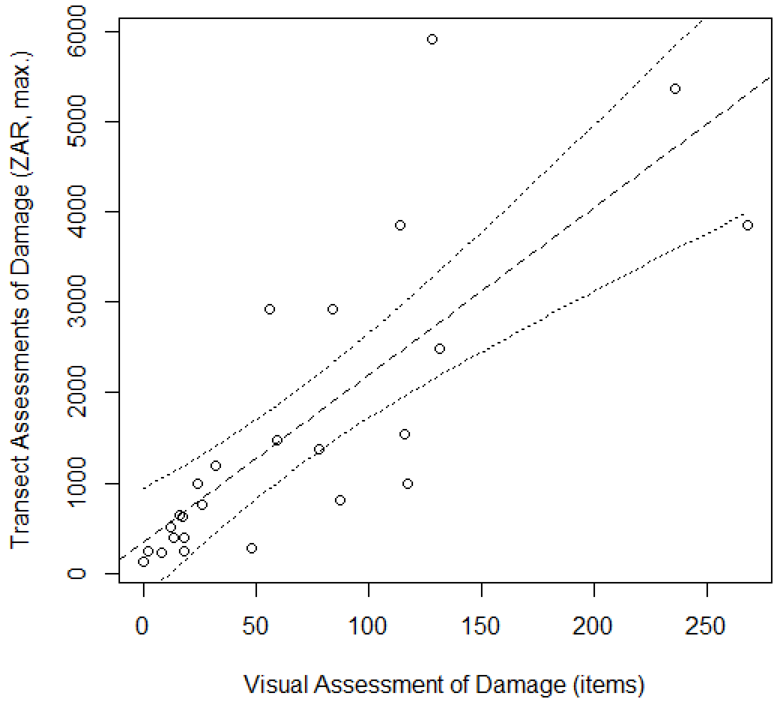


Figure 7.8: Relationship between rapid damage assessment (visual) counts and transect damage counts. Dashed line shows the linear regression, dotted lines show the confidence intervals for the slope estimate.

7.4 Discussion

7.4.1 Damage is underestimated

Crop damage by wildlife is often overestimated by farmers when compared with quantitatively measured damage (Tchamba 1996; Naughton-Treves 1997; Sekhar 1998; Siex & Struhsaker 1999; Mackenzie & Ahabyona 2012); very few crop raiding studies report farmers underestimating damage (Conover 1988). However, the farmer on the current study farm underestimated his crop losses to wildlife, by an average of 65%. In her study of crop raiding macaques (*Macaca ochreata brunnescens*) in Buton, Indonesia, Priston (2005) reported that farmers experiencing low levels of damage are less accurate at estimating damage, whereas those experiencing medium or high levels are more accurate and even underestimate damage. This commercial crop farmer appears to fit into the latter category.

Given that most crop raiding studies examine subsistence farming, commercial farmers in the present study certainly experience higher levels of loss in terms of value – compare the £78-£89 per hectare loss on the current study farm in a single season (three months) with £24.70-33.33 per hectare lost annually in Rajasthan, India (Sekhar 1998), £15.85-32.04 per hectare lost annually in Waza-Logone, Cameroon (Tchamba 1996), and £47.13 lost over a six month period per household in Kibale National Park, Uganda (per hectare rate not available, Mackenzie &

Ahabyona 2012; all losses have been converted from local currencies to British pounds per hectare of crops to aid comparisons). However, as Mackenzie & Ahabyona (2012) point out, losses under the subsistence context can be substantial when taking into account median household capital asset wealth in the study areas; as such, comparisons between subsistence and commercial economic crop losses cannot really be made. Nevertheless, high levels of damage in the study area could explain why farmers underestimate losses, as per Priston's theory.

Underestimating average losses by up to 65% is quite substantial. In order for a deterrent method to be effective and socially acceptable the value of the resource to be protected (in this case, the value of current crop loss) must exceed the cost of the deterrent. Under current circumstances, where this value is perceived to be much lower than it actually is, this leads to an under-investment in crop protection by farmers (Conover 1998; Engeman et al. 2010).

Under-investment in crop protection can have a huge effect on deterrent efficiency. During the crop season under study, the farmer believed his economic loss through wildlife crop damage was ZAR14,200; potentially a ZAR25,953 underestimate when compared with transect estimates of damage. This farmer therefore underestimates the amount he could spend, without mitigation costing more than crop losses, by ZAR26,000 per crop season. This underestimation is likely to have an impact on farmer decisions about deterrent methods. For example, the electric fence is a very effective method of crop protection (Chapter 9, section 9.4.2), but many farmers feel it is too expensive (Chapter 8, section 8.3.1.3). These opinions may change if farmers are aware that measured crop losses are much higher than they perceive.

The methods used to estimate crop losses to wildlife require careful interpretation of the results. Due to the limitations of data collection methods, the damage estimates in this study should themselves be treated as underestimates; the transect methods used to estimate costs of damage per field do not take into account crop items removed from fields by wildlife. We know from primate crop raiding behaviour observations that primates alone add a further ZAR14,219-16,250 of damages to field A16-15 (Chapter 5, section 5.4.6); almost four times as much damage as that that remains within the field. If damage remaining within a field was a reasonable proxy for items removed then predictions could be made for losses to other fields. However, different crop raiding species visit different fields with unequal frequencies and most likely have differing rates of damaging crops within the field and crop removal. Further investigation would therefore be required to make these predictions. Conservative estimates would however further strengthen the conclusion that the farmer is underestimating damage.

Conversely, these calculations could be overestimating damage. Counts of damaged butternuts included crop items of all sizes, but only large butternuts are sent to market. Calculating economic loss based on damaged butternuts of all sizes could therefore be an overestimate. However, butternuts that are damaged when small may have grown to a harvestable size had they not been damaged; it is therefore difficult to say whether transect estimates are likely to be under- or overestimated based on this issue.

Lastly, this research was carried out on a single farm and would need to be replicated many times to confirm whether the study farming community as a whole underestimate crop losses to wildlife. It has been demonstrated time and again that losses are not always equal across farms (Besser & Brady 1986; Wywialowski 1994; Naughton-Treves 1997; Jonker et al. 1998; Naughton-Treves 1998; Siex & Struhsaker 1999; Hill 2000; Chhangani et al. 2008), so it is important that damage to more than one farm be estimated before firm conclusions are made. Nevertheless, the current study provides the first evidence that commercial crop farmers may underestimate crop damage sustained by wildlife.

7.4.2 Location of damage is accurately identified

Many crop raiding studies report that most wildlife crop damage occurs at the farm-forest edge (Naughton-Treves 1997; Rao et al. 2002; Linkie et al. 2007; Priston 2009), and this is certainly true in this study. The length of field exposed to natural vegetation has a significant effect on damage, with fields that have a greater length of exposure receiving higher amounts of damage. Fields that are buffered by crops on every side receive very little damage.

Distance from the river, which provides prime habitat and sleeping sites for primates, does not appear to affect damage. Given the extensive literature that states damage decreases with increasing distance from natural areas, it could be assumed that farmers who plant their crops along the river will sustain higher levels of damage than those who plant further from the river. However, the river provides irrigation for crops, and so most crop farms are positioned alongside a river to increase yields; farmers therefore have little choice in positioning crops. Fortunately, these results suggest that distance from the river is not as important as whether fields are buffered by other crops. Farmers therefore need to worry less about where they locate their crops (which is perhaps very good news, as they have little choice but to plant near rivers in order to irrigate) and more about what is immediately surrounding their crops.

In fields that sustain particularly high amounts of crop loss there is also a pattern of damage along non forest-farm edges, such as between fields A13 and A17, and A16 and A12. This is likely due to crops being depleted at the forest-farm edge and wildlife consequently using pathways between fields to move further into the crops. We then see damage limited along these path edges rather than spreading into the middle of the field. This suggests that larger crop fields may be safer than smaller fields because they have a bigger centre. Further analysis including field size could confirm this.

Knowledge of the location of high-damage areas is important for mitigation purposes. Although farmers are generally accurate in their perceptions of where damage occurs, mapping damage highlights a few misconceptions. Firstly, on the east side of block A, the farmer believes that A22 receives the highest damage, and this is reflected in his decision to position field guards at this end of the farm. It would be more effective for him however, to place at least one of the guards towards A12 which in fact receives more damage. Even a simple change in guard location, a method that requires no further cost or effort, may have positive consequences for crop protection.

Secondly, it is worth noting the high levels of damage in fields A17 and A13. Primates were never seen entering here, suggesting that species other than primates had caused these high levels of damage. Much of the farmers' attentions are however focused on primates, which is likely at the expense of protecting crops against other species. Mitigation employed on the farm during the observation season was the use of daytime field guards located on the eastern side of the block, which gave little protection against the likely nocturnal raiders entering A17 and A13 (there were relatively few diurnal raiders other than primates, see Chapter 6). These damage maps therefore highlight the need for additional deterrent methods on the west side of block A, which are aimed at species other than primates.

Lastly, these maps highlight areas overlooked by farmers that need mitigative attention. Crop damage in block C appears to be largely underestimated, while the farmer believes that block B receives no damage at all. Although these areas do not sustain as much damage as block A, implementing protective measures in these areas could nevertheless reduce damage.

7.4.3 Rapid damage assessment

The rapid damage estimation method reveals information on all these misconceptions. I would therefore highly recommend the use of this quick and simple method by farmers to gain a more accurate understanding of where crop damage occurs and which areas need most mitigative attention. It would also be a useful method for monitoring mitigation – for example, if moving guards from A22 towards A12 caused raiders to shift their foraging patterns back towards A22, this could quickly be picked up by repeating this estimation technique.

7.4.4 Conflict management implications

Obtaining knowledge of how much crop is lost to wildlife and where on the farm damage occurs is an important part of mitigation planning. With this knowledge, deterrent methods can be more efficiently implemented and accurately located; without this knowledge, farmers are at best making educated guesses on where and how they utilise their mitigation. Although this may work in some instances – for example, they accurately perceive where they should concentrate mitigation – it may not work in others – for example, they underestimate how much they should spend on deterrents. However, it must be kept in mind that recording absolute crop losses experienced by farmers does not necessarily fully explain how wildlife impacts on those people's lives (Hill 2005).

It appears that the most important factor in determining the amount of crop lost on this commercial crop farm is the level of exposure a field has to natural habitat; distance from fields to natural habitat has certainly been linked to the intensity of raiding many times (Hill 1997; Linkie et al. 2007; Chhangani et al. 2008; Priston 2008). Fields that are entirely enclosed by other crop fields receive very little damage, while those bordering natural vegetation receive more damage. I would therefore highly recommend considering the use of buffer crops that are at least 100m wide (Hill 1997; Saj et al. 2001; Tweheyo et al. 2005; Wallace 2010). It would be useful to investigate whether these buffers actually need to be planted with crops, or whether a fallow field would have the same effect as a planted field. This would save money and labour by not having to plant a crop that is not going to be sold. If fallow fields do not provide the same effect, then research into which crops should be planted as buffers is required (Naughton-Treves 1998). Ideally, this crop should be cheap and non-labour intensive to cultivate. If farmers have to invest as much in these crops as they do in their market crops, then there is little point in using them. This research would require a lot of consultation with farmers to gain an understanding of the cultivation costs of different crops and finding a buffer crop that would be acceptable to the farmers. Land use may also be an issue and would need to be considered (Lee & Priston 2005).

CHAPTER 8: FARMER EVALUATIONS OF MITIGATION METHODS

8.1 Introduction

The following chapter is the third and final chapter presenting my anthropological research findings, using information obtained through semi-structured interviews, participant observation and a farmer mitigation workshop (see Chapter 2, section 2.2.1 for methods). The aim of the workshop was to discuss with the 30 participating farmers a number of deterrent methods used to protect crops from wildlife. The workshop was interactive; I presented each idea and then a discussion was had between the farmers on their opinions and perceptions of each method. Unfortunately, the results from Chapter 5 were not yet available to present to the farmers at this workshop.

Using the results from this workshop and the knowledge gained through interviews and participant observation, I selected a number of these deterrent methods for further discussion, presented in this chapter. The outcome of this discussion was to select the mitigation methods that will be tested in the following chapter. The results and discussions will again be presented simultaneously. I will first present data profiling the range of mitigation methods currently employed and previously tried in the study area. I will then discuss several deterrent methods, using both farmers' opinions and information from the literature. I conclude the chapter with suggestions for field mitigation trials (Chapter 9).

8.2 Current Mitigation Employed

Table 8.1 shows the range of mitigation methods employed on each study farm. For detailed information on study farms see Chapter 2, section 2.2. The most common method currently used in the study area is the employment of field guards. Shooting is also a popular method, especially against primates, although many farmers did not describe this as a mitigative method despite using it to deter wildlife. As seen in many studies investigating crop raiding on subsistence farms, commercial farmers also use a variety of techniques to deter wildlife from crops (Studsrød & Wegge 1995; Hill 1997, 2000; Naughton-Treves 1998; Sekhar 1998; Wang et al. 2006; Warren 2008; Marchal & Hill 2009; Arlet & Molleman 2010).

Table 8.1: Methods of deterrent employed on the study farms.

Farm	Day guards	Night guards	Night patrols	Dogs	Scarecrow	Gas gun	Light prisms	Electric fence	Fence	Stones at bottom of fence	Tin cans on fence	Trenches	Hanging dead baboons up	Trapping	Shooting
A	✓				✓				✓						
B	✓		✓					F	✓	✓					✓
C	✓				✓	✓		✓							✓
D	✓								✓						S
E	✓								✓			✓			S
F	✓	✓			✓			✓							
G	✓	✓				T		T							S
H	✓	✓							✓	✓					S
I	✓								✓					✓	S
J	✓	✓							✓				✓		✓
K					✓						✓				✓
L	✓			T	T			✓							
M	✓						T								✓
N	✓							✓							

T: previously tried
F: planning on implementing soon
S: known to shoot, but not mentioned when questioned about mitigation methods used

8.3 Analysis and Discussion

A large number of deterrents were discussed during the mitigation workshop, too many for all to be reviewed here. Many techniques received negative reviews from farmers as effective deterrents, and where my biological results suggest nothing to the contrary, I do not discuss these techniques here. These included methods such as light prisms, barbed wire fencing, scarecrows, catapults and changing crop types.

Therefore, I only discuss methods which farmers perceived as having the potential to be effective as deterrents and/or which my biological data suggests could be useful. I review these methods based on data obtained from independent crop damage investigations (Chapters 5-7), how farmers perceive these methods to be acceptable and effective (this chapter) and information from the literature. I first discuss the mitigative methods that were subsequently chosen for trialling (Chapter 9). I then discuss two deterrent methods which were not chosen for trialling during this study, but may however have the potential to be developed under further investigation, based on the knowledge gathered throughout this study.

8.3.1 Deterrents for testing

8.3.1.1 Field guarding: making improvements

Field guarding is the most straightforward method used to prevent crop raiding, involving a person simply chasing animals away from the crops (Sillero-Zubiri & Switzer 2001). The advantages of guarding are that it is simple, low-tech and if carried out by farmers alone does not involve any additional financial costs. However, one farmer on his own is unlikely to be effective on large commercial crop farms, where guarding then becomes labour intensive (Sekhar 1998; Lee & Priston 2005; Wang et al. 2006; Marchal & Hill 2009; Mackenzie & Ahabyona 2012). Since foraging efficiency is so much greater when feeding on crops, primates can wait many hours for the opportunity to raid (Strum 1994); successful guarding therefore requires people to be in the fields for long periods of the day and whenever crops are vulnerable throughout the year (Hill 2000). For those who do guard themselves, guarding can result in missed opportunity costs, through reduced time to complete other work with consequently lost income or missed schooling if children must guard fields (Naughton-Treves 1997; Naughton-Treves 1998; Woodroffe et al. 2005). Guarding can also lead to increased risks of being injured by wild animals (Sillero-Zubiri & Switzer 2001). Lastly, as with most deterrent methods, chasing animals from one field can simply result in raiding of a nearby field (Wang et al. 2006; Warren 2008; Warren et al. 2010).

Despite its drawbacks, guarding is the most commonly used deterrent method in many wildlife crop raiding areas (Naughton-Treves 1997; Hill 2000; Sillero-Zubiri & Switzer 2001; Tweheyo et al. 2005; Wang et al. 2006; Warren 2008; Mackenzie & Ahabyona 2012), including the current study area. It is considered to be the most successful strategy in some areas (King & Lee 1987; Studsrød & Wegge 1995; Sekhar 1998) and the only remaining viable option in others (Nijman & Nekaris 2010). Field guarding is considered to be around 70-90% effective at reducing crop damage by raiding animals in the study area.

> *The guards more or less 70% [effective].* (F12)

> *I would say about 80% [effective], because now they don't just come in, now they sit there and wait, so where they would have been in for half an hour now they will just run in and run out and then she'll go there and chase them off, so they have less time eating.* (F06)

> *The guards are quite effective, but they do still come in and they do still make problems so I'd say about 80% for the guards.* (F04)

I think the guards are quite effective… the guards I would say are 90% effective. (F02)

Other studies report that guarding may reduce, but not necessarily prevent damage to crops by wildlife (Warren 2008).

It is clear from data collected on primate crop raiding behaviour in Chapter 5, section 5.3.5 that there is scope to improve the effectiveness of guarding in the study area; detection rates for vervets are low, and departure times for baboons after chasing begins are slow. Further investigation into improving effectiveness of guards is also encouraged in other studies (Strum 1994; Naughton-Treves 1998; Hill 2000). The key to successfully guarding crops involves early warning systems, vigilance, and active response (Sitati & Walpole 2006; Hedges & Gunaryadi 2010); the data collected in this study show that guarding has the potential to be improved in two ways: through the use of early warning systems to increase detection and increasing the perceived fear of guard response.

Early warning alarm system

While the field guards in the current study responded to 81.7% of baboon raids, they only chased 15.5% of vervet raids (Chapter 5, section 5.3.5). As explained in Chapter 5, such a low response rate to vervets is more likely due to the vervets' discrete raiding style rather than guard negligence; difficulty detecting raiding animals by guards has been reported elsewhere (Warren 2008; Wallace 2010). Some form of early warning system that alerts guards to the presence of vervets entering crop fields could therefore drastically improve guarding against vervet crop raiding. In this situation, the system itself would not be intended to work as a deterrent, but instead work alongside the guard, providing an alarm to any approaching raiders. This could increase detectability of inconspicuous species and therefore raise field guard response rates.

Cow bells or tin-can-and-stone noise makers are the most common methods used for providing early warning systems; these are tied to fences, making noise any time an animal moves against the fence (Osborn & Parker 2002; Graham & Ochieng 2008; Hedges & Gunaryadi 2010). Osborn & Parker (2002) recorded an increase in farmer detection of elephants entering crop fields from 42% to 67% with the use of cow bells as an early warning system, while Hill & Wallace (2012) found that a net with bells attached effectively alerted farmers to the presence of crop raiding primates. Conversley, Graham & Ochieng (2008) report that bells are ineffective as an alarm system for elephants.

During discussions at the mitigation workshop, the farmers present were not keen on the idea of bells used as an alarm system. One farmer expressed his view that raids are not chased because of guard negligence:

You know what, they [guards] know that they [primates] are in there anyway. (F06)

The results from Chapter 5 may have given farmers a better understanding of the nature of vervet raiding and the difficulty in detecting every raid when guards have multiple fields to protect, and that alarm systems could increase the effectiveness of their field guards. However, when the method was explained to a field guard, she was very enthusiastic about the idea and believed it would help her protect the crops more efficiently.

There was also concern with the expense of this method:

It would be cheaper to lose one tomato seed out there, than buy 11 or 12 of these to cover kilometres [of fence]. (F06)

Disadvantages of using bells as an alarm system include the number of bells required for such large farms, and the potential for bells being stolen (Graham & Ochieng 2008). However, cattle bells are relatively inexpensive (ZAR61 per bell in the study area) and the cost would be a one-off purchase. They are also readily available within the area and many farmers already possess a number of bells. Furthermore, they require very little maintenance or further effort once they are attached to the fence.

Despite the farmers' disenchantment with the idea, the data on such a low response rate by guards to vervet raiding as well as the simplicity of the method encouraged me to select an early warning system using bells for trialling. The reaction from the field guard and the belief that it would aid her deter vervets provided further encouragement for the trial. This method will therefore be tested in Chapter 9, section 9.2.

Bear bangers

Field guarding is effective as long as primates are afraid of people (Lee & Priston 2005); adding elements to guarding that increase risk perceived by primates will therefore improve its deterrent efficiency (Strum 1994). King & Lee (1987) suggest that guards known to carry threats are more effective. Baboons in particular are more afraid of men than women or children and those carrying weapons pose more of a risk than those that do not (Box 1991; Strum 1994; Hill 1997; Sillero-Zubiri & Switzer 2001). Many weapons are already in use by guards with mixed effectiveness, including drums, throwing stones, slingshots, spears, bow and arrow, whips, torches, airguns, bells, and dogs, among others (Maples et al. 1976; King & Lee 1987; Tchamba 1996; Hill 1997, 2000, 2005; Knight 1999; Hill et al. 2002; Hurn 2005; Lee & Priston 2005; Webber 2006; Nahallage et al. 2008; Warren 2008; Arlet & Molleman 2010; Warren et al. 2010; Mackenzie & Ahabyona 2012; Lemessa et al. 2013). Guards within the study area used sticks to bang on fences, buckets to drum on and picked up stones from the ground to throw at the primates.

