OLD WINE IN NEW BOTTLES: A REVIEW AND ANALYSIS OF THE LONG SHIELDS MODEL

A Traditional Concept Adapted To Mitigate Human-Lion Conflict

Lovemore Sibanda

Thesis submitted for the degree of Doctor of Philosophy

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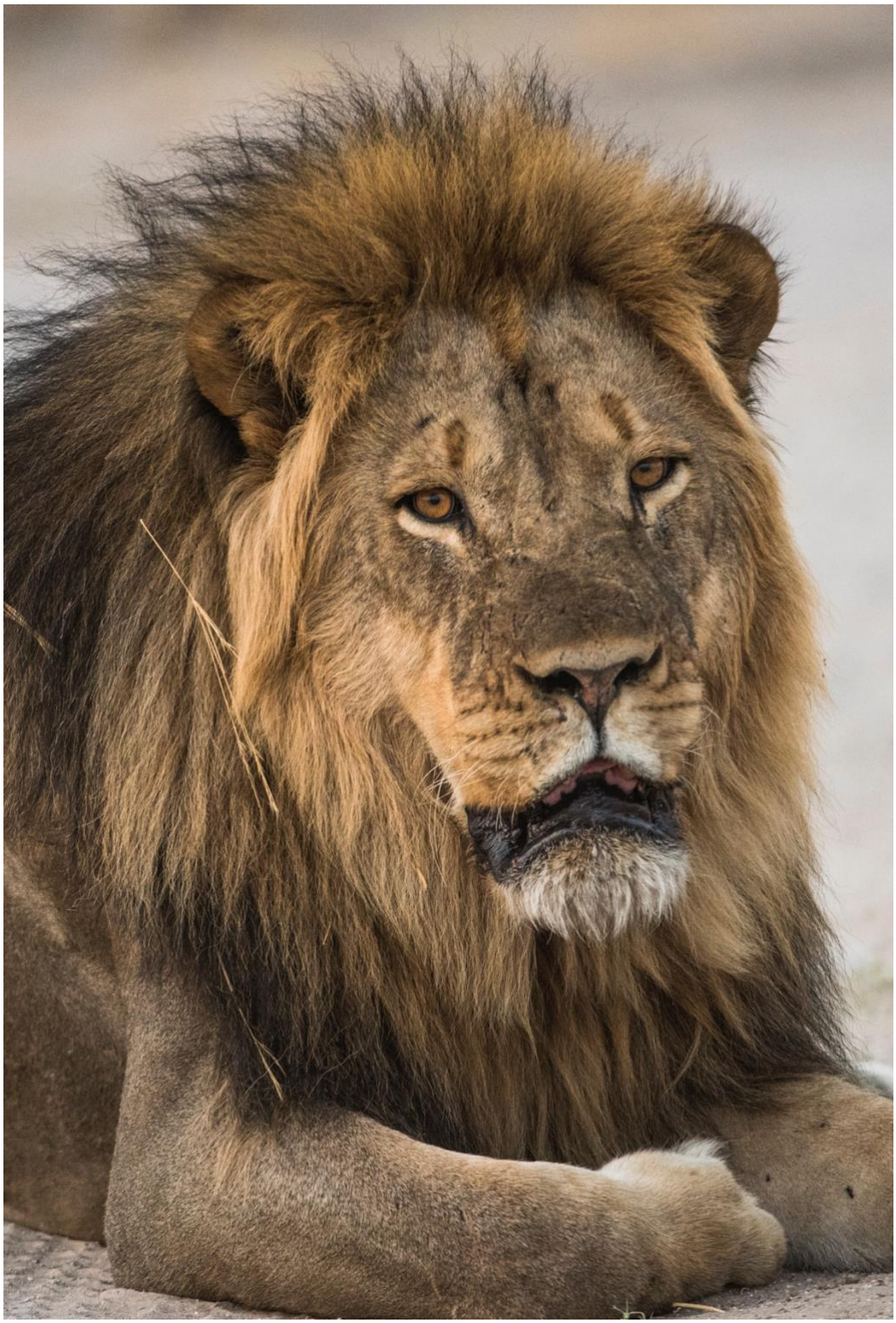
Lady Margaret Hall College, University of Oxford

Trinity Term 2020

This thesis is dedicated to

Mum,

with love!



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ABSTRACT

Conflict with humans over livestock is a major threat to lion (*Panthera leo*) populations across their range in Africa. Lions kill livestock, a major source of livelihood for marginalised communities, and farmers kill lions in return. How to effectively mitigate this conflict remains a major conservation challenge till this day. In this thesis, I evaluate the effectiveness of the Long Shields Community Guardian programme (in short: Long Shields programme), a community-based, non-lethal human-lion conflict intervention that seeks to mitigate the impacts from lions by encouraging farmers to adopt behaviours that reduce the risk of livestock depredation. Specially, I examine (a) baseline attitudes towards lions and lion conservation; (b) attitudes towards lions before and after the implementation of the Long Shields programme; (c) trends in livestock losses to lions before and after the implementation of the Long Shields programme, and (d) barriers that prevented the adoption of the Long Shields programme. My results reveal that farmers' attitudes towards lions are strongly negative and seem to be influenced by perceived losses rather than the actual losses to lions. Attitudes varied based on the geographic location where the farmer lived as well as the farmer's ethnic group (**Chapter 2**). Subsequently, I detected a positive shift in attitudes of farmers that were part of the Long Shields programme (i.e., treatment group), including those that were part of the control group but exchanged information with their peers in the treatment group, than those of farmers in the control group (**Chapter 3**). My results also revealed that farmers that were part of the Long Shields programme experienced a significant reduction (up to 40%) in livestock loss to lions since the start of this programme in 2013, compared to the period 2008-2012 before the programme was initiated, while livestock losses increased for farmers that were not part of this programme. The number of lions killed annually due to retaliatory killing by farmers also declined by 41% since the implementation of the programme in 2013 (**Chapter 4**). My results also revealed that although the Long Shields programme was effective and well perceived by the majority of participants, a minority of farmers in the programme area continued to suffer higher livestock losses to lions than did others. Continuance of higher livestock losses to lions, despite all efforts from the programme personnel, seemed to be influenced by various barriers such as poor communication, negative attitudes towards the programme, and lack of trust in the programme itself, and in some cases, the programme personnel (**Chapter 5**). Although here we focus on human-lion conflict, our evaluation design and overall findings are applicable to other human-carnivore conflicts situations in other areas.

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Thank you!

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Declaration

I **Lovemore Sibanda**, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that I have acknowledged and indicated this in the thesis. Certain chapters have been developed and written in collaboration with other authors whose affiliations and contributions I highlight. This thesis is **47,343** words long excluding references, appendices, tables and figures.

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Chapter One: General Introduction



"A pride of lions in Ngweshla, Hwange National Park"

1.1: Human-wildlife conflict: a global perspective

Since the beginning of the 20th century, the world human population has increased from one to seven billion (World Population Prospects, 2019), and is predicted to further increase to nine billion by 2050 (Wittemyer et al., 2008). The most substantial increase in the human population is predicted in areas next to wildlife protected areas i.e., geographical spaces managed to achieve the long-term conservation (Craig et al., 2004). The increase in the world human population, together with the growing demand for food, will lead to an increased demand for land and subsequently an upsurge in the conflict between humans and wildlife (Woodroffe et al., 2005b; Young et al., 2010).

Conflict between humans and wild animals, commonly referred to as human-wildlife conflict (HWC), is widespread throughout the globe and arises when the needs and behaviour of wild animals impact negatively on the goals of humans and *vice-versa* (Madden, 2004). The IUCN

SSC Human-Wildlife Task Force defines HWC as "the struggles that emerge when the presence or behaviour of wildlife causes actual or perceived threat, direct or recurring threats to human interests or needs, leading to disagreements between groups of people and negative impacts on people/or wildlife" (IUCN, 2020). HWC is triggered by different circumstances such as the competition for resources e.g., water, disease transmission, crop-raiding, threat posed to human safety, loss of human life and livestock depredation (Ontiri et al., 2019). Generally, HWC is a broad and complex subject involving several levels (Zimmermann et al., 2020), and a wide range of species in different situations e.g., the endangered fruit-bats (*Pteropus niger*) and farmers in Mauritius, hen harriers (*Circus cyaneus*) and gamekeepers in the United Kingdom (Thirgood & Redpath, 2008), coyotes (*Canis latrans*) and urban dwellers in North America (McLellan & Walker, 2020), as well as elephants (*Loxodonta africana*) and subsistence farmers in Africa (Naughton-Treves et al., 2005).

HWC negatively affects rural communities living alongside protected areas whose support is crucial for species conservation (Dickman, 2008; Zimmermann et al., 2020). The impacts from HWC to humans are either direct, indirect or both (IUCN, 2020). Examples of direct costs include livestock depredation, crop-raiding, attacks on humans, while examples of indirect or hidden costs include the time spent herding or guarding crops, fear and stress (Barua et al., 2013). Direct costs such as depredation result in serious financial losses, especially surplus killing, a situation where a predator kills multiple animals in one attack (Kruuk, 1972). Indirect costs also result in a large loss for subsistence farmers; however, they are difficult to quantify even though they are often substantial (Barua et al., 2013). Both direct and indirect costs can be detrimental to species conservation, and have been shown to drive people to retaliate against wild animals (Young et al., 2010). Therefore, to promote coexistence[1] between humans and

[1] Dynamic but sustainable state in which humans and wild animals co-adapt to living in a shared landscape where human interactions with wild animals are government by institutions that ensure long-term carnivore population persistence, social legitimacy, and tolerable levels of risk.

wild animals, conservation interventions should aim to address both the direct and indirect costs incurred from wildlife (Madden, 2004).

Although not a new phenomenon, HWC is considered a primary threat to biodiversity conservation (Young et al., 2010). In response to HWC, humans respond by setting snares, traps, poison or advocating for the government-controlled killing of supposed problem species (Loveridge et al., 2010b). The killing of wild animals by humans in retaliation or preventive persecution is complicated by past experience, fear and wider underlying social tensions (Redpath et al., 2014). Specifically, conflict with people over livestock has resulted in the extirpation of many carnivore populations from most of their range across the globe (Inskip & Zimmermann, 2009) and continues to contribute to the extirpation of several other species (Woodroffe et al., 2005b). Examples of such species include the wild dog (*Lycaon pictus*) (Nyhus, 2016), wolves (Chapron & Treves, 2016), jaguars (*Panthera onca*) (Zimmermann et al., 2005) and cheetahs (*Acinonyx jubatus*) (Lindsey et al., 2013). At present, as many as 75% of large terrestrial carnivores are threatened with population decline and range contraction (Wolf & Ripple, 2017), especially those that require vast territories (Sillero-Zubiri et al., 2007).

Populations of large carnivores do relatively well in wildlife protected areas; however, most protected areas are not large enough to contain far-ranging species (Geldmann et al., 2013). These species range beyond the boundary of protected areas where they come into conflict with people. HWC can be so severe that it creates a sink which ultimately affects the viability of the population inside the protected area (Loveridge et al., 2010a; Di Minin et al., 2016). Therefore, successful coexistence with humans is key to maintain viable populations of large carnivores outside protected areas and also to facilitate movement between protected areas (corridors) (Cushman et al., 2018). However, the predicted increase in world human populations in areas

next to protected areas will present challenges to large carnivore conservation unless human-carnivore coexistence can be improved (Wolf & Ripple, 2016).

In response to the global increase in human-wildlife conflict, conservationists have realised the need to work beyond protected wildlife areas to effectively sustain viable wildlife populations (Treves et al., 2006). Various conflict interventions, to try and minimise the negative impacts of wild animals and promote peaceful coexistence, have been developed (van Eeden et al., 2018). These interventions differ in user-friendliness, cost to install and maintain, longevity and of course, effectiveness (Gehring et al., 2010). Broadly, existing interventions can be divided into two main groups; lethal and non-lethal techniques (Krafte Holland et al., 2018; Moreira-Arce et al., 2018). Lethal techniques are associated with the death of supposed problem animals, e.g., shooting or hunting and poisoning (Vantassel, 2012). Lethal methods are generally expensive, for example, in the United States Department of Agriculture and Wildlife Services programme spent over US$127 million controlling predators (Goldfarb, 2016). Although, lethal techniques are seen as a 'quick fix', they are less-effective in long-term and there is also evidence that lethal control may not be very effective at controlling or eradicating problem behaviour (Linnell et al., 1997). In contrast, non-lethal methods involve techniques that do not directly result in the death of an animal and are therefore preferred especially when mitigating conflict that involves a species threatened with extinction (McManus et al., 2014). Examples of existing non-lethal techniques include; translocation, fencing of protected areas, guarding, zoning amongst others (Loveridge et al., 2010b). Non-lethal methods can be further sub-divided into three categories: (a) those that target the wild animal, e.g., beehive fences and chilli- briquettes in elephants (Hedges & Gunaryadi, 2009); (b) those techniques that target the behaviour of the farmer, e.g., law enforcement and conservation education programmes (Biggs et al., 2017; Marchini & Macdonald, 2019), and; (c) those that target both wild animals and farmer behaviour e.g., the Lion Guardians

programme in Amboseli (Hazzah et al., 2017). Generally, techniques that target both wild animals and the behaviour of the farmer are more effective in the long-term (Krafte Holland et al., 2018).

Large carnivores are a high conservation priority because of several ecological, economic and cultural reasons. For example, large predators are valued because of their role as umbrella species for more extensive habitat protection (Roberge & Angelstam, 2004) as well as flagship species for broader conservation issues (Albert et al., 2018). Economically, carnivores are a source of income to host countries through tourism (van der Meer et al., 2016). Ecologically, large carnivores play an important role in ecosystem function as apex predators (Macdonald & Sillero-Zubiri, 2010). Given the above, loss of large carnivore species has cascading effects on their prey populations and could result in serious ecological consequences such as alteration in food webs and disruption of ecosystem function (Miller et al., 2016). Hence, the reason why the conservation of large carnivores and effective mitigation of human-carnivore conflicts are a major conservation priority (Ripple et al., 2014).

A species that deserves high conservation priority because of its role in the ecosystem and beyond is the African lion (*Panthera leo*) (IUCN, 2016). The lion is the largest carnivore in the Africa and is a member of the Felidae family. On average, adults males weigh between 186 to 225 kg, while adult females weigh between 118-143 kg (Smuts et al., 1980). Home range sizes vary across prides and sexes; for example in Hwange NP, Loveridge et al. (2009) found that the average home range size was 388 km^2 and 478 km^2 for females and males, respectively. Lion populations do relatively well in protected areas; however, protected areas are not large enough to contain this wide-ranging species (Sillero-Zubiri et al., 2007). Lions range widely beyond the boundaries of protected areas where they come into close contact with communities living along the edges (Bauer et al., 2016). With fewer than 30, 000 individuals in the wild, the

lion is currently listed as 'vulnerable' on the International Union for the Conservation of Nature's species red list (IUCN, 2016). Over the last two to three decades, the lion population has reduced by almost 43% and their habitat by approximately 95% (Bauer et al., 2016) (**Figure 1).** Therefore, to maintain a viable population in the future, effective mitigation of human-lion conflict along the boundaries of protected areas is key to persistence (Bauer et al., 2015a).

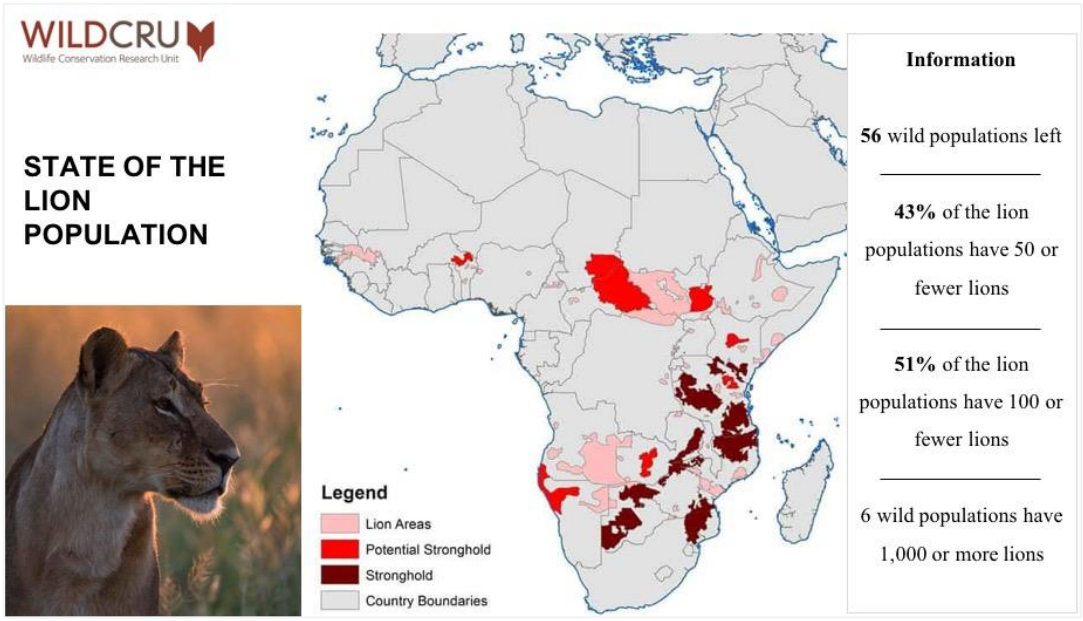


Figure 1*: A map showing the historic and the current distribution of lion populations.*

A wide range of technical tools have been developed to minimise livestock depredation by lions as well as other carnivores. These tools range from low-cost traditional techniques such as livestock herding (Ogada et al., 2003), to predator-proof enclosures (Lichtenfeld et al., 2014) and modern methods such as flashlights installed around livestock enclosures to deter lions (Lesilau et al., 2018). Nonetheless, effective mitigation of human-lion conflict is proving to be a challenge in most areas (IUCN, 2020). This is because most of these tools have not been evaluated scientifically and therefore, whether they are effective or not (and under what conditions) remains unknown (Gurd, 2012). Further, conflict between humans and lions (as well as other predators) is complex and motivated by deep rooted cultural beliefs and social

norms that vary widely across geographical areas and are not easy to explore (Dickman, 2010; Zimmermann et al., 2020). The variation in these factors means the 'one-size-fits-all' principle does not always apply to conflict interventions. While the 'problem' may look similar across different areas, a solution that is effective in one area/species might have undesirable effects in another (Dickman & Hazzah, 2016). Hence, the need to develop targeted, effective and culturally appropriate HWC interventions (Redpath et al., 2017).

The impact of wild animals on humans engenders negative attitudes and behaviours (Manfredo, 2008). By definition, attitudes 'represent a positive or negative evaluation of an object (e.g., a programme), and can influence how an individual behaves toward a wildlife species or conservation action (Bennett, 2016a). Moreover, attitudes influence behaviours and are invaluable for conservation evaluation (Manfredo & Dayer, 2004). There are several social science theories that have been proposed to explain people attitudes toward objects, e.g., the Theory of Planned Behaviour (Ajzen, 2011).

In this particular study, I draw insights from two social science theories: the Cognitive Hierarchy (Fulton et al., 1996), and the Diffusion of Innovation (Rogers, 2004). The cognitive Hierarchy theory is a behavioural economic model that is used to explain the human thought process. It states that the human behaviour is guided by a hierarchy of interrelated cognitions including attitudes, values[2], value orientations[3], norms[4] and behavioural intensions[5]. Further, this particular theory proposes that stable and deep-rooted values provide a foundation for belief patterns which in turn influence more specific attitudes and then behavioural intensions and individual behaviours (Fulton et al., 1996). In conservation this particular theory has been

[2] Personal beliefs towards an object
[3] The principles of right and wrong that are accepted by an individual or a social group
[4] An individual perception of whether people important to them would approve of them performing the behaviour
[5] Motivational factors that influence a given behaviour. The stronger the intension the more likely the behaviour will be performed.

used to explore value orientations amongst different audiences (Chase et al., 2015) to forest planning issues (Whittaker et al., 2006). I particularly chose this theory because it offers an advantageous framework for systematically understanding the wildlife-related beliefs and interests of various segments of a community.

Conservation interventions are successful if they are fully-adopted by the intended end-users. The Diffusion of Innovation (DoI) theory is a behavioural theory that seeks to explain why and how new ideas or practices (i.e., innovations) are adopted (or not) by different members of a social system (Rogers, 2004). This theory has been used in health-care (Scott et al., 2008) and agriculture (Rogers, 2004), and increasingly in conservation efforts (Mbaru & Barnes, 2017) to provide valuable insight into the barriers and motivations to adopt or reject new ideas or practices (Hubbard & Sandmann, 2007). A hallmark of the theory is 'diffusion', referring to the rate at which an innovation spreads through a social group over time, and 'innovation', which refers to the novel idea or practice that is to be adopted. As suggested by Hubbard and Sandmann (2007), 'the diffusion framework is a fairly involved framework that includes several "sub-theories" or concepts [which] provide insight into human and social nature, including how new information is accepted (or not accepted) by potential users'.

1.2: Background of the study

The Hwange-Matetsi Protected Area Complex (HMPAC) in northwestern Zimbabwe is of global importance for lion conservation (Cushman et al., 2018). This protected area complex is part of the wider Kavango Zambezi Transfrontier Conservation Area (KAZA TFCA), one of the world's sixth-largest lion populations stronghold (IUCN, 2016). However, like in other lion rangelands across Africa, the local lion population in the HMPAC is under threat (Loveridge et al., 2010a). Anthropogenic mortality (i.e., conflict with farmers, trophy hunting) accounts for 42% of the total lion mortality in this area, which is unsustainable (Loveridge et

al., 2017). The human-lion conflict situation in the HMPAC is well-understood, and the situation has been found to be influenced largely by livestock not brought home to a pen at night (Kuiper et al., 2015; Loveridge et al., 2017). Consequently, between 2009 to 2013, subsistence farmers living along the HMPAC lost over 1,000[6] domestic animals (estimated cost = US$ 50,000) to lions (Loveridge et al., 2017). The majority (80%) of the depredation occurs during night time and outside protective enclosures when livestock is left to graze when it should have been enclosed in overnight protective enclosures (Loveridge et al., 2017). Kuiper et al., (2017) revealed that incidences of lion attacks on livestock peak during the wet months when livestock are herded in areas closer to protected areas. In retaliation for livestock depredation, local farmers use illegal lethal methods such as snaring or poisoning to kill supposed problem animals (Loveridge et al., 2010a). Problem animal control (PAC)[7] by the authority officials is also common (Loveridge et al., 2010a). Approximately 50 lions (*ca*. 10% of the total lion population) were killed in conflict related incidents in HMPAC between 2008 to 2016 (Loveridge et al., 2017). This lion mortality rate is unsustainable, and a human-lion conflict intervention was necessary.

In 2012, in collaboration with the rural district councils (RDCs), traditional leaders and the local communities, we developed the Long Shields Community Guardian programme (hereafter: "the *Long Shields programme"*), a non-lethal, community-based, human-lion conflict intervention for the HMPAC. This programme was inspired by the Lion Guardians programme in Amboseli, Kenya (Hazzah et al., 2014). The main objective of the Long Shields programme is to promote human-lion coexistence by encouraging farmers to adopt livestock husbandry practices that minimise the risk of livestock depredation by lions such as guarding livestock during the day and enclosing livestock in protective enclosures during night time.

[6] 1,000 livestock is equivalent to 20% of the total livestock population in our study area
[7] The legal lethal destruction of 'problematic' wild animals such as lions

Evidence shows that herding livestock during the day and penning them at night is an effective method against depredation by wild carnivores (Ogada et al., 2003). In addition, the Long Shields programme aimed to mitigate losses to lions, through assisting farmers to: (a) recover missing livestock; (b) build and implement reinforced livestock enclosures; (c) utilise a smartphone early-alert system in concert with satellite collared lions; and, (d) haze/chase problem lions back into the park when they come close to human settlements.

The Long Shields programme was introduced in several stages. The first stage involved a baseline interview survey in 2010-2012, where 632 farmers across 82 villages were interviewed to assess attitudes towards lion. We held several meetings (n = 8) with our stakeholders, and after that, we selected 14 local farmers (women = 2, men = 12; mean age: 21 - 65 years old) to be trained as Long Shields Community Guardians (hereafter: *Community Guardians*) based on recommendations from community leaders. In selecting our prospective Community Guardians, we used the following criteria: geographic location, physical fitness, English literacy, respectability and trust amongst their community, and previous direct experience with lions (e.g., physically chased a lion). Community Guardian were then trained by the Trans-Kalahari Predator Programme (WildCRU, University of Oxford) in lion tracking, the use of radio-telemetry and GPS equipment, data collection protocols (e.g., livestock depredation assessment), and conflict mitigation techniques (e.g., herding, enclosure fortification). Additionally, Community Guardians were trained to use the lion early-alert system through the WhatsApp smartphone platform (WhatsApp.Inc, 2009). As part of this system, between 2013 and 2017, we identified and collared 23 lions (female = 6, male = 17, across 9 prides) selected because their home ranges significantly overlapped with the local farming communities outside the protected areas. These lion satellite collars took one location every two hours. Whenever lions were within three kilometres of the park boundary, an alert message was sent via the Community Guardians to a network of farmers within the treatment

villages. Lions that crossed the park boundary and approached human settlements were hazed (or chased) by the Community Guardians plus volunteers from the treatment villages with the use of a '*vuvuzela'*, a plastic horn that produces an irritating sound of about 127 decibels (dBA) (Petracca et al., 2019). But whether this intervention programme has been effective or not is an important question that this study seeks to answer using an impact evaluation approach.