Data from Chapter 5, section 5.3.5 show that the time delay from the onset of chasing by guards to the termination of raiding by baboons ranged from 0 to 6 minutes 35 seconds, with a mean of 26.8 seconds. Increasing primates' perceived risk of guarding is predicted to decrease the delay between the onset of chasing and raid termination, and thus shorten raid duration.. Given the strong positive correlation between raid duration and number of food items removed (Chapter 5, section 5.3.2), this will ultimately lead to a reduction in crop damage.

Kaplan (2013) provides convincing evidence that bear bangers are effective at deterring baboons. Bear bangers are small cartridges fired into the air using a pen-sized launcher. Originally designed as bear deterrents, they make an audible pop when fired and a loud gunshot style noise a few seconds later about 20-30m away in the direction fired (for example, see Mountain Equipment Co-op 2016). Kaplan (2013) used bear bangers to deter baboons from entering residential areas in Cape Town with immediate success that showed no decline over a 10-month period; four years later they remained successfully in use. Kaplan reports that lack of habituation, which was unexpected, may have been due to pairing bangers with human presence, making their spatial and temporal deployment unpredictable, as well as the production of two noises, the second often directly above the group. He also suggests that the bear bangers efficacy may additionally be in part due to the history of conflict in the area, with many baboons having been shot in the past – as is also the case within the study area. Harris & Davis (1998) also suggest that the resemblance to a gunshot sound no doubt enhances the effectiveness of the bear banger in scaring animals that are already hunted or shot at with firearms.

The use of bear bangers was suggested to the study farmers at the mitigation workshop, and the farmers were interested in the idea. However, there were a few restrictions farmers placed on the use of bear bangers, which rendered it unfeasible for use in this area. The first was the fire risk that firing a cartridge posed. Although there have been no incidences of fire caused by the use of bear bangers in Cape Town (Professor Justin O'Riain, personal communication), bear bangers do pose a potential fire risk, especially in dry vegetation (Brooks et al. 1990; Kaplan 2013). It was felt that fire was too big a risk in such a dry area.

> *If you could remove the fire risk that it imposes, particularly in a dry area like this.* (F17)

The second restriction with the bear banger was the risk of injury that it could potentially cause another person. Bear bangers can be dangerous if used improperly, but with correct use are not usually hazardous (Kaplan 2013). Given pre-existing racial attitudes, farmers feared that guards may misuse the device to deliberately harm one another or the farmers themselves.

> *A pencil flare is very dangerous.* (F10)

> *They [guards] are going to argue around the campfire, then there will be a lot of issues [if they have bear bangers].* (F18)

Lastly, farmers were concerned over the range of the device:

> *They'll [baboons] soon learn the range if the thing. I take my gun with me when I can, they know that within 400m they are in trouble, after 400m they will sit at the top of a baobab and look at you. They just know what the range is.* (F17)

However, Kaplan (2013) suggested that the guard can affect the unpredictability of the noise by changing the direction and flight path of the cartridge; this may have increased the bear bangers efficacy relative to a static noise or one associated exclusively with a person, such as blanks from a fire arm. Furthermore, as long as the range at which baboons perceive to be outside of danger is beyond the crop fields, then the banger is doing its job. Not mentioned by the study farmers, but an additional disadvantage is that loud noises produced by bear bangers may disturb people, domestic animals and non-target wildlife (Gilsdorf et al. 2002). At the Mountain Equipment Co-op (2016), a single launcher costs $16.50 CAD (ZAR191.78/£8.24) while a pack of six cartridges cost $17.75 CAD (ZAR206.31/£8.87). Depending on deployment frequency, which may or may not decline over time, this deterrent method could potentially be quite expensive. Advantages on the other hand are that bear bangers are easy to use and place the explosion closer to baboons, rather than originating at the guard (Harris & Davis 1998; Kaplan 2013).

Study farmers discussed the possibility of further altering the bear banger design, to include for example a smell that accompanied the explosion to reinforce the danger perceived by baboons.

> *If you perhaps replace the flare component with something like pepper, a pepper mist or something like that, that you could fire into the troop and it would cover them all with chilli powder*. (F17)

An adaptation that removes all risk of fire and harm to people, and incorporated a secondary sensory deterrent (such as the inclusion of pepper mist) may prove effective in this rural area, and would certainly be socially acceptable to the people involved. Unfortunately, although trials on this mitigation method were planned, it was not possible to find a device with these adaptations before the time of trialling, and it was therefore not tested in this study. There is nevertheless opportunity here for further investigation.

8.3.1.2 Acoustic repellent: motion-activated sound

Agriculturalists have used many kinds of sound-producing techniques to repel vertebrate crop raiders from their fields, including shouting, drumming, commercially available noise making devices, and recorded animal sounds (Koehler et al. 1990). A commonly used acoustic repellent is the gas gun, a propane or acetylene powered mechanical device that produces a periodic loud, banging noise to frighten animals away (for example, see EnviroGuard 2016). The bangs are produced by igniting gas, which resembles the noise of a shotgun. Designed specifically for agricultural use, it was originally built as a bird-scaring device and is now also employed to reduce aeroplane collisions with birds, by scaring birds away from runways at airports (Harris & Davis 1998).

A number of studies report the gas gun to be effective at reducing crop damage (Stickley et al. 1972; Conover 1984; Cummings et al. 1986), most reporting effectiveness against birds, but it has also been reported as ineffective by others (Harris & Davis 1998; Gilsdorf et al. 2004). A major drawback of the device is that animals quickly adapt to the sound, especially without the use of other techniques that reinforce the threat of the cannon; as such it becomes ineffective after a short while (Harris & Davis 1998; Steensma 2009). When discussing the use of gas guns in the study area, the problem with habituation was iterated many times by farmers.

> *Gas guns work, but only for a while… I've seen steenbok, duiker, warthog underneath it, literally under the gas gun and it doesn't even pick its head up, it's still feeding and eating.* (F01)

> *No, they'll get used to that as well, so no.* (F12)

The length of time for which the gas gun effectively deters animals varies from study to study. Pfeifer & Goos (1982) report that gas guns deter coyotes from depredating ranches for an average of 31 days, while Belant et al. (1996) found that systematic detonations every 8-10 minutes deterred deer for only two days. The duration for which gas guns are reported to be effective on baboons in the study area also varies from one farmer to another.

> *We tried it last year, it doesn't work. It worked for the first few days, but then it doesn't work.* (F05)

> *It will maybe work for a week, two days, three days and then they just get used to the sound because even when they're not at the field the gas gun goes and he gets used to the sound of it and then he just comes in.* (F15)

For the first week it worked, the next week they ran close to the gas gun and played with it. (F08)

If it's not dry and there is food… it'll be effective for maybe 2 months… when it's dry then it's effectiveness is gone, they'll start taking chances and getting used to it, and just go past it, because they are hungry. (F01)

Effectiveness of the gas gun varies with methods of presentation. It can be improved if the frequency of explosions and number of shots per firing sequence varies, as well as if the device is moved to a different area and the direction of firing is changed every second or third day (Koehler et al. 1990; Hygnstrom et al. 1994; Harris & Davis 1998). Shorter periods between shots keeps animals more easily dispersed, at least for birds (Harris & Davis 1998), although this can speed up habituation (Gorenzel et al. 1994). Furthermore, effectiveness can be maximised through incorporation of additional control techniques, especially those that reinforce the threat of the cannon (Koehler et al. 1990; Belant et al. 1996). These techniques essentially prolong habituation.

The main advantage of the gas gun is that it is not labour-intensive; it is simply placed within the crop field and left to operate on its own, requiring only daily checks (Koehler et al. 1990). It can also be moved and the direction, timing and volume of the blasts can be controlled (Harris & Davis 1998). Furthermore, they can be used both day and night. However, the units are very loud, which can cause problems when being deployed near residential areas, and disturb domestic and non-target animals (Gilsdorf et al. 2002). The affected area is relatively small, and as such the gas gun is more practical for small acreages; it is generally impractical and too expensive for large areas (Koehler et al. 1990).

Study farmers were also concerned about the cost of the device, mentioning that the device is very expensive and has to be filled every three to four days, which will cost at least ZAR1,000 a month. Also mentioned was that people steal the device. The product advertised on EnviroGuard's website (EnviroGuard 2016) sells for £275 (~ZAR6500.00) plus VAT, while 10 litres of propane fuel costs around £35 (~ZAR835).

When asked whether they thought the gas gun was something that would work as a deterrent against baboons, study farmers were split in their opinions. Many (53.8%) felt that the gas gun is not an option because it simply does not work. Others, however, suggested that it may work for a short time and could be used alongside field guarding.

If you could give a gas gun to the guards that would help them a lot, not having to run all that much but shooting and making a noise. (F02)

During discussions at the mitigation workshop, it was unanimously agreed that the gas gun isn't worth trying. However, building on the gas gun's design, adaptations were suggested and discussed with the farmers. In an attempt to reduce habituation, two amendments were considered. The first is to incorporate the use of a motion detector, so that sound is triggered whenever, and only when, an animal is detected entering the crop field. Motion-activated explosions reduce habituation, probably because detonations are less predictable than systematic explosions, and have been shown to increase habituation time from two days to one to two weeks (Belant et al. 1996). The second adaptation involves playing a range of different sounds rather than using a single 'explosion', which is likely to increase its effectiveness as a deterrent (Bomford & O'Brien 1990). These adaptations generated positive responses from farmers, who thought they might work and were worth trialling.

That will be something that will affect them. (F18)

I think that would definitely be worth trialling. (F17)

A device such as this is not currently available on the market, so the cost of such a device is unknown. However, it is likely to have similar drawbacks to the gas gun in terms of cost. To cover an area as large as these commercial farms, a number of the devices may be required, depending on the range of the motion-detector and the sound output. The amount of power required would also depend on the frequency with which the device is activated. Given the interest from the farmers, it was decided that the 'idea' would be trialled, using an observer to act as a motion detector by activating sounds played on an MP3 player connected to a speaker when baboons entered crops (Chapter 9, section 9.3). If the idea works then materials and costs will be investigated further.

8.3.1.3 Physical barrier: electric fence

Alongside guarding, fencing is one of the most commonly used methods of crop protection (Sekhar 1998; Woodroffe et al. 2005; Wang et al. 2006; Warren 2008). It is used in an effort to keep animals out of crop fields, but for animals that can dig or climb fencing has limited effectiveness (Strum 1994; Sillero-Zubiri & Switzer 2001; Hill 2005; Arlet & Molleman 2010). A variety of materials have been used for crop fencing, such as netting, rope, wood, stone or barbed wire and electrical fencing (Studsrød & Wegge 1995; Thouless & Sakwa 1995; Knight 1999; Archabald & Naughton-Treves 2001; Wang et al. 2006).

Electrical fencing relies on conditioned avoidance – a learning process through which most animals can be trained to avoid objects associated with unpleasant experiences (McKillop & Sibly 1988). Lighter materials are required to construct electrical fences, which means they are easier and less costly to construct than conventional wildlife fencing, as well as being more durable due to the reduced physical pressure placed on the fence by wildlife (Hoare 1992). Power outages and load shedding are a concern for farmers in South Africa, but it has been suggested that brief periods of electrical failure may not incur excessive costs given the conditioned avoidance of the fence that often occurs (McKillop & Sibly 1988). However, it has also been suggested that because of this behavioural conditioning, animals should never be allowed to experience power dead sections of fencing (Hoare 1992). Furthermore, farmers report that baboons know when the fence does not have power.

> *They will walk next to the fence but will not try to jump in, they can hear when the fence is on and working… They are very clever, they can hear when the fence is off.* (F01)

Maintaining an electrical fence is expensive and must be carried out regularly and indefinitely (Pickard 2007). However, if well-constructed and maintained electric fences have a long life, and once both people and wildlife learn to respect the fence, the cost of maintenance should be low and can be carried out by relatively unexperienced staff (Hoare 1992). Furthermore, alarms can be fitted to monitor fence breaks. Burrowing animals can be a problem as they breach access not only for themselves but also for other animals that use the holes they dig (Hoare 1992); fence specifications can be designed to prevent this however, such as by burying wire mesh below ground level (Hoare 1992; Kaplan 2013). Alternatively, holes can be filled daily. Vegetation alongside the fence can cause power outages, and can also be used by animals, particularly primates, to climb over the fence. Vegetation must therefore be cleared, which also facilitates maintenance and allows most animals to sight the fence well and therefore usually avoid being harmed by or damaging it (Hoare 1992). Electrified fences, particularly those with alarm systems, are also effective deterrents against theft by humans (Hoare 1992).

Electric fencing provides the benefit of excluding a wide range of species (Hoare 1992), however it can also harm a variety of wildlife. Electric fencing can kill animals that get caught between the electric strands and wire mesh, as large as a 240kg adult male greater kudu, although smaller, less mobile animals are more at risk (Hayward & Kerley 2009). Bushbuck, tortoises, pangolins, monitor lizards, snakes, frogs and rats have all been reported to be killed by electric fences (Burger & Branch 1994). There are ways to minimise such risks, such as incorporating small flags into the fence design to make it more visible and including non-electrified bottom wires to keep small animals from being electrocuted (Hayward & Kerley 2009). Burger & Branch (1994) provide comprehensive recommendations on how to reduce the risk of mortality from electric fences to tortoises.

The high costs involved in electrical fencing often makes it impractical to carry out controlled experiments to determine its effectiveness in deterring crop raiding wildlife; this has resulted in very little information published on the subject (but see Thouless & Sakwa 1995; Kaplan 2013). Reports of electric fence effectiveness at excluding wildlife from designated areas, whether through controlled experimentation or anecdotal evidence, are varied. Reidy et al. (2008) found that electric fences reduced crop damage by feral pigs by up to 65%, but were not 100% pig-proof; Kioko et al. (2008) found that electric fencing reduced elephant crop-raiding, but suggested that other landscape factors are important in determining the effectiveness of the fence. Huygens & Hayashi (2000) found electric fencing to be effective at keeping out black bears, while Strum (1987) reports that she has not seen an electric fence that is 'baboon-proof'. Reports from farmers within the study area also varied widely. Some maintained that the electric fence is effective:

> *The electric fence is the only thing that really works.* (F10)

While others assert that electric fences cannot keep baboons out of crop fields:

> *It doesn't work… I have got a fence which is electrified, and they can climb through it.* (F18)

> *You cannot keep baboons out with an electric fence, there are always the wooden posts that you cannot electrify and they know which one this is – you can see them lining up to get over [the fence] using this one that isn't electrified.* (F19)

> *They learn very quickly which line they can touch to get through or how to go about getting across the fence without touching the wires.* (A03)

A recent study focussing on urban human-baboon conflict in Cape Town has shown electric fencing to be very successful at keeping baboons out of residential areas (Kaplan 2013); as a result Kaplan suggests that certain designs can be 100% 'baboon-proof'. It is suggested that one of the most important factors determining the success of electric fences are the specifications used (Thouless & Sakwa 1995). This could certainly be an explanation for one farmer's statement:

> *[Farmer A] has no problems [with baboons] because they have electric fences, but over at [Farmer B's] you see them every day and the electric fence doesn't work there.* (F10)

The main concern farmers had about the electric fence at the mitigation workshop was the cost. Discussions were had on what specifications would increase effectiveness, but all agreed that this would be astronomically expensive. However, during the following field season, the residents from Farm B (who unfortunately had been unable to attend the workshop the previous year) erected an electric fence around their crops. I decided to take advantage of this and test the effectiveness of the electric fence. Furthermore, given the large underestimation of crop damage by one of the study farmers (Chapter 7, section 7.3.1), if this pattern is true for other farmers in the area, then the cost of electric fencing may not be so dear if the farmers were more accurately aware of the savings they would be making in the long-term. This method will therefore be tested in Chapter 9, section 9.4.

8.3.1.4 Predator model: rubber snake

Models of predators have been utilised as visual stimuli to frighten away problem wildlife; most studies documenting these use the devices to repel birds (Conover 1979; Conover 1984; Belant et al. 1998; Gilsdorf et al. 2002). The reason for this may be that birds are more visual than mammals, insofar as they possess colour vision and the ability to see ultraviolet light; most mammals are colour blind or generally cannot detect colours that are used to advertise unpalatability and provoke avoidance in birds (reds and yellows, Mason 1998). This is not true of catarrhine primates however, who possess trichromatic colour vision (Regan et al. 2001); nevertheless there is only anecdotal evidence of predator models being used to deter primates, for example, tourist lodges in Kenya put out leopard skins to ward off vervets, who are reported to react with frantic alarm calls (Box 1991).

Scarecrows – essentially models of people – have been used, mostly ineffectively, to ward wildlife away from crop fields (Marsh et al. 1992; Mason 1998). During the mitigation workshop, the discussion on scarecrows was very short-lived due to its perceived ineffectiveness:

> *You've seen how many people I have in the fields chasing baboons, so if they don't work how will a scarecrow work?* (F06)

However, the reported effectiveness of predator models in deterring birds is mixed. Models significantly reduced number of birds visiting feeders as well as bird damage to corn fields (Conover 1979, 1984), but were ineffective at reducing starling use of nest boxes (Belant et al. 1998). During the current study, farmers reported using rubber snakes to frighten away baboons, but again with mixed effectiveness. One farmer explained how his father had trouble with baboons messing with the camera trap he used to monitor his game, and in response placed a plastic snake on top of the camera. He claimed that this made the baboons leave the camera alone, because baboons are afraid of snakes. However, later in the season the same farmer reported that rubber snakes have no effect on baboons, and instead baboons will just *'play with the snake'* (F06). Another interviewee found rubber snakes to be ineffective:

We put rubber snakes out which worked once or twice but really not often. (A03)

Conversely, one farmer reported rubber snakes to be effective at deterring baboons, but questioned how they would work around an area as large as crop fields:

Something I can give you that works, just on a small scale… I bought a rubber snake and that thing kept them away… but how do you do it around a crop field? (F18)

During the course of the study one farmer asked if we would test the effectiveness of rubber snakes at deterring baboons. Thus, with the help of a Masters student we tested this method of deterrence, finding it to have no effect whatsoever on whether baboons would take bait protected by a rubber snake (Lucas 2015). However, the snake was small compared to predatory snake species (python, *Python sebae*) in the area, and given the lack of movement from the snake model baboons likely habituated very quickly to its presence. This latter concern was pointed out by one of the interviewees:

Rubber snakes, total waste of time because they learn within a day that this this isn't moving, second day I reckon they have worked this out, these things are dead and then it's just ignored… No I don't think snakes work unless they are robotic and they move. (A02)

Moreover, Conover (1979) found the mobility of predator models to be a critical factor in determining their effectiveness, and Marsh et al. (1992) recommend that for best results predator models should appear lifelike, be highly visible and be moved frequently. Perhaps with the right model and improved techniques, effectiveness of predator models on deterring baboons could be enhanced. Whether these would be efficient at keeping baboons away from crop fields however is another concern and warrants further investigation.

8.3.2 Other deterrent opportunities

8.3.2.1 Planting strategy: buffer zones

A buffer zone is essentially a monoculture of less desirable crops or regions of partially cleared land surrounding crops that make access to fields more difficult for wildlife crop raiders (Lee & Priston 2005). Buffer crops which are grown for 'sacrifice' are particularly effective because there is no expectation from farmers of yield (Lee & Priston 2005), but there nevertheless remains a cost of planting crops from which there will be no economic return. When presented to the farmers at the mitigation workshop, the use of buffer crops was not met with enthusiasm, but instead with a number of concerns. It was suggested that baboons would simply feed on this crop before moving into the marketable crops; most farmers suggest there is nothing that baboons will not eat.

> *So you're suggesting that they must feed on this plant before they get into the crop.* (F10)
>
> *What are you going to plant? You tell me a crop that the wildlife isn't going to eat.* (F04)
>
> *There's no such thing because they eat... anything.* (F03)

The size of commercial crop farms was also a problem:

> *On a small scale it might work, but some of these guys have got massive sections of land… it just wouldn't work on a large scale.* (F17)

However, the results from Chapter 7, section 7.3.2 show that the most important factor determining amount of damage sustained within a field is the length of its exposed edges to natural habitat; those buffered on all sides by crops receive very little, if any, wildlife damage. Given that this study and many others show that primates do not tend to move further than 100 m into the farm (Hill 2000; Priston 2005; Priston 2009; Wallace 2010), I suggested that the use of a buffer zone at least 100m wide may be an appropriate deterrent method (Chapter 7, section 7.4.3). If this buffer zone simply required land to be left fallow, this would eliminate some of the farmer concerns about using a buffer crop and would require less cost and labour input from the farmers themselves. It could also increase guard effectiveness as guards will have better visibility and more time to spot raiders before they reached the crops.

The idea would of course have to be presented to the farmers again, along with the results from Chapter 7, to determine whether this method would be appropriate and acceptable to the farmers. If it were, the technique would also need to be trialled, to determine whether it has an impact on raiding. It would be no use farmers clearing land – potentially natural vegetation – if primates were to simply travel further into the farm because the first 100m provided no crops, the risk might simply not be great enough. This method was not trialled in Chapter 9, but does however warrant further investigation in the study area.