1.3: Impact evaluation framework

Impact evaluation (IE) is defined as a measure of the extent to which the intervention's intended outcome has been achieved (Gertler et al., 2011). IE goes beyond examine the goals of an intervention, it also examines the unintended impacts (Gurd, 2012). Specifically, in conservation, IE is vital for several reasons: it enables conservationists to show which interventions work and which ones do not, so that limited resources (e.g. financial) can be best used for maximum benefits (Ferraro & Pattanayak, 2006). Further, it allows conservationists to learn from their mistakes and not to waste time and resources on ineffective interventions (Gunaryadi et al., 2017). In addition to the reasons stated above, the main reason I am particularly interested in evaluating the impact of the Long Shields programme is because it presented an invaluable opportunity to learn and to contribute knowledge to broader human-carnivore conflict mitigation. Additionally, the potential to replicate this intervention programme to other areas faced with a similar problem is high. A step-by-step process of conducting an IE that I followed is summarised below in **Figure 2**. In sequence, the IE framework involves: (i) developing any evaluation plan, (ii) developing and piloting the survey instrument, (iii) conducting baseline survey and analysis, (iv) conducting a follow-up survey and analysis, and (v) disseminating findings (**Figure 2**).

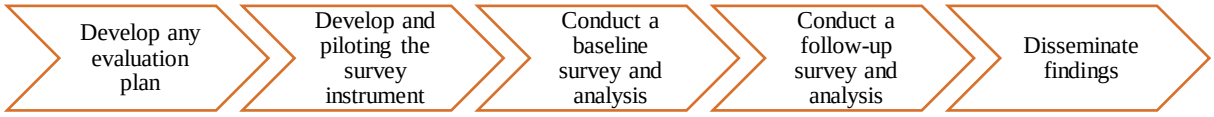


***Figure 2**: Steps to conducting an Impact Evaluation (IE)*

One common method of evaluating the impact of intervention programmes in public health as well as in other fields is by utilising a Theory of Change (ToC). ToC is a methodology that follows a logical and chronologically ordered sequence of causal linkages to illustrate the inputs, activities, target audiences, and desired outcomes of the programme under evaluation (Margoluis et al., 2009). Theory of change defines a programme's long-term goals (i.e., actual and desired goals) and then maps backward to identify the necessary preconditions that must be in place to achieve these goals (Woodhouse et al., 2015).

To evaluate the impact of the Long Shields programme, I utilised a Theory of Change (ToC) (see **Figure 3**). I chose to utilise this framework because it is flexible and particularly useful in collecting baseline data (Woodhouse et al., 2015). It also allows adaptive management through evaluating and monitoring at each stage of the intervention rather than evaluating when the ultimate goal has been achieved (van Eeden et al., 2020). Further, the ToC framework is robust and has been used in different conservation contexts such as evaluating the impacts of illegal wildlife trade (Biggs et al., 2017), public awareness campaigns (Howe et al., 2012) and human-wildlife conflict mitigation efforts (Morehouse et al., 2020).

In designing the ToC, I also incorporated two behaviour change theories: (i) The Elaborate Likelihood Model of Persuasion (Petty & Cacioppo, 1986) and (ii) The Theory of Reasoned Action (Fishbein & Ajzen, 1975). The Elaborate Likelihood Model of Persuasion, proposes that people's attitudes towards object are subjected to change and this depends on the amount of thoughtful consideration that occurs in response to a persuasive communication. Under this

model, there are two types of attitude change: the central route and the peripheral route. The two types attitude change differ in the amount of elaboration involved. The central route can occur when there is high cognitive elaboration whereas the peripheral route can occur in the absence of cognitive elaboration. For example, peoples' attitudes are likely to change by the central route if they are presented with new information that they find stimulating. In contrast, attitudes are likely to change the peripheral route if new information is presented on a subject that people find uninspiring and without their active involvement. The central route change is more long-term, influences ones' behaviour (e.g., lion killing) and it is more resistant to counter-persuasion than the peripheral route (Petty & Cacioppo, 1986).

The Theory of Reasoned Action, proposes that the intentions to engage in behaviour are the most immediate determinant of that behaviour. In turn, intentions are influenced by attitudes, normative pressure and perceived behavioural control. Further, this theory proposes that for one to perform a certain behaviour, there should be one or more conditions that must be true, and these conditions include: there are no environmental constraints to undertaking the behaviour and the person has the necessary skills to preforming the behaviour; the person believes there are advantages to preforming the behaviour than disadvantages; they perceive that there is normative social pressure to perform the behaviour (Fishbein & Ajzen, 1975). We draw upon these two theories to explain how the intervention (i.e., the Long Shields programme) will bring about the desired change.

1.4: Long Shields programme indicators of success

An indicator is a metric describing the transition between two states of interest (Jones et al., 2017). Indicators range from knowledge-focused, where the sole purpose is to facilitate learning about a system, to action-focused, to inform policy (Jones et al., 2017). Indicators of success are invaluable for decision-making and useful in communicating with non-specialists

(Schiller et al., 2001). Further, they are a valuable tool in evaluating conservation effectiveness as they allow tracking of outcomes over time (Eklund et al., 2020). Using our ToC, I listed the following Long Shields programme indicators of success: (a) a decrease in number of livestock killed by lions over time; (b) a positive shift in self-reported changes in attitudes towards lions and the Long Shields programme in general; and (c) a reduction in the number of lions killed in retaliation over time (**Figure 3**). In summary, this research study tests whether the indicators or conditions listed above were fulfilled or not.

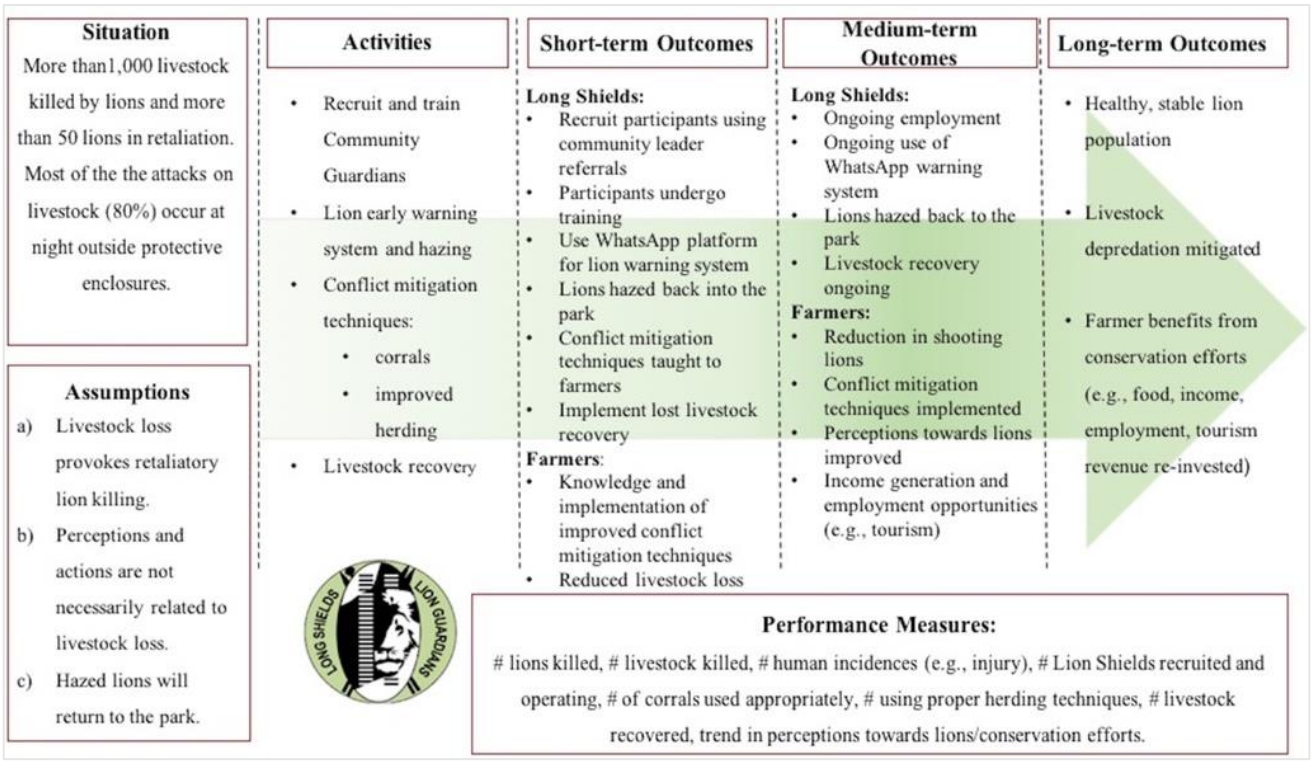


***Figure 3**: The Long Shields Community Guardian programme Theory of Change*

1.5: Long Shields programme impact pathway

An impact pathway maps 'how' the intervention will bring about the desired change (Woodhouse et al., 2015). Specifically, it describes how the outcomes were derived from the activities listed. In this research study, I hypothesised that the Long Shields programme activities listed in **Figure 3 (**e.g. hazing lions, encouraging farmers to adopt behaviours that

reduce depredation risk and warning farmers of approaching lio**ns)** will result in: (a) a reduction in livestock loss to lions (both perceived and actual); (b) reduction in personal safety risk; and, (c) the awareness of and demonstrated effort by the Long Shields Community Guardians, would result in a positive shift in farmers' attitudes toward lions (including the adoption of the programme), and ultimately fewer lions killed in retaliation for livestock loss over time. Whether or not these assumptions hold true is what I set to examine.

1.6: Study aims and objectives

Using the Long Shields programme in Zimbabwe as an example, the main purpose of this research is to evaluate the effectiveness as well as to demonstrate the potential value of conservation intervention programmes designed in collaboration with local communities. Specifically, the following four research objectives, which form the framework for this thesis, were addressed.

Objective 1*:* To explore baseline perceptions towards lions, protected areas, and the socio-economic factors influencing these perceptions to inform the design of culturally appropriate and community-led human lion conflict intervention.

Hypothesis: The risks and costs from living with lions and other potentially damage-causing wild animals would negatively affect a farmer's perception towards lions and conservation authorities, while benefits derived from conservation activities will have a positive effect on perceptions.

Objective 2*:* To examine the self-reported changes in farmers' attitudes towards lions before and after implementation of a human-lion conflict intervention programme.

Hypothesis: The implementation of a human-lion conflict intervention programme will lead to a significant positive shift in attitudes towards lions for participating farmers compared to non-participating farmers.

Objective 3: To examine the changes in livestock loss to lions as well as the prevalence of retaliatory lion killing by farmers before and after implementation of a human-lion conflict intervention programme.

Hypothesis: As a result of the human-lion conflict intervention programme's activities I would see (a) a significant decrease in livestock depredation by lions for participating farmers (treatment group) in comparison to non-participating farmers (non-treatment group), and; (b) a significant reduction in lion retaliatory killings by participating farmers after the introduction of the programme.

Objective 4*:* To examine factors that can limit or advance uptake of human-carnivore conservation programmes by end users, using the Long Shields programme as a case study.

Hypothesis: Persistent or higher livestock losses, and related to this, economic loss and increased risk to personal safety might be predicted by late adoption of the human-lion conflict intervention by farmers.

1.7: Study area

This study was conducted in three rural communities located alongside the HMPAC. Two communities border the Hwange National Park: (a) Tsholotsho (Matupula Chieftainship, 2,171 km^2); (b) Mabale (Nelukoba-Dingani Chieftainship, 480 km^2); while the third community (c) Victoria Falls (Mvuthu-Shana Chieftainships, 655 km^2) border the Zambezi National Park (**Figure 4**). The three rural communities differ in (a) ethnic groups; (b) financial losses to

depredation and (c) benefits from wildlife via tourism and trophy hunting (through the Communal Areas Management Programme for Indigenous Resources (CAMPFIRE) and private operators), which makes them ideal sites for a comparative study. Further differences across study sites are summarised in **Table 1**. For example, farmers in Tsholotsho are Ndebele speaking and therefore belong to the Ndebele ethnic group, while in Mabale and Tsholotsho, local people are a mix of Ndebele, Tonga and Nambya ethnic groups.

The smallest unit in our area is farmstead or household, which refers to a group of people, related by blood or marriage living together as a family. Several farmsteads of up to 25 make up a village, led by a village head or '*Sobhuku'*. The number of farmsteads in a village ranges between six and 72. The role of the village head is to chair the village assembly. Several villages of up to ten, make up a community. A community is led by a Chief, whose main role is to lead cultural ceremonies and to preside over disputes (Population Service International, 2020).

Climate

All three communities are situated in an area which is classified as semi-arid (average rainfall: 550-600 mm) and three seasons are distinguished: (a) a cold-dry season (May-August); (b) a hot-dry season (September-November); and (c) a wet season (December-April) (Guerbois et al., 2012). The low-nutrient Kalahari soils and low levels of income (most of these farmers are subsistence farmers with no other sources of income) mean farmers in these areas are at the brink of hunger (Sanchez, 2002).

Human sources of livelihood

Crop husbandry and extensive livestock rearing are the main sources of human livelihoods (Kuiper et al., 2015; Loveridge et al., 2017). The principal crops cultivated are maize (*Zea*

mays), millet (*Pennisetum glaucum*) and sorghum (*Sorghum bicolor*), whereas the main domestic stock reared are cattle (*Bos taurus*), donkey (*Equus asinus*), sheep (*Ovis aries*) and goat (*Capra hircus*) (Kuiper et al., 2015; Loveridge et al., 2017).

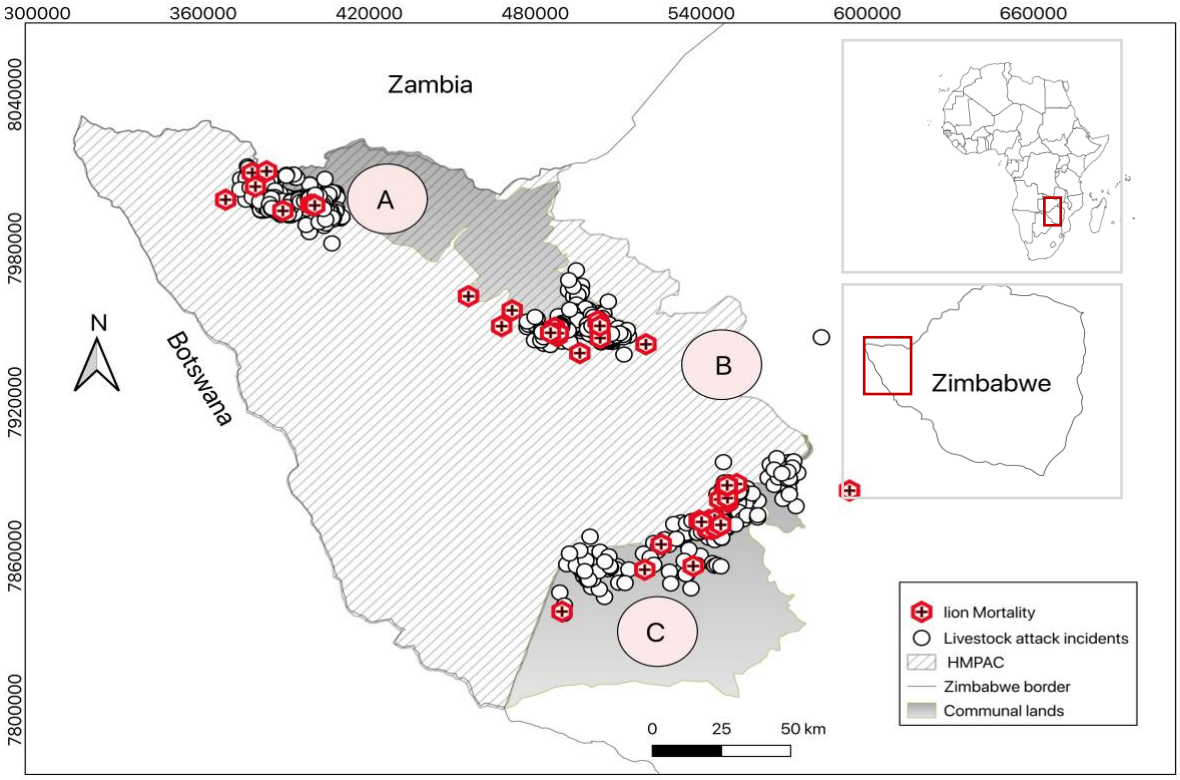


Figure 4: *A map of our study area, in northwestern Zimbabwe (A= Victoria Falls; B = Mabale and C = Tsholotsho).*

Table 1*: Population size, residential density and ethnic groups of our study sites (Tsholotsho, Mabale and Victoria Falls) in northwestern Zimbabwe*

Parameters	Tsholotsho	Mabale	Victoria Falls
Area (km^2)	2,171	480	655
Density (buildings/ km^2)	1.8	6.2	6.1
Ethnic Groups / (%)			
- Ndebele	99	48	57
- Tonga	0	20	14
- Nambya	1	32	29
Depredation costs/ farmstead[a]	US$8.93	US$4.34	US$7.79

[a] *Source: Loveridge et al., (2017a)*

Impacts from wild animals

In the study area, crop-raiding (Guerbois et al., 2013) and livestock depredation by wild carnivores is common (Loveridge et al., 2010b). Other studies (Kuiper et al., 2015) have shown that the lion and spotted hyaena often kill high-value livestock (i.e., cattle and donkeys). In contrast, the leopard (*Panthera pardus*), jackal (*Canis mesomelas*), wild dog (*Lycaon pictus*), and cheetah (*Acinonyx jubatus)* occasionally prey on small, low-value stock (i.e., goat and sheep) (Rasmussen, 1997). Consequently, compared to other predators, financial losses to the lion and spotted hyaena can be relatively high. In addition to livestock depredation, there is also the risk of personal injury from lions, whether real or perceived (Kushnir & Packer, 2019). Although previous studies show that lion attacks on human are rare (Loveridge et al., 2010b), between 2008 and 2019, there were four reports (two injuries and two fatalities) of people attacked by lions in the study area.

Problems with lions (and other wild animals) in the rural communities are jointly managed by the Zimbabwe Parks and Wildlife Management Authority (ZPWMA) and the Rural District Councils (RDCs), with lethal control as the most commonly used intervention (Loveridge et al., 2010b). However, Mabale, Tsholotsho and Victoria Falls are all part of CAMPFIRE: a community-based natural resource management programme that aims to provide benefits to rural communities that live with wildlife (Frost & Bond, 2008). This programme generates revenue through trophy hunting, ecotourism, and land leasing fees (Frost & Bond, 2008). Fifty-five percent of the total revenue from CAMPFIRE is supposed to be distributed to local communities to be used for community development projects such as drilling water sources and renovating clinic and classroom blocks (Mutanga et al., 2017); However, the intended benefits often fail to reach the local communities (Taylor, 2009). Unlike in other countries within the KAZA TFCA, e.g. Botswana and Namibia, farmers part of this study area do not

receive financial compensation from the Government for livestock and crop losses to wild animals.

1.8: Experimental design

Of the total 82 villages across the entire study area, 50% (n = 41) were assigned to the treatment group (i.e., subjected to the Long Shields programme) and the remainder (n = 41) villages were not subjected to any treatment. The allocation of villages to the treatment was *not* random, given the objective of the programme was to solve a real-world problem. Also, there are ethical considerations when assigning people to treatment or non-treatment groups in the face of potentially life-threatening carnivore conflict. Due to non-random allocation of villages, I adopted a quasi-experimental design with Before-After Control-Intervention (BACI) measurements (Thiault et al., 2017). Under this design, I sampled treatment and control groups of farmers simultaneously before as well as five years after the Long Shields programme implementation. I specifically chose this study design because it is robust (Smokorowski et al., 2017) and commonly applied to estimate causal effects of an intervention on a target population when the random assignment to treatment is not possible (Gore et al., 2008).

1.9: Overview of research methods

This research study employs two research methods to collect the data: (a) semi-structured interviews (Chapters 2, Chapter 3 and Chapter 5) and (b) livestock attack records (Chapter 4).

Semi-structured interviews

Semi-structured Interviews (SSIs) are commonly used to explore attitudes towards wildlife, particularly large carnivores (Dickman, 2005; Marchini, 2010; Western et al., 2019). Following Dickman (2008), SSIs with open and closed-end questions formed the primary method of data collection. SSIs were utilised because that they allow the interviewees to give detailed

responses in their own words. The surveys were organised in three phases: (a) the baseline survey was conducted in 2010-2012; (b) the follow-up or repeat survey was conducted in August 2017; and, (c) a more programme-focused survey to explore the rate of intervention uptake by farmers was conducted in 2018.

The survey instrument consisted of five main sections: (a) general information (e.g., number of people living in each farmstead, sources of livelihood); (b) mechanisms farmers use to guard against crop and stock losses to wild animals; (c) perceptions towards wild animals (including the lion); (d) livestock losses to wild carnivores and (e) wildlife utilisation (including attitudes towards the Hwange-Zambezi Wildlife Area and the benefits from the CAMPFIRE programme) (see Appendix I and II for the before and after survey instruments respectively). Survey questions were designed following the guidelines set out by White et al. (2005): less contentious questions were asked during the early stages of the interview while more complex questions (e.g., attitude related questions) were asked later when the interviewee's confidence had increased.

The survey instrument was pilot-tested in the Mabale community on 20 farmers of varying age and gender to identify possible. Within each village, 20% of the total farmsteads were selected for the survey and a systematic sampling technique was utilised, i.e., every fifth household regardless of whether they owned livestock or no was selected. Participation in the study was strictly voluntary, and all farmers gave verbal free and informed consent to participate. To minimise response bias (e.g., social desirability) (White et al., 2005), the purpose of the study was explained before commencing the interview, and there was no monetary compensation for participants. The head of the farmstead was interviewed in their preferred language (i.e.,

Ndebele, Tonga or *chi*Nambya). Only one person per farmstead was surveyed, and the aim was to survey equal samples of men and women. Each interview session lasted ±90 minutes[8].

During the repeat survey, the same farmers who participated in the baseline survey were approached and asked the same questions using the same survey instrument. This is because we wanted to accurately detect possible changes in attitudes after an intervention. The repeat surveys were conducted by four interviewers (woman = 1, men = 3), who were different from the ones that conducted the baseline surveys (i.e. the lead author and two other male interviewers) to minimise bias in the responses. In order to further minimise bias, the interviewers were not affiliated to the Long Shields programme and were not told which villages participated in the programme and which ones did not.

Occurrence records

I also utilised records of livestock attacks collected over a 10-year period (i.e., from January 2008 to December 2017) and this includes records of retaliatory lion killings by farmers collected during the same timeframe. The data were comprehensively monitored by the lead author assisted by co-authors. I define an *'attack'* as an event in which a lion killed or injured one or more livestock species. The majority of livestock depredation and lion mortalities were reported directly to Long Shields programme personnel, with an incident report form used to collect event details. To assess the farmer's accuracy in carnivore identification, each farmer was shown pictures of different carnivores and their paw prints, which they were asked to identify. To validate livestock loss incidents, each incident was independently verified by visiting the incident site. All incidents were confirmed with the village head who, as part of

[8] This includes time taken to verify kill-sites in the grazing area etc.

their official civil responsibilities, keeps a register of all livestock owned by people residing in the village.

1.10: Thesis structure

The thesis includes four data chapters summarised briefly below. The chapters are formatted as scientific papers; therefore, there is some overlap in information across chapters, e.g., information on the study area as well as the Long Shields programme, the intervention that I evaluate in this study. The four chapter build on each other.

Chapter One:

General introduction

The general introduction, provided an overview of the human-wildlife conflict around the globe and methods that have so far been developed to limit the impacts of human-wildlife conflict. I also discussed the human-lion conflict situation in our study area and the Long Shields programme, the community-based, non-lethal, human-lion conflict intervention programme that we, in collaboration with local communities, introduced in our study area. I presented the aims as well as the goals of the Long Shields programme, and how we thought the intervention programme would bring about the desired change. Towards the end of the introduction, I presented the aims, objectives of this research study and a general summary of our research methods.

Chapter Two:

Exploring perceptions of subsistence farmers in northwestern Zimbabwe towards the African lion in the context of local conservation actions

In preparation for the introduction of a human-lion conflict intervention programme along the boundaries of two protected areas in northwestern Zimbabwe, I explored the perceptions held

by subsistence farmers (living in communal lands within the CAMPFIRE programme area in northwestern Zimbabwe) towards the African lion (*Panthera leo*) and related conservation interventions undertaken by management authorities. The results from this chapter provided baseline information which we used for comparison with attitudes after the introduction of the intervention programme in the next chapters.

[Chapter published in *African Journal of Wildlife Research*]

Chapter Three:

Evaluating the effects of a conservation intervention on rural farmers' attitudes toward lions

I examine the self-reported changes in farmers' attitudes (towards the African lion (*Panthera leo*) before and after the introduction of the Long Shields programme. I hypothesise that the before-after change in attitudes of farmers who participated in the Long Shields programme would be significantly more positive than those of farmers who did participate in this programme. Results from this study contribute to the growing literature on programme evaluation, and I demonstrate that people's attitudes are valuable for assessing the impact of conservation programmes.