8.3.2.2 Lethal method: shooting

Throughout human history, agriculturalists have used an array of techniques to reduce competition with wildlife via lethal control (Treves & Naughton-Treves 2005). Typically used for common animals, the underlying assumption is that conflict will decline when animals are removed (Treves & Naughton-Treves 2005). Furthermore, surviving individuals may gain a relative advantage by avoiding humans and pass on their learned avoidance to future generations (Treves & Karanth 2003). One of the most common lethal methods currently used, both in commercial and subsistence farming, is shooting (Conover & Decker 1991; Biquand et al. 1994; Jonker et al. 1998; Marchal & Hill 2009; Warren et al. 2010; Strum 2010); on ten of the 14 study farms shooting is used in attempts to keep baboons and sometimes other wildlife away from crops.

Despite shooting being widely used within conflict scenarios, there is very little published evidence that lethal control methods reduce the impact of crop raiding, unless all of the pest animals are removed (Osborn & Hill 2005). Studies that document shooting as a method of conflict mitigation report only anecdotal evidence of mixed effectiveness – none of these report results from systematic surveys (King & Lee 1987; Balakrishnan & Ndhlovu 1992; Jonker et al. 1998; Knight 1999; Admassu 2007; Marchal & Hill 2009; Nyirenda et al. 2011). Farmers in the current study also report mixed effectiveness of shooting.

One interviewee, though not a crop farmer, stated that once shot baboons would not come back:

> *I shoot a couple of them, and then they bugger off and they don't come back. They don't even come and drink at the waterhole for weeks, they know their place. .. If you hammer them every time they come to the house, they learn that they get hammered there so they tend to stay away… Last year we had a lot of problems with the one house there they kept coming, and then I shot a couple and then it was fine. They have stayed away the whole of this year. So they do learn.* (A01)

Anecdotal evidence within the literature also states cases of shooting being effective. As a result of shooting a female vervet monkey by a uniformed game warden, all uniformed men were subsequently avoided (King & Lee 1987). Marchal & Hill (2009) report that many Indonesian farmers consider shooting the most successful preventative measure, while Japanese villagers claim that the shotgun provides the best defence against primates (Knight 1999).

However, the crop farmers within the current study advocate that it is only a matter of time before baboons return after being shot at. Perhaps the reason for the interviewee's statement above is that without the vast availability of a nutritionally valuable food source (such as crops) it is not worth the risk for primates to return to the location of shooting. The reported length of time after which primates will return to crops after having been shot at is highly variable among study farmers, ranging from a few minutes to one to two weeks.

> *You might kill a baboon in the morning and in the afternoon they'll climb across the dead baboon to get into the field.* (F02)

Shooting, that's not really effective, they tend to stay away for a few days but they'll be back, they won't stop coming. (F03)

Shooting helps for a week then they are back again… It's a short term replacement, not a long-term [solution]. (F12)

It will keep them away for about a week or two, but then they come back again. (F08)

Again, anecdotal evidence in the literature provides evidence for varying lengths of success from shooting. Other South African farmers report shooting baboons keeps the group away for anywhere between one day and a week (Pahad 2011). Control shooting had only a marginal effect in reducing crop damage in Zambia (Balakrishnan & Ndhlovu 1992), as has been found in other studies (Sillero-Zubiri & Switzer 2001). Further evidence suggests that shooting does not reduce crop damage, despite its continued use (Balakrishnan & Ndhlovu 1992; Tchamba 1996; Jonker et al. 1998; Warren et al. 2010; Pahad 2011).

There are a number of reasons why shooting is unlikely to be effective as a primate deterrent. Killing primates as pests is ineffective because after the initial deaths, the remaining animals learn extreme caution but continue to raid (Strum 1994). Study farmers also acknowledge this:

Shooting does work, but you're making them more clever… you shoot the first two or three times, you can get them, but after that they are very clever, you won't get them, you won't get close enough to get a shot on them. (F10)

You can shoot the first four or five and then you won't shoot them because they are too clever, if they see your bakkie [car] or anything they just run away. (F08)

Conversely, one farmer believes that shooting is ineffective at deterring baboons because baboons (as any animal) do not recognise and associate an activity with death.

If an animal sees another animal dead by a waterhole he will still drink the water, whereas a human would recognise that the water killed the animal and wouldn't drink it… they just don't recognise the risk of injury or death. (F16)

This farmer spoke of when his father shot a baboon and broke its shoulder, but later that day the same baboon was in the crop fields again. Studies show that conflicts do recur in the same location after the removal of a few individuals, as well as after the removal of more than just problem individuals (Treves & Karanth 2003). Killing appears to provide only a temporary measure before other animals take up the activity or adjacent animals move into the vacated area (Altmann & Muruthi 1988; Osborn & Hill 2005); primate socio-ecology suggests that when prime resource-rich habitats are vacated, as would be the case in control shooting, removed individuals are quickly replaced (Osborn & Hill 2005) – also recognised by this farmer:

> *You can't kill all the baboons, it's like any problem animal, you can't kill all of them, you're not able to because they just keep coming in and coming in, others will move into their territory, so you cannot keep shooting it, it won't work.* (F15)

One farmer stated that the effectiveness of shooting is dependent on the availability of natural food (the influence of which is discussed in Chapters 3 and 5):

> *Baboons are very clever, so if you do shoot them, sometimes they stay away for a week or two, and then they'll come back. But like now, when they're so adamant, it's really dry, you'll shoot one every day and they'll just keep on coming back, because they don't have another choice, because they have to eat.* (F01)

As there are no systematic studies on the effectiveness of shooting as a crop raiding deterrent, there is no evidence to back up this theory. However, given the significant increase in raiding as natural vegetation availability decreases (Chapter 5, section 5.3.3) it is logical that shooting would keep animals away for longer when there is plenty of other food available, but baboons would be more persistent when there is less to eat.

Farmers do not always 'shoot to kill' but rather 'shoot to scare'; using guns to generate shots in the air as a method to scare animals away (Studsrød & Wegge 1995; Sekhar 1998). This rhetoric was used by some of the study farmers. According to these farmers, shooting causes baboons to be more 'skittish' to sounds and more afraid of humans.

> *Shooting helps, it's effective. If you shoot a baboon… they are much more sensitive to sounds, so any small sound or something will chase them off, even if it's not your vehicle, they'll hear something and take off, so they're much more skittish.* (F01)

> *You'll frighten them for a while, the main thing is that they associate a human being with a gun, so when they see a human they run… if you shoot every now and then, yes, then the guard also, when they see him they run.* (F09)

> *If I see them close to the field I just shoot a few shots into the bush, to try and scare them, it will keep them away for about a week or two, but then they come back again.* (F08)

Non-lethal shots act more as a noise deterrent than a lethal method of control, the effectiveness of which is evaluated is section 8.3.1.2. The reason given for non-lethal shots being ineffective is that the farmers would have to be in the fields all day, which they do not have time for.

> *The thing is you can't be there all day, you'll chase them now and they'll see you leave and they'll just come back, so it doesn't work at all – shooting them doesn't work.*
>
> (F15)

> *Shooting [doesn't really work], because you shoot maybe one and then 50 go out, but in two hours' time they will be back. So you have to be there all the time.* (F16)

> *They are clever, they will see when there is nothing going on, when there is no one around and they'll always take a chance.* (A01)

In the study area, shotguns are used by the farmer themselves; field guards do not have access to their use. Given the concerns surrounding the use of bear bangers by field guards (section 8.3.1.1), providing the use of shotguns to guards would only be more inappropriate from the farmers' perspectives than bear bangers in this area. However, given the nature of the farmers' beliefs – that if farmers were available to shoot at raiding animals all day, then non-lethal shots would be more effective – this gives the impression that an accessory such as a bear banger would prove very useful in increasing the effectiveness of guards, who are present in the fields all day.

There are a number of disadvantages with the use of shooting as a control method. Shooting can be a costly venture and needs to be continued and regulated over a period of time (Osborn & Hill 2005); as stated by the study farmers, they do not have time to be at the fields all day. Animals can be injured rather than killed, which leads to ethical and animal welfare issues, and can also make the conflict situation worse – an animal that cannot forage naturally because of an injury is more likely to be reliant on easily obtained foods, such as crops (Imfene 2016). Shooting can disrupt the social networks of group living animals, resulting in increased stress and aggression levels (Pahad 2011). There are also demands from consumers that wildlife is dealt with using non-lethal techniques. Indeed, if commercial farmers want to export their crop from South Africa they have to be a member of a group called Global G.A.P. (Global G.A.P. 2016); this group requires problem wildlife to be dealt with in certain non-lethal ways. Baboons can also be very difficult to shoot.

> *I'd shoot 10 a day if I can… but it's not that easy.* (F02)

However, elimination of problem animals may facilitate public approval for the protection of the remainder (Treves & Karanth 2003) and may placate locals and deter them from illegal killing of wildlife (Treves & Naughton-Treves 2005).

During the mitigation workshop shooting was not deemed to be very successful:

> *Last week, at my house, the baboons came in [the crops], there's nothing there, I took the gun, three shots, they ran away, I was back in the house, not five minutes, everyone was back, so, scaring them is not going to work, even with a gun.* (F06)

At the workshop, the discussion quickly descended into a conversation about there being too many baboons in the study area, a subject that was discussed in Chapter 3, section 3.3.2. This suggests that shooting baboons gives the farmers a sense of control over the problem of there being too many baboons. Despite being used as a mitigation method, the rhetoric on shooting often involved farmers trying to control the numbers of baboons.

> *I shot 80 not so long ago… and the troop is just as big as it was a couple of years later… you just can't do anything.* (A01)

> *Most of the crop farmers shoot, it's no good not to shoot, then it will just get overcrowded.* (F02)

Shooting is therefore not likely to stop unless the baboon population is perceived by farmers to be under control and reducing. Given the sensitive nature of discussing the killing of wildlife, and the fact that it is an illegal activity in many of the areas it is carried out, it is very possible that incidences of shooting are under-reported (Marchal & Hill 2009). Interestingly, only five of the 10 (F02, F05, F12, F13, F16) study farmers that discussed shooting did so when asked what mitigation methods they use to protect their crops. All others revealed they shoot baboons during other parts of the interview. It may be that some farmers do not view shooting as a protective method – there are very different opinions as to its effectiveness – or those who did not list shooting as a deterrent method may not do so because they believe it to be illegal (Chapter 3, section 3.3.2).

Although not a deterrent method that I would encourage the use of, given the aim of the study in developing non-lethal methods of deterrent, there is nevertheless a need for further investigation into shooting, if only to determine how to decrease the frequency with which it is used as a deterrent method. The notion of 'shooting to scare' also warrants further investigation into providing field guards with accessories such as bear bangers.

8.4 Conclusion

In this chapter I have reviewed the deterrent methods that were perceived positively by farmers as potential deterrent techniques. I will trial three of these techniques in the following chapter, knowing that they fulfil the criteria of being socially acceptable to local commercial crop farmers. The crop raiding data presented in the previous chapters (Chapters 5-7) helped to direct these decisions and provided knowledge on what kind of methods need to be implemented on the study farm. The data also allowed me to investigate ideas that are viewed as inappropriate by study farmers, but perhaps because of misconceived ideas. For example, farmers believe that unresponsiveness to primate raids by guards is due to negligence, but the different response rates between the two primate species and the nature of primate raiding itself, suggests that it is more an issue of detection than negligence. Provided with this information, farmers might be more willing to trial the use of an early warning alarm system.

I have selected three deterrent methods for trialling: the use of bells as an early warning alarm system for vervet crop raiding; the use of a motion-activated acoustic device to repel baboons from crop fields; and erecting an electric fence around the crops to keep all wildlife away from crops.

Two further methods that will not be trialled in the following chapter, but nevertheless warrant further investigation, were also discussed. The use of buffer zones became an interesting method to investigate after the analysis in Chapter 7, section 7.3.2 showed that crops buffered on all side by other crop fields received very little damage. Trialling this method would likely require lengthy consultation with farmers as clearing land or altering planting strategies to leave buffer fields fallow would require permission and cooperation from farmers. I also believe that the use of shooting as a deterrent method requires further investigation, both through a 'shoot to scare' method, which could be implemented via a technique such as bear bangers, and a 'shoot to kill' method. I would not advocate the use of the 'shoot to kill' method, but rather, given the occurrence of problem baboon shooting in the area, further investigation could determine the reasons why it is so heavily used despite its perceived ineffectiveness, which in turn would reveal how to reduce its use in the area.

CHAPTER 9: MITIGATION TRIALS

9.1 Introduction

There is a growing literature that details and tests various strategies for reducing crop loss to wildlife (Ellins et al. 1977; Conover 1979, 1984; Nicolaus et al. 1983; Bomford & O'Brien 1990; Osborn & Rasmussen 1995; Thouless & Sakwa 1995; Belant et al. 1996; O'Connell-Rodwell et al. 2000; Gilsdorf et al. 2004; Parker & Osborn 2006; Webber 2006; Horne & Page 2008; Lucy E. King et al. 2009; Chelliah et al. 2010; Hedges & Gunaryadi 2010; Wallace 2010; Fairet 2012; Hill & Wallace 2012; Kaplan 2013). Nevertheless, there are very few studies investigating mitigation techniques aimed at deterring primates from raiding commercial crop farms. As such, the aim of this final chapter is to trial three mitigation techniques for protecting commercial crops from raiding primates.

In Chapter 5, data on field guarding revealed a very low detection frequency for vervet crop raiding. Inability to detect crop raiders has also been reported to reduce the effectiveness of guarding in other areas (Warren 2008; Wallace 2010). Early warning alarm systems can alert guards to the presence of raiding (O'Connell-Rodwell et al. 2000) and have been proven effective elsewhere (Sitati & Walpole 2006). Osborn & Parker (2002) used cow bells to increase farmer detection of elephants entering crop fields from 42% to 67%, while Hill & Wallace (2012) found farmers were effectively alerted to the presence of crop raiding primates with the use of bells attached to a net fence. I will use cattle bells attached to existing crop fences to determine the effectiveness of bells as an early warning alarm system on increasing the response frequency of guard reactions to vervet raids.

A number of farmers in the study area either currently use or have tried using a gas gun as an acoustic repellent to raiding wildlife, with little success. Numerous studies have also shown the gas gun to be ineffective at deterring wildlife for any length of time (Belant et al. 1996; Harris & Davis 1998; Gilsdorf et al. 2004). However, when discussing this technique at the mitigation workshop, various adaptations were suggested in an attempt to improve the effectiveness of the gas gun. The first was to include a motion-detector, so that sounds are played only when crop raiders attempt to enter the farm. Motion-activated explosions reduce habituation by being less predictable (Belant et al. 1996). The second adaptation was to include a variety of sounds, rather than just a gunshot sound as used in the gas gun. Playing a variety of sounds is likely to increase effectiveness as a deterrent (Bomford & O'Brien 1990). I will determine the effectiveness of a motion-activated acoustic deterrent using a variety of sounds, on reducing baboons raiding frequency, raiding duration and amount of crop removed.

Fencing is one of the most commonly used methods of crop protection, and electrical fencing is the most effective type of fence to do this (Sekhar 1998; Woodroffe et al. 2005; Wang et al. 2006; Warren 2008; Hayward & Kerley 2009). The high costs involved in electrical fencing often make it impractical to carry out controlled experiments (Thouless & Sakwa 1995). Although many crop farmers felt the electric fence was effective but too expensive (Chapter 8, section 8.3.1.3), one farmer in the study area had plans to erect an electric fence during the following field season. This coincided with my field work on trialling mitigation techniques, and so the effectiveness of this method was tested. Taking advantage of this situation, I will determine the effectiveness of an electric fence on reducing crop visits by all raiding wildlife.

An important part of testing the effectiveness of a new mitigation strategy is to determine what the measures of success will be (Bomford & O'Brien 1990; Osborn & Hill 2005). If success is determined by an increase in tolerance from farmers, effectiveness will need to be measured in a different way than if success is determined by a reduction in crop damage, through for example, interviews instead of crop damage assessments. The measure of success in the following trials is determined by the trial itself: the success of the early warning alarm system will be measured by a change in the response frequency of guards to vervet raids; the success of the motion-activated sound device will be measured directly by the amount of crop removed by baboons and indirectly through reduction in baboon raiding frequencies and durations (these have been shown to correlate positively with damage, Chapter 5, section 5.3.2); the success of the electric fence will be measured by a reduction in crop visit frequencies by all wildlife. The reduction in crop damage associated with each method will, where possible, be quantified into an economic saving made by the deterrent and compared with the cost of implementing and maintaining the mitigation method.

As described in the previous chapter, the techniques trialled were developed using the biological data collected on the nature and extent of primate crop raiding throughout this study, as well as results from interviews and workshops. All methods have therefore been discussed with local farmers, are feasible and locally acceptable, and, given their experience in farming with baboons, are considered by farmers less likely to fail than those tried before.

9.2 Improving Field Guarding: an Early Warning Alarm System

9.2.1 Methods

Study site

The early warning alarm system trial was conducted on a single crop field (A4) on Farm B (Figure 9.1a, see Figure 2.3 and Table 2.1 in Chapter 2, section 2.2 for the farm's wider location and crops grown in the area). The field was selected based on where crops were currently being grown and where vervets were known to cross the fence frequently to gain access to these crops. Butternuts were planted in January 2014 and harvesting was completed in June 2014. A pop-up hide was erected on a corner of the crop field, about 100 meters from the fence where bells were attached (Figure 9.1b). The location gave the observer a full view of the fence line, crop field and guard activities. Bells were attached to the top wire along 80m of the crop fence. 27 bells were used, spaced 3m apart. Short pieces of string were attached to the bells' clappers; these allowed the observer to 'turn off' the bells by tying tightly around the clapper, bell and fence (Figure 9.1c).

Experimental protocol

Data were collected for one month from 8 June to 6 July 2014. A two day on, one day off schedule was followed, resulting in 18 observation days. Observation days were split equally between 'bells-on' and 'bells-off' days. Bells-off days provided a control; bells-on days were selected at random, two days randomly chosen using a random number generator from every four consecutive days, to ensure an even spread throughout the trial period. This schedule ensured no seasonal effects interfered between control and experimental days. Bells were 'turned off' at the end of each observation session, as well as on observer off days, to ensure they did not ring when data were not being collected. Explanations were given to both farmer and field guard that bells were there to provide warnings of vervet entry and the guard should respond whenever she heard ringing. They were also told the bells would be switched on and off at random, so the guard should not rely on hearing the bells, but guard as normal.

Observations occurred for eight hours per day. Working hours were varied on a 06:00-14:00, 08:00-16:00 and 10:00-18:00 cycle, to ensure that all daylight hours were observed. Data

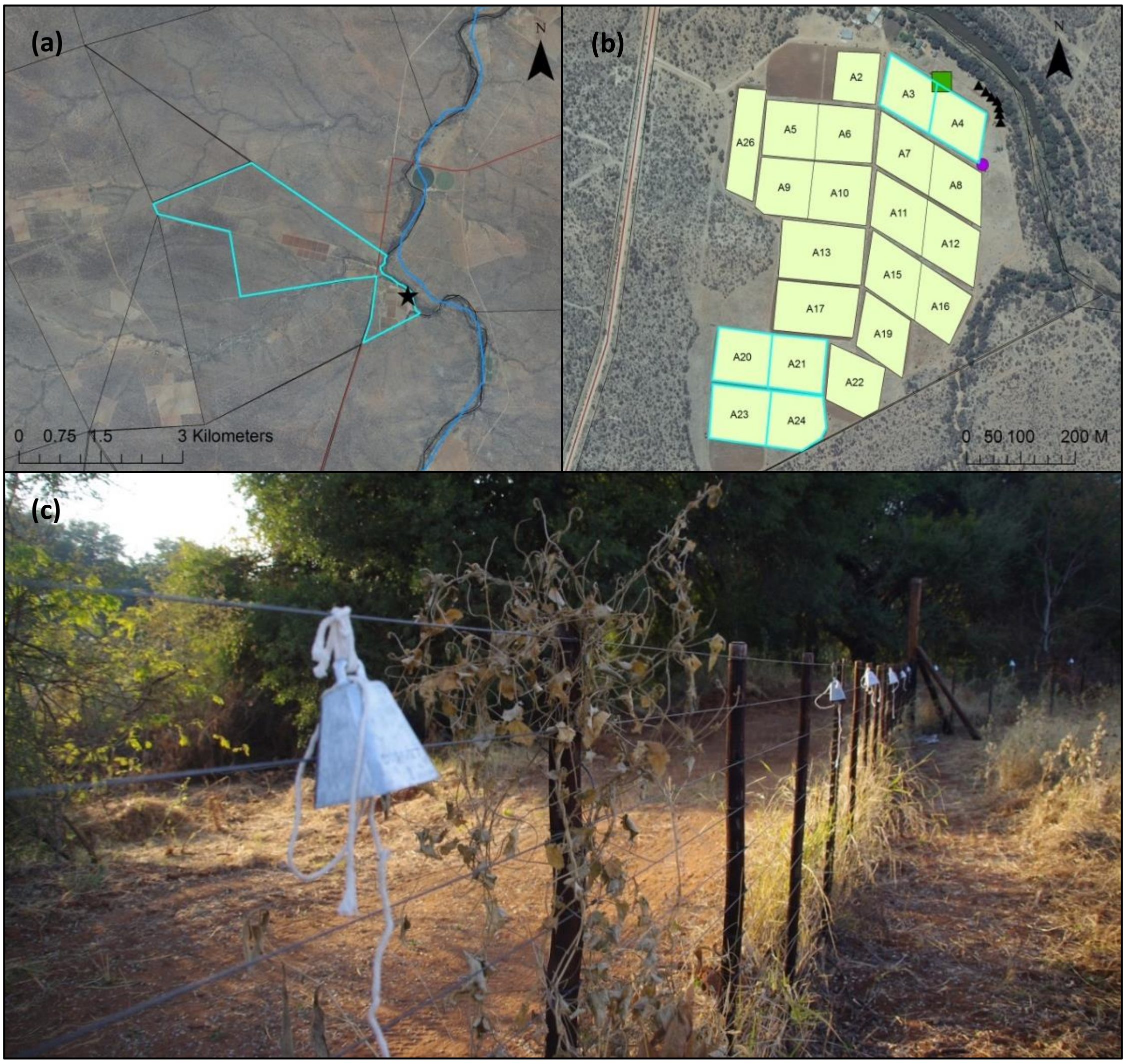


Figure 9.1: (a) Location of the early warning alarm system trial. The black star indicates the experimental site location; black lines demarcate farm boundaries, Farm L is highlighted in blue, red line shows the main road, blue line indicates the river. (b) Illustrates the set-up of the experimental site. The green square indicates the observer hide, purple circle the location of the guard activities, black triangles indicate where the bells were installed. Highlighted crop fields indicate those planted with butternuts at the time of testing; all other fields have no crops. (c) Set-up of bells attached along a section of the fence line.

collection and definitions followed the protocol for crop raiding behaviour (see Chapter 2, section 2.2.2.2). Videos were coded to provide information on duration of raid, number of raiding individuals, number of crop items taken from the field as per these methods, with the additional information of timing of bell rings, guard response to bells and guard response to raiding.