[Chapter published in the *Journal of Human Dimensions of Wildlife]*

Chapter Four:

Effectiveness of community-based livestock protection strategies: a case study of human-lion conflict mitigation

I examine the change in livestock loss to lions as well as the prevalence of retaliatory lion killing by farmers before and after the Long Shields programme. I hypothesise that as a result of the programme's activities I would see a significant decrease in livestock depredation to

lions for participating farmers (treatment group) compared to non-participating farmers (non-treatment group), as well as a significant reduction in lion retaliatory killings by participating farmers after the introduction of the programme. I demonstrate that, through relevant community-based approaches, livestock depredation by lions can be effectively reduced and that the Long Shields conflict mitigation model could be considered in other contexts for addressing human-lion or other carnivore conflicts.

[Chapter under review in *Oryx- international Journal of Conservation*]

Chapter Five:

Better late than never: a case study using diffusion of innovation theory to understand the adoption of a human-lion conflict intervention

One of the complexities of mitigating human-wildlife conflict is that farmers need to adopt the new interventions and use them, but that is not always the case. What if farmers do not use interventions that they helped design? In this chapter, I explore factors that can limit or advance the uptake of and use of human-carnivore conservation programmes by subsistence farmers. I use the Long Shields programme as an example. Results from this chapter provide insight into factors that can limit or advance human-carnivore conservation programmes.

[Chapter accepted in *Carnivore Damage Prevention News*]

Chapter Six:

General Discussion

I begin by reviewing the aim and objectives of this study, after that, I review the key findings including the advantages and disadvantages of the community programmes using the Long Shields programme as an example. Thereafter, we discuss the implications of our findings to

species conservation and lion conservation in particular. Finally, I make recommendations and future priorities for research.

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Chapter Two: Exploring Perceptions of Subsistence Farmers in Northwestern Zimbabwe Towards the African Lion in the Context of Local Conservation Actions

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In fond memory of 'Cecil-the-lion'

** This chapter has been published in the African Journal of Wildlife Research*

2.1: Chapter summary

We explored the perceptions held by subsistence farmers (living in communal lands within the CAMPFIRE programme area in northwestern Zimbabwe) towards the African lion (*Panthera leo*) and related conservation interventions undertaken by management authorities. Conceptually guided by the cognitive hierarchy, we used a semi-structured, face-to-face interview format to collect data across three different farming communities bordering Hwange and Zambezi National Parks. Ordinal regression models were used to analyse the data. Our results illustrate that farmers' perceptions towards lions were strongly negative and appeared to be associated with the geographic location in which the farmer lived, as well as the farmer's ethnic group. We also found that perceptions towards lions were not associated with specific livestock losses or to the potential benefits farmers received from wildlife conservation, e.g., school classroom blocks or road improvements. Instead, we suggest that fear of lions and perceived risk to livestock or human wellbeing may play a stronger role in shaping farmers' perceptions compared to actual livestock losses. Moreover, we suggest that sharing information across farmer social networks within a community area, along with the potential for media attention over sensational events, may also influence perceptions towards lions. Our results contribute a baseline dataset for future applied research in this area, and provide insight into developing locally-meaningful conservation interventions, including the type of information to be shared, channels for communication, and the benefits derived from participating in wildlife conservation.

Keywords: human-lion conflict, livestock depredation, *Panthera leo*, subsistence farmers, Zimbabwe

2.2: Introduction

Worldwide, large carnivore populations are declining (Inskip & Zimmermann, 2009). This decline can be attributed to the increase in human population growth and associated resource use resulting in a reduction of natural prey, habitat fragmentation or loss, and the over-exploitation of certain species (Ripple et al., 2014). Given that the world's human population is predicted to continue to increase (Gerland et al., 2014), especially in areas next to protected areas (Wittemyer et al., 2008), a further decline in large carnivore populations can be expected, unless human-carnivore coexistence can be improved (Woodroffe, 2000).

A species struggling with the consequences of human population growth is the African lion (*Panthera leo*) (Bauer et al., 2016). With fewer than 30,000 individuals remaining in fragmented populations, lions have been extirpated from 85% of their historic range, with an overall population decline of 43% over the last two decades (Bauer et al., 2016). One of the few areas in Africa with a sizable lion population is the Hwange-Matetsi Protected Area Complex (HMPAC) in Zimbabwe (IUCN, 2016). This area supports *ca*.700 lions and is part of the wider Kavango-Zambezi Transfrontier Conservation Area (KAZA TFCA) population: one of only six remaining areas that support over 1,000 lions (IUCN, 2016). In the HMPAC, lions are commonly killed by local subsistence farmers in retaliation for livestock loss (Loveridge et al., 2010a). For example, between 2009 and 2017 more than 50 lions, most of which were females and dispersing young males, were killed in conflict-related incidents and many more from trophy hunting (Loveridge et al., 2017). Loveridge et al. (2010a) demonstrated that anthropogenic mortality, conflict with farmers included, accounts for up to 42% of the total lion mortality in this area, which is unsustainable.

To safeguard the future of lion populations, governments and conservation organisations in lion-range countries need to develop effective coexistence strategies (IUCN SSC Cat Specialist

Group, 2018). However, fundamental to developing coexistence strategies is understanding the perceptions and actions of the local people that share the landscape with lions (Hill, 2015; Gebresenbet et al., 2018). As such, our study draws conceptual insights from the cognitive hierarchy framework (Fulton et al., 1996) as well as other relevant literature (Ajzen, 2001; Bennett, 2016a; Amit & Jacobson, 2017). Within this conceptual framework we first explore perceptions (or beliefs), defined as how a person observes, interprets and evaluates an experience, object, action or other social entity (Pickens, 2005). Perceptions can change over time, and can be influenced by various external factors (e.g., age, gender, education), the collective sharing of information, as well as normative behaviours (Bennett, 2016a). However, perceptions are context-specific and therefore cultural, social, economic and environmental factors must be considered (Woodford et al., 2016).

Examining local perceptions can be helpful in conservation policy, in terms of understanding peoples' views on wildlife species or the role of different governance arrangements and their impact on livelihoods and conservation objectives (Bennett, 2016a). Specifically, risk perceptions can be very important to understanding human relations with lions, as well as the practices they adopt or enact (Amit & Jacobson, 2017). Moreover, perceptions of governance arrangements to conserve lions or other wild species can be useful to identify issues of legitimacy, appropriateness, or inclusivity (Bennett et al., 2017). Perceptions "represent a facet of the truth" (Bennett 2016, p. 588), and can influence how an individual assesses the value of a wildlife species or conservation action (Bennett, 2016a). Additionally, perceptions (including changing perceptions) can influence the actions or behaviours that individuals choose to enact (Manfredo & Dayer, 2004).

While several studies [e.g. Dickman (2005); Parry and Campbell (2009); Mkonyi et al. (2017)] have assessed perceptions towards lions and other carnivores in African countries, this

information is lacking for Zimbabwe's HMPAC. As such, in preparation for the introduction of a human-lion conflict intervention programme, we conducted semi-structured interviews to explore farmers' perceptions and actions towards lions and conservation authorities and management interventions. Specifically, we explored: (a) the perceptions, and factors influencing perceptions, of local farmers towards lions; (b) current practises or actions that farmers use to mitigate conflict with lions; and, (c) farmers' perceptions towards conservation actions.

Additionally, given that the lion is not the only species that comes into conflict with local farmers in this area (Loveridge et al., 2017), we also gathered perception data on other wildlife species that have the potential to cause negative livelihood impacts, and compared these to perceptions of lions. The other species included the elephant (*Loxodonta africana*) and spotted hyaena (*Crocuta crocuta*). We hypothesised that the risks and costs from living with lions and other potentially damage-causing wild animals would negatively affect a farmer's perception towards lions and conservation authorities, while benefits derived from conservation activities will have a positive effect on perceptions. More specifically, we predicted that perceptions towards different damage-causing species are associated with the extent of damage (e.g., costs) and level of human safety threat. Taken together, we suggest that understanding perceptions and actions of farmers towards lions and conservation authorities will help develop relevant coexistence strategies with farmers, as well as provide baseline data that can be used to gauge community support for lion conservation in the area and across other lion range countries (Amit & Jacobson, 2017; Gebresenbet et al., 2017).

2.3: Methods

Study Area

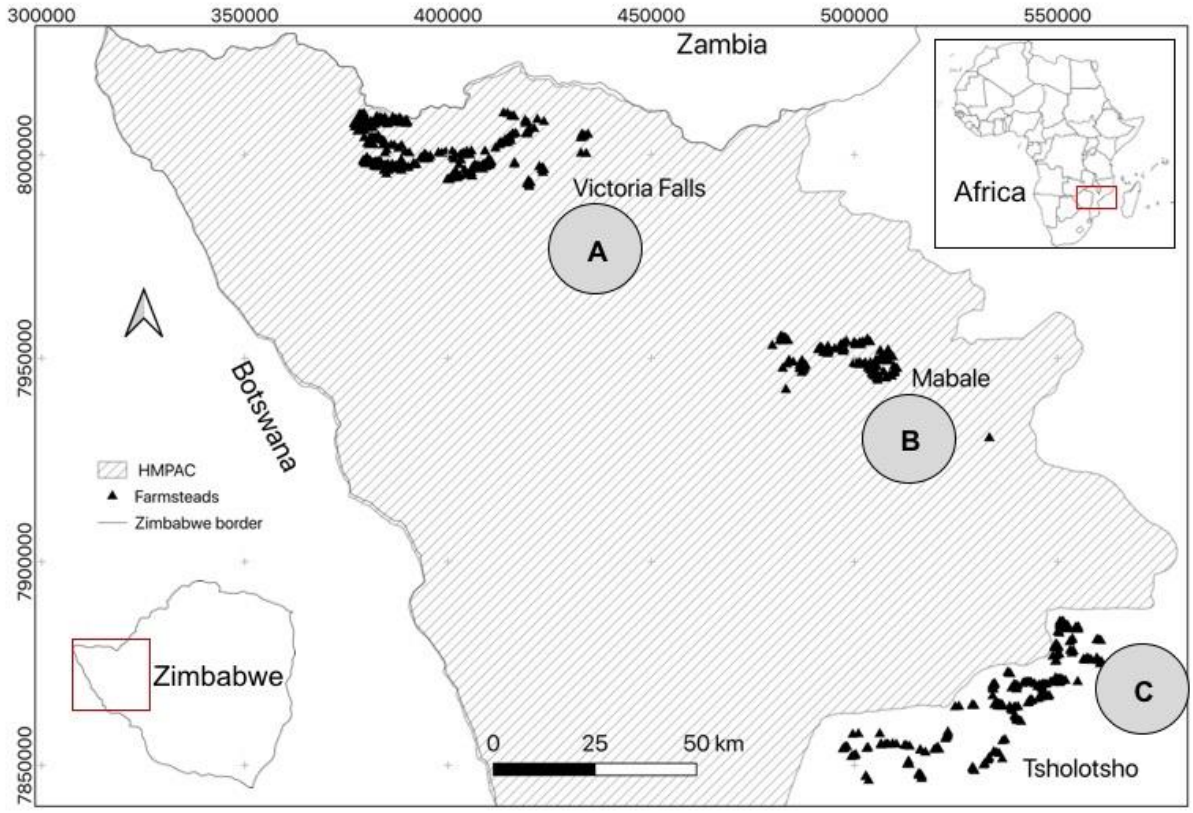


Figure 5*: Our study sites (Tsholotsho, Mabale and Victoria Falls) within the Hwange-Matetsi Protected Area Complex (HMPAC) in northwestern Zimbabwe, where 632 semi-structured interviews were conducted to explore perceptions of subsistence farmers towards lions (Panthera leo).*

This study was conducted in three rural communal land sites located alongside the boundaries of protected areas in northwestern Zimbabwe, and were selected based on their (a) proximity to protected areas; (b) differences in ethnic groups; (c) financial losses to depredation; and (d) the benefits from Communal Areas Management Programme For Indigenous Resources (CAMPFIRE). Other site characteristics are summarized in **Table 2**. Of the three rural communities, two border the Hwange National Park: Tsholotsho (Matupula and Siphoso Chieftainships: 2,171 km^2) and Mabale (Nelukoba-Dingani Chieftainship: 480 km^2), while Victoria Falls (Mvuthu and Shana Chieftainships: 655 km^2) was the third site and borders the Zambezi National Park (**Figure 4**). All three rural communities and the mentioned protected areas are part of the wider KAZA TFCA.

Table 2*: Characteristics of our study population based on population size, residential density and ethnic groups in HMPAC, Zimbabwe*

Parameters	Tsholotsho	Mabale	Victoria Falls
Area (km^2)	2,171	480	655
Density (buildings/ km^2)	1.8	6.2	6.1
Ethnic Groups / (%)			
- Ndebele	99	48	57
- Tonga	0	20	14
- Nambya	1	32	29
Depredation costs/ farmstead[a]	US$8.93	US$4.34	US$7.79

[a] *Source: Loveridge et al., (2017)*

All three rural communities are also part of CAMPFIRE. CAMPFIRE's objectives are to devolve natural resource management to the local community level and provide direct benefits to rural communities living with wildlife (Frost & Bond, 2008). CAMPFIRE generates revenue through trophy hunting, ecotourism, and land leasing fees (Frost & Bond, 2008). Fifty-five percent of the total revenue from CAMPFIRE is intended for distribution across the local communities by the Rural District Councils (RDCs) for community development projects (CAMPFIRE, 2016). Management of wildlife across communal lands is jointly shared by the Zimbabwe Parks and Wildlife Management Authority (ZPWMA) and the RDCs, with lethal control as the most commonly used intervention regarding damage-causing wildlife species, including lions (Karidozo et al., 2016).

Ecologically, the area is semi-arid (average rainfall: 550-600 mm) with three distinguishable seasons, a cold dry season (May-August), a hot dry season (September-November), and a wet season (December-April). Livestock rearing and crop farming are the primary livelihood sources with cattle (*Bos taurus*), donkey (*Equus asinus*), sheep (*Ovis aries*) and goats (*Capra hircus*) as the main livestock, and maize (*Zea mays*), millet (*Pennisetum glaucum*) and sorghum (*Sorghum bicolor*) the main crops (Kuiper et al., 2015). Livestock depredation of high-value

livestock, such as cattle and donkeys, is commonly done by lions and spotted hyaenas, with leopards (*Panthera pardus*), African wild dogs (*Lycaon pictus*), cheetahs (*Acinonyx jubatus)* and black-backed jackals (*Canis mesomelas*) occasionally preying on small lower-value stock such as sheep and goats (Rasmussen, 1997). Previous studies have shown that poor livestock herding practices (e.g., not corralling at night) and seasonality can influence livestock attacks (Kuiper et al., 2015). During the wet season farmers herd their livestock in areas closer to the national park, further away from the human communities, exposing livestock to high depredation risk (Kuiper et al., 2015).

Tsholotsho has experienced the highest financial losses due to livestock depredation followed by Victoria Falls, while Mabale has the lowest (Loveridge et al., 2017). Also, farmers in Tsholotsho reportedly receive more financial benefits from wildlife, through the RDCs, than farmers in Victoria Falls or Mabale (CAMPFIRE, 2016). However, Victoria Falls rural community close to the major regional tourism hub of Victoria Falls and where farmers from these villages have the opportunity to receive more benefits from tourism activities (e.g., village tours) (L. Sibanda, pers. obs., 2012). Regardless, livestock rearing is particularly important across the study area, with culturally-embedded values for livestock, as a source of food, income, and cultural identity (Moyo & Swanepoel, 2010). These livestock roles may play a role in influencing perceptions towards lions, as well as perceptions of conservation authorities and organizations, particularly given historical views of pastoralism as environmentally destructive (Dickman, 2008). Given that livestock losses to lions can be relatively high, coupled with perceived risk or reality of personal injury or death, perceptions towards lions can be negative (Kushnir & Packer, 2019). Such negative perceptions have the potential to negatively impact conservation efforts and can incite emotional responses related to fear of lions and livestock losses (Johansson et al., 2016).

Data collection

Data were collected using a semi-structured interview format, informed by Dickman (2008), consisting of closed and open-ended questions organized into five sections: (a) demographics (e.g., age, number of people per farmstead, primary livelihood sources); (b) perceptions (Likert-based) towards lions, and in comparison to other damage-causing species; (c) livestock husbandry practices or actions taken towards lions (i.e., farmer actions); (d) actual livestock losses to lions, and (e) perceptions towards the conservation authorities of the HMPAC and CAMPFIRE and their management actions (**Appendix I**).

We tested the interview questions with 20 farmers of varying age and gender, selected randomly from Mabale, and included their responses in the final analysis. Mabale was chosen because it is the most central of the three study sites. After testing the interview, we used a systematic sampling approach to select every fifth farmstead in each village across the three study sites, interviewing only one adult male or female (i.e., self-identified 'head' of farmstead) in each home. We attempted to interview males and females (> 18 years) as equally as possible. Recognizing the importance of human ethics in conservation activities, we fully explained the purpose of the study before commencing with each interview, with all respondents giving verbal free and informed consent to voluntarily participate (Brittain et al., 2020). To help minimise response bias (e.g., social desirability) we did not provide monetary compensation to participate. Each interview was conducted in the farmer's preferred language (*isi*Ndebele, *chi*Nambya or Tonga) and the responses were recorded in English. Each session lasted ± 90 minutes including the time taken to verify kill sites in the grazing area.

To validate livestock losses to wildlife, we only considered losses ≤12 months prior to the interview and used a two-point validation system. First, we compiled a separate incident report and interviewed the farmer to establish which carnivore species was responsible. To assess the

farmer's accuracy in carnivore identification, we showed each farmer pictures of different carnivores and their paw prints, which they were asked to identify. Next, we recorded whether the attacks were officially reported to the local authorities (e.g., village head, ZPWMA, RDC), and confirmed all losses with the village head who, as part of his civil duties, keeps a register of all conflict reports in their village.

Perceptions towards lions were determined by asking: "How much do you like or dislike lions and why?" and respondents selected a response from a five-point Likert-based response: "strongly like", "like", "neither like nor dislike", "dislike" and "strongly dislike". To determine perceptions towards the desired the lion population change we asked: "What would you like to see happening to the current lion population, around your village, in the future and why?" The respondents selected a response from: "increase", "decrease" and "stay the same". To determine farmer actions taken towards lions we asked: "What do you do to protect your livestock and why?". Perceptions towards conservation authorities and management actions were determined by various questions like: (a) "Are you aware of the HMPAC and what do you think of it and why?" and respondents selected a response from a five-point Likert-based response: "strongly like", "like", "neither like nor dislike", "dislike" and "strongly dislike"; (b) "How important do you think it is to protect wildlife in Hwange/ Zambezi NP?" and the respondent also selected a response from a five-point Likert-based response: "very important", "quite important", "neither important or unimportant", "quite unimportant" and "very unimportant"; (c) "How important do you think it is to protect wildlife in the communal lands?" and the respondent selected a response from a five-point Likert-based response: "very important", "quite important", "neither important or unimportant", "quite unimportant" and "very unimportant"; (d) Are you aware of the CAMPFIRE programme and have you ever benefited from this scheme?".

Data analysis

To determine whether or not our sample size was adequate to detect meaningful effect sizes we performed a post-hoc statistical power analysis for sample size estimation using an online sample size calculator (www.surveysystem.com/sscalc.htm#one) with the following parameters: Confidence Levels = 95%; Confidence Interval = 4, Population (rounded off to the nearest thousand) = 8,000. We used descriptive statistics (mean ± *SD*) to summarise farmers' demographic information. Factors influencing perceptions towards the lion (listed in **Table 3**) were analysed using Generalised Linear Mixed Models (GLMMs) with a binomial error structure and logit-link function in R-statistical software (R Core Team, 2019). We fitted cumulative-link models to the ordinal response using the '*clmm*' function in 'ordinal' package (Christensen, 2015). The response variable (perceptions) was generated using a 1-5 scale, where 1 represents 'strongly dislike' and 5 represents 'strongly like'. Collinearity between categorical predictors was assessed using contingency tables, whereas collinearity between continuous predictors was assessed using the function '*corr'* in R. Linear models (with function '*lm'* in R Statistical Software) were used to assess correlation between categorical and continuous predictors, with the continuous predictor as a response. Two variables with R^2 greater than .50 were considered substantially correlated, therefore, one of the two variables was excluded from the final model (see **Supplementary Tables S1 & S2** for correlations). To determine which of the two to exclude, we calculated the variance-inflation factor (VIF) using the '*vif*' function in '*car'* package (Fox & Weisberg, 2019) and excluded a variable with a VIF greater than 10 (James et al., 2014). For example, the variable 'age' was highly correlated with the number of years a farmer had been in an area (residence) (R^2 = .54, p < .001), so we excluded the variable 'age' (*vif*=12.04) from the final model to reduce redundancy.

Table 3: *Full list of predictor variables used to predict perceptions of subsistence farmers towards the lion in northwestern Zimbabwe. * means there is no evidence of any non-linear effects.*

Predictor variable	Explanations	Variable type
(a) Ethnic group	Which ethnic group does the respondent belong to, as indicated by first language.	Categorical: 1=Tonga, 2= Nambya, 3= Ndebele 4= Other
(b) Education	The respondent's level of formal education and assuming this predictor serves as a proxy for knowledge	Ordinal*: 0= None, 1= Primary, 2= Secondary & above
(c) Age	Respondent's age (in years)?	Numeric: (18-92)
(d) Proportion of livestock lost to lion	Livestock losses to lion in the preceding 12 months, expressed as a proportion of livestock owned	Continuous: 0-1
(e) Benefits from wildlife	Perceived benefits from National Park or the CAMPFIRE programme	Binary: 0= No, 1= Yes
(f) Village	Name of village	68 different villages
(g) Permanence	Number of years the farmer had been present in the area?	Numeric: (<1-83)
(h) Area	Which study site is the farmer from?	Nominal: 1= Mabale 2= Tsholotsho, 3= Victoria Falls
(i) Income	Did the farmer list livestock-rearing as a major source of income?	Binary*: 1=Yes; 0= No
(j) Position in the farmstead	What is the role of the farmer in the farmstead?	Binary*: 0= Dependant; 1= Head of farmstead
(k) Farmstead size	How many people live in the farmstead, together with the respondent?	Continuous: (possible range from 1-21)
Perceptions towards lions	Using a scale 1-5, where 1 represents 'strongly dislike' and 5 represents 'strongly like', how much do you like lions, and why?	Ordinal: 1= Strongly dislike,2= Dislike, 3= Neither like nor dislike, 4= Like, 5= Strongly like

The following variables were included as fixed effects in the candidate models: (a) demographic variables (farmstead size, level of education ethnic group, position in the

farmstead); (b) socio-economic variables (residence, area, self-reported benefits from national parks, self-reported benefits from CAMPFIRE); and (c) personal losses to lions (livestock lost to lions within 12 months preceding the interview). We controlled for possible clustering of similar responses between study villages by adding the variable 'village' as a random effect to the model. We used the package '*MuMIn*' (Bartoń, 2019) for model averaging and ranking of the candidate models using the Akaike Information Criterion (AIC) value (Burnham & Anderson, 2002). Given that several models had similar levels of support, we used model-averaging, considering all models up to a cumulative Akaike weight of .95. Possible non-linear effects in the ordinal and continuous predictors were explored graphically using the package '*sure'* (Liu & Zhang, 2018). To support our analysis, we also include key quotes from interviewees to highlight farmer perceptions. To explore how perceptions towards lions compare with several other damage-causing species, we first performed a Friedman's Rank-Sum test and then used Wilcoxon Signed-Ranks tests to determine pairwise differences between the lion, elephant, leopard, African wild dog, black-backed jackal and spotted hyaena given the potential for these species to cause similar negative livelihood impacts.

2.4: Results

General farmstead characteristics

Results from the post hoc power analysis indicate the projected sample size needed for this study was approximately n = 558 interviews, which is less than the 632 interviews that we collected in total. We therefore conclude that our sample size was more than sufficient to achieve adequate power to detect meaningful effect sizes. The 632 farmers (men = 48%, women = 52%; response rate = 100%), where from Mabale (n = 124), Tsholotsho (n = 234) and Victoria Falls (n = 274), which is a sample size proportionate to the total farmer population in each site. The average age was 52.15 ± SD = 16.08 years (median: 53 years; range: 18-92

years), and the average time a farmer had been a resident in their respective village was 33.75 ± *SD* = 19.39 years (median: 34 years; range: <1-83 years). The average farmstead size combined for all three study sites was 6.41 ± *SD* = 2.96 people (median: 6; range: 1-21). The majority of the farmers (89%) had at least attained primary education. Crop farming (95%) and livestock rearing (63%) were the main sources of livelihoods, both for direct consumption and income generation.

Perceptions towards lions

Across the three communities, self-reported perceptions towards lions were strongly negative (mean: 1.3 ± *SD* = .72; median: 1), with the majority (93%) disliking lions and indicating they wanted a decrease in the lion population (86%). Perceived livestock loss from lion depredation was a commonly stated reason for negative perceptions (82%) even by farmers who experienced no livestock losses to lions in the 12 months preceding the interview (71%). For example, one male farmer (32 years old) who owned no livestock mentioned:

"*Lions kill our livestock! I don't own cattle myself [but] I depend on my neighbour's cows to plough my fields. So, if a lion killed my neighbour's cows, I also suffer [from] their loss"*[9].

In another example, one female farmer (47 years old) from Tsholotsho indicated she had not witnessed lions killing livestock directly but had learned of these events from others in her village:

"*Lions killed cows belonging to one old lady from Mlevu village [in Tsholotsho], and she was left nursing a young calf after the mother died. The old lady was left with nothing, her kraal become a source of wood for fire after all her cows were killed by lions. She was made poor to this day*".

[9] The interviews were conducted in local language and the quotes were translated by L. Sibanda (2020)

In contrast, a small proportion of farmers held either neutral (3%) or positive perceptions (4%), though these farmers indicated they would still like to see a decline in the lion population in future (36%), as stated by one female farmer (57 years old): "*Too much of anything can be a problem, we don't want the lion numbers [in the area surrounding their village] to increase because they might end up eating us [humans] and our livestock*".

Despite the perceived risk of livestock loss from lions, we found no evidence that farmer perceptions towards lions were associated with actual livestock losses, nor did we find an association between perceptions and demographics (e.g., position) or socio-economic factors (e.g., residence, farmstead size, benefits received from HMPAC or CAMPFIRE) (**Table 3**). Further, our results indicate significant variations in perceptions regarding lions across the study sites (**Table 4**) (see also **Supplementary Figure S1**). The farmers in Victoria Falls had the most negative perceptions (mean = 1.2 ± *SD* = .44; median: 1), followed by Tsholotsho (mean = 1.4 ± *SD* = .77; median: 1), and Mabale (mean = 1.6 ± *SD* = 1.00; median: 1).

For example, one farmer (female, 44 years old) from Victoria Falls mentioned: "*I strongly dislike lions, a few weeks back lions attacked a male relative while herding livestock and [the lion] started feeding on him after he fell unconscious, such is unheard of*". We also found a significant difference in perceptions towards lions amongst ethnic groups, which are intermixed across all villages (**Table 4**) (see also **Supplementary Figure S2**). The farmers who identify with the Nambya ethnic group had the most negative self-reported perceptions towards the lion, followed by the Ndebele and the Tonga ethnic group with the least negative perceptions.

***Table 4**: Summary of model-averaged coefficients calculated using the MuMIn package in R. The results below show a significant 'Area' and 'Ethnic group' effect.*

	Estimate	Std. Error	*z* value	Pr(>|z|)
Area (reference area = Mabale)				
Tsholotsho	-.45	.48	.94	.35
Victoria Falls	-1.68	.51	3.27	< .001*
Ethnic group (reference ethnic group = Nambya)				
Ndebele	.59	.43	1.40	.16
Tonga	2.34	.77	3.02	< .001*
Benefits from:				
Hwange /Zambezi NPs	-.43	.38	1.12	.26
CAMPFIRE	.22	.29	.76	.45
Proportion lost to lions				
Donkeys	-.69	.70	.99	.32
Cattle	-.36	.35	1.02	.31
Socioeconomic variables				
Education	-.17	.19	.90	.37
Residence status	-.01	.01	.63	.53
Farmstead size	.03	.04	.65	.52
Livestock income	-.13	.31	.42	.67

*Statistically significant

Perceptions towards other damage-causing species

We found that perceptions towards lions were significantly more negative compared to perceptions towards other damage-causing wildlife species, including elephants despite crop-raiding being listed as a higher threat to livelihoods than livestock depredation (**Figure 5**). For example, one male farmer (39 years) compared perceived benefits from elephants to those from lions:

"Elephants only come in this village during the cropping season but lions come here more frequently…even though elephants raid my crops, when an elephant is shot, I get meat that I sell and get money to buy mealie-meal to feed my family. But when a lion is killed what do I get? I don't eat lion meat".

While, another farmer (female, 51 years old) mentioned that they disliked lions, cited the risk that a lion poses to humans especially children: "*A lion is dangerous and scary especially [for] young children but adults too, but other predators like the jackal are not scary instead they are scared of humans*".

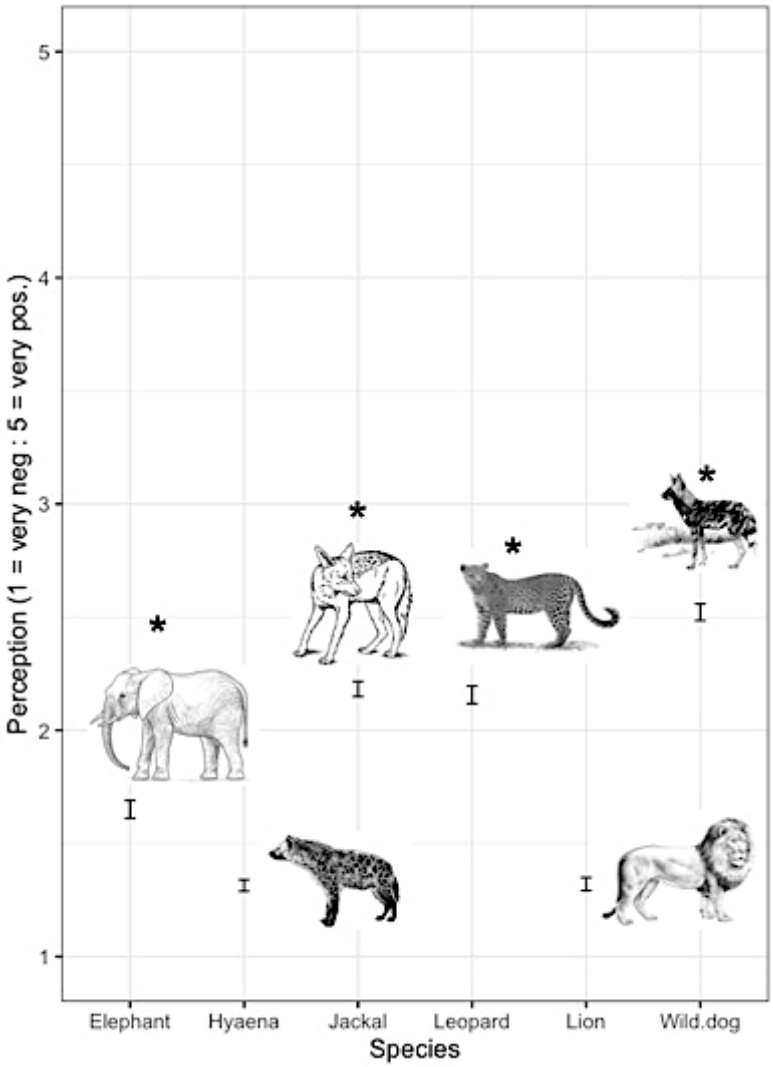


***Figure 6**: Perceptions of subsistence farmers towards different damage-causing wild animals. The error bars represent the standard error (SE). The asterisk (*) means the perception score is significantly different to that held towards lions.*

Farmer actions towards lions

To protect livestock against wild carnivores, 45% of the farmers reported they herd their livestock during the day; 54% mentioned they enclose their livestock in protective enclosures

or corrals at night; whilst 1% mentioned they use deterrents (e.g., fire and scarecrows) (1%), to protect livestock against wild carnivores. A male farmer (47 years old) stated: *"We [him and his family] herd our livestock during the day and pen then at night, otherwise if we don't, we may lose all our livestock to wild predators"*.

***Table 5**: Perceived threats to the farmer's livelihood, presented per study site and as total percentage of farmers who listed this threat. Rank is based on the total percentage of farmers who mentioned the threat based on all sites combined. Seven farmers were excluded from this particular analysis because they did not have any clear responses.*

No.	Threat	Mabale (n = 124)	Tsholotsho (n = 228)	Vic Falls (n = 273)	All sites combined (n = 625)	Rank
1	Crop raiding	60	25	27	33	1
2	Economic circumstances	4	15	28	18	2
3	Livestock depredation	18	18	12	15	3
4	Drought and natural disasters	6	8	21	13	4
5	Disease in family	2	11	7	7	5
6	Lack of government assistance	4	6	1	3	6
7	Inadequate water sources	3	8	0	3	6
8	Malnutrition	1	4	3	2	8
9	Disease in livestock	2	4	2	2	8
10	Lack of agricultural inputs	2	2	1	<1	10
11	Stock theft	1	<1	1	<1	11
12	Accidental death in livestock	0	<1	1	<1	12

Reported livestock losses

A total of 393 livestock were reportedly killed by carnivores, with the spotted hyaena cited as the main culprit followed by the lion. During the same period, more livestock were reported to have died of disease (n = 467), yet disease was rarely mentioned as a threat to livelihoods (2%). Reports of lion attacks on humans were very low, with only one farmer from Chief Shana area

in Victoria Falls reportedly attacked by a lion in August 2012. Farmers did not perceive livestock depredation to be the greatest livelihood threat. Instead, farmers reported elephant crop raiding, followed by economic circumstances (e.g. unemployment and poverty) as greater threats (**Table 5**).

Table 6: *Perceptions towards the HMPAC and reasons to like or dislike the HMPAC. The value in the table below represents the percentage of farmers who mentioned the corresponding response. Seven farmers were excluded from this particular analysis because they did not have clear responses.*

Attribute	Mabale (*n* = 124)	Tsholotsho (*n* = 228)	Vic. Falls (*n* = 273)	Combined for all sites (*n* = 625)
Perceptions towards the HMPAC				
Very negative	7	6	13	9
Negative	9	20	3	10
Neither	4	14	12	11
Positive	57	50	13	36
Very positive	23	10	59	34
Reasons for positive perceptions towards the HMPAC				
Provision of resources for people, e.g., meat	16	11	10	11
Management of wildlife impacts	15	22	48	32
Protection of wildlife and habitats for future generations	42	32	17	27
Reasons for negative perceptions towards the HMPAC				
Wildlife has a negative impact on lives and livelihoods	9	8	5	7
Protected areas do not provide benefits	18	28	22	23

Perceptions towards conservation actions

Farmers in Victoria Falls held more positive perceptions towards the HMPAC (4.0 ± *SD* = 1.13, median: 4), compared to farmers from Tsholotsho (mean = 3.4 ± *SD* = 1.38, median: 3) and Mabale (3.8 ± *SD* = 1.41, median: 4) (**Table 6**). Farmers mentioned the assistance received from the authorities in managing negative wildlife impacts (32%) and the role the HMPAC

plays in safeguarding wildlife resources for future generations (27%) as reasons to feel positive towards the HMPAC. However, 78% of the farmers disagreed that protecting wildlife, including lions, was important in the communal lands of the HMPAC, which contrasts with the 77% who indicated they thought it was important to protect wildlife in Hwange or Zambezi National Parks. For instance, one farmer (female, 34 years) who held negative perceptions towards wildlife conservation in the communal lands said:

"We like wild animals, especially lions, only when they are in the park where they belong. But the opposite can be said when they come to village lands. This is because wild animals such as lions are dangerous to my livestock as well as my children and therefore when a lion comes to my village it should be killed because it will call other lions here".

With regard to the CAMPFIRE programme, only 18% of farmers perceived the programme as directly beneficial, with benefits including the construction of a local clinic and school classroom block (10%), provisioning of water sources (7%), and meat from elephant hunts (1%). The remaining (82%) indicated they would like the CAMPFIRE programme to discontinue, citing the damage from wild animals and lack of direct benefits at the farmstead level as reasons. For instance, a male farmer (53 year old) mentioned:

"*The problem with CAMPFIRE is that their wild animals destroy our crops and livestock and I do not benefit anything in return…CAMPFIRE ought to be completely discontinued".*

One male farmer (83 years), responded to the same question and gave a similar answer though from a different angle:

"When CAMPFIRE started we used to get dividends per farmstead but today that no longer exists. CAMPFIRE is of no benefit at all yet their wild animals destroy our crops and kill our livestock. We don't want CAMPFIRE, we are better off without CAMPFIRE".

Overall, 70% of the farmers blamed the ZPWMA and CAMPFIRE for livestock depredation. One male farmer (40 years old) mentioned that: *"If my neighbour's cow ate my crops I blame the owner…If a wild predator killed my livestock, I blame the [national] parks and CAMPFIRE, who are the owners of wild animals".*

Proposed solutions in response to depredation and other damages caused by wild animals included direct compensation [financial compensation (74%), food aid (20%)], and wildlife management-related activities [e.g., translocation (5%), lethal removal of problem animals (54%), fencing the HMPAC (26%), more research (13%)]. A combined 8% of farmers had no opinion on proposed solutions.

2.5: Discussion

Farmers' perceptions towards lions were largely negative, with perceived livestock depredation as their most commonly stated reason. Most farmers, including those with neutral or positive perceptions, indicated they wanted to see a decrease in the future lion population. This is not unexpected considering that lions can pose serious risks to human livelihoods and safety (Mulder et al., 2019). This is also consistent with other recent research on human-lion relations and conservation activities in the HMPAC (Western et al., 2019). We expected perceptions towards lions to be associated with costs and benefits derived from the species. However, we found no evidence that actual livestock loss, impacts on personal income, or benefits received from CAMPFIRE were factors influencing farmers' perceptions towards lions. For example, there was no significant difference between the perceptions of farmers that did lose livestock to lions in the 12 months preceding interviews to those that did not. Both groups indicated they strongly disliked lions regardless of actual depredation. We also found that farmers in Victoria Falls held the most negative perceptions towards lions. This sentiment may have been caused by a lion attack on a local farmer during our study period.

Our findings appear to be in accordance to Dickman et al., (2014) who found that farmers adjacent to Ruaha National Park in Tanzania disliked lions despite having no direct experience of livestock depredation, a phenomenon they referred to as 'contagious conflict'. This contagious conflict, or what we suggest as being contagious negative perceptions towards lions, is conceivably exacerbated by rare and tragic events compared to the accumulated effects of more common incidences (Naughton-Treves et al., 2005). Infrequent though sensational carnivore attacks on humans, coupled with stories told through social interactions or media depictions, has been found to influence peoples' perceptions of risk (Gore et al., 2005; Sabatier & Huveneers, 2018).

We suggest that if sensational information like the risks posed by lions is communicated through trusted sources, such as community or village leaders, other well-respected farmers, or popular news media, this information can influence farmers' perceptions and ultimately, attitudes (Putnam, 1993; Rose et al., 2018). Certainly, trust along with social norms (i.e., sociological guidelines for accepted thought and action), are important aspects of social capital, and social capital demonstrably influences conservation outcomes (Davenport & Hassan, 2019). We suggest that future research could explore both the risk categories that farmers ascribe to living with lions (Amit & Jacobsen, 2017), and the social capital and networks of information flows amongst farmers, government, and non-governmental organisations.

This would enable a better understanding of what factors, whether emotional, cognitive or experiential, might influence farmer perceptions and actions towards lions as well as what and how information flows across farmer networks (Amit & Jacobson, 2017). In turn, conservationists would be well advised to craft effective communication tools to share accurate human-lion coexistence strategies. That said, we also suggest future study could explore farmers' value orientations towards different wildlife species more broadly, to better develop

a broader array of human-wildlife coexistence strategies based on fundamental beliefs and goals (Manfredo & Dayer, 2004; Dietsch et al., 2016). Likewise, future study could utilise the Theory of Planned Behaviour (Ajzen & Fishbein, 1980) to better understand the rational planned choices behind different human behaviour (Amit & Jacobson, 2017) in the context of lion conservation.

We also found that farmers' perceptions towards lions are related to a farmer's ethnic group. The Tonga ethnic group had the least negative perceptions towards lions. This is possibly because traditional beliefs amongst the Tonga identify the lion as having an important cultural value as a spirit of the rain-maker '*Mpande'* (L. Sibanda, pers. obs., 2012). Such cultural beliefs are common in most African cultures, for example, the San people from the Kalahari consider lions as their brothers and therefore tolerate their coexistence (Thomas, 2003). As demonstrated elsewhere, understanding and incorporating cultural beliefs and values in conservation programmes is important to gain support for lion conservation efforts (Infield et al., 2017). For example, Kenya's Lion Guardians programme in Amboseli has successfully shifted cultural values that promote killing lions amongst young Maasai men to monitoring and guarding lions, and protecting their village by utilising predator-proof livestock enclosures (Hazzah et al., 2014). In addition, Mulder et al. (2019) suggests that shifting lion-killing culture can occur through the use of locally-developed and culturally-relevant village bylaws, drawing on local institutions and leadership to shift otherwise negative perceptions and detrimental behaviours or actions. However, caution is urged if or when suggesting that certain cultural beliefs are misconceived or wrong, given issues related to ethical quandaries of imposing new belief systems (Manfredo et al., 2017; Pooley et al., 2017).

When comparing farmers' perceptions towards lions with other damage-causing wild animals, we found perceptions to lions were more negative. This remained consistent even when

compared to elephants, despite crop-raiding reportedly imposing a higher negative livelihood impact than livestock depredation. We suggest this may be influenced by the association of perceived benefits from elephants outweighing the potential risks they pose (Naughton-Treves et al., 2005; Bel et al., 2013). Farmers were also found to hold stronger negative perceptions towards lions, followed by spotted hyaenas, in comparison to leopards, jackals, or African wild dogs. As with elephants, these species may be perceived as less risky to human livelihoods or wellbeing, in this case because they were reported to predate on lower-value livestock (e.g. sheep and goats) and are considered to generally be more easily deterred. We also consider that, as with other studies, the ease which a damage-causing animal is deterred can influence peoples' perceptions towards them (Hill, 2004). It follows then that lions are assessed to pose a greater risk, both for livestock depredation and human injury or death, and in turn influence more negative perceptions amongst farmers (Goldman et al., 2010).

Certainly, other studies have shown that perceptions towards wild animals, and particularly those with which farmers experience conflict, are influenced by the risks and costs imposed, along with the potential benefits derived from, living with these animals (Parry & Campbell, 2009; Barua et al., 2013). However, we also consider this phenomenon may also be explained by cognitive polyphasia, a concept in social psychology which suggests multiple different and sometimes contradictory ways of thinking and reasoning can be held simultaneously about an object or subject (Buijs et al., 2012; Hovardas & Korfiatis, 2012). This might explain how and why farmers have constructed their perceptions towards different damage-causing species relative to the conflict and risk (whether real or perceived) they experience (Hovardas, 2018). It would be informative for future research to explore the social constructions and representations farmers hold for lions and other wildlife species, as findings can help craft locally-relevant conservation actions (Figari & Skogen, 2011; Buijs et al., 2012).

With regard to farmers' perceptions of conservation actions, i.e., what needs to happen in the event of livestock depredation (or crop raiding), the majority of farmers indicated they would like the authorities to provide financial compensation. Currently in this area there is no compensation programme despite being a widely utilised strategy elsewhere, with demonstrated positive outcomes for carnivore species in some areas (Bauer et al., 2015b). Arguably though, compensation schemes require significant and sustainable funding resources, usually from the government, and most ultimately fail because of lack of resources, monitoring, poor administration and moral hazard (i.e., when pay-outs unintentionally encourage lax herding by farmers) (Dickman et al., 2011). Given the numerous difficulties associated with compensation schemes, we suggest this is not currently an appropriate solution in northwestern Zimbabwe. Rather, we recommend that conservation authorities prioritise damage prevention through educational outreach and working with farmers, over compensation.

Using the data collected from this study, we suggest coexistence strategies can be designed that help address the knowledge gaps or misinformation as well as develop outreach efforts that in turn foster useful skills for farmers in mitigating lion conflict. Farmers also indicated they would support the translocation of problem lions as another management action. However, given the numerous difficulties associated with the capture and movement of problem animals, including financial, logistical, biological, and ethical, as well as homing behaviour where translocated animals move back to the original site, we suggest this is not a promising solution (Loveridge et al., 2010b). Instead, we advocate minimising contact between lions and livestock through improved livestock herding (e.g., constant presence of herders, use of guard dogs) and livestock protection (e.g., fortified enclosures, night-time penning). We also suggest a lion early-warning system may be beneficial to proactively mitigating conflict while simultaneously addressing risk perceptions.

In regards to perceptions related to conservation activities at the programme level, we found that farmers generally held positive perceptions towards the HMPAC. Specifically, farmers indicated that the assistance received from government authorities in managing the impacts from wildlife (e.g. shooting problem elephants), combined with HMPAC protecting wildlife species and habitat for future generations, were important factors influencing their perceptions. More specifically, farmers from Victoria Falls held stronger positive perceptions towards HMPAC than farmers from Mabale and Tsholotsho. This may be related to the fact that farmers in Victoria Falls enjoyed greater direct benefits through increased tourism and employment opportunities compared to the other two communities.

However, we found no evidence to suggest farmers' perceptions towards lions were influenced by the benefits provided from CAMPFIRE, whether income generated from wildlife activities (tourism, trophy hunting), construction of classroom blocks, medical clinics, water boreholes, or road repairs. In fact, districts who reportedly received the highest financial benefits from CAMPFIRE (Tsholotsho US$50,452 annually, versus Mabale and Victoria Falls US$11,862 combined) (CAMPFIRE, 2016) did not hold positive perceptions towards lions. Moreover, even when CAMPFIRE benefits were received, the majority of farmers indicated they wanted the programme to discontinue.

This is in line with other research which has identified the shortcomings of CAMPFIRE (Frost & Bond, 2008; Taylor, 2009). In part, we suggest these negative perceptions may be influenced by the relatively paltry revenue received from CAMPFIRE, when compared to mean annual financial losses to predators over this period of time [Tsholotsho $34 882, Mabale $13 054, Victoria Falls $31 413, (Loveridge et al., 2017)]. Additionally, benefits are distributed at the ward level rather than to the individual farmer, despite the individual farmer directly experiencing livestock loss, suffering economically or risking personal injury or worse. While

other studies have demonstrated that direct benefits accrued from wildlife conservation activities can improve perceptions towards carnivores and coexistence, and influence the adoption of desired conservation practices (Dickman et al., 2011), this appears to hold true only when the benefits are accrued at a local or proximate level and reflect the needs and values of the people expected to live with wildlife (Romañach et al., 2007).

Indeed, successful benefits schemes are characterised by the enthusiastic participation of local people, including the development of what constitutes a benefit, clear guidelines and expectations as to what conservation actions must be taken in order to receive benefits, reasonable consequences for failure to honour agreements, and acceptable criteria for the distribution of benefits (Archabald & Naughton-Treves, 2002; Bulte & Rondeau, 2005). We suggest future work with local leaders is needed to develop contextually-relevant benefits schemes, and ensure that conservation benefits are delivered at an appropriate scale and are appropriate to human values, livelihoods and wellbeing. In working with community to solicit their perceptions, values and needs, it is our hope that we can also encourage and nurture positive perceptions towards lions, and ultimately influence positive coexistence (Newmark & Leonard, 1993; Fiallo & Jacobson, 2009).

2.6: Conclusion

We explored the perceptions and actions towards lions and conservation activities in northwestern Zimbabwe between 2010-2012. Our findings provide insight into human-lion relations in the area, and a valuable baseline for future conservation monitoring and for developing locally-meaningful conservation interventions. Self-reported perceptions towards lions were strongly negative and were not directly related to either a farmer's actual livestock loss, personal income, or direct benefits received from the CAMPFIRE programme. Further, we found that despite the potential for livestock depredation, economic loss or personal safety

risks, perceptions towards lions were more negative compared to perceptions towards other damage-causing wildlife species (i.e., elephants, hyaenas, leopards, jackals, African wild dogs). This is despite the fact that elephant crop-raiding was reported as a higher livelihood threat than livestock depredation. Overall, we found that perceived depredation and safety risk, along with geographic location and ethnic group, appear to play a stronger role in influencing farmers' lion perceptions. This suggests that understanding the cultural context and peoples' proximity to protected areas, coupled with developing locally-relevant benefits, are important factors to consider when designing lion conservation interventions.

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Contributions

Andrew J. Loveridge conceived the experiment. Lovemore Sibanda and Bongani Dlodlo conducted the interviews. Lovemore Sibanda reviewed the literature, analysed the data, wrote

the final manuscript and responded to reviewers comments. Esther van der Meer, Ewan Macdonald, Courtney Hughes, Andrew J. Loveridge, Roger Parry, Jane Hunt and David W. Macdonald commented on draft manuscripts. Andrew J. Loveridge secured funding for this study. Esther van der Meer, David W. Macdonald and Andrew J. Loveridge supervised the doctoral study.