Data analysis

Guard response to vervet raids was tallied for bells-on and bells-off days (using raid as the sample unti). Statistical analysis was not possible due to the small sample sizes. Raiding behaviour and navigation around the bells are discussed using ad-hoc data from behavioural observations.

9.2.2 Results

27 vervet crop raids were recorded during this trial; 17 during bells-off days and 10 during bells-on days. A single raid occurred during the two-day training period, of which both days were bells-on days. Baboons were occasionally seen outside the crop fence, but were never observed entering the field during testing.

Do guards respond to more raids when bells are heard?

Of the 10 raids that occurred during bells-on days, bells were rung on five of these occasions. Unfortunately, on three of these raids the field guard was not visible to the observer, so it was unclear whether she responded to the bells or not. It cannot be assumed that because the guard did not become visible to the observer she had therefore not responded to the raid. As bells were always rung by vervets on their way out of the crop field (see below), the guard may have responded to the bell and seen the vervet leaving but subsequently not moved into the observer's sight because the animal had already left the field. On the remaining two occasions the guard reacted to the bells when they were rung. In contrast, on the 13 occasions that vervets raided during bells-off days, and the guard was visible to the observer, she did not respond to a single raid (Figure 9.2). Statistical analysis to test whether guards have a greater response frequency when bells are rung was not possible on these data, with only two occasions when bells were rung and the guard was visible.

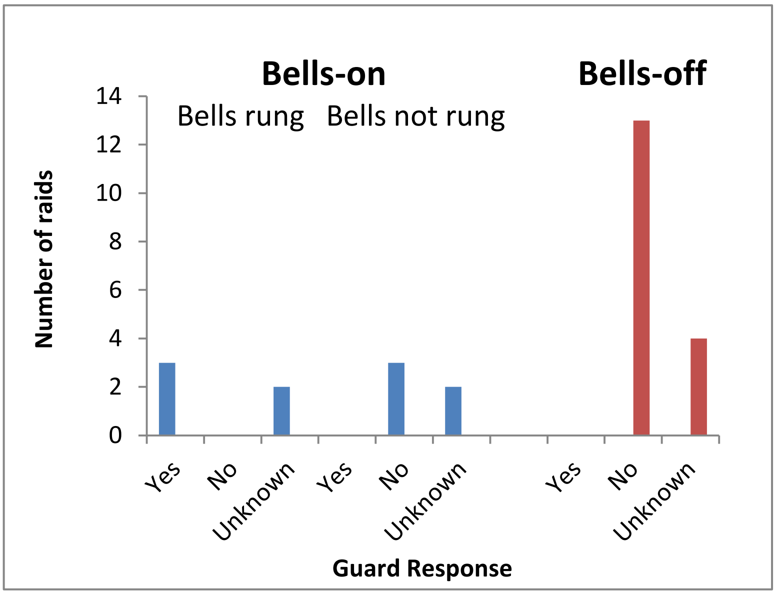


Figure 9.2: The number of raids to which the guard responded or did not respond, during bells-on day when bells were both rung and not rung (blue) and during bells-off days (red).

Do bells result in vervets changing their raiding behaviour?

During raids when bells were 'on' but did not ring (n = 5), vervets managed to navigate their way across the fence without ringing the bells. On every occasion when bells were activated (n = 5), this happened after the vervet had raided, when it was making its way out of the crop field. On these occasions the guard engaged in actively looking towards the vervet, but chasing was not involved as the vervet had already left the crop field. To cross without ringing bells, vervets did not necessarily enter through sections where bells were not present, although sometimes this occurred, but often crossed carefully lower on the fence (bells were only attached to the top wire), managing to cross without making a sound. It was not possible to test whether raid durations were shorter when bells were activated, because this only occurred after rather than before the raid had taken place and therefore no raids were chased.

9.2.3 Discussion: an early warning alarm system

The concept of an early warning system for detecting crop raiders seems a suitable method to improve field guarding within the study area. Although the sample size was small, when the alarm was triggered and the guard was visible, a response was seen on 100% of occasions. When the alarm system was off, not a single raid was responded to. Indeed, early warning systems have previously been shown as an important tool in alerting guards and subsequently reducing susceptibility to crop damage (O`Connell-Rodwell et al. 2000; Sitati et al. 2005).

The bells functioned as an alarm system – they rang when the fence was disturbed and could be heard by both the observer and the field guard at their respective locations. A concern with the bells was that if they were too light they would ring with the wind, but if they were too heavy they would not be activated by a smaller animal such as the vervet. Despite these concerns, cattle bells worked as desired – activated by vervets but not by the wind. However, bells did not turn out to be effective at providing an alarm system for vervet crop raiders. From the first day that bells were in position, vervets were able to cross the fence without sounding the ring. Vervets are very cautious raiders, spending a noteworthy amount of time paying attention to what is happening on the farm before they raid (personal observation). This cautious attitude on entering crops, which is abandoned for a more hurried exit, is probably the reason why bells were only activated (if they were activated at all) post-raiding. Since the bells were attached to the top wire of the crop fence this may have allowed vervets to pass through the lower wires without ringing the bells. A net fence, such as that used in Hill & Wallace (2012), may be more effective at causing the bells to ring from whichever section of the fence vervets use.

During the field season we briefly tried rearranging the bells, attaching three bells to each meter section of the fence (one on the top strand, one at the bottom and one in the middle). This arrangement was not trialled for long enough to warrant data analysis (due to time constraints, only six raids were observed), but the observer quickly became aware that the vervets relocated their point of entry into the field where bells were not attached to the fence. To trial this arrangement properly would have required a larger number of bells and more time in the field. Avoiding bells from the very beginning suggests that the novelty of the object combined with the risk associated with crop raiding activity may have played a part in vervets' avoidance of the bells. Furthermore, if three bells per meter of fence were effective at providing an alarm system, at a cost of ZAR61 per bell this system would cost ZAR183 (£10.24) per meter – more than three times the cost of the electric fence (see section 9.4). As such, bells may not be the answer for an alarm system in this context. Further investigation, perhaps with a more inconspicuous warning system such as a motion detector, might prove more effective as an alarm system.

9.3 Disruptive Deterrent: Acoustic Repellent Methods

9.3.1 Methods

Study site and group

The acoustic deterrent trial was conducted on Farm A (Figure 9.3a). This farm and three of its neighbours are crop growers (see Figure 2.3 and Table 2.1 in Chapter 2, section 2.2 for the farm's wider location and crops grown in the area). The farm manager believes that three baboon groups visit the farm, one of which frequently visits the waterhole where the experimental site was set up. This group was labelled Sylvester group, recognisable by a large male who had lost his tail (Figure 9.3b). There were occasional visits by one or more other unknown groups, but these visits were rare and brief. The experimental site was located just south of the crop fields (470m from the nearest crop field). A hide was constructed as an observation post at 35m from the baiting station (Figure 9.3c and d).

A full group count of the Sylvester group was not possible, but the group consisted of at least 26 individuals, comprising a minimum of one adult male, three adult females, one adolescent female, 11 juveniles and 6 infants. There were a further four individuals that were counted but not categorised, due to visual encounters not being sufficient to make a classification.

Provisioning protocol

One crate (54x35x25cm) of honeydew melons was placed at the bait site each morning, to create a small food patch that would act as a 'crop' for the purpose of this experiment. Provisioning continued until baboons visited the bait with a minimum frequency of three out of seven consecutive days (representing the average daily visit frequency of baboon crop raiding in the area, calculated from the crop raiding behaviour data, Chapter 5, section 5.3). A camera trap was set up about four meters from the bait site, which was used to determine the frequency with which baboons were visiting. Provisioning lasted for a period of 20 days (20 June – 9 July 2014), after which the criteria was met for baseline data collection to commence.

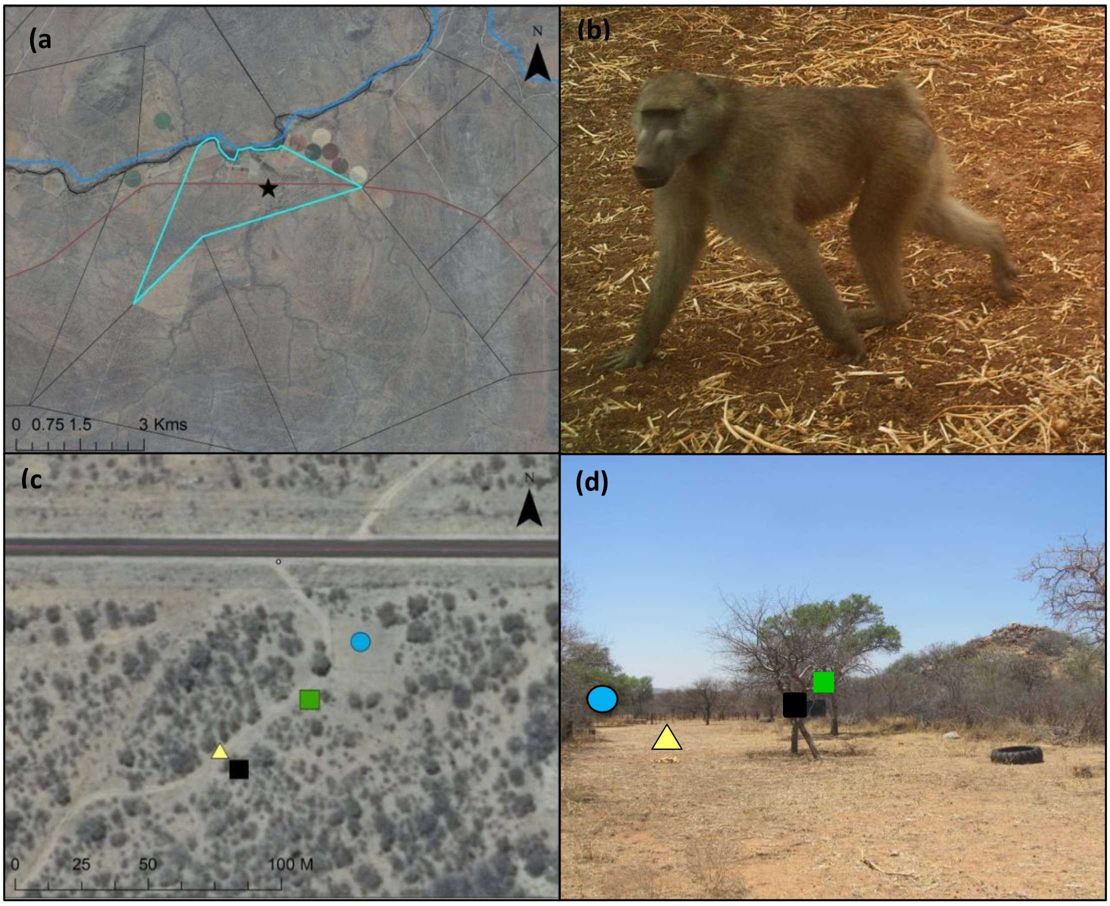


Figure 9.3: (a) Location of the acoustic experimental site. The black star indicates the experimental site location; black lines demarcate farm boundaries, Farm N is highlighted blue, red line shows the main road, blue line indicates the river. Nearby crop fields can be seen. (b)Large male that indicated the Sylvester group was present. (c) and (d) Set-up of the experimental site. The yellow triangle indicates the bait site, black square the camera trap location, green square the location of the observation hide. The blue circle shows the location of the waterhole.

Baseline protocol

Baseline data were collected on the frequency and duration with which baboons visited the bait site, and the amount of bait consumed, before any deterrent was put into place. The baseline protocol was conducted for six days (10 – 15 July 2014), between the hours of 08:00 and 15:00. One crate of honeydew melons were placed at the bait site each morning before observations started. A single observer collected data from their location inside the hide. Instantaneous scans were performed every five minutes, recording human noise or disturbance at the site, animal activity (including species, location, activity, and age and sex if known), and amount of bait remaining. Baboon visits to the bait were recorded with a video camcorder. The camcorder was set up for the view to encompass the entire food patch and as much of the surrounding area as possible (about 10m either side of the baiting station). Recording was started as soon as any baboon entered the camcorder's field of view (i.e. before the baboon reached the food patch), and was stopped when the last individual had left the field of view and at least one minute had passed without any baboons being visible on the camcorder. At the end of an observation day the amount of bait remaining was assessed (using five categories: 1 – no bait taken, 2 – more than half remaining, 3 – less than half remaining, 4 – scraps remaining, i.e. parts of melon remain but no whole melons are present, 5 – all bait taken); any left overs were removed from the site at the end of each session.

Experimental protocol

The experimental protocol was started immediately after the baseline phase was completed. The protocol was operated for 28 days (17 July – 17 August 2014, less four off-days), by which time habituation to the deterrent had occurred. During this protocol sounds were activated each and every time a baboon approached within one meter of the food patch. These were played by the human observer using an MP3 player connected to an SME-AFS Amplified Field Speaker on its loudest setting (5 watt amplified speaker), placed two meters from the hide. Four human-derived sounds (a gunshot, a car engine, a field guard shouting and a human conversation) were played in a random sequence using the shuffle function on the MP3 player. These were sounds that were regularly heard on the farm, and those which baboons most likely associate with humans. If any individual lingered within this predefined area, the sounds were played continuously until all baboons had left this space. Data collection occurred in the same manner as for the baseline protocol. Figure 9.4 outlines the three phases.

Provisioning Phase

One crate of fruit per day until baboons visit for 3 in 7 consecutive days. No observer

20 June – 9 July

↓

Baseline Phase

One crate of fruit per day. Observer, no sounds played.

10 July – 15 July

↓

Experimental Phase

One crate of fruit per day. Observer, sounds played when baboons visit until habituation.

17 July – 17 August

Figure 9.4: Outline of the acoustic deterrent experimental protocol

Data analyses

For the purpose of this analysis, a visit to the food patch (hereafter referred to as a raid) occurred each time one or more baboons were present within an arm's reach (approximately 0.2-0.5m) of the food patch. A raid started when the first individual reached this distance to the food patch and ended when the last individual left the patch; that is, when the last baboon was distant enough from the bait that he/she could no longer reach out and take a food item. The number of individuals participating in each raid was counted. Without being able to individually identify baboons, each and every visitor to the food patch was counted, whether it was the same individual twice or two different members of the group. The total time spent raiding and the number of individuals involved in raiding was totalled for each group 'site visit'. A site visit started when the first baboon was visible to the observer (or camera trap during the provisioning phase) and ended when the last baboon went out of sight and more than one hour passed (see Chapter 2, section 2.2.2.1) without sighting another individual.

The difference in the number of visits to the experimental site between the baseline and experimental phases was tested using a paired Wilcoxon rank-sum tests. Visit frequency data were compiled using the provisioning, baseline and experimental phase data, and started from the first day that baboons visited the food patch. For this analysis, data from the provisioning phase were included with the baseline data (there were no differences in number of visits per day between provisioning and baseline data, Wilcoxon rank-sum test: $n_{prov} = 14$, $n_{base} = 6$, $W = 42$, $P = 1$). Number of visits per day from the first day of sound activation were tested for an increase over time (for habituation) using Spearman's rank correlation rho. This analysis was repeated for the number of raids per day. However, data on the number of raids per day were not available via camera traps and therefore data during the provisioning phase were not included in this analysis.

Duration data were analysed from the baseline and experimental phases, but not from the provisioning phase, and only included days on which there was a visit from the Sylvester group. Visits from other groups were not included as it was unknown how many times they had previously been subjected to hearing the sounds, and therefore habituation could not be assessed. Difference in duration of visits at the experimental site between the baseline and experimental phases were tested using a Wilcoxon rank sum test. Total durations per day from the first day of sound activation were tested for an increase over time (for habituation) using Spearman's rank correlation rho.

Bait removal data were analysed from all three phases, and Wilcoxon rank sum tests were performed to test for differences in the amount of bait removed between the baseline and experimental phases. Two sets of data were used for this analysis. The first included all days throughout the trial on which bait was available to the baboons; the second data set included only days on which there was a visit to the site from the Sylvester group. All statistical tests were performed in R (R Core Team 2014).

9.3.2 Results

Frequency and duration of visits

Baboons made significantly fewer visits to the experimental site during the period when sounds were being used as a deterrent (mean = 0.54 visits per day, SD = 0.56) than during the baseline period (mean = 1.00 visits per day, SD = 0.69; Wilcoxon rank-sum test: n_{base} = 20, n_{exp} = 28, W = 390.5, P = 0.011, Figure 9.5). There is a significantly positive correlation between days since the experimental sounds started and the number of visits to the site per day (Spearman's rank correlation rho: r = 0.431, n = 28, P = 0.022) however, indicating habituation to the sounds.

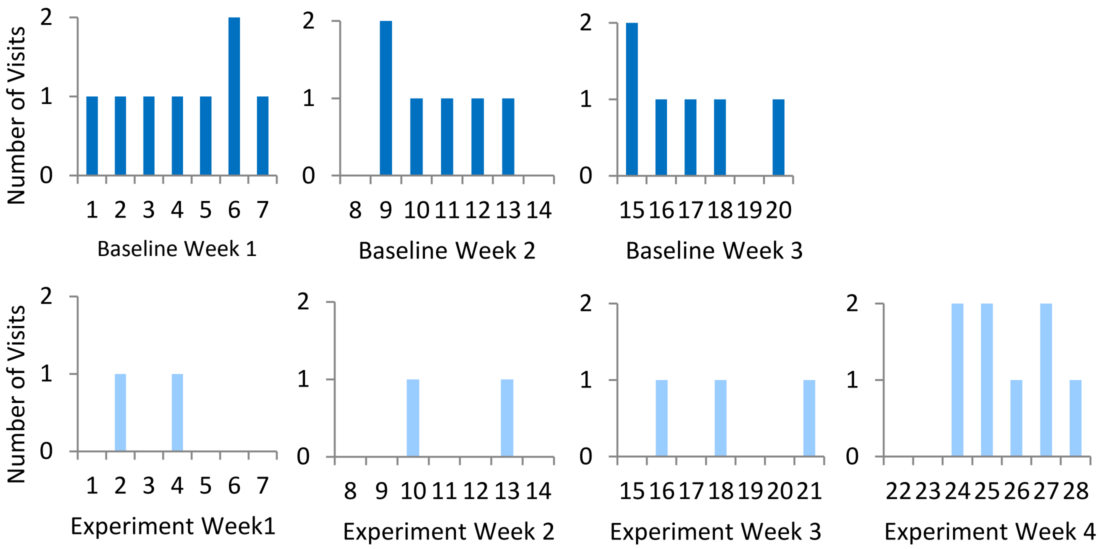


Figure 7: Distribution of the number of baboon site visits during both the baseline phase (dark blue) and the experimental phase (light blue).

The number of raids per day was not significantly different between the two phases (baseline mean = 13.67 raids per day, SD = 10.67; experiment mean = 8.54 raids per day, SD = 12.79; Wilcoxon rank-sum test: n_{base} = 6, n_{exp} = 28, W = 114.5, P = 0.147, Figure 9.6). Nevertheless, there is a significantly positive correlation between days since the experimental sounds started and the number of raids per day (Spearman's rank correlation rho: r = 0.380, n = 28, P = 0.046), again indicating habituation to the sounds.

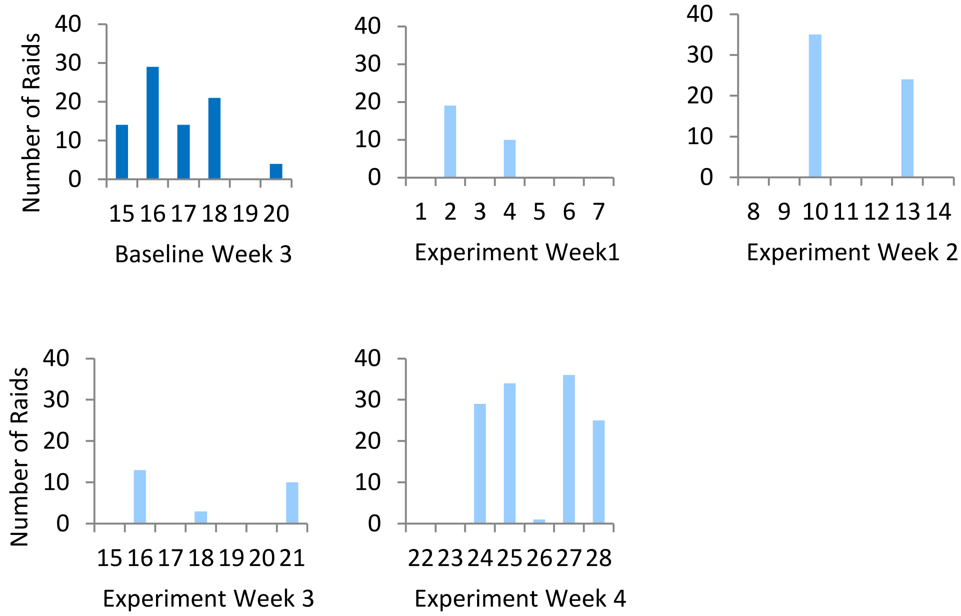


Figure 8: Distribution of the number of baboon raids during both the baseline phase (dark blue) and the experimental phase (light blue).

When baboons visited the site, the visit duration did not significantly change between the baseline (mean = 44.2 minutes, SD = 24.4) and experimental phases (mean = 71.6 minutes, SD = 33.7; Wilcoxon rank sum test: n_{base} = 5, n_{exp} = 12, W = 14, P = 0.104). There was no significant correlation between visit duration per day and days since the experimental sounds started (Spearman's rank correlation rho: r = 0.329, n = 12, P = 0.297). There was also no significant change in raid duration per day between the baseline (mean = 10.1 minutes, SD = 9.5) and experimental phases (mean = 28.5 minutes, SD = 26.7; Wilcoxon rank sum test: n_{base} = 5, n_{exp} = 12, W = 18, P = 0.234). There was no significant correlation between raid duration per day and days since the experimental sounds started (Spearman's rank correlation rho: r = 0.413, n = 12, P = 0.185). Figure 9.7 displays the distribution of visit and raid durations across the trial on days that baboons visited the experimental site.

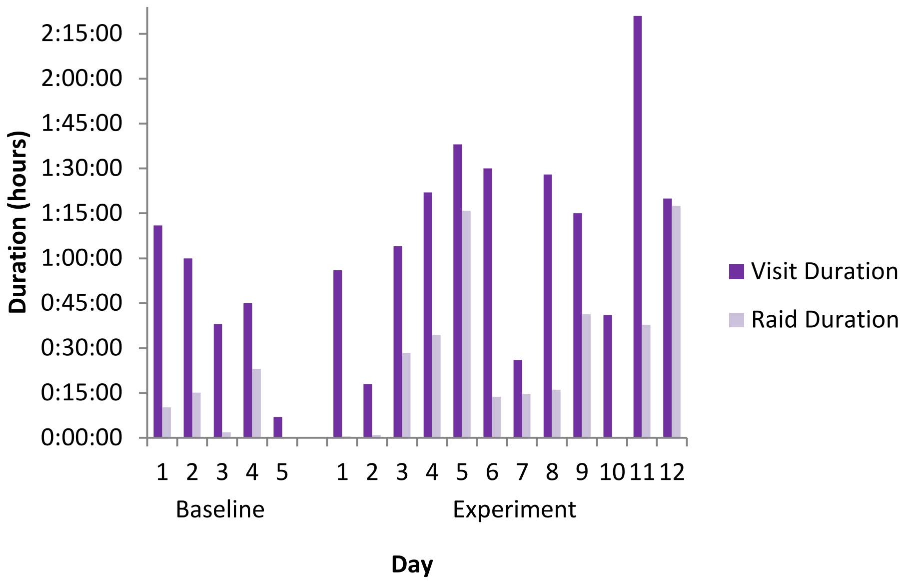


Figure 9: Distribution of the duration of baboon visits (dark purple) and raids (light purple) for each day baboons visited the site, during the baseline and experimental phases.

Bait removal

There was significantly less bait taken when sounds were used as a deterrent than during the baseline period (Wilcoxon rank sum test: n_{base} = 17, n_{exp} = 28, W = 356, P = 0.003, Figure 9.8). There was also a significant positive correlation between days since the experimental sounds started and the amount of bait taken (Spearman's rank correlation rho: r = 0.401, n = 28, P = 0.034), indicating habituation to sounds.

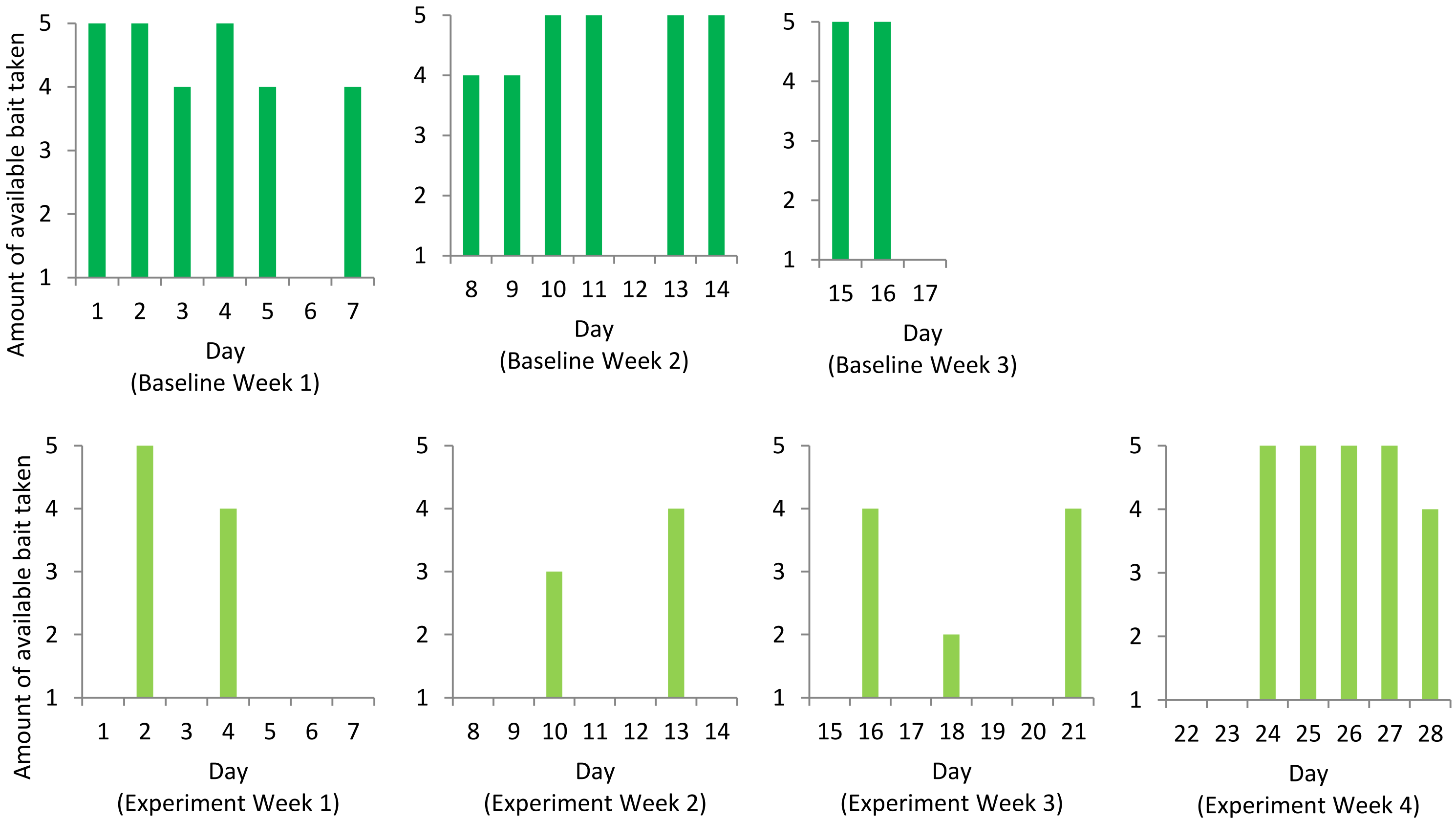


Figure 10: Amount of available bait that was eaten by baboons for each day of the trial (by category: 1 - no bait taken to 5 - all bait taken), for baseline (dark green) and experimental (light green) phases.

However, the amount of bait consumed on days when the experimental site was visited did not differ significantly between the baseline and experimental phases (Wilcoxon rank sum test: $n_{base} = 12$, $n_{exp} = 12$, W = 89, P = 0.288, Figure 9.9).

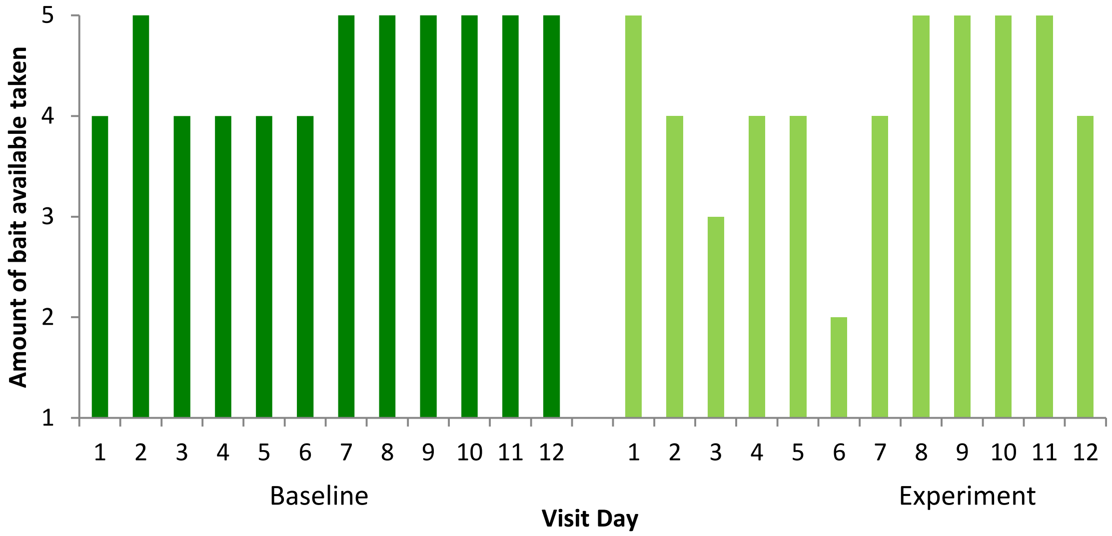


Figure 11: Amount of available bait eaten by baboons for each day they visited the site (by category: 1 - no bait taken to 5 - all bait taken), for the baseline (dark green) and experimental (light green) phases. NB. First two days of baseline data were removed for equal sample size.

9.3.3 Discussion: acoustic repellent method

The use of sounds as a deterrent method had a significant effect on the frequency with which the Sylvester group visited the site. During the baseline period, the group visited on 17 out of 20 days when bait was available (85%); this was reduced to 12 out of 28 days during the experimental phase (43%). A reduction in visit frequency equates to a reduction in crop loss – when including all experimental days in the analysis the amount of bait removed was significantly reduced during the experimental phase.

When baboons did visit the bait site during the experimental phase the number of raids per day actually increased. This is due to the nature of the 'raiding' that occurs. Prior to the experimental sounds being played, the baboons were relaxed at the site and spent time sitting and eating directly at the bait. When sounds were played however the raids initially (until the baboons habituated to the sounds) became 'grab and run' raids, where the baboons ran in, grabbed a food item and immediately ran away. This resulted in a higher number of shorter raids once the sound trial had started. This likely accounts for the non-significant result when testing the difference in the number of raids per day between the two phases (the mean number of raids per day during the experimental phase is lower than the baseline phase because this takes into account all the days when there were no visits, and therefore no raids, to the bait site).

Ad-hoc data collection showed that during the baseline period, raids most often involved individuals casually approaching and lingering at the food patch until they were ready to leave. The dominant male was usually the first to arrive at this limited resource and would protect the food patch against all others, until he was ready to leave. Arrival order to supplementary food patches predicated on dominance was also shown by Kaplan et al. (2011). A few individuals from the Sylvester group would make a grab and run attempt at retrieving a food item, but more often than not would be chased away by the dominant male. Once the male moved off, others would approach and only then would more than one individual be seen within the bait zone. When sounds were put into place as a deterrent, arrival order predicated by dominance was no longer apparent. The deterrent initially triggered fear in all individuals, including the dominant male; instead of spending time at the food patch, all individuals made 'grab and run' raids. The lack of a dominant male on the bait allowed more individuals to access the food, but the sounds did not stop the bait being taken. Grab and run raids continued until all the bait was finished. The duration of visits to the site and the amount of bait that was removed when a visit took place was no different than before the sounds were played. The use of human-derived sounds therefore had no significant deterrent effect on 'crop damage' when the Sylvester group were at the experimental site.

It did not take long for baboons to habituate to the sounds, to the point where it no longer affected even their frequency of visits. Baboon habituation to sound deterrents has been shown before (Biquand et al. 1994), as has habituation to sounds by other wildlife (Bomford & O'Brien 1990; Koehler et al. 1990). The trial was stopped after the baboons returned to their baseline frequency of visiting at least five out of seven consecutive days. This occurred on the 24^{th} day after the experimental phase commenced, suggesting that the sounds were effective as a deterrent for about a three week period. Unfortunately the Biquand et al. (1994) sound trial on baboons did not report time to habituation, so comparisons cannot be made.

There are a number of suggestions that could improve the effectiveness of this deterrent; including regularly moving the sound source, supporting the sounds with additional methods, such as other sensory deterrents, or reinforcing the sound with real danger (Bomford & O'Brien 1990; Biedenweg et al. 2011). Combining a motion detecting sound device such as this with a field guard would not only reinforce the sounds with real danger, but would also provide the guard with an effective alarm system for when any animal is entering the crops. Furthermore, the device could be used only in the dry season, when crop raiding is particularly intense, so that baboons do not habituate to the device year-round. This kind of device is not currently available on the market, so the cost of such a device is unknown. To cover an area as large as these commercial farms, a number of the devices may be required, depending on the range of the motion-detector and the sound output. The amount of power required would also depend on the frequency with which the device is activated. Further investigation into creating and costing such a device is required.

9.4 Barrier: Electric Fence

9.4.1 Methods

Study site and group

The electric fence trial was conducted across two years on Farm B (Figure 9.10a). In the 2013 crop season – prior to the electric fence being erected – the field A16 was selected for camera trap data collection based on farmer reports of it being the most raided field where crops were grown at the time. The electric fence was erected around the whole of block A (shown in Figure 9.10b) prior to the 2014 crop season. For the 2014 crop season, camera traps were moved to field A12; crops were not grown in A16 during this time and A12 was the nearest field with crops (Chapter 7, section 7.3.1 actually shows that field A12 sustains more crop damage than A16 during the 2013 period). The two fields were situated side by side and covered an area of one hectare each, roughly 100x100m (Figure 9.10b).

The Buttercup group – recognised through a GPS collar on one of the adult females (Figure 9.10c) – were frequent visitors to these fields, although it is not certain that they were the only group to visit. A full count of the Buttercup group revealed the group consisted of 123 individuals.

Experimental protocol

Camera traps (Bushnell 2010 Trophy Cameras) were used to collect data on frequency of visits for both wildlife raiders and human activity on the farm, following the camera trap protocol set out in Chapter 2, section 2.2.2.2. Five cameras were positioned along A16's edge during the 2013 crop season, from 26 May to 30 June 2013, before the electric fence was erected. Butternuts were planted in this field from February to August 2013. After the electric fence was erected, five camera traps were positioned in A12 from 3 October to 7 November 2014. Tomatoes were planted in this field from August to December 2014. During both years cameras were operational for 36 trap days each.

An electric fence was constructed around the crop fields (Figure 9.10b) from 14 September to 30 September 2014, and was switched on 2 October 2014. 2.5km of fence was erected around all crop fields. The height of the fence was 2.4m, consisting of 23 wire strands spaced 10cm apart

(Figure 9.11a). Specifications were as follows: five electrified wires at the top, each separated by a non-electric wire – preventing primates from climbing over the fence (Figure 9.11b); one electrified off-set wire in the middle of the fence, at a 45° angle to the rest of the fence – preventing animals such as leopard and caracal entering (Figure 9.11c); three electrified wires at the bottom of the fence, each separated by a non-electrified wire, at a 45° angle to the fence. The bottom electrified wire is placed very close to the ground, preventing anything from digging (Figure 9.11d). The fence is not buried into the ground. Metal droppers are spaced 3m apart.

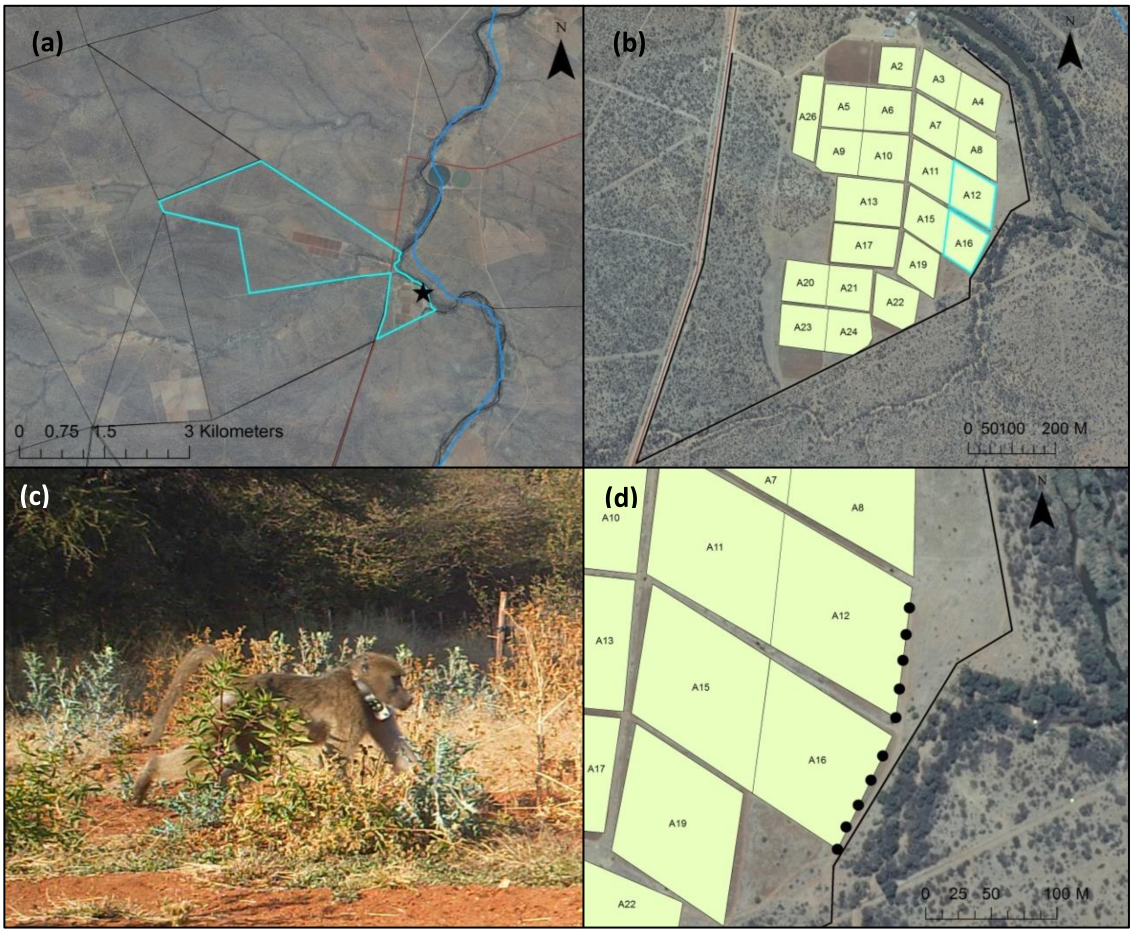


Figure 12: (a) Location of the electrical fence experimental site. The black star indicates the experimental site location; black lines demarcate farm boundaries, Farm L is highlighted in blue, the red line shows the main road, and the blue line shows the river. (b) Location of the electric fence (thick black line) and the two experimental crop fields (highlighted in blue). (c) Collared adult female that indicated the Buttercup group was present. (d) Location of the camera traps (black circles) along the edge of each crop field. All cameras faced north/north-east along the crop edge.

Data analyses

Number of field visits were calculated for each species that was recorded in either or both years. Wilcoxon rank-sum tests were performed on each species to establish significant differences in visit frequencies between years.

Figure 13: (a) Fence is 2.4m high. (b) Five electrified wires at the top (identified by the black plastic insulators on the droppers), each separated by a non-electrified wire. (c) One electrical wire offset at a 45^{o} angle to the fence. (d) Three electrified wires at a 45^{o} angle to the fence, each separated by a non-electrified wire.

9.4.2 Results

The electric fence significantly reduced visits to the crop fields by almost all crop raiding wildlife, with most species undergoing a 100% reduction in visits (Table 9.1). Visits from banded mongoose and honey badger were reduced, but not significantly so – probably due to the small number of visits by these animals overall. The number of visits by scrub hare and helmeted guineafowl did not significantly increase from 2013 to 2014. There was no change in the number of visits between years for the African civet.