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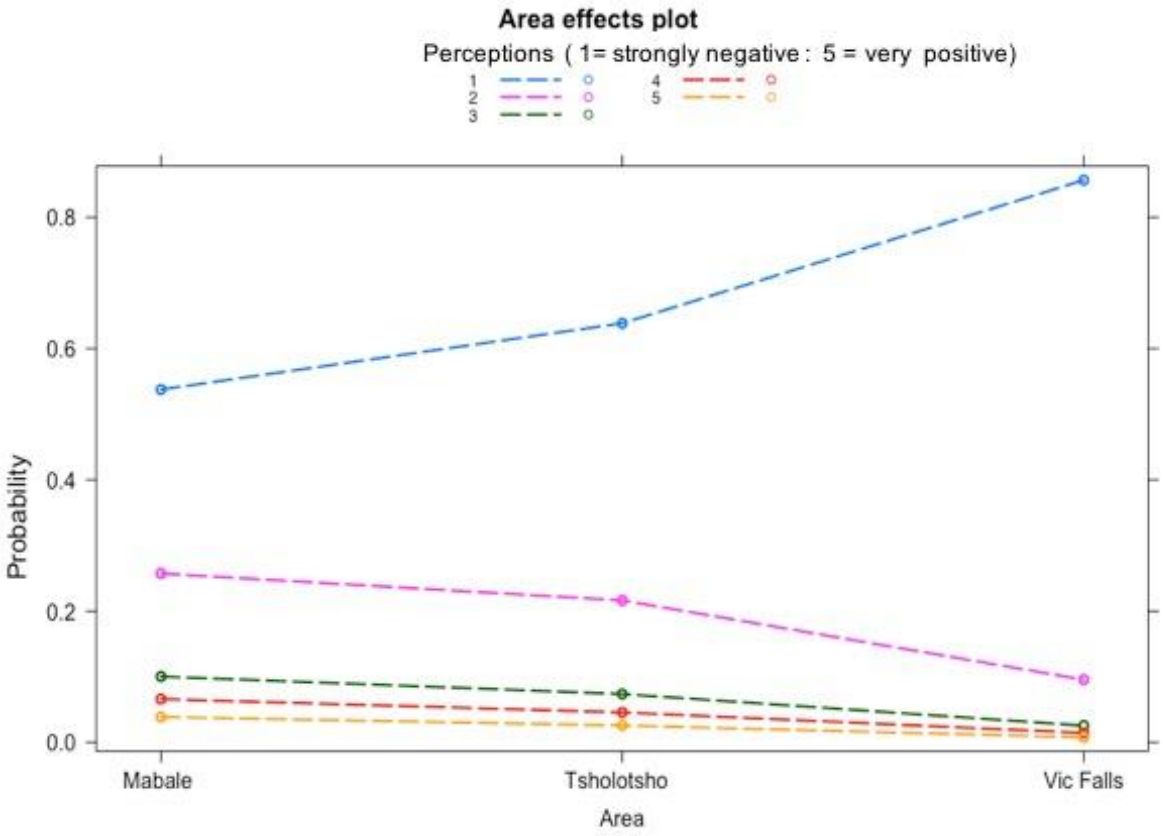
2.8: Supplementary Material

Supplementary Table S1: Correlation between numeric predictor variables, the highlighted values represent statistically significant correlation between two variables on the x and y tabs

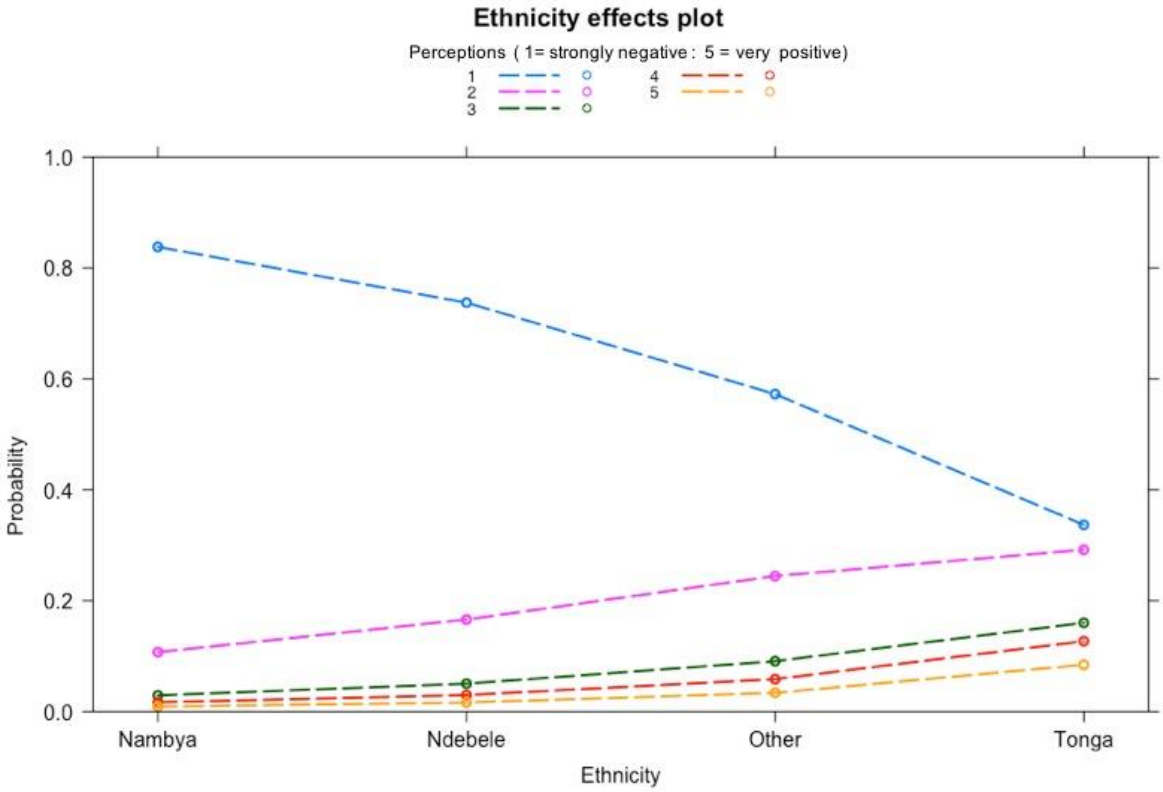
Explanatory variables	Age	Permanence	Household size	No. of cattle owned	No of donkeys owned	No of shoats owned	Ratio of donkeys killed by lions	Ratio of goats killed by lions	Ratio of cattle killed by lions	Total livestock killed by lions
Correlation coefficients (R^2)										
Age	1.00	.54	.12	.16	.13	.06	.03	-.06	-.05	.04
Permanence	.54	1.00	.13	.17	.12	.08	.01	-.04	-.04	.02
Household size	.12	.13	1.00	.25	.19	.15	.06	-.01	.01	.12
No. of cattle owned	.16	.17	.25	1.00	.46	.48	.04	.03	-.02	.24
No. of donkeys owned	.13	.12	.19	.46	1.00	.35	.01	.00	-.01	.12
No. of shoats owned	.06	.08	.15	.48	.35	1.00	.01	.01	.00	.17
Ratio of donkeys killed by lions	.03	.01	.06	.04	.01	.01	1.00	.04	.01	.27
Ratio of goats killed by lions	-.06	-.04	-.01	.03	.00	.01	.04	1.00	.07	.40
Ratio of cattle killed by lions	-.05	-.04	.01	-.02	-.01	.00	.01	.07	1.00	.48
Total livestock killed by lions	.04	.02	.12	.24	.12	.17	.27	.40	.48	1.00
p-values										
Age		< .001	< .001	< .001	< .001	.16	.38	.17	.25	< .001
Permanence	< .001		< .001	< .001	< .001	.06	.82	.37	.36	< .001
Household size	< .001	< .001		< .001	< .001	< .001	.16	.78	.71	< .001
No. of cattle owned	< .001	< .001	< .001		< .001	< .001	.34	.48	.54	< .001
No. of donkeys owned	< .001	< .001	< .001	< .001		< .001	.75	.97	.81	< .001
No. of shoats owned	.16	.06	< .001	< .001	< .001		.77	.87	.97	< .001
Ratio of donkeys killed by lions	.38	.82	.16	0.34	.75	.77		.27	.72	< .001
Ratio of goats killed by lions	.17	.37	.78	0.48	.97	.87	.27		.09	< .001
Ratio of cattle killed by lions	.25	.36	.71	0.54	.81	.97	.72	.09		< .001
Total livestock killed by lions	.28	< .001	< .001	< .001	< .001	< .001	< .001	< .001	< .001	

Supplementary Table S2: Correlation between categorical predictor variables. The shaded *p*-values represent variables that are significantly correlated.

	BCAMP	BNP	Village	Position	Education	Area	Income_liv	Ethnicity
BCAMP	1.00	.13	3.56	.29	< .001	< .001	< .001	< .001
BNP	.13	1.00	< .001	.13	.13	.54	.74	.48
Village	3.56	.01	1.00	< .001	< .001	< .001	< .001	< .001
Position	.29	.13	< .001	1.00	< .001	< .001	< .001	< .001
Education	.01	.13	< .001	< .001	1.00	< .001	< .001	< .001
Area	< .001	.54	< .001	< .001	< .001	1.00	< .001	< .001
Income_liv	.02	.74	< .001	< .001	.01	< .001	1.00	< .001
Ethnicity	< .001	.48	< .001	< .001	< .001	< .001	< .001	1.00



Supplementary Figure S1: A graph illustrating the effects of area on perceptions towards lion. The different coloured lions represent the different perception classes. The probability of *observing* very negative perceptions *(line 1) is* greater in Victoria Falls communal area.



Supplementary Figure S2: A graph illustrating the effects of ethnicity on perception towards lion. The different coloured lions represent the different perception classes. Evidence suggests that the probability of observing very negative perceptions was greater in the Nambya ethnic group.

Chapter Three: Evaluating the Effects of a Conservation Intervention on Rural Farmers' Attitudes Toward Lions

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"Mans' mind, once stretched by a new idea, never regains its original dimensions"

Oliver W. Holmes

** This chapter has been published in the Journal of Human Dimensions of Wildlife*

3.1: Chapter summary

Using an experimental approach, we analysed the self-reported changes in farmers' attitudes towards the African lion (*Panthera leo*) and a community-based lion conservation programme (i.e., the Long Shields Community Guardians), before and after implementation. This programme protects livestock and mitigates lion depredation through non-lethal means, with the aim of promoting human-lion coexistence. Results indicated a significant positive shift in attitudes of lions by farmers in the treatment group. This was also the case for farmers in what was recognized as a second unplanned treatment group, called the intermediate group, who learned about the programme through communication within their peer network. This article contributed to the growing literature on conservation evaluation and demonstrates that people's attitudes are valuable for assessing the impact of conservation programmes.

Keywords: conservation, *Panthera leo*, human-lion coexistence, intervention, Long Shields Community Guardians programme, impact evaluation

3.2: Introduction

Three-quarters of the world's large carnivore species are under threat due to habitat destruction, prey depletion and persecution by humans (Inskip & Zimmermann, 2009). These pressures will only intensify with an ever-increasing human population (Wolf & Ripple, 2016). A species prone to conflict with humans is the African lion (*Panthera leo*), a keystone species in the African savannah, and both economic (e.g., tourism) and cultural values (IUCN, 2016). These values alone, however, are often insufficient to provide widespread protection, and the world's lion population has been severely reduced (Bauer et al., 2016).

A primary threat to lion populations is direct persecution by farmers in retaliation for real or perceived livestock loss (IUCN, 2016). Livestock are an important source of income, food, and cultural significance (Sibanda et al., 2020a). If carnivore depredation occurs retaliatory killing can ensue (IUCN, 2016). Lions are killed by farmers using wire-snares and poison (Bauer et al., 2016). This is true for lions in Zimbabwe's Hwange-Matetsi Protected Area Complex (HMPAC), which hosts one of six remaining lion populations numbering over 1,000 (IUCN, 2016).

The impacts of humans on lions have been studied in the HMPAC. Most lion attacks on livestock occur at night when livestock are left to freely graze instead of being secured in protective enclosures (Kuiper et al., 2015). Between 2008 and 2016 lions killed over 1,000 domestic animals and farmers killed at approximately 50 lions in response to attacks on livestock (Loveridge et al., 2017). This presents an opportunity to develop and implement locally relevant conservation interventions that raise awareness of these impacts and build knowledge and skills to reduce negative impacts on livelihoods.

Methods to protect livestock from wild carnivores have ranged from protective enclosures (Sutton et al., 2017) to livestock guarding dogs (Marker et al., 2005). There is, however, no

universally applicable solution to reducing human-carnivore conflict. For example, Heberlein and Ericsson (2008) predicted that hostility towards large carnivores can increase over time with an increase in individual reports, stories and negative experiences. Houston et al. (2010) suggest that familiarity with large carnivores can reduce negative sentiments. It is crucial that the impact of wild carnivores on humans are adequately addressed, through locally targeted and culturally appropriate interventions, recognising that a solution that is effective in one area might have undesirable effects in another (Dickman & Hazzah, 2016).

3.3: Theoretical Background

Evaluation is a process that critically examines the extent to which the intervention's intended outcome has been achieved (Gertler et al., 2011). Evaluation enables conservationists to show which interventions work and which ones do not so that limited resources can be best used for maximum benefits (Ferraro & Pattanayak, 2006). Conservationists can learn from their mistakes and not to waste time on ineffective interventions (Gunaryadi et al., 2017). However, most conservation interventions designed to mitigate the conflict between humans and wild animals, have not been evaluated scientifically (van Eeden et al., 2018). Identified reasons include limited financial resources and difficulties related to study design (Baylis et al., 2016). According to Sutherland et al. (2004), the lack of evaluation has slowed progress towards evidence-based conservation.

Most published articles on impact evaluation have largely focused on measuring decreases in livestock loss to illustrate effectiveness (Miller et al., 2016), rather than quantifying changes in human attitudes or adoption of desired behaviour. The latter are often more meaningful measures of success, having a positive impact on the former (Hogg & Vaughan, 1995). Perception refers to how a person observes, interprets and evaluates an experience, object, action or other social entity (Pickens, 2005). Attitudes ‘represent a positive or negative

evaluation of an object (e.g., a programme), and can influence how an individual behaves toward a wildlife species or conservation action (Bennett 2016, p. 588). Attitudes influence behaviours and are invaluable for conservation evaluation (Manfredo & Dayer, 2004).

In 2012 in collaboration with the local community, we developed the Long Shields Community Guardians programme (hereafter: the *Long Shields programme*), a non-lethal, community-based, human-lion conflict intervention that encouraged local subsistence farmers to learn about, and adopt proactive behaviours that reduce the risk of livestock depredation. The Long Shields programme was modelled on the Lion Guardians programme in Amboseli, Kenya, which aims to provide non-lethal solutions, from educational outreach to actively deterring lions, to reduce human-lion conflict and promote coexistence (Hazzah et al., 2014).

We used the Theory of Change (ToC), a methodology following a logical, ordered sequence to designing a programme or evaluation (Woodhouse et al., 2015), to illustrate the inputs, activities, target audiences, and desired outcomes of the Long Shields programme (**Supplementary Figure S3**). The ToC conceptual framework is useful in collecting baseline data and prioritising the activities and goals of future programmes (Morehouse et al., 2020). ToC is flexible and has been used in different conservation contexts such as evaluating the impacts of illegal wildlife trade (Biggs et al., 2017), public awareness campaigns (Howe et al., 2012) and human-wildlife conflict mitigation efforts (Morehouse et al., 2020).

Using ToC, we hypothesised that: (a) a reduction in livestock loss to lions (both perceived and actual); (b) reduction in human safety risk; and, (c) awareness of and demonstrated effort by the Long Shields Community Guardians, would positively shift farmers' attitudes towards lions, and motivate adoption of this programme. Our efforts should result in positive attitudes of the Long Shields programme itself.

In this article, we sought to establish whether the Long Shields programme was effective in influencing a positive shift in attitudes towards lions. We utilised a quasi-experimental design to estimate the effects of an intervention in situations where random allocation of subjects to treatment and control groups is not possible (DiNardo, 2008). Researchers use quasi-experimental design because of ethical considerations, difficulty in randomising subjects, and small sample sizes (Woodhouse et al., 2015). We chose this design to avoid ethical issues associated with random assignment of subjects to treatment (DiNardo, 2008).

More specifically, (a) we examined attitudes towards lions before and after the implementation of the Long Shields programme, and compared the changes between farmers that participated in this programme (i.e., treatment group) and those that did not (i.e., control group). We hypothesised that the programme would lead to a significant positive shift in attitudes towards lions for participating farmers compared to non-participating farmers. We also explored farmers' attitudes of the Long Shields programme compared to other lion conflict mitigation strategies (i.e., electric fence, livestock herding, compensation, canvas mobile bomas[10], lethal control). This article contributed to the impact evaluation literature and demonstrated that attitudes are useful for assessing the impact of conservation programmes.

3.4: Methods

Study Area

This case-study was conducted in 82 villages across three rural communities alongside the boundaries of HMPAC. Two communities bordered Hwange National Park: Tsholotsho (Matupula and Siphoso Chieftainships, 2,171 km^2, 42 villages) and Mabale (Nelukoba-Dingani Chieftainship, 480 km^2, 11 villages), while Victoria Falls (Mvuthu and Shana Chieftainships,

[10] a novel method that uses polyvinyl chloride (pvc) curtains to house and protect livestock against wild carnivores at night

655 km^2, 29 villages) bordered Zambezi National Park (**Figure 7**). The smallest unit was a farmstead (a group of individuals related by blood or marriage living together), several farmsteads of up to 25 (range: 6 - 86 farmsteads) made up a village. Each village was administered by a village head and several villages made a community (range 11 - 42 villages). The three communities were selected based on their: (a) proximity to protected areas; (b) differences in ethnic groups; (c) financial losses to depredation; and (d) benefits from Communal Areas Management Program for Indigenous Resources (CAMPFIRE). The study area is semi-arid with an average annual rainfall of 550-600mm (Loveridge et al., 2017). Livestock included cattle (*Bos taurus*), donkey (*Equus asinus*), sheep (*Ovis aries*) and goat (*Capra hircus*). Methods used to guard livestock against wild carnivores included herding during the day and penning livestock at night (Kuiper et al., 2015). Electric fences and compensation were currently not in use, although farmers mentioned that these methods existed in the 1970s and 1980s (Sibanda et al., 2020a).

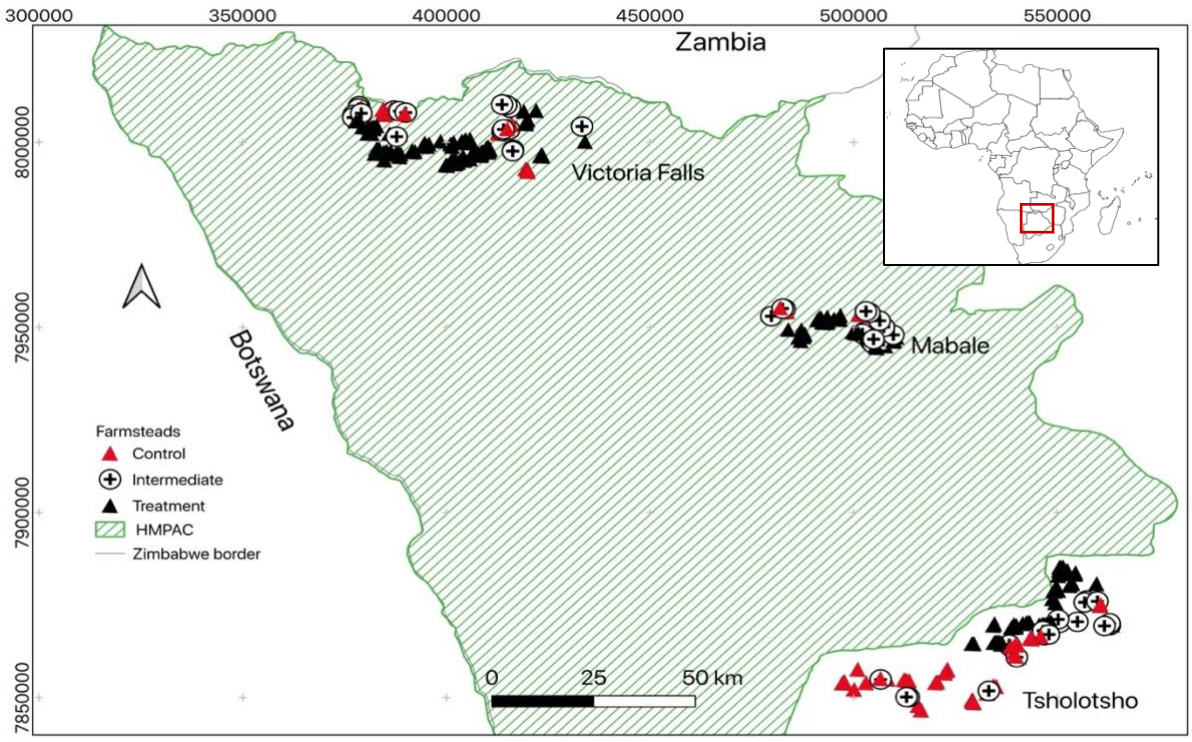


***Figure 7**: The map of our study area in northwestern Zimbabwe*

Case-Study: Long Shields Programme

In setting up the Long Shields programme, we followed six key stages. First, we conducted a baseline survey to understand the attitudes of farmers towards lions and factors influencing these attitudes (Sibanda et al., 2020a). In consultation with the local traditional leaders, we used the Theory of Change framework to develop a logical model of behavioural change. Thereafter, we recruited our Community Guardians (n = 14), residents in the area and recommended by local traditional leaders and the wider the community. We selected candidates based on previous direct experience with lions (e.g., people who had physically chased a lion), literacy, residency within the local area and good standing in the community. Community Guardians were then trained by the Trans-Kalahari Predator Project (WildCRU) in lion tracking and the use of radio-telemetry, Global Positioning System (GPS) data collection protocols (e.g., livestock depredation assessment) and conflict mitigation techniques (e.g., herding, enclosure fortification). Community Guardians assisted their peers to: (a) recover missing livestock; (b) build strong livestock enclosures; (c) warn farmers of approaching lions; and (d) haze or chase problem lions back into the park. We piloted the programme in Mabale communal area for six months (August - December 2012) before expanding the programme to Tsholotsho communal land in January 2013 and Victoria Falls in June 2016. Between 2013 and 2017, we identified 21 lions (males = 14; females = 7) (Mabale = 6; Tsholotsho = 9; Victoria Falls = 6) and fitted them with (satellite) GPS collars to monitor their movement. We selected lions for collaring based on their home ranges overlapping local farming communities outside of the protected areas and whether the animals were likely to disperse (e.g., young males). Each satellite collar took one location every two hours. Whenever lions were within three kilometres of a protected area boundary, a warning message was sent via Community Guardians to a network of farmers within treatment villages. Lions that crossed the park boundary and approached human settlements would be hazed (chased) by the

Community Guardians plus volunteers within the treatment villages using a '*vuvuzela'*, a plastic horn that produces an irritating sound of about 127 decibels (dBA) (Petracca et al., 2019).

Evaluation Design

To evaluate the changes in attitudes towards lions, we used a quasi-experimental design with Before-After Control-Intervention (BACI) measurements. We surveyed treatment and control groups of farmers simultaneously before and after the introduction of the Long Shields programme. Of the 82 villages, 50% (n = 41 villages) were selected to participate in the Long Shields programme while the remainder (n = 41) villages were not exposed to any treatment. The selection of villages in the programme was *not* random given the objective of this programme was to solve a real-world problem. We selected villages that previously sustained significant livestock depredation to be part of the programme.

Data Collection and Sampling

Data were collected before and five years after the Long Shields programme was implemented, hereafter designated the pre-programme and post-programme surveys. Prior to programme implementation, data were collected between 2010 and 2012 preceding the introduction of the Long Shields programme. Data were collected using a face-to-face semi-structured interview format. The survey protocol was pilot-tested in Mabale, on 20 randomly selected farmers of varying age and gender. We included their responses in the final analysis. For full-scale evaluation, we used a systematic sampling approach to select every fifth household in each of the 82 villages and interviewed one adult male or female (i.e., self-identified 'head' of farmstead) in each home, attempting to interview males and/or females over 18 years as equally as possible. We used this approach to avoid a clustered selection of respondents. In total, we interviewed 632 farmers [Mabale = 124, Tsholotsho = 234 and Victoria Falls = 274; response

rate = 100%]. The sample was proportionate to the total farmer population at each site. We explained the study's purpose before each interview; all interviewees consented to voluntarily participate (Brittain et al., 2020). Interviews were conducted in the farmer's language of choice (i.e., *isi*Ndebele, *chi*Nambya or *chi*Tonga) and responses were transcribed in English.

Measuring Attitudes

The interviewer asked: 'How much do you like or dislike lions and why?' Farmers selected a response from a five-point scale: '5 = strongly like', '4 = like', '3 = neither like nor dislike', '2 = dislike' and '1 = strongly dislike' and explained why. We also asked farmers their views on what they would 'like to see happen to the current lion population, around your village, in the future and why?' Responses included: 'increase', 'decrease' and 'stay the same' and also explained why. Questions we used to assess farmers' familiarity, level of participation and attitudes towards the Long Shields programme are listed in Table 7.

In August 2017, we repeated the same face-to-face interviews with the same farmers, to determine the impacts of the programme after implementation. We also added new questions to assess the farmers' awareness of the programme, level of participation, and overall attitudes towards the programme itself. To help minimise possible interviewer and respondent bias, data were collected by four independent interviewers (woman = 1, men = 3) different from those in 2010-2012. The trained interviewers were not aware of which villages had participated in the programme previously to avoid bias in recording responses.

During post-programme surveys we found evidence that treatment and control groups exchanged information about the Long Shields programme, including lion warnings provided to participating villages. As such, in addition to the treatment and control group, we found we needed to include a third analysis group (an intermediate group). We defined the intermediate

group as farmers who were originally assigned to the control group but exchanged information about lions and the intervention with farmers in the treatment group.

Table 7: *Statements regarding affective attitudes, tolerance towards lions, familiarity of the Long Shields programme*

Questions	**Answer options**
How much do you like or dislike the lion?	1 = 'strongly dislike': 2 = 'dislike', 3 = 'Neutral', 4 = 'like', 5 = 'strongly like
What would you like to see happening to the current lion population in the future?	1 = 'increase', 2 = 'decrease' or 3 = 'stay the same'
Are you familiar with the Long Shields Community Guardian programme?	Yes/No
Do you have Community Guardians in your village?	Yes/No
If yes, what is the role of the Long Shields Community Guardian programme?	Open ended
Do you receive warning messages from your Community Guardians?	Yes/No
If yes, what do you do when you get these warning messages?	Open ended
Personally, how do you perceive the Long Shields Community Guardian programme and why?	1 = 'very unimportant'; 2 = 'unimportant'; 3 = 'neither' 4 = 'important', 5 = 'very important'

Data Analysis

We used linear regression models to examine whether demographic and socio-economic characteristics of farmers that participated in the Long Shields programme were similar between groups. Dependent variables included: (a) age, (b) household size, and (c) livestock holdings, while treatment status and communal area were independent variables.