Table 9.1: Frequency of wildlife visits at the electrical fence experimental site for 2014 compared to 2013.

Species and species group	Visit Frequency 2013	Visit Frequency 2014	Frequency Difference	% difference	W	P Value
Baboon	20	0	-20	-100	936	<0.001
Vervet	43	0	-43	-100	1098	<0.001
Primates	63	0	-63	-100		
Bushbuck	119	10	-109	-92	1207.5	<0.001
Porcupine	15	0	-15	-100	864	<0.001
Scrub hare	0	2	2	+100	612	0.160
Other wildlife	134	12	-122	-91		
Francolin	12	4	-8	-67	804	0.013
Helmeted guineafowl	0	2	2	+100	612	0.160
Birds	12	6	-6	-50		
African civet	1	1	0	0	648	1
African wild cat	12	0	-12	-100	846	<0.001
Banded mongoose	2	0	-2	-100	684	0.160
Small spotted genet	8	0	-8	-100	774	0.006
Honey badger	1	0	-1	-100	666	0.331
Carnivores	24	1	-23	-96		
All species	233	19	-214	-92		

9.4.3 Discussion: electric fence

The results suggest that the electric fence deterred both primate species from visiting the crops, as well as most other wildlife. Despite there being no crop entries, there were reports from the farmer of both baboons and vervets outside the electric fence on a number of occasions during the 2014 camera trapping period. At the time of writing (August 2015), the farmer reported that the baboons tested the fence and found two locations that they were able to enter, but once these areas had been fixed the baboons were no longer able to get into the crops. After this they saw primates at least twice a week, but they did not come into the fields. He reported no damage by baboons or monkeys to this crop.

During the 2013 pre-electric fence period, behavioural observations of primate crop raiding estimated that 628 butternuts were removed from this one field by primates during the 36 day period (derived from data in Chapter 5, section 5.3.1). This is equivalent to 78 bags of butternuts, which at the time of harvest were sold for an average of ZAR35-40 per bag, equating to at least ZAR2,730-3,120 in primate damages. Since there were no primate entries into the crop field during 2014 this represents a significant saving.

The fence also prevented porcupine from entering, as well as keeping out most carnivores. Although the fence did not completely exclude bushbuck, it did reduce crop visits from this species by 92%. Bushbuck were able to access the crop via a gate near to the farmer's house, an entry point which primates would not use given the proximity to human habitation. There were no bushpig or warthog entries recorded in either period, despite these two species being jointly ranked as the worst crop raiding species by one of the farmers on this farm (Chapter 6, section 6.3.1). However, during the full 2013 camera trapping observation period (March to September, Chapter 6, section 6.3.2) there were 14 crop entries by bushpig and warthog, indicating they are a raiding species. There were no occurrences of raiding by these species during the 2014 trial, and the farmer reported no further raids by these animals up to the time of writing. The fence was not able to exclude the two bird species – francolin and helmeted guineafowl – from the fields, although it did appear to reduce the number of visits by francolin. Scrub hare and African civet were not excluded by the fence, although their numbers of visits were very small.

The electric fence cost ZAR140,000 (ZAR56 per meter) to install, and electricity and maintenance is estimated at R5,360 per year. During the 2012/2013 crop season, the farmer estimated around R19,000 of wildlife crop damage (2-3% of crops, Chapter 6, section 6.3.1) within the fields now enclosed by the electric fence. With the electric fence in place, the farmer estimated damage to these crops at 0.28%. This equates to a reduction in sustained damage to R1,773-2,660 per year, and therefore an estimated increase in crop value of R16,340-17,227 per year. In addition, the use of an electric fence means that workers do not have to be paid to guard fields, this equates to a further saving of R95,000 per year. Taking into account annual damage reduction, elimination of guarding fees and electricity and maintenance costs, the use of an electric fence is estimated to make savings of around R106,000 per year. Although the initial outlay of costs to install an electric fence are high, at these rates it would take less than two years for the fence to pay for itself. Further investigation is required into the values of the variety of other crops grown in the study area, to obtain estimates on the pay-back rate of erecting electric fences around other crop types.

However, a number of differences between the two survey periods may have impacted these results. Although a different field was surveyed in 2014 (A12), this is unlikely to have had any effect. The two fields are situated side by side and share most of the same attributes. A12 was situated a little further from the fence than the 2013 field (A16), but only by 20m at the minimum distance. Both primates were observed in A12 during the 2013 season, which in fact received more damage than A16 during this period (Chapter 7, section 7.3.1). Different crops were planted during each survey – in 2013 butternuts were grown, while during 2014 tomatoes were planted, which could affect raiding frequency if wildlife have crop preferences. However, baboons were observed feeding on both butternuts and tomatoes within the study area, and given that, at the time of each survey, there was only one crop type present, it is unlikely that a possible preference affected the frequency with which they visited the fields.

A more likely factor to affect the results was the time of year that surveys were done. The 2013 survey was carried out during May and June, a particularly dry period, while the 2014 survey was done during October and November, which was not as dry. Many studies have shown that baboons raid more when it is dry and natural food availability is low (Sekhar 1998; Kagoro-Rugunda 2004; Hockings et al. 2009; McLennan & Hill 2010; Nyirenda et al. 2011; Lemessa et al. 2013), a point on which most of the farmers in the study agreed (Chapter 4, section 4.2.2). It could therefore be argued that the reduction in raiding is not a function of the presence of the electric fence, but rather a function of environmental factors. However, further reports obtained from the farmer after having subsequently been through the dry season indicate that there was no further raiding by baboons within the electric fence. Furthermore, baboons have been spotted outside the fence and were not able to get into the crops.

There are a number of disadvantages to the electric fence, other than its high cost. Firstly, the use of an electric fence can result in deaths of a number of species through unintended electric shock (Burger & Branch 1994). A number of animals have been found electrocuted to death around electric fences in the study area – the farmer reported a number of deaths at this site including an African python, leopard tortoise and an impala. However, if the right specifications are followed, such as those laid out in Kaplan (2013), these unnecessary deaths can be avoided (Professor Justin O'Riain, personal communication). Kaplan's specifications include a fence height of 2.4m with 15 electrified strands, the lowest of which is 0.015m above ground. The lowest electrified wire on the study fence was not positioned low enough to deter animals such as tortoises from going underneath, however, neither was it high enough for these animals to pass under without getting shocked.

Secondly, the electric fence affords no protection to the crops when there are power cuts. Load shedding (interrupting the supply of power in some areas to meet demands in other areas) is a common occurrence in South Africa. Crops can be particularly vulnerable during these times when fences are not electrified, especially when guards have been removed from the fields. The use of solar power may avoid these issues and would also lower the cost of powering the fence.

9.5 General Discussion

It has been suggested that deterrent methods work better in combination with one another, and are unlikely to be effective when used alone (Naughton-Treves 1998; Treves & Karanth 2003; Peterson et al. 2004; Zimmermann et al. 2009). In line with this, the outcome of these mitigation trials suggest that the techniques tested may indeed work better if used in combination.

The use of bells as an early warning alarm system is clearly not an efficient method of increasing field guard detection of vervet crop raiders. However, these trials did not rule out the use of an alarm system altogether, a technique which could increase guard response frequency and consequently decrease vervet crop damage. A more appropriate alarm system is likely to be one that is more inconspicuous than bells attached to the fence, so that it is more difficult for vervets to circumnavigate setting off the alarm. A motion-activated acoustic device could be used as an inconspicuous early warning alarm system. As suggested in the discussion of the acoustic device, the device itself would work better if coupled with a separate method that reinforced the sounds with real danger, such as combining the device with field guards. This would not only increase effectiveness of the device by reinforcing the danger with guarding, but would also increase the effectiveness of guarding. It would both increase detection frequency by providing an early warning alarm system and increase the perceived fear of the guard, who would become associated with the sounds. Perhaps a combination of these methods and the use of a guard accessory such as the bear banger (see Chapter 8, section 8.3.1.1) would prove a sufficient combination to keep primates out of crop fields. Further investigation on a combination of these techniques is required to determine this.

The use of an electric fence appears to be effective at keeping most crop raiding wildlife away from crops. Electrical fencing has rarely been recommended for crop protection because its high cost renders it unfeasible as a mitigation method for subsistence farmers (Osborn & Hill 2005). Commercial crop farmers however do not have the same limitations. Although the start-up costs are very high, the savings made through the protection of large areas of high value crops on commercial farms make the electric fence a feasible long-term solution. Many of the commercial farmers in this study were concerned about the high costs of installing an electric fence, but with the potential that they underestimate their crop losses (Chapter 7, section 7.3.1) these opinions may change given accurate estimates of their crop losses. Some study crop farms already use electric fencing, but with little success. This suggests that recommendations on the correct specifications for using electric fencing to protect crops from wildlife needs to be published and made available for these farmers.

However, albeit very effective, the electric fence does not exclude all wildlife; it cannot prevent birds from entering crops. Once again a combination of methods is required. As discussed in Chapter 6, section 6.4.2, the use of a deterrent method such as scarecrows may prevent crop damage from birds. Although not sufficient at deterring primates, it may be effective at deterring birds, particularly if a pop-up mechanism or noise maker was included (Marsh et al. 1992; Gilsdorf et al. 2004; Richardson 2014). Again, further investigation is required to determine the combination of these techniques.

CHAPTER 10: DISCUSSION

10.1 Introduction

The overall aim of this thesis was to identify, implement and assess a number of mitigation strategies to prevent baboons from raiding commercial crop farms. Here I present a summary of the main research themes and the assessments of the mitigation methods trialled to suggest a number of recommendations for mitigative purposes and future research.

10.2 Main Findings

10.2.1 The farmer-baboon relationship

Ambiguity and uncertainty

People's attitudes toward nature are complex, and are rarely as simple as being positive or negative (Dietz et al. 2005 Hurn 2005; Loudon et al. 2006; Campbell-Smith et al. 2010; Goldman et al. 2010). The farmer-baboon relationship in Blouberg Municipality is no exception. Many aspects of the baboon fill farmers with conflicting emotions: baboons' intelligence is both respected and criticised; their human-likeness makes them entertaining to watch but at the same time assigns moral obligations to baboons which cannot be kept; they belong in the environment, but elicit anger when found on the farm; they feed on crops when there is little natural food availability because they are hungry, but also because foraging on crops is easy and they are lazy.

Many of these ambiguous and uncertain emotions can be explained through Mary Douglas' theory of 'matter out of place' (Douglas 1966). Dirt is matter out of place and therefore a product of the social understanding of environmental order: *"shoes are not dirty in themselves, but it is dirty to place them on the dining table"* (page 37). Indeed, this is how society defines problem animals, "*much as we may define a weed as a plant in the wrong place… so some animal pests too are only pests when in inappropriate numbers or in the wrong context*" (Putman 1989, page 2). For the farmers under study, baboons are a problem within the realms of the crop farm, but out in the 'wild' they are appreciated and enjoyed.

Responsibility

Farmers take on some of the responsibility for the farmer-baboon conflict prevalent in the study area, as well as for certain baboon behaviours. They recognise that baboons belong in the environment, have a role to play, and should not be eradicated from the area. Farmers also identify that baboons were present in the area first – by moving into the area and starting to plant crops, farmers recognise that they essentially initiated the conflict. Farmers acknowledge that an increase in the local baboon population (as they perceive it) is partially a result of their own crop farming activities. They also believe that their behaviour towards baboons directly affects baboons' behaviour, for example, persecuting baboons reduces baboon aggression towards people. This ownership of the problems with baboons suggests that farmers are likely to also take ownership of the solutions (Campbell & Mattila 2003).

Frustrations and concerns

One of the study farmers' biggest concerns, which was articulated throughout the study, was the size of the local baboon population. Most participants believe the population is already too big and is currently increasing and, furthermore, many desire the population to decrease, because baboons cause too much damage on their farms (Chapter 3, section 3.3.2). Unfortunately, there are currently no available data on the baboon population size within this farming community to be able to determine its size and trends. However, whether or not these beliefs are true, this concern needs to be addressed. If baboon numbers are expanding, or even only perceived to be expanding, then the problem animal status of baboons perceived by crop farmers will only get worse, and will ultimately lead to reduced tolerance by farmers and increased conflict with baboons.

Control appears to be another issue concerning commercial crop farmers in this study. Weather and insect pests can cause bigger limits to crop yields, but vertebrate crop raiding is the factor that concerns farmers the most in terms of what limits their yields. Weather is impossible to control and with current technology and the availability of many kinds of pesticides, insect pests are regarded by farmers as being easy to control. Wildlife crop raiding on the other hand falls ambiguously between the realms of something that can and cannot be controlled. The frustration over believing wildlife raiding *should* be controlled but not being *able* to do so probably keeps wildlife raiding at the forefront of farmers' minds.

With primates being the most difficult of wildlife crop raiders to control (Saj et al. 2001; Wang et al. 2006; Marchal & Hill 2009), it is no surprise that a lack of control over baboons was a theme present throughout interactions with farmers. Their intelligence and adaptability makes many deterrent methods inadequate (Strum 1994, 2010), and their organised raiding strategies make baboons extremely difficult to keep out of crops (Hill 2000). The belief of many farmers that they cannot legally 'deal with' problem baboons probably escalates the frustrations that farmers experience through this perceived lack of control (Hill 2004). This lack of ability to control baboons engenders a range of negative perceptions, leading to baboons being pesticised, viewed as deceptive and consequently lethal methods of retaliation being utilised (see also Fiallo & Jacobson 1995; Hill 2005; Warren 2008; Costa et al. 2013).

10.2.2 Wildlife crop raiders

Camera trap data revealed 20 wildlife species within the study area that visit crop fields and potentially cause crop damage (Chapter 6, section 6.3.2). Both the perceptions of raiding wildlife and observed wildlife crop raiding vary across the study farms.

Baboons appeared to cause most crop damage within the study area, as reported in many other crop raiding studies (Naughton-Treves 1997; Hill 1997, 2000; Tweheyo et al. 2005; Treves 2008; Warren 2008; Hill & Webber 2010; Mackenzie & Ahabyona 2012; McLennan & Hill 2012); farmers appear to accurately perceive baboons as their biggest problem in terms of wildlife crop raiders. Natural food availability is the driving force behind the intensity of baboon crop raiding (Chapter 5, section 5.3.3), concurring with many other studies (Naughton-Treves et al. 1998; Sekhar 1998; Kagoro-Rugunda 2004; Admassu 2007; Hockings et al. 2009; McLennan & Hill 2010; Strum 2010; Nyirenda et al. 2011; Pahad 2011). Many of the farmers also appear to be aware of this pattern, although some believe that baboons raid anytime crops are present, perhaps explained by the seasonal overlap between reduction in natural food availability and crop harvesting in the study area.

Vervets were also a frequent crop raider within the study area, but rather than natural food availability, the presence of baboons appears to be the driving force behind vervet crop raiding. Although many species spatially supplant others in the wild (Struhsaker 1967), I have not come across any crop raiding studies that have described this occurring within crop fields. Nevertheless, the effect might be anticipated given the fact that baboons are reported predators of vervets at many other sites (DeVore & Washburn 1963; Altmann & Altmann 1970; Hausfater 1976; Willems & Hill 2009).

Together, baboons and vervets spent around 50% of behavioural observation time in farm visits, implying that the farm was at risk of crop raiding by primates for almost half the daylight hours. There was a positive correlation between farm visit time and number of crop raids. However, almost half of observed farm visits did not involve any raiding at all.

Farmer perceptions of wildlife crop raiding species appear to be best explained by a combination of duration of raids, average species group size and the amount of overlap between a species' raiding activity and farmer activity within the crops. However, when using this combination of factors there still remains variation and outliers to the relationship, suggesting there may be other influences on farmer perceptions which are not accounted for in this study. Warthog, bushpig and porcupine appear to be overestimated in farmer perceptions of how much damage they cause and it is interesting that they are all nocturnal species in this farming landscape. Bushbuck, guineafowl and baboons appear to be underestimated. Other potential influencers of farmer perceptions to consider are the value of the species to the farmer, perceived danger from the species, species body size , ability of the farmer to control the animal, whether the species causes damage elsewhere, and if the species raiding activity enables other species to raid (Fiallo & Jacobson 1995; Hill 1997; Naughton-Treves 1997; De Boer & Baquete 1998; Woodroffe et al. 2005; Riley 2007; Costa et al. 2013).

10.2.3 Crop loss to wildlife

Crop damage caused by wildlife raiders on a single study farm during one crop season was estimated at ZAR35,134-40,153 for one crop type (Chapter 7, section 7.3.1). In addition, estimates obtained from a single crop field within this farm suggest primates remove a further ZAR14,219-16,250 worth of crops from the field during their raids (Chapter 5, section 5.3.1). Given that other fields on the farm were also raided by primates, this farmer's losses is likely to be above ZAR49,353-56,403. The most important factor in determining the amount of damage a field sustains appears to be the exposure it has to natural vegetation (Chapter 7, section 7.3.2); similarly many studies report crop loss to decrease with increasing distance from wild areas (Studsrød & Wegge 1995; Hill 1997, 2000, 2005; Naughton-Treves 1997, 1998; Sekhar 1998; Saj et al. 2001; Rao et al. 2002; Kagoro-Rugunda 2004; Wang et al. 2006; Agetsuma 2007; Linkie et al. 2007; Chhangani et al. 2008; Priston 2008, 2009; Anthony et al. 2010; Prasad et al. 2011; Lemessa et al. 2013). Fortunately for these commercial crop farmers, who have little choice but to plant crops near the river to acquire irrigation, the distance a crop field is located from the river appears to have little effect on amount of losses sustained (Chapter 7, section 7.3.2).

10.2.4 Commercial crop farmers tend to underestimate

When it comes to crop raiding and baboons, the data obtained from both biological and social methods suggest that the commercial crop farmers within my study area tend to underestimate baboons. Farmer predictions of crop damage undervalued transect estimated losses by around 65% (Chapter 7, section 7.3.1). Most studies on farmer perceptions of crop damage report that farmers tend to overestimate losses (Conover 1998; Siex & Struhsaker 1999), but these are mostly reports from subsistence farmers. Priston (2005) suggests that farmers experiencing medium or high levels of damage are more accurate and even underestimate damage, as compared with those who experience low levels; commercial crop farmers appear to fit into this category. That commercial farmers sustain even more damage than previously perceived makes finding an effective deterrent method against crop raiding by wildlife all the more necessary and urgent. Farmer perceptions of baboon group sizes were also underestimated during the study, where data were available for comparisons (Chapter 3, section 3.3.2).

10.2.5 Deterrent methods

Guarding

Guards are used by almost all commercial crop farmers that participated in the study. Chapter 5, section 5.3.5 reveals that field guards respond to baboons far more often than vervets, suggesting there is a detection problem with vervets. Guards were also found to respond more often to raids that involved more individuals, which are likely to be easier to detect. Guard delays in responding to primate raids have a significant effect on crop damage. Baboons appear to be less fearful of guards than vervets. When chased by guards baboons take a longer time to vacate the crops than do vervets. Furthermore, as it is currently performed, chasing appears to have no effect on whether primates return to crop fields to undertake subsequent raiding after being chased out. Guards responded more often to raids occurring in the morning than the afternoon, implying that guard fatigue may be reducing response rates. The data collected on field guarding led to a number of suggestions being made on ways to improve the effectiveness of guarding (see section 10.3.2.2).

Early warning alarm system

Chapter 9, section 9.2 reveals that bells were not successful at providing an early warning alarm system that alerted guards to vervet raiding. Although they functioned as an alarm system, ringing when the fence was disturbed and could be heard by the field guard, vervets were able to cross the fence carefully without ringing the bells. A more comprehensive alarm system, that vervets are not able to circumnavigate, would be more appropriate. Further research is required into developing such a system.

Motion-activated acoustic repellent

The use of sounds as a deterrent significantly reduced the frequency of baboon raiding and the amount of crop they consumed (Chapter 9, section 9.3). However, habituation occurred after about a three week period. The use of such a method may work alongside field guarding. Guarding could reduce habituation by reinforcing the danger perceived from the sounds (Belant et al. 1996; Koehler et al. 1990), while the sounds could provide a useful alarm system to alert guards to raiding animals (Hill & Wallace 2012). Future research should test this combination of techniques.

Electric fencing

Electric fencing successfully excluded primates, and most other wildlife raiders, from crop fields (Chapter 9, section 9.4). Despite its high cost (ZAR56 per meter), its return in savings – both in crop loss and field guard labour costs – proves it to be a cost-effective long-term investment in crop protection, particularly once farmer underestimations of crop loss are taken into account. Fence design in the study area needs to be modified slightly to avoid causing unnecessary deaths of small animals (Burger & Branch 1994), but otherwise it is a very effective deterrent strategy for commercial crop farmers.

10.3 Conflict Management Implications

10.3.1 Prior to mitigation, gather information

Many aspects of human-wildlife conflict are often misconceived by the people involved, and the assumptions that researchers make prior to investigations can often be wrong (Mishra 1997; Goldman et al. 2010; Hill & Webber 2010). This can lead to difficult or bad choices when it comes to implementing mitigation. Therefore, before any deterrent methods are considered, it is extremely important to obtain accurate knowledge of the situation.

Identify the species involved

Within the current study, there were clear cases of farmers inaccurately blaming species for crop damage (Chapter 6, section 5.6.3.3). This is problematic for two reasons:

- underestimating species leads to other animals being unduly blamed; mitigation targeted at these animals will not be productive in reducing damage
- overestimating species leads to these animals being targeted instead of the real perpetrators; mitigation targeted at these species will again not be productive in reducing damage (Mishra 1997).

It is clear that a systematic survey to establish which species are causing damage is needed before any mitigation strategies are put into place.

Identify crop losses accurately

As well as obtaining information on which species need deterring it is also a good idea to know where exactly most damage occurs. Underestimation of crop losses by commercial crop farmers can lead to under-investment in crop protection by farmers (Conover 1998; Engeman et al. 2010). Deterrent techniques that cost more themselves than what they save in damages are not worth implementing, but if damages are higher than perceived by farmers it is worth spending more on superior deterrent methods. Electrical fencing appears to be a very effective barrier at protecting crops from wildlife, but is not used by many farmers because it is perceived to be too expensive. If farmers realised the savings they could make by erecting an electric fence, more might be inclined to invest in this method. Consequently, crop damage would decrease. It is important then for farmers to be able to accurately estimate crop losses to wildlife. Knowledge of the location of high-damage areas is also important, in order to know where best to implement mitigation.

Obtaining accurate data on crop damage

The amount of damage caused by wildlife species can be estimated through camera trap surveys. Using the information obtained, average group sizes multiplied by duration of raiding appears to provide a proxy for crop damage caused by each species (Wallace 2010; Chapter 5, section 5.4.2). Many commercial farmers in the study area already possess camera traps, and this is a non-labour intensive method of collecting data.

The rapid damage estimation method appears to reveal where damage occurs across the farm. This method involves walking along the edges of each crop field, and counting the number of damaged butternuts located within the distance equivalent to the width of two rows. Care must be taken not to count crop items twice when walking around corners. Estimations take roughly 10-15 minutes per one hectare crop field.

10.3.2 Deterrent recommendations

10.3.2.1 Increasing farmer tolerance

Given that a 100% effective solution to baboon crop raiding seems unlikely (Strum 2010; Enari & Suzuki 2010), it is important to combine implementing new techniques with increasing farmer tolerance; raising tolerance of damage can be as important as reducing damage itself (Woodroffe et al. 2005). Farmer levels of tolerance should be determined and damage should be reduced to this level; if these levels are not realistic, tolerance should be increased to realistic levels that mitigation can provide.

It is important to gather information on people's attitudes towards wildlife because the positive views that people involved in human-wildlife conflict hold of these animals can be used to increase tolerance towards the species in question (Goldman et al. 2010). Despite a high level of conflict with baboons, the level of support from farmers for the continued existence of this species is high – this, as well as the values that these farmers hold towards the environment, can be drawn upon in aid of increasing tolerance. The clear interest in baboons shown by these commercial farmers throughout the study suggests that an education programme to increase tolerance is likely to be well received.

Education programmes can be used to increase tolerance for wildlife by those involved in conflicts (Gore et al. 2006; Romañach et al. 2007). As well as providing recommendations for mitigation, an educational programme for the study area should include:

- Educating the public on current environmental laws, particularly those who do come into conflict with wildlife on a regular basis. More than half the study farmers incorrectly believe it is illegal for them as a landowner to shoot a problem baboon. This perceived lack of legal deterrent control methods fosters negative perceptions of the animal in question (Hill 2004).
- Educating people about baboons, how they operate and the ecosystem services they may provide, such as their potential role in seed dispersal (Kunz & Linsenmair 2008), could reduce conflict by dispelling negative perceptions such as baboons being deceptive, malicious, greedy and wasteful. This could reduce frustrations farmers feel towards baboons' behaviour and increase tolerance.

As well as increasing farmer tolerance, it would also be beneficial to continue in the search for a deterrent method that could at least give farmers a higher level of control over baboons than they currently feel, if not total control.

10.3.2.2 Improving guarding

Field guarding is used by almost every commercial crop farmer in the area, and is also a popular deterrent method used elsewhere (King & Lee 1987; Naughton-Treves 1997; Sekhar 1998; Sitati et al. 2005; Warren 2008; Arlet & Molleman 2010; Nijman & Nekaris 2010). Within the study area, field guarding is considered to be around 70-90% effective at reducing crop damage by raiding animals. It is clear that there is scope to improve the effectiveness of guarding; further investigation into improving guards is also encouraged in other studies (Strum 1994; Naughton-Treves 1998; Hill 2000). The key to successfully guarding crops involves early warning systems, vigilance, and active response (Sitati & Walpole 2006; Hedges & Gunaryadi 2010).

The results from the early warning alarm bells suggest that the alarm system needs to be inconspicuous so that raiders cannot easily avoid setting off the alarm. A motion-activated sensor was suggested. The results from the motion-activated acoustic deterrent suggest that repellent sounds need to be reinforced with real risk. I therefore suggest that the use of a motion-activated system be further investigated. This should provide an alarm system to alert guards and fearful sounds to repel primates. In combination with the use of field guards, who would reinforce the danger perceived from the sounds by chasing primates, this could provide a more effective method than current guarding. Furthermore, if the guard had use of a weapon such as the bear banger this would further reinforce risk and may aid the guard in removing groups from the vicinity of the farm as well as the crop fields.

Data also provided information that enabled the following further recommendations to be made as suggestions to improve field guarding within the study area:

- Guards should be more persistent in their chasing and attempt to deter farm visits as well as crop raids, by chasing primates away from the farm and not just the field. Extra guards may be required for this. Increasing perceived fear of guards by baboons would help accomplish this (see below).
- Baboons are not particularly afraid of women or children (Strum 1994, 2010; Hill 1997; Sillero-zubiri & Switzer 2001); female guards may consequently not be most effective at deterring raiding baboons. Females should be replaced with male guards or given a weapon (Hill 1997).
- A higher occurrence of baboon damage occurs in the morning. An extra field guard could be used during morning sessions, who is then removed in the afternoons. This method would need monitoring to assess whether baboons change their raiding patterns in response to this change in mitigation.
- Guards are more likely to respond to crop raids in the morning than the afternoon, which may be due to guard fatigue occurring by afternoon sessions. This could be prevented by employing two guards for half day shifts, rather than one for the whole day.
- Baboon groups are larger than perceived by farmers. Using one field guard to chase large groups of baboons may not be effective. Use extra field guards where groups are large.
- Guards may not be placed in the best location. Damage maps suggest that a simple change in guard location, a method that requires no further cost or effort, may have positive consequences for crop protection.

10.3.2.3 Other recommendations

As well as increasing farmer tolerance and improving guard effectiveness, a number of other recommendations were uncovered from the data. Some of these apply only to the farm on which data were collected, but farmers could gain suggestions for their own farms by using the methods of simple data collection provided in this thesis.

- Mitigation must be targeted at both primate species. A reduction in baboon raiding may lead to an increase in vervet raiding, unless deterrent methods affect both species.

- Additional deterrent methods that are targeted at species other than primates are needed on the farm. Maps show high levels of damage in an area where primates are known not to visit, suggesting that there are other wildlife species that are causing high levels of damage.
- Bushbuck appear to be a greater problem than perceived. Fences are not used to protect crops, possibly because primates (climbers) and pigs (diggers) are perceived to be the major problems. Bushbuck could easily be excluded with fencing (Lindsey et al. 2011).
- Guineafowl appear to be underestimated. Low-tech techniques may prove effective at deterring these birds; simple techniques such as moving scarecrows should be trialled (Marsh et al. 1992; Gilsdorf et al. 2004; Richardson 2014).
- Some areas of the farm are overlooked by farmers and need mitigative attention. A block of crop fields were estimated by the farmer to have received no damage, and yet damage maps showed fairly high levels of damage in this area.
- Larger crop fields may be safer than smaller fields because they have a bigger centre and a smaller edge-area ratio.
- Since fields buffered on all sides by other crop fields receive very little damage, sacrificial buffer crops of 100m width may prove very effective (Hill 2000; Lee & Priston 2005; Priston 2005, 2009; Wallace 2010). If fallow fields provide the same effect, this would be more cost-effective and less labour-intensive, otherwise types of buffer crops need to be further explored.
- Most crops planted in the area are raided by wildlife; the only exception may possibly be chilli. Chilli is not an appropriate cash crop in the study area as money cannot be made from it. Further investigation needs to be carried out to determine whether chilli is a crop that is unpalatable to wildlife and could be used as a 'sacrificial' buffer crop.

10.4 Reflection

The interdisciplinary nature of this research allowed me to obtain knowledge that would otherwise not have been available had disciplinary methods been carried out separately. Being able to compare one set of data with the other was extremely valuable and facilitated many of the final mitigative recommendations. Through the understanding that farmers underestimate their crop losses to wildlife, I am able to recommend electrical fencing as an effective deterrent method. Farmers currently believe the electric fence is too expensive to implement, but once presented with these interdisciplinary results farmers may see that this is not the case and subsequently decide to invest in electrical fencing. Since the fence is so effective, this will ultimately lead to a reduction in conflict between farmers and many species of wildlife. Testing the electric fence without providing an estimate of how much farmers underestimate real crop losses, and therefore savings, may not have had the same effect.

Furthermore, one data set helps to inform the other, subsequently leading to better results. Had I conducted the mitigation workshop without the knowledge I obtained through observing primate raiding behaviour, I would not have suggested the use of an alarm system. The biological data suggests that, provided with an appropriate alarm system, this method may well improve guard effectiveness and subsequently reduce crop damage. Without this knowledge this method would have been immediately dismissed. Conversely, biological data suggest that an effective deterrent may be the use of bear bangers. Without farmer input, this method may have been suggested, and even trialled. This would not only have been a waste of time, because it is not an acceptable method within the region, but it may have also frustrated farmers, to be recommended a method which they cannot use.

Although crop raiding on commercial farms occurs under very different circumstances from subsistence farm raiding, there are nevertheless similarities between the two. Both sets of farmers suffer with the inability to control raiding wildlife, and despite numerous attempts have not found an acceptable and effective method of control. Both groups of farmers also have to deal with disappointments from the authorities, both have expectations that are not being met and both feel the authorities are not well enough informed to make the decisions regarding crop raiding that they do. Both feelings of lack of control and unfulfilled expectations have been shown to reduce farmer tolerance, increase perceptions of risk and increase conflict (De Boer & Baquete 1998; Hill 2005; Costa et al. 2013).

Lastly, these commercial farmers appear to be dealing with this human-wildlife conflict alone. The sharing of knowledge and ideas between these farmers would likely benefit all involved. Farmers were very keen to come to both the workshop and the final presentation I gave before I left South Africa, and many were keen to be involved in my research. Each month farmers in the local area get together to conduct an agri-meeting, but to my knowledge, wildlife crop raiding is not discussed here. The establishment of a group where farmers can share their frustrations, and the failures and successes regarding deterring crop raiders would have a positive impact on all involved.

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Appendices

Appendix 1: Information sheets provided to participants

(a) For interview participants

Date……………..

Dear…………………………

I am a student from Durham University in England, and am here to study the experiences that people in this area have with wildlife, and in particular baboons.

Through my study I would like to understand the local attitudes, perceptions and tolerance towards wildlife, baboons and crop raiding, and what these problems mean for you. I would like to work with you, to find out more about your culture and way of life, and in particular to discover your experiences with baboons, which are invaluable to me in this study.

I will also be investigating the nature and scale of crop raiding within the area, as well as certain aspects of baboon ecology. This information will help us to understand when, how and why baboons raid crops, an understanding that will help in developing effective prevention methods against future crop raiding.

Everyone participating in this study does so voluntarily. You are free to decline or withdraw at any time without reason. I would like to audio record our discussions so I can recall them and often I may also make notes. I will always ask your permission first. Only I will have access to this information, which will be securely stored. For the purposes of the interview data your identity will remain anonymous, as each interview will be identified by a number. Sometimes an interviewee’s statements or descriptions of their location can give away clues to identity and compromise absolute anonymity. If you have any concerns about this please discuss it with me.

Thank you very much for your time. I am happy to discuss the project with you if you have any questions, and in the future I will ensure that you are able to contact me by letter, phone or email.

Leah Findlay

Research Postgraduate

Durham University

(b) For study farm owners

Date……………..

Dear…………………………

I am a student from Durham University in England, and am here to study the experiences that people in this area have with wildlife, and in particular baboons.

Through my study I would like to understand the local attitudes, perceptions and tolerance towards wildlife, baboons and crop raiding, and what these problems mean for you. For a proportion of the people taking part I would also like to measure the scale and nature of crop raiding on their land. I am hoping that if your land is suitable for this you will agree to my taking these measurements. These data will help me build a model for predicting the future risk of crop raiding. Such a model will help towards understanding which areas are most at risk from crop raiding and why. Following this, I hope to run pilot projects to examine the effectiveness of different protection methods. I will also investigate baboon ecology to understand when, how and why baboons raid crops. The specific factors I investigate will depend on what you and other participants identify as important issues.

I would like to work closely with you, to find out more about your culture and way of life. In particular, I would like to discover your experiences with baboons, which are invaluable to me in this study.

Everyone participating in this study does so voluntarily. You are free to decline or withdraw at any time without reason. I would like to audio record our discussions so I can recall them and often I may also make notes. I will always ask your permission first. Only I will have access to this information, which will be securely stored. For the purposes of the interview data your identity will remain anonymous, as each interview will be identified by a number. Sometimes an interviewee's statements or descriptions of their location can give away clues to identity and compromise absolute anonymity. If you have any concerns about this please discuss it with me.

Thank you very much for your time. I am happy to discuss the project with you if you have any questions, and in the future I will ensure that you are able to contact me by letter, phone or email.

Leah Findlay

Research Postgraduate

Durham University

Appendix 2: Consent form signed by all interviewees

Consent form to participate in Leah Findlay's PhD research project at Durham University.

Date ………………..

This declaration certifies that I (insert name) ………………………………….. give my full consent to participate in the research project conducted by Leah Findlay, Durham University. I have understood the aims and objectives of the research project and the treatment of the information. The nature of the research has been fully explained to me including my rights to remain anonymous and withdraw from the research project at any time without further need for justification.

I (delete as appropriate) do / do not give permission to use an audio recorder during interviews. I understand that this information will only be used as a memory aid for the purposes of transcribing the written material and details concerning my identity will remain anonymous.

If you agree to be audio recorded during interviews, please state whether you would prefer your information to be destroyed after completion of the research project or let it be retained by the individual researcher for future research use: (delete as appropriate) destroyed / retained.

Thank you for your participation and cooperation with the research project.

Signed………………………………………….

Appendix 3: Interview Guide

(a) For crop farmers

Date: **Interview ID:**

Start time: **End time:**

Name of property: **Location of property:**

Location of interview:

Farming

1. What is the main use of your property (game farm, cattle farm, crop farm, hunting, tourism conservation etc.):
2. How long have you been on this property? (Living and farming) (Where did you live before)
3. How long have you been farming? (What did you do before)
4. What is your main crop?
5. Can you tell me about the sort of problems that limit your crop yields?: (Does wildlife feature here?)
    - What kinds of problems limit crop yields? Rank them

Baboons

6. What one word would you use to best describe a baboon?
7. Do you have baboons on your property?
8. How do you feel when you see them on your property (and in your crops)?
9. How do you feel about baboons when you see them in the wild?

Baboon population

10. Do you think the number of baboons in this area is low/moderate/high/don't know?
11. Since you came to this area (or in the past 10 years – state which), do you think that the baboon population has increased, decreased or stayed the same? Why?
12. How many baboon troops do you think are in the area now?
13. What do you think is the average group size of baboons in this region? Do you think this is large?
14. Would you like the baboon population here to increase, decrease, stay the same, disappear? Why?

Human-wildlife conflict

15. Do you have problems with animals damaging your crops?
16. Which species damage your crops? Rank them
17. Which crops receive the worst damage? Do all the crops get raided?
18. How much crop do you lose to wildlife (%)?
19. How does this loss affect you (economic loss, extra staff, plant bigger fields)?

20. Where in the field does damage occur, is it different for different crops, why?
21. Why do you think that animals raid your crops?
22. When was the last time that your crops were raided, which species was responsible?
23. Other than crop damage, do you have any other problems with wildlife?
24. Do public or consumer concerns about wildlife affect the way you deal with problem wildlife?
    - E.g. is there a system in place where farm produce is identified as being wildlife friendly (i.e. you do not kill problem wildlife) which affects the consumers decision on whether or not to buy your crop?
    - Do you conform to this system? Does this affect your sales?
25. Is there any type of insurance that can cover you against wildlife damage to crops?

Baboon conflict

26. (Do you have problems with baboons raiding crops?) – if not already mentioned
27. How much crop loss is caused by baboons alone (%)?
28. How often do baboons raid your crops?
29. Which crop do baboons cause the most damage to?
30. Does baboon damage occur more frequently at certain times of the year? When, why?
31. When was the last time that baboons raided your crops?
32. Has the problem with baboons changed over the last few years – increased, decreased or stayed the same? Why?
33. Are baboons dangerous when they enter your farm – do they threaten the safety of you or the farm workers?
34. Do you think that you get more or less crop damage by baboons than your neighbours? Why?
35. Do you consider baboons as a game species or a pest species? Why?
36. Is it illegal to shoot a baboon in this area?
37. Baboons are no longer classed as a problem animal, but are now classed as game. What do you think of this change – of baboons no longer being treated as a problem animal?
38. Do you think that this classification and the laws surrounding it are suitable to your situation – would you change them if you could?

Participatory Mapping

- Map of crops
    – show where the greatest areas of damage occurs - why
    – show how many and where the baboon troops come from

Preventing Crop Damage

39. Do you protect your crops against damage by wildlife?
40. Can you tell me all the methods that you currently use, which species they target and the cost of implementing these methods:

    Method used: Target species: Annual Cost

41. Do these methods solve the problem of wildlife raiding your crops?
    - If not, do they minimise damage caused and by how much?

42. Which of these methods do you think is most effective?
43. Have you previously tried any other methods?
    - What were they?
    - Were they effective?
    - Why did you stop using them?
44. Can you tell me whether you think the following methods are effective or not –

    LIST OF MITIGATION METHODS

45. (If not 100% effective) If there was a more effective way to keep wildlife away from your crops would you be willing to change to these, including paying for the installation and management costs of such methods?
46. Is there a level of crop loss that you would tolerate from wildlife damage – if so what is it?
47. Is there any type of government aid available to help you prevent crop damage or compensate your losses to wildlife?

<u>Perceptions of Nature</u>

48. What do you think about the wildlife living in your area? Why?
49. Do you think that the conservation of these species is important?
    - Yes – which species and why?
    - No – which species and why?
50. Do you think that wildlife is useless if it does not provide a monetary value to people?
    - Yes – why?
    - No – what other values do wildlife provide?

Is there anything else that you would like to say?

(b) For non-crop farming participants

Date: **Interview ID:**

Start time: **End time:**

Name of property: **Location of property:**

Location of interview:

Farming

51. What is the main use of your property (game farm, cattle farm, crop farm, hunting, tourism conservation etc.) / What is your occupation?
52. How long have you been on this property? (Living and farming) (Where did you live before)
53. How long have you been doing this? (What did you do before)

Baboons

6. What one word would you use to best describe a baboon?
10. Do you think the number of baboons in this area is low/moderate/high/don’t know?
11. Since you came to this area (or in the past 10 years – state which), do you think that the baboon population has increased, decreased or stayed the same? Why?
12. How many baboon troops do you think are in the area now?
13. What do you think is the average group size of baboons in this region? Do you think this is large?
14. Would you like the baboon population here to increase, decrease, stay the same, disappear? Why?
7. Do you have baboons on your property?
8. How do you feel when you see them on your property?
9. How do you feel about baboons when you see them in the wild?

Baboon Problems

26. Do you have any problems with baboons? What are they? Rank them. **Skip 2 sections if no.**
28. How often do baboons give you problems?
30. Do these problems occur more frequently at certain times of the year? When? Why?
31. When was the last time baboons troubled you?
32. How do these problems affect you? (Cost, equipment)
33. Why do you think the baboons do this?
32. Has the problem with baboons changed over the last few years – increased, decreased or stayed the same? Why?
34. Do you think that you have more or less problems with baboons than your neighbours? Why?
33. Are baboons dangerous when they enter your property – do they threaten the safety of you/staff/guests?

Mitigation

39. What do you do to try and prevent baboons causing you problems?
40. Do these methods solve the problems? Do they minimise damage? By how much?
41. Have you previously tried anything else?
    - What were they?
    - Were they effective?
    - Why did you stop using them?
42. Is there any type of government aid available to help you prevent damage by baboons or to compensate your losses?

Perceptions/Laws

35. Do you consider baboons as a game species or a pest species? Why?
36. Is it illegal to shoot a baboon in this area?
37. Baboons are no longer classed as a problem animal, but are now classed as game. What do you think of this change – of baboons no longer being treated as a problem animal?
    Do you think that this classification and the laws surrounding it are suitable to your situation – would you change them if you could?
    Do you shoot baboons on your property? Why (hunting/problem animals)? How often? How many this year?

Other Wildlife

23. Do you have problems with any other wildlife? Which species? What do they do?

Perceptions of Nature

46. What do you think about the wildlife living in your area? Why?
47. Do you think that the conservation of these species is important?
    - Yes – which species and why?
    - No – which species and why?
48. Do you think that wildlife is useless if it does not provide a monetary value to people?
    - Yes – why?
    - No – what other values do wildlife provide?

Is there anything else that you would like to say?