Changes in Attitudes towards Lions

To test for changes in lion attitudes between treatment, control and intermediate groups, we first calculated the difference-in-difference (Abadie, 2005) score by coding from 1 ("strongly dislike") to 5 ("strongly like") and subtracted the score 'before' from the score 'after' the introduction of the Long Shields programme. The scale for 'change in attitudes' ranged from -4 to +4 where the extremes represented a shift from 'strongly like' to 'strongly dislike' and from 'strongly dislike' to 'strongly like' respectively; 0 represented 'no change'. Logistic regression models were fitted with a cumulative-link function ("*clmm*") (Christensen, 2015). We tested if the changes in attitudes of farmers participating in the Long Shields programme were significantly different from those in the control group. The calculated difference-in-difference scores were included in the candidate model as the dependent variable while the: (a) treatment status (control, intermediate and treatment) and (b) area (Mabale, Tsholotsho, Victoria Falls) were included as categorical independent variables. We controlled for possible clustering of similar responses between study villages by adding the variable 'village' as a random-effect to the model. We used the '*sure*' package (Liu & Zhang, 2018) to scrutinize model diagnostics using surrogate residuals. To test for significant ($p \leq .05$) differences in attitudes between the treatment, control and intermediate groups, we performed Likelihood Ratio Tests (LRT) comparing models with and without the effect of interest. All analysis were conducted in R statistical software (R Core Team, 2019).

During our post-programme surveys we found evidence that treatment and control groups of farmers exchanged information, as a result, we calculated the 'effective communication range' (i.e., the distance between farmers in the treatment and intermediate groups where communication channels influenced a change in attitudes). To determine this, we used the function '*variog'* in R-package 'geoR'.

3.5: Results

We interviewed 338 subsistence farmers; we excluded nine interviews from the analysis because of missing responses to key questions. The remaining 329 interviews used in analysis included farmers from the Mabale (n = 64), Tsholotsho (n = 125) and Victoria Falls (n = 140) communal areas. Of these, 55% were men and 45% were women, with an average age of 59.73 ± (SD = 14.78). Fifty-three percent of the farmers were part of the treatment group, 19% in the intermediate group, and 28% in the control group.

Farmer Characteristics

The average age of the farmers (Z = -0.35, p = 0.72), livestock holdings (Z = 0.36, p = 0.72) and household size (Z = 0.77, p = 0.44) were similar for the treatment and the control group, with intermediate group calculation included here in the control group. Sources of human livelihoods remained the same over the study period, both before and after introduction of the Long Shields programme. Crop farming and livestock rearing were listed as the primary livelihood sources.

Changes in Attitudes towards Lions

Compared to before, results indicated a positive shift in self-reported attitudes towards lions after the introduction of the Long Shields programme, for farmers in both the treatment and intermediate groups (**Figure 8**). This before-after change was influenced by participation in the Long Shields programme (F = 2.95, df = 2, p = 0.05). The change in attitudes was significantly different to the control group (**Table 8**). No evidence suggested these changes were affected by the communal area that farmers lived in (F = 1.91, df = 2, p = 0.36).

We also found that since the introduction of the Long Shields programme, farmers' opinions of lion population status have changed, with more farmers indicating they would like to see

either stable or increasing lion populations across the area (**Table 9**). However, there participation in the Long Shields programme had no detectable effect on desired lion population trends (F = 1.13, df = 2, p = 0.34), nor did the communal area in which a farmer lived (F = 0.41, df = 2, p = 0.66).

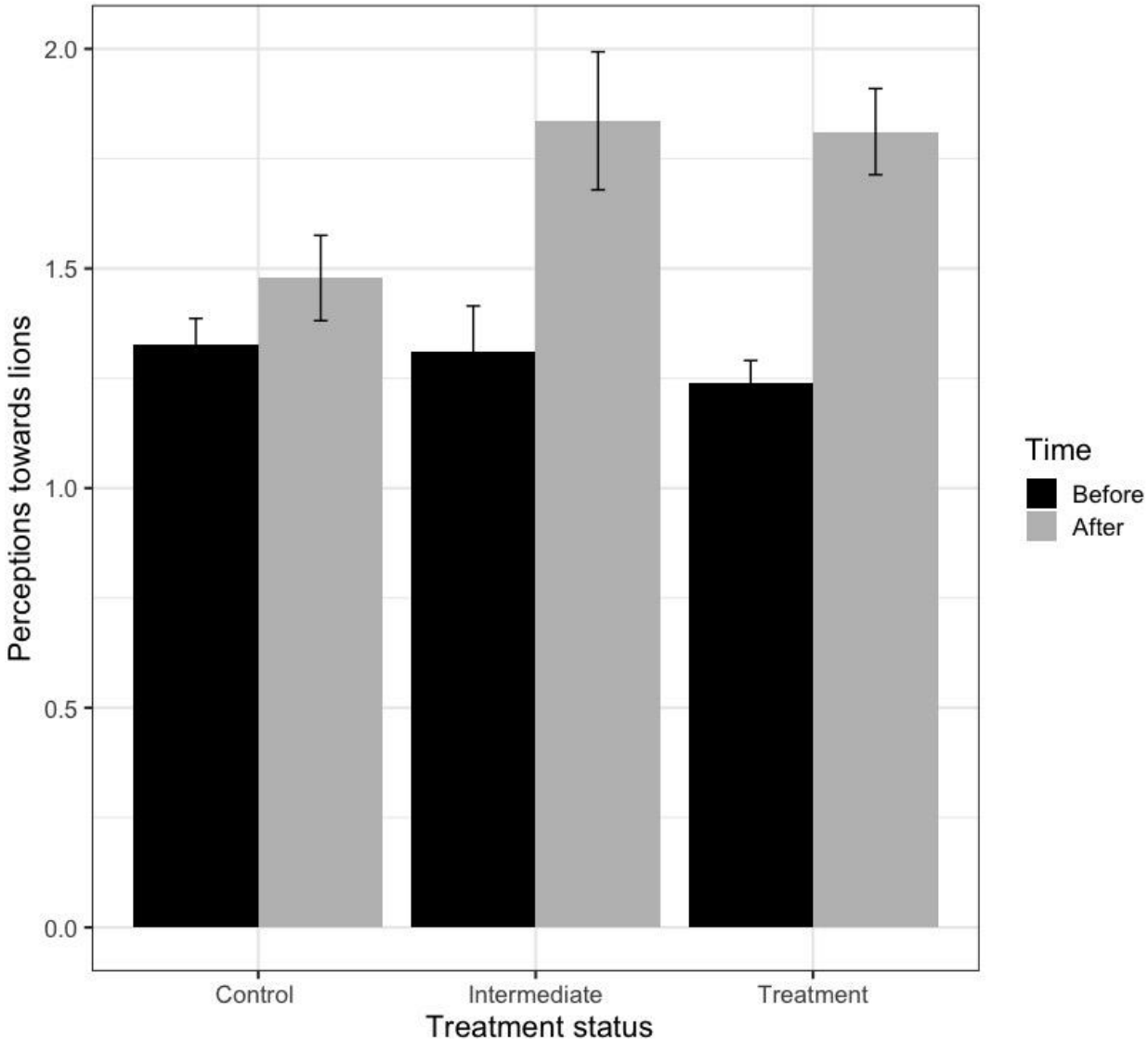


Figure 8: *Attitude changes towards lions before and after the introduction of the Long Shields Community Guardian programme*

***Table 8**: Parameter estimates of an ordinal regression model used to determine whether or not the before-after changes in attitudes of farmers in the control group were significantly different to those in the treatment or intermediate groups*

	Estimate	Std. Error	z-value	Pr(>|z|)
Reference= Control group				
Intermediate	0.71	0.34	2.11	0.03*
Treatment	0.67	0.28	2.39	0.02*

Attitudes towards the Long Shields Programme

Of the farmers that participated in the Long Shields programme (i.e., treatment and intermediate groups), 87% agreed with the statement that lions have the right to exist, with 32% indicating they are now less fearful of lions because of the Long Shields programme. Over half (52%) of participating farmers indicated that because of the programme they were less concerned about lions attacking livestock at night, and 64% strongly agreed that depredation incidents had decreased as a result of the Long Shields programme. Since 2013, over 100 livestock enclosures had been reinforced, and over 2,200 messages warned farmers of approaching lions. Over ninety percent (91%) of farmers agreed the early-warning messages helped them avoid direct livestock losses to lions (**Figure 9**). No evidence suggested these attitudes were affected by the area that farmers lived ($F = 2.39$, $df = 2$, $p = 0.09$).

Ninety percent of farmers in Long Shields programme felt the programme was important. Perceived benefits of the programme included the early-warnings of approaching lions (52%), the programme physically deterring lions off village lands (15%), collating livestock depredation reports (11%), and educating farmers on building lion-proof livestock enclosures (7%). Upon receiving warning messages 78% of the farmers more closely monitored their

livestock and avoided areas of high lion risk, and 8% of farmers in the treatment group had assisted Community Guardians to physically deter a lion back into the park.

In contrast to other human-lion conflict interventions (i.e., electric fence, livestock herding, compensation, canvas mobile bomas, lethal control), 21% of farmers perceived electric fences as the most effective technique to protect against lion depredation, followed by traditional livestock herding (19%) and canvas mobile bomas (18%). Seventeen percent of farmers believed the Long Shields programme was the most effective technique; lethal removal (15%) and financial compensation (10%) ranked fifth and sixth respectively.

Fourteen percent of farmers shared lion warning messages with neighbouring farmers across other villages. The effective communication range was 178*m* (**Figure 10**). Conceivably, this is how a proportion of the farmers in the control group, which we in turn categorized as the intermediate group, became aware of the Long Shields programme.

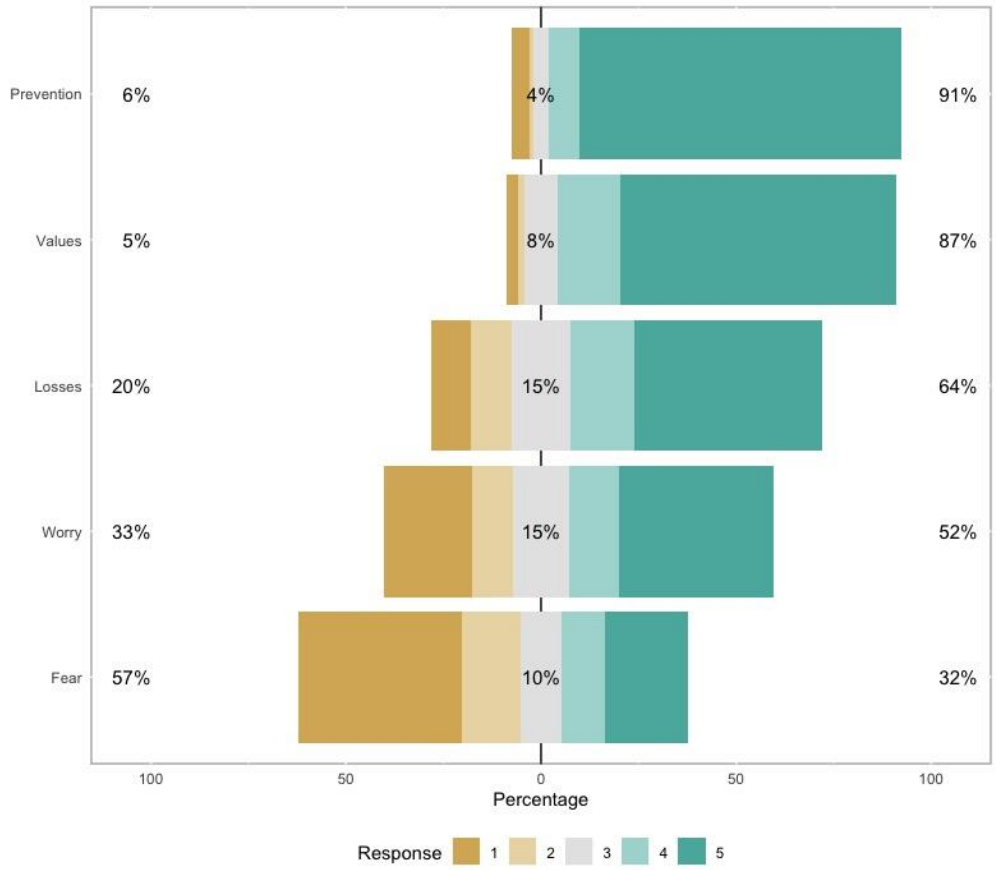


Figure 9: *A bar plot of Likert scaled statements (below the figure) regarding the Long Shields programme Theory of Change (ToC)* *** *Prevention***: *Warning messages from the Long Shields programme have helped (you) avoid impact from lions;* ***Values***: *Lions have the right to exist;* ***Losses***: *Depredation incidents have decreased as a result of the Long Shields programme;* ***Worry***: *You are less worried of lions attacking livestock inside corrals at night as a result of the Long Shields programme;* ***Fear***: *You are now less fearful of lions as a result of the Long Shields programme (1= strongly disagree:5 = strongly agree).*

***Table 9**: Farmers' desired lion population trends before and after the introduction of the Long Shields programme in the treatment, control and intermediate group. The values represent percentages*

	Treatment (*n* = 175)		Intermediate (*n* = 65)		Control (*n* = 88)	
What would you like to see happening to the current lion population in the future?	Before	After	Before	After	Before	After
Increase	0	5	0	2	2	5
Decrease	94	66	89	72	95	65
Stay the same	5	29	8	26	3	30
No clear opinion	2	0	3	0	0	1

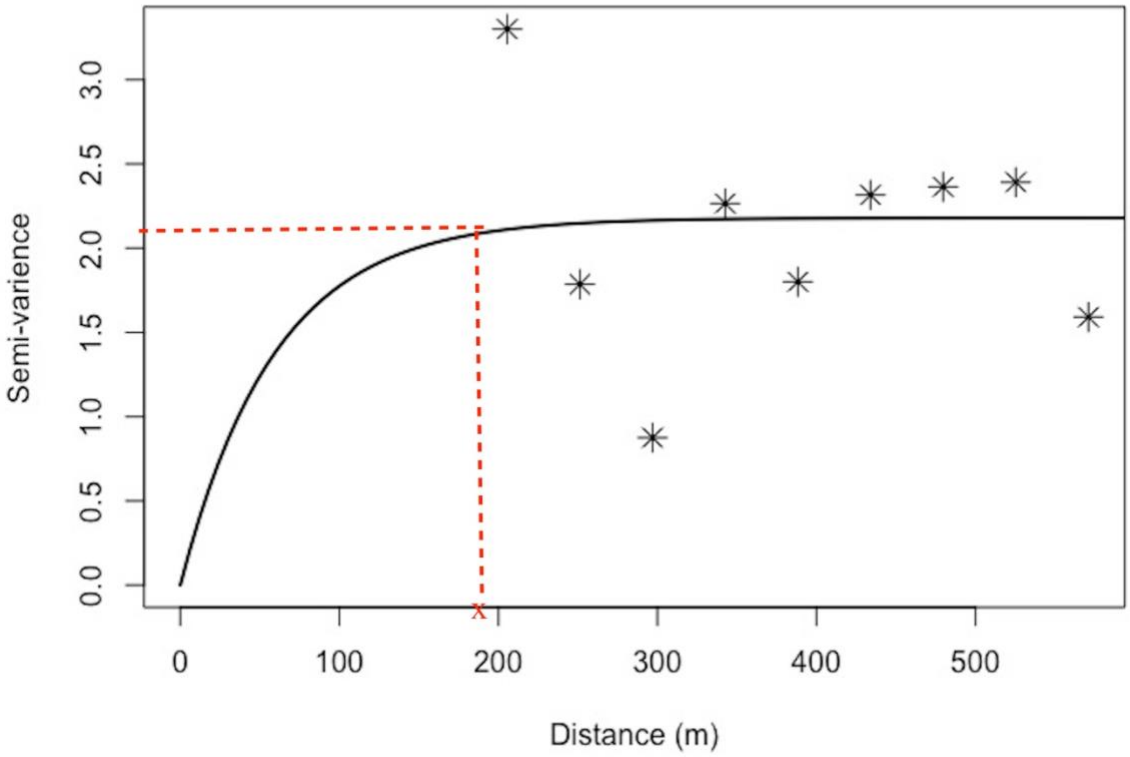


***Figure 10**: An omnidirectional variogram to determine the effective communication distance/ range between farmers part of the Long Shields programme and those who were not. We found the effective range to be 200 meters (Actual = 178 m). This means farmers in the control group that were within this range had their attitudes influenced by the treatment neighbour.*

3.6: Discussion

We evaluated farmers' attitudes towards lions, before (2010) and after (2017) the Long Shields programme was implemented. Surveys conducted before the Long Shields programme was introduced revealed that a majority (>90%) of farmers in our study area largely held negative attitudes of lions, with perceived livestock depredation cited as the primary reason influencing this negativity (Sibanda et al., 2020a). This work informed both the design of the Long Shields programme and evaluation, hypothesising that a decrease in (real or perceived) lion-caused livestock depredation would result in a positive shift in farmer attitudes and result in adoption of proactive mitigation techniques.

As expected, farmer participation in the Long Shields programme, and even familiarity with the programme, resulted in a positive shift in attitudes of participating farmers (treatment and intermediate groups) towards lions compared to those in the control group. This included farmers' opinions regarding the desired state of future lion population in the area, dropping from 93% to 65% of those wanting to see the population decrease. Farmers part of the programme thought the current lion population could be managed with the help of the Community Guardians. These findings were comparable to those of a study conducted in southern Kenya, where attitudes of Maasai warriors towards lions improved following the implementation of the Lion Guardian programme (Hazzah et al., 2017).

Nearly two-thirds (63%) of farmers that were part of the programme reported livestock depredation had decreased, attributed to the Long Shields programme. This perception by farmers is supported by our preliminary analysis on livestock depredation, which showed a 40% drop in livestock losses for farmers directly involved in the Long Shields programme, which is larger than the drop experienced by farmers who were not part of this programme. The majority of participating farmers were largely responsive to early-warning messages about

lions in their vicinity, delivered through the WhatsApp system (> 2,200 messages sent to farmers in 5 years). This enabled farmers to monitor their livestock and avoid grazing in areas of high lion risk, thereby reducing the threat of depredation. Over 90% of the farmers stated this was the most important activity of the Long Shields programme. Similarly, a study in northern Botswana showed that warning people of approaching lions is an effective tool against lions because it encourages active risk management (Weise et al., 2019).

In contrast, fewer than 50 farmers approached the Community Guardians for assistance recovering lost livestock, despite the programme offering this to farmers needing help. These low numbers suggest this activity may not be needed or relevant to farmers or may not be well known or understood. Similarly, we found that farmer participation in helping Community Guardians track and haze or chase lions was generally low, with fewer than 10% participating. This is in contrast to other evidence indicating that hazing lions in large groups is effective against livestock depredation (Petracca et al., 2019). In future, the Long Shields programme should consider checking with farmers to see if these activities are relevant and desired, and if so, crafting and communicating clear information about these activities, recruitment process and related benefits.

Some factors may be attributed to influencing positive changes in lion attitudes, aside from directly decreasing livestock depredation. Working with trusted and respected community members, to develop the relevant solutions they wanted, helped pave the way for shifting attitudes towards lions. Working with communities to develop locally-relevant conservation solutions is not a new concept. It ensures that the aims, actions and outcomes of intervention programmes are relevant across stakeholders and aligned with the interest of the community. It also increases levels of trust and fosters a sense of stewardship towards carnivores and

certainly warrants future use, albeit careful consideration for feasibility, sustainability and appropriateness (Morehouse et al., 2020).

Normative social communication, such as the discourse shared between farmers about the Long Shields programme, has the potential to influence not only farmers' attitudes of the programme but also of lions and decisions to change their behaviours (Hill, 2004). Some degree of social influence apparently affected our control group farmers, as 41% had awareness of the Long Shields programme from other farmers (14%) sharing lion early-warning messages. Farmers indirectly benefiting from the programme, via information communicated from their peers (social spillover), has the potential to influence their attitudes of lions. This result also demonstrated that the positive impacts of the Long Shields programme were extended beyond our target audience, suggesting that the diffusion of such information across different people or villages can bode well for lion conservation elsewhere (Rogers, 2004). When resources are scarce, staggering treatment and non-treatment across villages may be effective, given the role of social spillover. It would be interesting to explore if other farmers outside our study area voluntarily choose to change their behaviours and adopt conservation practices based on information shared through farmer social networks (Wallen & Daut, 2017).

With regards to how the Long Shields programme ranks relative to other human-lion conflict interventions; results indicate that farmers ranked the Long Shields programme as the fourth most (perceived) effective technique against lion depredation after electric fences, traditional herding and canvas mobile bomas (a novel method that uses moveable polyvinyl chloride curtains placed over crop fields to house livestock against predators at night). However, the advantage of the Long Shields programme relative to other conflict tools is that it combines several mitigation techniques such as assisting farmers reinforce their corrals, education programmes, direct deterrence of lions and an early-warning system, which add to its

effectiveness as an effective tool against livestock depredation by lions. The Long Shields conservation model is flexible, with careful adaptation, the model can be scaled up to mitigate different human-carnivore conflict situations. By collaborating with local farmers, this programme may increase a sense of community, improve communication and stimulate local communities to be directly involved in lion conservation which is not always the case with other techniques.

Although the results of our evaluation are informative and encouraging, we acknowledge there are some limitations. The allocation of villages to the Long Shields programme was not random. We introduced the programme in villages that had sustained higher livestock depredation in the past. Critics suggest that non-random treatment allocation could result in regression-to-the-mean, a statistical phenomenon that makes natural variations in data appear like genuine change (Barnett et al., 2005). This is less likely to be a problem in this study because the high impact villages have been in that category for some time, meaning they did not just happen to be experiencing high impact from lions at the time of the study. Additionally, 47% percent of the farmers that participated in the 'pre-intervention' survey did not participate in the 'post-intervention' survey due to absence, sickness, death or relocation. While unfortunate, this large drop-out rate is not uncommon in long-term studies that involve human participants (Lugtig, 2014). We had sufficient participation to provide evidence of the impacts of the Long Shields programme.

3.7: Conclusion

Conservation scientists increasingly emphasize the need to evaluate the effectiveness of human-wildlife interventions across different contexts (Baylis et al., 2016). However, impact evaluation is no easy task and often not the principal objective when interventions are conceived and implemented (Woodhouse et al., 2015). Our study utilised a Theory of Change

(ToC) to both plan our programme's activities and outcomes, and evaluate its impact on farmers. ToC was a useful conceptual guide and suggested future conservation activities adopt this approach. Specific to farmers, both the treatment and intermediate groups held positive attitudes for the Long Shields programme and had a positive shift in their lion attitudes. However, we acknowledge this positive shift in attitudes may not translate into desired conservation action, and that the effects of interventions like these on lion population trends will require long-term engagement and evaluation. Our results highlighted the importance of considering human attitudes in conservation programming, to help provide evidence about human-animal relations as well as the effect of conservation activities on people (Bennett, 2016b). Information on attitudes can be useful in behavioural models. The positive impact of the Long Shields Community Guardians programme for farmers demonstrated an important first step for contributing baseline knowledge of interventions in this area, and practically supporting farmers to coexist with lions.

Contributions

Andrew J. Loveridge and Lovemore Sibanda conceived the before-after control-impact experiment. Lovemore Sibanda reviewed literature and analysed the data. Lovemore Sibanda wrote the final manuscript and responded to reviewers' comments. Courtney Hughes, Paul Johnson, Esther van der Meer, Jane Hunt, David W. Macdonald and Andrew Loveridge commented on draft chapters. Lovemore Sibanda supervised the Long Shields programme assisted by Liomba J. Mathe, Roger H. Parry and Bongani Dlodlo. Lovemore Sibanda supervised the data collection. Andrew J. Loveridge secured funding. Esther van der Meer, David W. Macdonald and Andrew J. Loveridge supervised the doctoral study.