Appendix 4: Questionnaire provided to interviewees

DEMOGRAPHICS:

Gender: **Age:**

Ethnicity (e.g. Afrikaans**):** **Religion:**

Occupation/Position on farm:

Number of people in household: **Number of dependents in household:**

Education: None
Primary
Secondary
University
Other, specify

LANDHOLDING:

Size of property:

Area of farm used and percentage of income for each activity:

Crops:	Size:	% of Annual Income:
Game:	Size:	% of Annual Income:
Livestock:	Size:	% of Annual Income:
Hunting:	Size:	% of Annual Income:
Tourism:	Size:	% of Annual Income:
Conservation:	Size:	% of Annual Income:

Do you have any other sources of income? If so please state the activity and % of annual income:

Number of employees: Male: Female:

CROP FARMING PRACTISES (ignore if you don't have crops):

Crops grown:	Tomato:	Size:	% of Crop Income:
	Potato:	Size:	% of Crop Income:
	Butternut:	Size:	% of Crop Income:
	Mealies:	Size:	% of Crop Income:
	Lucerne:	Size:	% of Crop Income:
	Tobacco:	Size:	% of Crop Income:
	Other:	Size:	% of Crop Income:

Methods of irrigation:

Herbicides/pesticides used (for each crop, what herbicide and when they are used):

Appendix 5: Invitations promoting Mitigation Workshop

Durham University

BABOON PROBLEMS?

Dear

I would like to invite you to a

BABOON CROP DAMAGE WORKSHOP

Please come to share your experiences with baboons damaging your crops. My research involves developing new and more effective ways of keeping baboons out of crop fields. I would like you to join me at this workshop to give your opinions on a number of old and new methods, so that you can contribute your knowledge to help overcome this serious problem.

Date: Wednesday 27th November 2013

Time: 18:00-20:00

Location: Mogalakwena River Lodge

20:00 Complimentary Braai

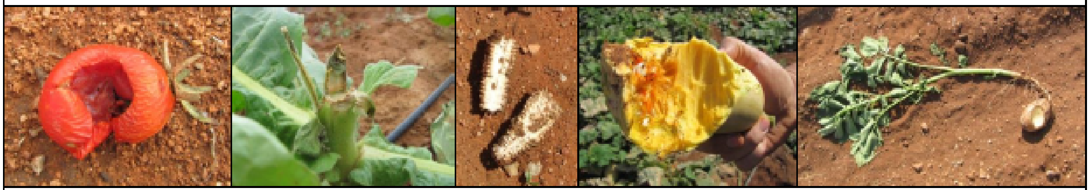
Cash Bar. If you would like to spend the night at Mogalakwena River Lodge please contact Anna on info@mogalakwena.com. For a discounted rate quote the Baboon Workshop.

RSVP by 25 Nov - spaces are limited

Contact Leah on: E: l.j.findlay@durham.ac.uk SMS: 079 802 9588

Durham University

BOBBEJAAN PROBLEME?



Liewe

Ek wil jou uitnooi na 'n

BOBBEJAAN OESSKADE WERKSWINKEL

Kom deel u ervaring van bobbejaan skade aan gewasse. My navorsing behels die ontwikkeling van nuwe en meer doeltreffende maniere om bobbejane uit gewas lande uit te kry. Graag nooi ek u uit om u kennis aangaande ou en nuwe metodes, om die ernstige probleem hok te slaan, met ons te deel.

Datum: Woensdag, 27ste November 2013

Tyd: 18:00-20:00

Plek: Mogalakwena River Lodge

20:00 Komplimentêre Braai

Kontant Kroeg. As jy graag die nag wil deurbring by Mogalakwena River Lodge kontak asseblief vir Anna op info@mogalakwena.com. Vir 'n afslag - kwoteer " Bobbejaan Werkswinkel".

RSVP voor 25 November - spasie is beperk

Kontak Leah by: E: l.j.findlay@durham.ac.uk SMS: 079 802 9588

Appendix 6: Posters promoting Mitigation Workshop

Durham University

BOBBEJAAN PROBLEME?

HET JY PROBLEME MET DIE BESKADIGING VAN GEWASSE DEUR BOBBEJANE?

KOM DAN NA DIE:

BOBBEJAAN OESSKADE WERKSWINKEL

Kom deel u ervarings met bobbejaan skade aan gewasse. My navorsing behels die ontwikkeling van nuwe en meer doeltreffende maniere om bobbejane uit gewas lande uit te hou. Ek wil graag he u moet betrokke wees by hierdie werkswinkel om u mening te gee op 'n aantal van die ou en nuwe metodes, sodat jy kan jou kennis kan deel om te help om hierdie ernstige probleem te oorkom.

Datum: Woensdag, 27ste November 2013

Tyd: 18:00-20:00

Plek: Mogalakwena River Lodge

20:00 Komplimentêre Braai

Kontant Kroeg. As jy graag die nag wil deurbring by Mogalakwena River Lodge kontak asseblief vir Anna by info@mogalakwena.com. Vir 'n afslag kwoteer "Bobbejaan Werkswinkel".

RSVP voor 25 November - spasie is beperk

Kontak Leah by: E: l.j.findlay@durham.ac.uk SMS: 079 802 9588

Durham University

BABOON PROBLEMS?

DO YOU HAVE PROBLEMS WITH BABOONS DAMAGING YOUR CROPS?

THEN COME TO THE:

BABOON CROP DAMAGE WORKSHOP

Use your experience with baboons to help develop new and more effective ways of keeping baboons out of crop fields. Join me at this workshop to voice your opinions on a number of old and new methods, and contribute your knowledge to help overcome this serious problem.

Date: Wednesday 27th November 2013

Time: 18:00-20:00

Location: Mogalakwena River Lodge

20:00 Complimentary Braai

Cash Bar. If you would like to spend the night at Mogalakwena River Lodge please contact Anna on info@mogalakwena.com. For a discounted rate quote the Baboon Workshop.

RSVP by 25 Nov - spaces are limited

Contact Leah on: E: l.j.findlay@durham.ac.uk SMS: 079 802 9588

Appendix 7: Research Ethics and Data Protection Committee Approval

(a) Pilot

Durham University

Research Ethics and Data Protection Committee
Department of Anthropology
Science Site, Durham DH1 3LE

Date 25/4/12

Dear Leah,

NOTIFICATION OF ETHICAL APPROVAL

Re: Human-primate conflict in the Soutpansberg Mountains, South Africa – Pilot Study

I am pleased to confirm that the above research project has been granted ethical permission by the Anthropology Department Research Ethics Committee. You can now start your research.

Approval is subject to the following general conditions:

1. Ethical approval is specific to this Project.
2. If significant changes to the Project become apparent, please notify the Ethics Committee.
3. If any unanticipated problems or adverse events arise that involve risk to participants or others, please report these to the Committee. The Committee may ask you to write a formal report about the problem, and may suggest amendments to your project.
4. After completion of the project, please submit an 'end of project' report which can be found on the DUO ethics pages.
5. Your application has been considered formally at today's Committee meeting, and has been approved.

Best wishes for your research!

Professor Michael Carrithers (CHAIR) cc (Supervisor)

(b) Research Ethics and Data Protection Committee

Durham University

Research Ethics and Data Protection Committee
Department of Anthropology
Science Site, Durham DH1 3LE

16 July 2012

Dear Leah

NOTIFICATION OF ETHICAL APPROVAL

Re: Human-primate conflict in northern Limpopo, South Africa

I am pleased to confirm that the above research project has been granted ethical permission by action of the Chair of the Anthropology Department Research Ethics and Data Protection Committee. You can now start your research.

Approval is subject to the following general conditions:

1. Ethical approval is specific to this Project.
2. If significant changes to the Project become apparent, please notify the Ethics Committee.
3. If any unanticipated problems or adverse events arise that involve risk to participants or others, please report these to the Committee. The Committee may ask you to write a formal report about the problem, and may suggest amendments to your project.
4. After completion of the project, please submit an 'end of project' report which can be found on the DUO ethics pages.
5. Your application will be considered formally at the next ethics committee meeting and you will be notified in due course.

Best wishes for your research!

M Carrithers

Professor Michael Carrithers (CHAIR) cc (Supervisor)

Appendix 8: Durham Life Sciences Ethical Approval

PERSONAL AND CONFIDENTIAL

Research Office

Memorandum

	L Findlay, Department of Anthropology
FROM:	S Welch, Research Governance and Policy Officer/ Secretary to the LSERP Committee
CC:	J Summerill, LSSU Manager Dr R Hill, Department of Anthropology L Brownlie, Department of Anthropology
DATE:	23rd July 2012
SUBJECT:	**Human-primate conflict in northern Limpopo, South Africa**

Dear Leah,

I refer to your application for ethical review of the above project. I am pleased to inform you that, having considered your application, the LSERP Committee Sub-Group has given ethical approval for your research project to commence.

Upon project completion a report (template attached) should be submitted for consideration by the LSERP Committee. Final reports should detail project outcomes and address any ethical issues which arose over the duration of the project.

In the case of student projects the final report may be submitted by the project supervisor.

With best wishes,

Sophie Welch

Appendix 9: Republic of South Africa Research Visa

Control No. A04454391 DHA-1635

REPUBLIC OF SOUTH AFRICA

VISITORS VISA

Name : FINDLAY L J

Passport No.: 207638365

Authority to proceed to the Republic to report to an immigration officer at a port of entry has been granted by the Minister of Home Affairs

Issued at : LONDON on 2012.07.27 No. of Entries: Multiple

Conditions : Enter on or before : 2014.01.27

TO CONDUCT RESEARCH AT MOGALAKWENA RESEARCH CENTRE FOR A PERIOD OF 18 MONTHS.

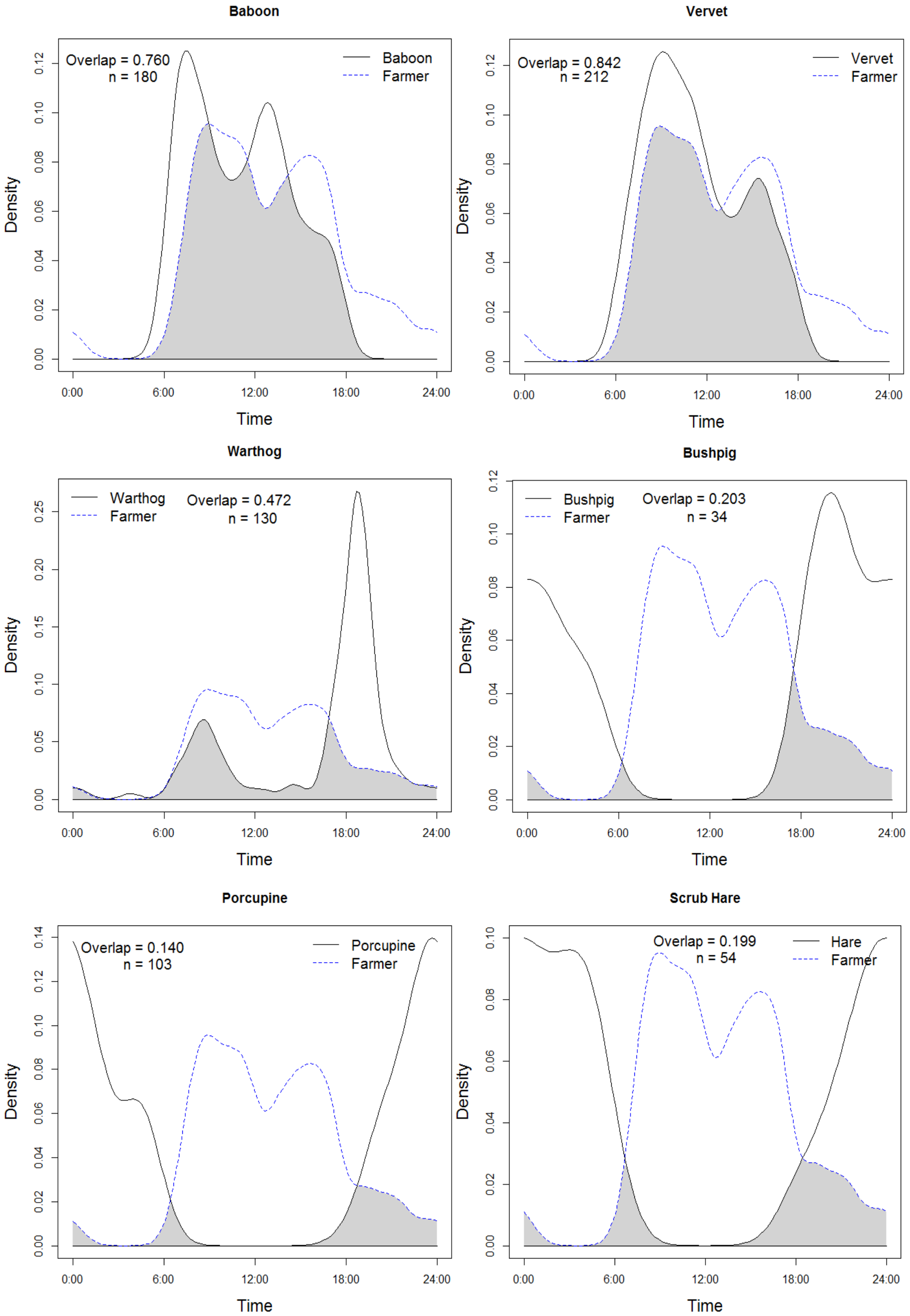
DEPOSIT LODGED,MAY PROCEED ON A SINGLE TICKET.

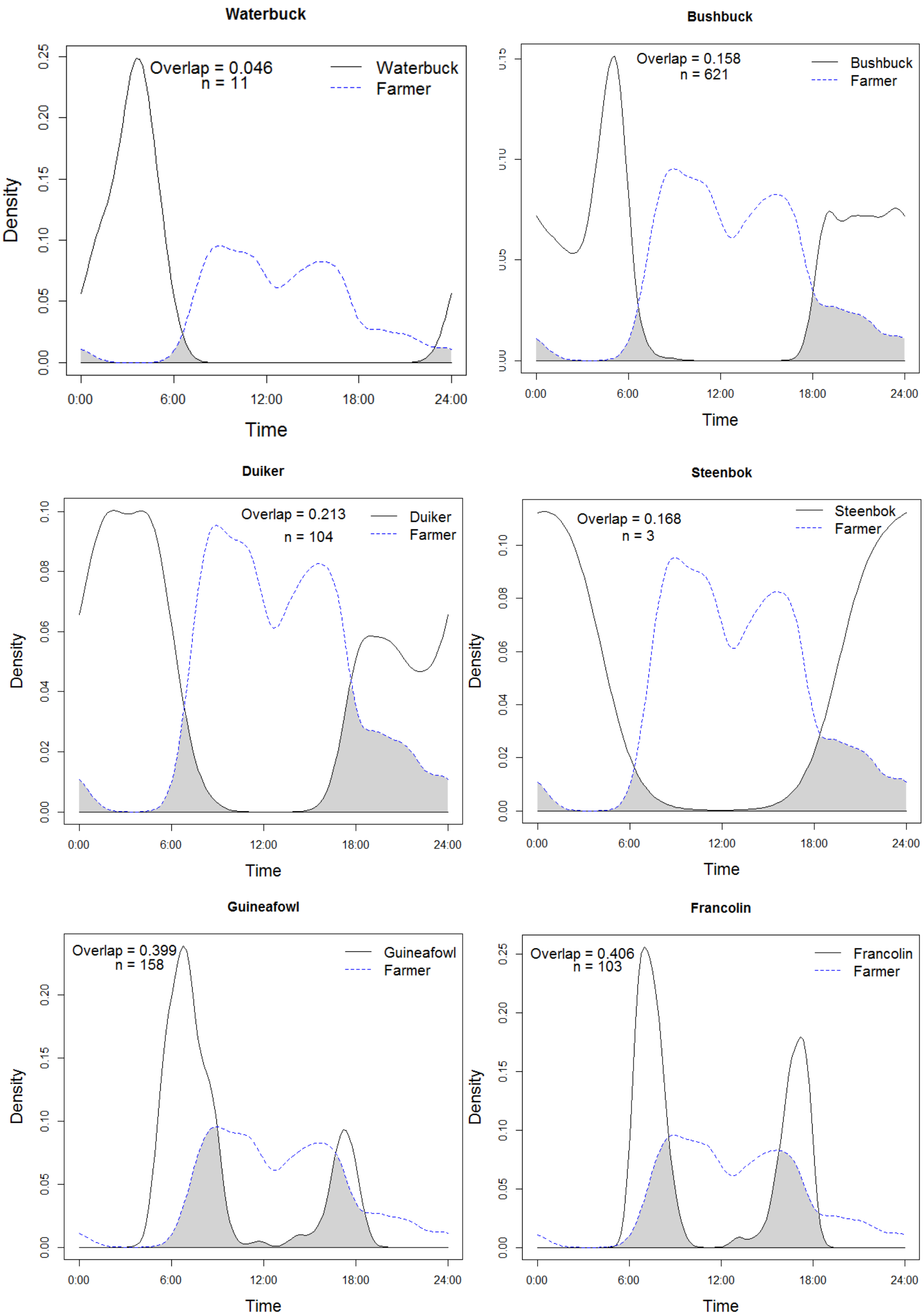
.... YWFNZLV

for Minister : Home Affairs

17

Appendix 10: Overlap density plots of farmer activity with wildlife crop raiders




Waterbuck
Overlap = 0.046
n = 11
Waterbuck
Farmer
Density
Time
Bushbuck
Overlap = 0.158
n = 621
Bushbuck
Farmer
Time
Duiker
Overlap = 0.213
n = 104
Duiker
Farmer
Density
Time
Steenbok
Overlap = 0.168
n = 3
Steenbok
Farmer
Density
Time
Guineafowl
Overlap = 0.399
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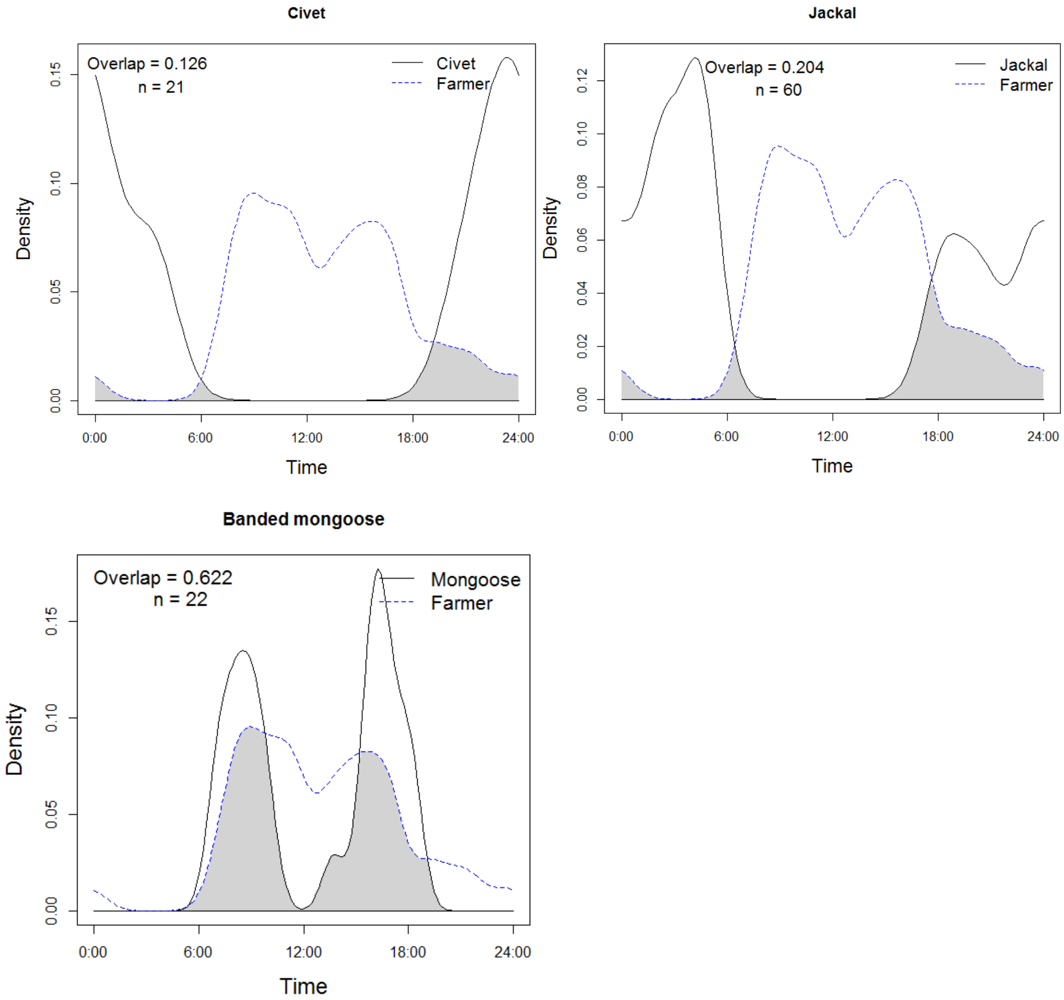
Guineafowl
Farmer
Density
Time
Francolin
Overlap = 0.406
n = 103
Francolin
Farmer
Density
Time



Density plots of overlapping activity between farmer and raiding species. Dotted blue lines indicate farmer activity within crop fields assessed with camera traps, while solid black lines represent the same for raiding animals. Shaded grey areas indicate where the activities overlap. The coefficient of overlap and sample size are also shown on each graph.