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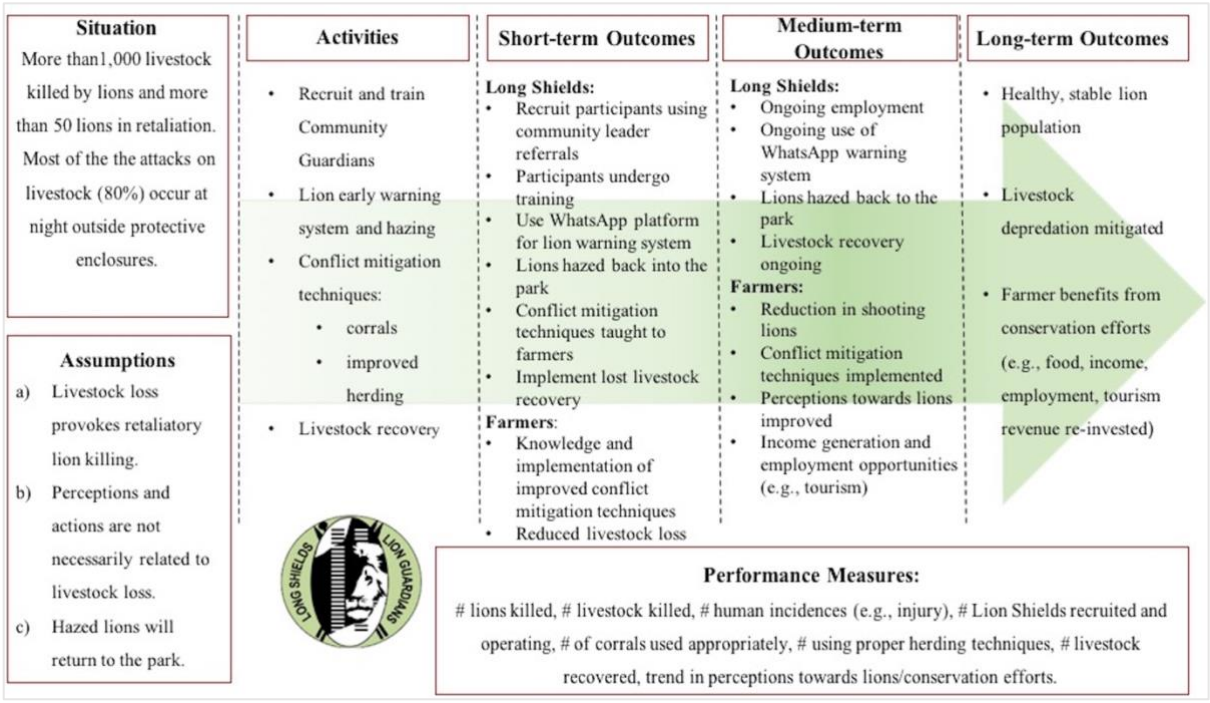
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3.9: Supplementary Material



Supplementary Figure S3*: The Long Shields Community Guardian programme Theory of Change*

Chapter Four: Effectiveness of community-based livestock protection strategies: a case study of human-lion conflict mitigation

Lovemore Sibanda, Paul J. Johnson, Esther van der Meer, Courtney Hughes, Jane E. Hunt, Roger H. Parry, Liomba Junior Mathe, Bongani Dlodlo, David W. Macdonald and Andrew J. Loveridge



In fond memory of the late Jeffrey Ndlovu (blowing a vuvuzela)(1967 - 2016), the Community Guardian for Ngamo village (2013-2016). Forever missed and cherished! Continue to rest in peace!

** This chapter is under review in Oryx- the international Journal of Conservation*

4.1 Chapter summary

Conservation scientists are increasingly emphasising the need to evaluate the effectiveness of human-wildlife conflict interventions across different contexts. In this study, we assessed the long-term efficacy of a community-based programme: the Long Shields Community Guardians. The programme protects livestock and mitigates depredation by lions through non-lethal means with the ultimate aim of promoting human-lion coexistence. Using an experimental approach, we measured temporal trends in livestock depredation by lions as well as the prevalence of retaliatory lion killing by farmers and wildlife managers. Farmers that were part of the Long Shields programme experienced a significant reduction in livestock loss to lions and the number of lions killed annually due to retaliatory killing by farmers dropped by 41% since the start of this programme in 2013, compared to the period 2008-2012 before the programme was initiated. Our results demonstrate the Long Shields programme can be a potential model for limiting livestock depredation by lions elsewhere. Additionally our study demonstrates the effectiveness of community-based conflict interventions in engaging community responses to livestock protection and ameliorating levels of retaliatory killing, thereby reducing human-lion conflict.

*Keywords***:** African lion, community-based conflict intervention, conservation, impact evaluation, livestock depredation, Long Shields Community Guardian programme, non-lethal, Zimbabwe

4.2: Introduction

Over the past two centuries, more than 75% of large carnivore populations have experienced substantial range contractions and population declines (Ripple et al., 2014). In particular, conflict with humans over livestock represents a significant threat to the persistence of carnivore populations (Wolf & Ripple, 2017). The world's human population is predicted to increase, which is likely to exacerbate human-wildlife conflict and lead to further declines in large carnivore populations (Wittemyer et al., 2008). Therefore, facilitating long-term coexistence between humans and wild carnivores is an urgent conservation priority (Ripple et al., 2014).

The African lion (*Panthera leo*), the largest predator in the savannah ecosystem, is negatively affected by the consequences of human-population increase (IUCN, 2016). Lion populations are extinct in North and Central Africa, declining in East Africa and populations are stable in Southern Africa. Conflict with humans along the boundaries of protected areas threatens the long-term viability of the remaining lion populations (Bauer et al., 2016). To safeguard the species, robust interventions are needed to reduce the impact of lions on humans, and the resulting retaliatory killing of lions (IUCN, 2016).

A diverse array of human-carnivore conflict interventions, both lethal and non-lethal, have been developed globally to minimise the negative impacts of wild carnivores (Miller et al., 2016). These interventions range from basic methods such as livestock herding (Ogada et al., 2003) to sophisticated techniques such as the use of lightweight metal collars which may protect livestock from depredation (McManus et al., 2014). However, many of these interventions have not been evaluated for effectiveness (van Eeden et al., 2018), mainly due to costs and the practical difficulties (Baylis et al., 2016).

The Hwange-Matetsi Protected Area Complex (HMPAC) in northwestern Zimbabwe is of global importance for lion conservation (Cushman et al., 2018). The protected area is part of the wider Kavango Zambezi Transfrontier Conservation Area (KAZA TFCA) and is home to one of the world's sixth-largest remaining lion populations, with more than 1,000 individuals (IUCN, 2016). As for many lion populations, persecution by farmers along the community-protected area interface in retaliation for livestock loss is a serious threat for this lion population (Loveridge et al., 2017). Over 1,000 livestock (19% of the entire livestock population) were killed by large predators including lions between 2008 and 2013, and in retaliation, approximately 50 lions (mostly females with dependent cubs and subadult males) were killed by farmers and local authorities during the same period (Loveridge et al., 2017). The factors influencing the frequency and magnitude of human-lion conflicts in this area are well studied. For instance, livestock depredation by lions peaks during the wet months, when livestock is herded away from crop fields in areas closer to the protected area (Kuiper et al., 2015). Further, the majority of lion attacks on livestock (>80%) occur at night when many livestock are left to graze unattended instead of being securely enclosed in overnight protective kraals (Loveridge et al., 2017).

In 2012, in collaboration with local traditional leaders, we introduced a community-based conflict mitigation programme known as Long Shields Community Guardian programme (hereafter: the 'Long Shields programme') in northwestern Zimbabwe. We collaborated with local communities to ensure that (a) our programme aims, actions and outcomes are relevant across stakeholders and aligned with the interest of the community and that; (b) our programme was locally appropriate and consistent with the norms and customs (Chase et al., 2004).

The Long Shields programme was modelled on the Lion Guardians programme in Amboseli, Kenya, which aims to provide non-lethal solutions, from educational outreach to actively

deterring lions, to reduce human-lion conflict and promote coexistence (Hazzah et al., 2014). We followed the Theory of Change (ToC), a methodology involving a logical, ordered sequence to designing and evaluating a programme, to causally illustrate the inputs, activities, target audiences, and desired outcomes of the Long Shields programme (Woodhouse et al., 2015). ToC has been used elsewhere in different conservation contexts (Morehouse et al., 2020) and can be particularly useful for structuring data collection and prioritising the activities and goals of future programmes.

As part of a broader evaluation, we hypothesised that: (a) a reduction in livestock loss to lions (both perceived and actual); (b) reduction in human-safety risk; and, (c) awareness of, and demonstrated effort by the programme, would positively shift farmers' attitudes towards lions and facilitate human-lion coexistence. Results to date suggest that hazing or chasing problem lions has been an effective method for deterring young lions from communal farmlands (Petracca et al., 2019) and that the programme is well-received within the target communities. Moreover, there has been a positive shift in farmers' attitudes and attitudes towards lions (Sibanda et al., 2020b). Evidence from other areas also suggests that assisting farmers in building sturdy livestock enclosures and alerting them of approaching lions are both effective methods for limiting livestock depredation by wild carnivores (Lichtenfeld et al., 2014).

To establish whether the Long Shields programme was effective in mitigating livestock depredation by lions, we examined the long-term trends in livestock depredation by lions before (2008-2012) and after (2013-2017) the implementation of the programme, and compared levels of livestock depredation between participating and non-participating farmers. We also examined the temporal trends in lion retaliatory killings by local farmers before and after the implementation of the Long Shields programme. We hypothesised that as a result of the programme's activities we would see (a) a significant decrease in livestock depredation by

lions for participating farmers (treatment group) in comparison to non-participating farmers (non-treatment group), and; (b) a significant reduction in lion retaliatory killings by participating farmers after the introduction of the programme.

4.3: Study Area

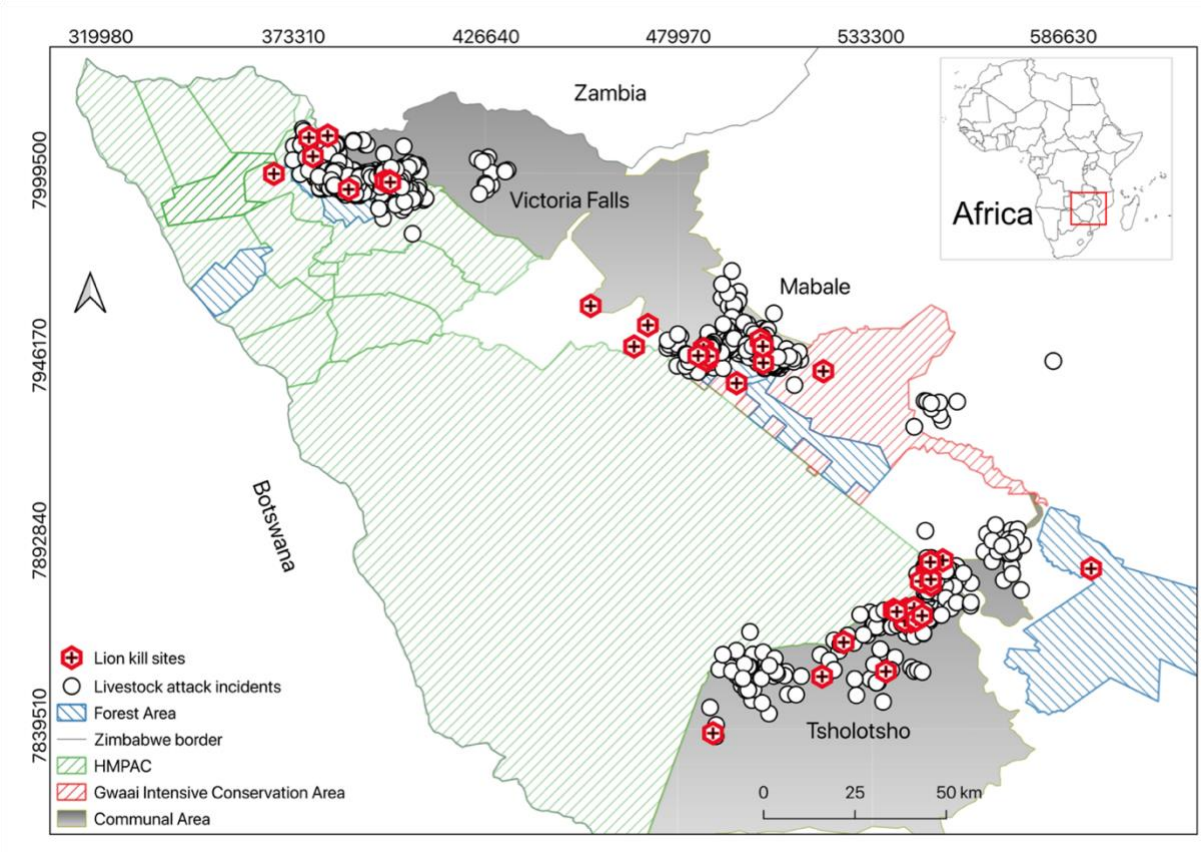


***Figure 11**: A map of our study area, northwestern Zimbabwe*

Our study was implemented in three rural communities in communal lands in northwestern Zimbabwe: (a) Mabale (Dingani Chieftainship: 480 km^2); (b) Tsholotsho (Matupula and Siphoso Chieftainships: 2,171 km^2) and; (c) Victoria Falls (Mvuthu and Shana Chieftainships: 655 km^2) (**Figure 11**). Mabale and Tsholotsho rural communities are situated adjacent to the Hwange National Park (HNP), while Victoria Falls communal area is located adjacent to the Zambezi National Park (ZNP). Both HNP and ZNP are part of the HMPAC. The Sikumi Forest Land provides a buffer between Mabale and HNP and Fuller Forest Land between Victoria

Falls and ZNP. Topographic and demographic differences between Mabale, Tsholotsho and Victoria Falls are summarised in **Supplementary Table S1**.

Ecologically, the study area is semi-arid with an average annual rainfall of 600 mm (Interannual CV = 25%) (Guerbois et al., 2013). Crop cultivation and livestock-rearing are the two primary sources of livelihoods. Common livestock reared include cattle (*Bos taurus*), donkey (*Equus asinus*), sheep (*Ovis aries*) and goat (*Capra hircus*) (Sibanda et al., 2020a). Some farmers herd their livestock and pen then at night as is traditional, though previous studies (e.g. Kuiper et al., 2015; Loveridge et al., 2017) have found evidence of some careless herding practices. Livestock is grazed on a specific designated rangeland usually located within the communal lands. Farmers in Tsholotsho and those in Victoria Falls graze their livestock in communal grazing areas located within the communal land while limited grazing opportunities in Mabale drive farmers to graze their livestock within a protected area (i.e. Sikumi Forest Land) in search of quality forage and water for their animals (Pers Obs.). Over the years, the village population and development has increased (Guerbois et al., 2013); as a result, the need to access the Sikumi Forest Land for grazing has contributed to an increase in livestock attacks by wild carnivores (Perrotton, 2015).

The Zimbabwe Parks and Wildlife Management Authority (ZPWMA) and the Rural District Councils (RDCs), are responsible for managing the wildlife outside the park. Frequently, lethal control (i.e., shooting) is the preferred method for dealing with conflict animals, especially for dangerous animals such as lions (Loveridge et al., 2010a). Legal prosecution of farmers for killing lions is not common, very few farmers (n = 2) were prosecuted for illegally killing a lion during the study period. Farmers do not receive financial compensation from the Government of Zimbabwe for either livestock or crop losses to wild animals (Sibanda et al., 2020a). Tsholotsho, Mabale and Victoria Falls are all part of the Communal Areas

Management Programme For Indigenous of Resources (CAMPFIRE), a community based natural resources management programme that seeks to provide benefit through RDCs to communities living alongside wildlife areas such as the provision of water sources, and the renovation of local schools, clinics and roads (CAMPFIRE, 2016). Although the CAMPFIRE model recorded significant success it was initiated in the early 1980s, recently most farmers', particularly in our study area, feel strongly negative towards the CAMPFIRE programme citing very few direct benefits (Western et al., 2019).

4.4: Methods

Experimental design

We used a quasi-experimental design with Before-After Control-Intervention (BACI) measurements (Thiault et al., 2017), where we sampled treatment and non-treatment groups of farmers simultaneously before and after the introduction of the Long Shields programme. This design is commonly applied to estimate the causal effects of an intervention on a target population when the random assignment to a treatment is not possible (Gertler et al., 2011). Our study involved a total of 99 villages (range: 10 – 75 farmsteads in each), all located within a 20 km radius from the park boundary. Of these, 47% (n = 46; Mabale = 9, Tsholotsho = 15 and Victoria Falls = 22) were part of the Long Shields programme while the remainder 53% (n = 53; Mabale = 18, Tsholotsho = 29 and Victoria Falls = 6) were not part of the programme. However, the selection of villages to be included in the programme was not random given the objective was to solve a real-world problem, so we selected villages that previously sustained significant livestock depredation. We considered it ethically unacceptable to randomly allocate villages affected by potentially life-threatening human-lion conflicts to treatment groups or non-treatment groups. Our experimental design was approved by the Social Science and Humanities Interdivisional Research Ethics Committee of the University of Oxford ref.

R52851/RE001, the Research Council of Zimbabwe ref. 02786 and the Zimbabwean Ministry of Rural Development ref. P/13/3.

The intervention: Long Shields Community Guardian programme

We introduced the community-based programme in six key stages. First, we conducted a baseline survey to understand the attitudes of farmers towards lions and factors influencing these attitudes (Sibanda et al., 2020a). In consultation with the local traditional leaders, we used the Theory of Change framework to develop a logical model of behavioural change (Supplementary Figure S4). Thereafter, we recruited 14 local farmers (men =12; women = 2) as Community Guardians. Community Guardians were selected from a short-list of candidates, recommended by local traditional leaders and the wider the community. We selected candidates based on previous direct experience with lions (e.g., people who had physically chased a lion), literacy, residency within the local area and good standing in the community. Community Guardians were then trained by the Trans-Kalahari Predator Programme (WildCRU, University of Oxford) in lion tracking and the use of radio-telemetry, Global Positioning System (GPS) data collection protocols (e.g., livestock depredation assessment) and conflict mitigation techniques (e.g., herding, kraal fortification). As part of the programme's early-warning system, we [between 2013 and 2017] identified 21 lions (males = 14; females = 7) (Mabale = 6; Tsholotsho = 9; Victoria Falls = 6) across nine prides/coalitions and fitted them with (satellite) GPS collars to monitor their movement. Only one or two individuals were collared per pride/coalition, and lions were selected for collaring based on their home ranges significantly overlapping with the local farming communities outside of the protected areas and whether the animals were likely to disperse. Each GPS collar took one location every two hours. Whenever lions were within three kilometers of a protected area boundary, a warning message was sent via Community Guardians to a network of farmers

within treatment villages. Lions that crossed the park boundary and approached human settlements would be hazed (chased) by the Community Guardians plus volunteers within the treatment villages using a '*vuvuzela'*, a plastic horn that produces an irritating sound of about 127 decibels (dBA) (Petracca et al., 2019). A long-term dataset collected using a combination of spoor and camera trap surveys suggest the lion population density (approximately 2.5 lions per 100 km^2) remained constant throughout the study (WildCRU, unpublished data). The Long Shields programme was piloted in Mabale communal area for six months before expanding the programme to Tsholotsho in January 2013 and Victoria Falls in June 2016.

Lion mortality and depredation monitoring

We comprehensively monitored livestock attacks by lions over a ten-year period, from January 2008 to December 2017, as well as retaliatory lion killing by farmers. We define 'an attack' as an event in which a carnivore killed or injured one or more livestock species. The majority of livestock depredation and lion mortalities were reported directly to Long Shields programme personnel, with an incident report form used to collect event details. For both livestock and lion mortality, we recorded the date of the incident (and date reported, as these may have varied), time of the incident, GPS coordinates of the household and/or incident site, likely predator responsible, livestock species attacked (e.g., cattle, donkey, sheep, goat), whether the incident occurred in or outside an enclosure, circumstances leading to retaliatory lion killing, and the cause of lion mortality (e.g., wire snare, shooting or poison). To assess the farmer's accuracy in carnivore identification, we showed each farmer pictures of different carnivores and their paw prints, which they were asked to identify. To validate livestock loss incidents, we independently verified each event by visiting the incident site. We also confirmed all incidents with the village head who, as part of their official civil responsibilities, keeps a register of all livestock owned by people residing in the village.

Evaluating programme success

To examine the effects of the Long Shields programme, we used Generalised Linear Mixed-effect Models (GLMMs) (Zuur et al., 2009) with a Poisson distribution in R-statistical software (R Core Team, 2019). The models were fitted using the function 'glmer' in package 'lme4' (Bates et al., 2015). The number of livestock lost to lions (mean per village averaged across the years) was included as the response variable while the following variables and their interactions were included in the model as fixed-effects: (a) Area (Mabale, Tsholotsho or Victoria Falls); (b) Treatment status (treatment or non-treatment) and; (c) Time (before or after). The effect of most interest was the interaction between treatment and time, as this tested the null hypothesis that there was no difference between treatment and control in the temporal trend. To control for clustering, we included 'village' in the models as a random-effect variable. To test the effectiveness of the community-based programme, we performed the Likelihood Ratio Test (LRT) (Bolker et al., 2009) comparing models with and without the effect of interest. Model validation to evaluate the presence of over- or under dispersion was through the inspection of residuals. Finally, to examine the association between the number of livestock lost to lions and the number of lions killed in retaliation, we performed a Pearson correlation test in R-Statistical software (R Core Team, 2019) using each year (i.e., the number of livestock or lions killed per year) as a data point.

4.5: Results

Depredation

Over the ten-year period, from January 2008 to December 2017, a total of 1,987 domestic animals were attacked by lions in 990 confirmed incidences (mean =16.59 ± *SD* 4.24 animals lost per month). The majority of livestock depredation incidents (67%) included cattle, donkeys (17%), shoats (i.e., sheep/goats) (14%) and other animals e.g. pigs (2%). The highest number

of incidents (n = 40%) occurred in Victoria Falls, followed by Tsholotsho (n = 34%) and Mabale (n = 26%). The proportion of lion attacks on livestock in and outside protective enclosures varied across the three communal areas ($\chi^2 = 93.52$, df = 2, $P < 0.001$), with Mabale having the greatest number of incidents inside kraals (32%). Moreover, the majority of lion attacks on livestock occurred during the night (61%) outside kraals (83%).

Long Shields programme effort

Between 2013 and 2017, the programme sent a total of 2,262 early-warning messages (average = 38 alerts per month) alerting farmers to approaching lions. Fifty-one farmers were assisted in recovering missing livestock (n = 386 livestock). Over the same period, 21 lions were hazed to chase them back into the park on a total of 116 occasions (mean = 5.5 chases per lion). More than half of the chases (n = 53%) were conducted in Tsholotsho, followed by Mabale (n = 40%) and Victoria Falls (n = 7%). One hundred and four farmers approached Community Guardians seeking assistance in reinforcing their livestock enclosures during the period 2013 to 2017**.**

Effectiveness of the Long Shields programme in limiting stock losses

Our findings indicate that average stock losses to lions were significantly reduced in the period after initiation of the programme in villages participating in the Long Shields programme (LR test for GLMM: $\chi^2 = 98.63$, df = 6, $P < 0.001$), **Figure 12** provides evidence that the before-after pattern differs between the treatment and control groups (see also supplementary table S2). However, the effectiveness of the programme was not uniform across all three communal areas. Average livestock losses to lions per village per year for participating farmers in Tsholotsho decreased from 19.27 ± *SD* = 15.00 before the programme, to 12.73 ± *SD* = 12.80 after the programme was implemented. In Victoria Falls, this was 17.55 ± *SD* = 20.70 for participating farmers before, to 11.23 ± *SD* = 14.40 after programme implementation. In Mabale, the average livestock loss to lions for participating farmers increased from 13.44 ± *SD*

= 14.00 before the programme to 25.44 ± *SD* = 20.40 after implementation. (**Figure 12**). We also found that average livestock losses for non-participating farmers in Tsholotsho decreased after the Long Shields programme was implemented (from 3.34 ± *SD* = 3.30 before the programme to 2.93 ± *SD* = 5.90 after implementation), though the decrease was smaller than for participating farmers) (**Figure 13**).

During 2008-2017, a total of 46 lions (males = 26; females = 20) were killed in conflict-related incidents in Mabale (*n* = 13), Tsholotsho (*n* = 23) and Victoria Falls (*n* = 10). Of these, 63% (*n* = 29, mean = 5.8 lions per year) were killed during the period before (2008-2012), while 37% (*n* = 17, mean = 3.4 lions per year) were killed during the period after the Long Shields programme was implemented (2013-2017) (Table 9). Thus, the number of lions killed in retaliation declined by 41%. Most of these lions (67%, *n* = 31) were shot as problem animals by officials (i.e., national parks, RDCs and hunters as part of CAMPFIRE), while farmers were directly involved in illegally killing 15 lions using either snares (*n* = 12), a spear (*n* = 2) or poison (*n* = 1). More collared lions were killed in Mabale that anywhere else (Table 10). Our findings also show that the proportion of lions killed illegally by farmers declined significantly since the implementation of the programme (χ^2 = 5.33, DF = 1, *P* = 0.02), while the number of lions legally shot by officials as problem animals remained unchanged (**Table 10**, **Table 11**). Finally, we found weak evidence for an association between the number of livestock killed by lions and the number of lions killed in retaliation by farmers (*rs* = 0.54, DF = 8, *P* = 0.11).

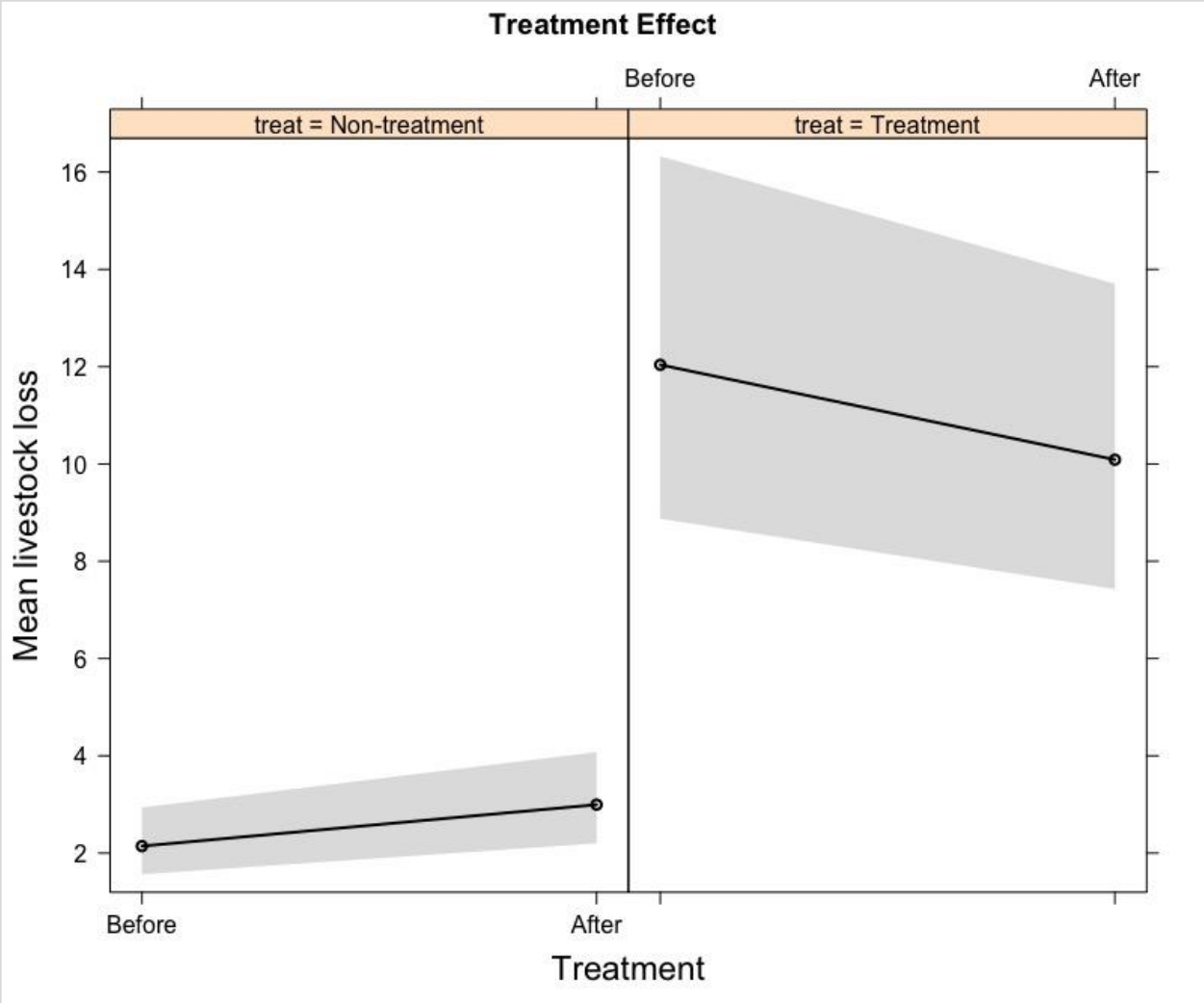


***Figure 12**: Average livestock loss to lions before and after the introduction of the community-based programme. The y-axis represents mean losses per village. The community-based programme was focused on villages that had sustained significant livestock depredation in the past, hence higher depredation in treatment sites.*

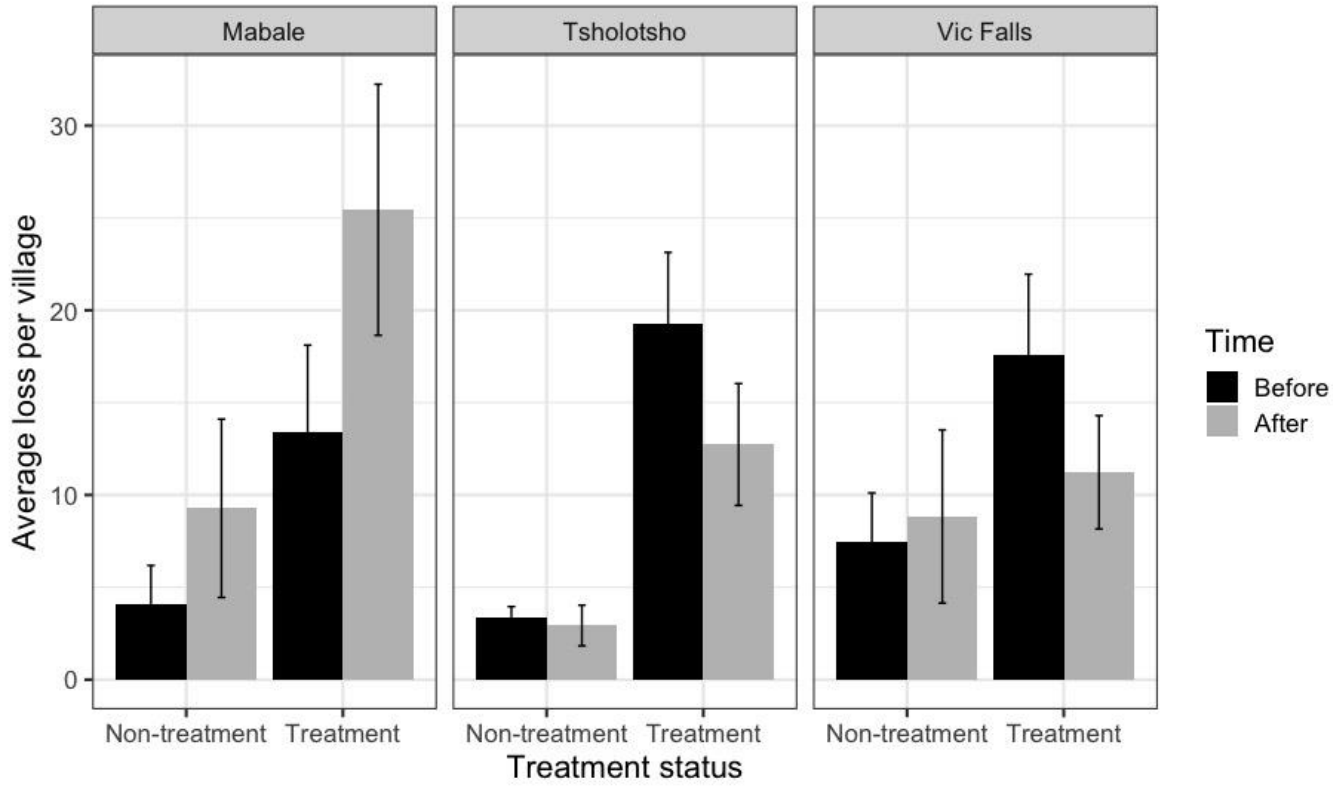


***Figure 13**: Average livestock lost to lions per village before (bars in black) and after (grey bars) the introduction of the community-based programme, across treatment and non-treatment farmers in three communal areas in northwestern Zimbabwe (2008-2017). The bars represent standard error (SE).*

Lion mortality before and after the programme

***Table 11:** Sources of lion morality in northwestern Zimbabwe, before (2008-2012) and after (2013-2017) the introduction of the community-based programme*

Mortality	Before	After
Official PAC	16	15
Snare	11	1
Poison	1	0
Spear	1	1
Totals	**29**	**17**

PAC = Problem Animal Control

Table 12: *Lion mortality in northwestern Zimbabwe before (2008-2012) and after (2013-2017) the introduction of the Long Shields programme across three different communities. Here we have further illustrate how many of the lions were collared ('Yes') or not ('No'). From the table, more collared lions were killed in Mabale than anywhere else.*

	Mabale				Tsholotsho				Victoria Falls			
	Before		After		Before		After		Before		After	
Collared?	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Official PAC	1	2	3	1	1	7	2	4	0	5	0	5
Snare	2	1	1	0	2	6	0	0	0	0	0	0
Poison	0	0	0	0	1	0	0	0	0	0	0	0
Spear	1	0	0	0	0	0	0	1	0	0	0	0
Total	**4**	**3**	**4**	**1**	**4**	**13**	**2**	**5**	**0**	**5**	**0**	**5**

4.6: Discussion

Our results indicate that farmer participation in the Long Shields programme is a significant factor in substantially reducing livestock loss to lions. Since the inception of the Long Shields programme in 2013, participating farmers in Tsholotsho and Victoria Falls recorded an overall decrease in livestock loss to lions compared to non-participating farmers. We suggest this is due to participating famers being alerted to approaching lions via the Long Shields programme, with farmers then taking action to move their livestock to areas with lower depredation risk. Further, we suggest that: (a) hazing lions that crossed over the park boundary into village settlements by using a '*vuvuzela'*, (b) encouraging farmers to report missing livestock to prevent attacks, and (c) assisting farmers to repair livestock kraals to avoid predation at night, may have also contributed to a decline in livestock depredation.

Although our overall findings indicate that losses to lions have decreased since the implementation of the Long Shields programme, the impact of the programme varied across study sites. Participating farmers in Mabale experienced an increase in livestock depredation over the course of the study. The reasons are difficult to disentangle; however, we suspect this

could be related to several large-scale demographic factors (e.g., increase human population, land-use change) that were beyond the scope of our initial study design. In all three sites, distinct social norms and regulations dictate local livestock grazing practices (Sibanda et al., 2020a). Farmers in Tsholotsho and Victoria Falls graze their livestock in specifically designated rangeland areas located within the communal lands. In contrast, farmers in Mabale graze their livestock within Sikumi Forest Land, a wildlife area where an agreement with the local forestry authorities entitles farmers to graze cattle up to 3km inside the forest boundary (Guerbois et al., 2013). The risk of livestock depredation by lions is generally higher in these wildlife areas (Valls-Fox et al., 2018). Further, Guerbois et al. (2013) report that the human population density in Mabale has been rising rapidly, with a 60% increase between 2000 and 2010. With this dramatic increase in the human population alongside the conversion of the landscape into crop fields, the number of farmers who are dependent on Sikumi Forest Land for water and grazing is increasing (Perrotton, 2015). There are reports that farmers are now venturing up to 7km into the wildlife area to find high-quality pasture, areas that are frequently used by lions (Valls-Fox et al., 2018). Therefore, the observed increase in livestock depredation rates in Mabale may be attributed to the expansion in the local human population and the cascading implications for livestock management practices that bring livestock and lions into ever-closer contact.

Another possible reason for observing the increased livestock losses in Mabale could be the local implementation of problem animal control measures. Our intervention relied on placing GPS collars on individual lions in a pride, enabling us to determine when the pride was sufficiently close to human settlements to send warning messages to farmers and initiate a chase event (Petracca et al., 2019). However, if lions continued to pose a threat, often after repeated livestock killing events, the communities can request assistance from the local authorities who have the legal power to shoot and kill individual lions classified as “problem animals”. The shooting of lions as a problem animal control measure occurred throughout our

study with a total of 15 lions being shot since the inception of the Long Shields programme (Mabale = 4, Tsholotsho = 6, Victoria Falls = 5) (see **Table 11**). However, in Mabale the majority (75%) of these lions were fitted with GPS collars (i.e., 50% of the total number of collared individuals in the area). This compromised our ability to monitor the movement of livestock raiding lions effectively and implement our early-warning system in that area. We therefore recommend that conservationists must understand and reflect on the possible differences or risks across their research sites when designing interventions and evaluation.

Interestingly, our findings indicate that livestock losses to lions for non-participating farmers in Tsholotsho were reduced. We suggest three possible reasons; (a) it could be that lions were more generally deterred overall from using communal land, which also benefited non-participating villages, or; (b) the exchange of alert messages to approaching lions actioned non-participating farmers to move their grazing livestock or; (c) the efficacy of using night-time kraals was communicated between participating farmers and their non-participating counterparts (Sibanda et al., 2020b). These findings suggest that the impacts of the Long Shields programme may have expanded beyond our initial target area. Similar results were also found in Assam, India, where farmers not part of a community-based human-elephant mitigation programme recorded a reduction in crop losses after they exchanged information on crop protection measures with peers who were programme participants (Zimmermann et al., 2009). Future work to understand communication channels and broader social networks is warranted.

The number of lions killed in retaliation has reduced by 41% since the start of the Long Shields programme in 2013. This includes a reduction in illegally killing lions by using wire snares. We suggest this is because lions found in proximity to villages were deterred by non-lethal methods (Petracca et al., 2019). Further, we suggest farmers perceive the actions of their local

Community Guardians as effective in mitigating depredation risk and therefore are less inclined to 'take matters into their own hands'. Additionally, farmers may have been hesitant to illegally kill lions that they knew were being closely monitored for fear of repercussions or arrest by wildlife authorities. Our results are comparable to Hazzah et al. (2014), where the retaliatory killing of lions by farmers in Amboseli decreased by almost 99% eight-years after the Lion Guardian programme was implemented. Involving local people in lion conservation, as well as recruiting influential young warriors as Lion Guardians, were factors contributing to the decline in lion killings. Indeed involving local communities in decision-making and planning can increase trust and foster a sense of stewardship towards carnivores (Morehouse et al., 2020). Moreover, collaborative approaches can ensure that the aims, actions and outcomes are relevant across stakeholders and aligned with the interest of the community, and that the intervention is locally appropriate and consistent with norms and customs (Chase et al., 2004). Similarly, by involving communities in the Long Shields programme, local farmers were directly involved in selecting their Community Guardians as well as informing the design of the programme. This importance of this approach, and the outcomes, cannot be overlooked or over stated.

We also found that the occurrence of government officials' legally shooting lions as problem animals has remained constant over time, suggesting that authorities have not changed their policy or behaviour. This may be 'ritual palliative', a situation where government officials shoot to appease affected communities (Hoare, 1995). The 'ritual palliative' response is common in human-elephant conflict (Hoare, 2012), and may negatively impact local lion populations. We therefore recommend further research into this aspect of lion management, including examining the barriers and opportunities to policy change, and related capacity-building for behaviour change, amongst wildlife managers (Hughes et al., 2020).

We found only a weak correlation between the number of lion-caused livestock depredation and the number of retaliatory lion killings by farmers. This suggests that farmers may not automatically kill lions that attack their livestock. We suspect this could be attributed to: (a) farmers' awareness that lion killing is illegal and carries a jail sentence if prosecuted; (b) most farmers lack the skills and weapons to kill a lion, and; (c) lion killing in this area is not a strong cultural tradition, at least when compared to East Africa (Loveridge et al., 2010a).

Although the results of our evaluation are informative and encouraging, we acknowledge there are some limitations. The allocation of villages to the Long Shields programme was not random. We focused the programme on villages that had sustained higher livestock depredation in the past than non-treatment sites. Critics suggest that non-random treatment allocation could result in regression-to-the-mean, a statistical phenomenon that makes natural variations in data appear like real change (Barnett et al., 2005). Fortunately, in our study this is less likely to be a problem because high impact villages have been in this category for some time, and did not happen to be experiencing high impact at the time of the study.

4.7: Conclusion

Using livestock depredation and retaliatory lion killing reports from farmers, we examined the effectiveness of a community-based conflict intervention programme, the Long Shields Community Guardians. Our study demonstrated that participating farmers recorded a significant reduction in livestock loss to lions than those not included in the programme. The primary reason for a decrease in livestock depredation was alerting farmers to the presence of lions and, in response, a shift of their livestock grazing to areas of lower risk (Sibanda et al., 2020b). The Long Shields programme did not have a detectable effect on the impact of other carnivores because it was designed specifically for investigating issues caused by lions. As hypothesised, the number of retaliatory lion killings by farmers was reduced by 41% since the

inception of the Long Shields programme, which we attribute to the alerts farmers received of approaching lions and the fact that lions were hazed to chase them back into the park (Petracca et al., 2019). Our overall findings indicate the Long Shields programme, and notably the collaborative and participatory approach to development the programme, is an effective conservation model which can be applied to a larger scale to promote human-lion coexistence. We conclude that through locally-relevant community-based approaches livestock depredation by lions can be effectively reduced, and this conservation model could be considered in other contexts for addressing human-lion or other carnivore conflicts.

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Contributions

Andrew J. Loveridge conceived the experiment. Lovemore Sibanda reviewed literature and analysed the data assisted by Paul Johnson. Lovemore Sibanda wrote the final manuscript and responded to reviewers' comments. Paul Johnson, Esther van der Meer, David W. Macdonald and Andrew J. Loveridge commented on draft chapters. Lovemore Sibanda supervised the Long Shields programme assisted by Liomba J. Mathe, Roger Parry and Bongani Dlodlo. Lovemore Sibanda, Jane E. Hunt, Liomba J. Mathe and Bongani Dlodlo collected the data.

Andrew J. Loveridge secured the funding for this study. Esther van der Meer, David W. Macdonald and Andrew Loveridge supervised the doctoral study.

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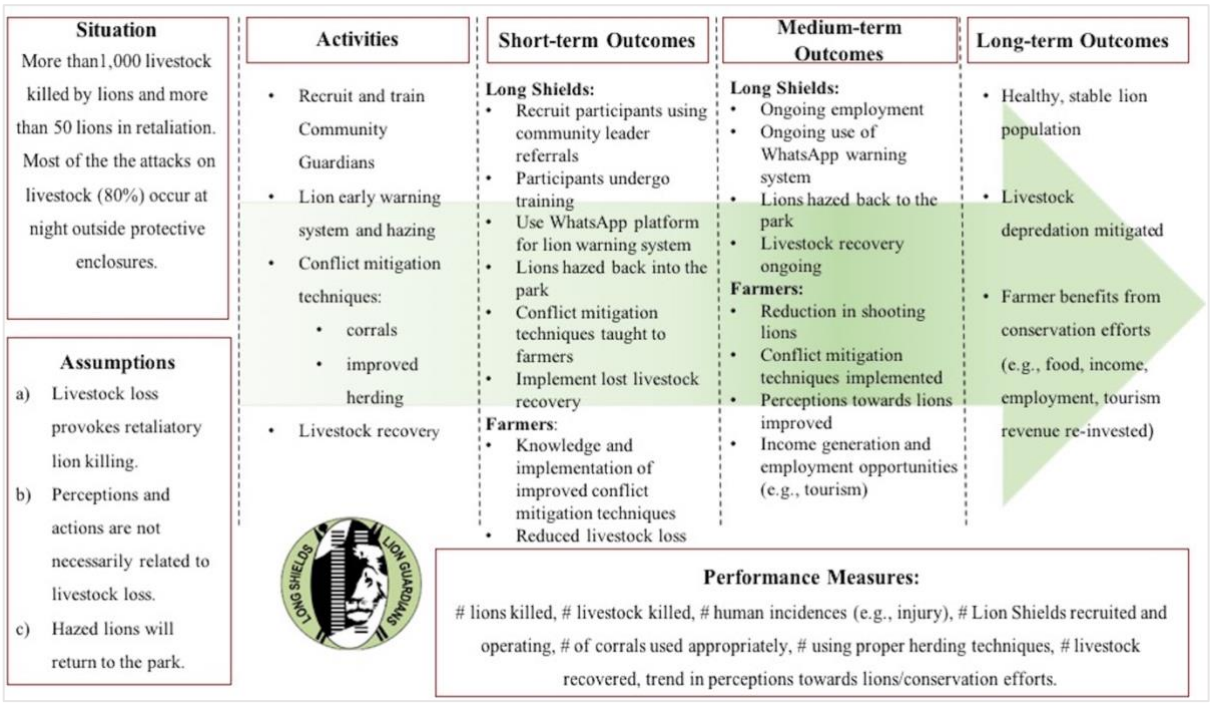
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4.9: Supplementary Material



Supplementary Figure S4*: The community-based programme's Theory of Change*

Supplementary Table S1*: Population size, residential density and ethnic groups of our study sites (Tsholotsho, Mabale and Victoria Falls) in northwestern Zimbabwe*

Parameters	Tsholotsho	Mabale	Victoria Falls
Area (km^2)	2,171	480	655
Density (buildings/ km^2)	1.8	6.2	6.1
Ethnic Groups (%)			
- *Ndebele*	99	48	57
- *Tonga*	0	20	14
- *Nambya*	1	32	29
Depredation costs/ farmstead*	US$8.93	US$4.34	US$7.79

** adapted from Loveridge et al. (2017); PA = Protected Area*

Supplementary Table S2*: Summary of model averaged coefficients calculated using 'lme4' package*

	Estimate	Std. Error	*z* value	Pr(>|z|)
(Intercept)	.96	.22	4.30	.01**
Tsholotsho	-.32	.26	-1.25	.21
Vic falls	-.18	.29	-.63	.53
Time (Before = reference)				
After	.33	.09	3.85	.01**
Treatment status (Non-treatment = reference)				
Treatment	1.73	.23	7.52	.01**
Interaction term				
After: Treatment	-.51	.10	-5.04	.01**

Chapter Five: Better late than never: a case study using diffusion of innovation theory to understand adoption of a human-lion conflict intervention

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"What is it that they are doing wrong?"

** This chapter was accepted for publication in the Carnivore Damage Prevention News*

5.1: Chapter summary

In 2013, we launched a community-based human-lion conflict intervention in western Zimbabwe to mitigate livestock depredation by lions (*Panthera leo*) and the killing of lions by local farmers in retaliation for livestock depredation. The objective of this programme was to promote human-lion coexistence by encouraging farmers to adopt livestock husbandry practices that reduce the risk of livestock depredation by lions. By 2017, incidents of livestock attacks by lions, for the majority of farmers that participated in this programme, had dropped by almost half. However, a minority of farmers in the programme area continued to suffer higher livestock losses to lions than did others. These were the farmers whose livestock losses remained high despite the gains generally experienced by participants in the Long Shields programme, which prompted us to investigate. Guided by the Diffusion of Innovation (DoI) theory, we conducted face-to-face semi-structured interviews with a selected sample of farmers in our study area to explore possible barriers that might explain this apparent late adoption and in turn, continuing livestock losses to lions. We found that late adoption was a predictor of continued elevated livestock loss. Continuance of higher livestock losses to lions, despite all efforts from the programme personnel, seemed to be influenced by various barriers such as: (a) poor communication; (b) negative attitudes toward the programme, and; (c) lack of trust in the programme itself, as well as, in some cases, programme personnel. Acting together, these barriers negatively influenced participation and adoption of the Long Shields programme by this minority, potentially resulting in continuing livestock losses to lions. Results from our study provide insight into factors that can limit or advance human-carnivore coexistence programmes, and we offer a framework to evaluate such conservation programmes.

Keywords: African lion, diffusion of innovation, human-lion coexistence, livestock husbandry, late adoption, livestock depredation, Long Shields programme, Zimbabwe, subsistence farmers

5.2: Introduction

Wildlife impacts on humans are complex conservation problem, that if not tackled adequately might turn into social conflicts (Redpath et al., 2013). Mitigating such impacts requires targeted interventions that engage the people expected to live with large carnivores (Vucetich et al., 2018). Conservationists around the world have invested much time and resources in designing interventions to mitigate negative impacts from wildlife as well as to provide positive benefits from conservation efforts (van Eeden et al., 2018). These interventions range from low-cost methods such as livestock herding (Ogada et al., 2003) and education programmes (Marchini & Macdonald, 2019), to more sophisticated techniques such as flashlights around corrals to deter predators at night (Lesilau et al., 2018) and in-depth farmer training programmes (Vaughn et al., 2016). However, many of these technical tools have not been evaluated scientifically (van Eeden et al., 2018).

One widely-known species, prone to conflict with humans, is the African lion (*Panthera leo*) (IUCN, 2016). Lions are threatened throughout their range, with a population reduction of almost 40% over the last three decades (Bauer et al., 2016). Conflict with farmers over livestock depredation is a major threat to lion populations, especially those alongside the protected area interface (Riggio et al., 2012). This is true for lions in Zimbabwe's Hwange-Matetsi Protected Area Complex (HMPAC), part of the Kavango-Zambezi Transfrontier Conservation Area (KAZA TFCA), which hosts one of six remaining populations numbering over 1,000 individuals (IUCN, 2016). In the HMPAC, the impacts of humans on lions (and vice versa) are well studied, with most lion attacks on livestock occurring at night when livestock are left to freely graze instead of being secured overnight in protective enclosures (Kuiper et al., 2015). Attitudes toward lions in this area are strongly negative, and are influenced by the geographic location in which the farmer lives as well as the farmer's ethnic

group (Sibanda et al., 2020a). Between 2008 and 2016, lions killed more than 1,000 domestic animals, with farmers killing approximately 50 lions in response to attacks on livestock (Loveridge et al., 2017). This conflict presented an opportunity to develop and implement locally relevant conservation interventions to help prevent further negative livelihood impacts, safeguard the local lion population in the future, as well as raise awareness and build knowledge and skills amongst farmers (Sibanda et al., 2020a).

In 2012, we developed the Long Shields Community Guardian programme (hereafter: "*Long Shields"*) in the HMPAC, a non-lethal, community-based, human-lion conflict intervention in northwestern Zimbabwe (Sibanda et al., 2020b). This programme was inspired by the Lion Guardians model in Amboseli, Kenya (Hazzah et al., 2014), and was designed to advance the well-being of both local people and lions. We used a Theory of Change (ToC), a methodology that follows a logical and chronologically ordered sequence of causal linkages, to conceptualise and plan the inputs, activities, and outcomes of the Long Shields programme (Margoluis et al., 2009; Woodhouse et al., 2015). These included: (a) implementing educational outreach amongst local farmers to encourage and train for optimised adoption of conflict mitigation techniques; (b) providing employment opportunities to local farmers (as Long Shields community guardians); (c) safeguarding local food and income opportunities (e.g., livestock); (d) cultivating pride in sharing the landscape with lions; and, (e) safeguarding lion populations for the future (Sibanda et al., 2020b).

In 2017, we used this ToC model to evaluate the effectiveness of the Long Shields programme, specifically farmers' perspectives of the programme and their adoption of conflict mitigation techniques. Our results revealed that, in the five years since the introduction of the programme, incidents of livestock attacks by lions had dropped by almost half (Sibanda et al, in review). However, our results also indicated that a minority of farmers in villages that were part of the

Long Shields programme continued to suffer higher livestock losses to lions than others participating in the same intervention programme. This, as part of a broader case-study, prompted an investigation of the reasons for continued livestock loss.

One plausible reason for ongoing losses might be late adoption by farmers of the conflict mitigation approaches introduced by the Long Shields programme. We chose to investigate our research question using the Diffusion of Innovation (DoI) theory (Rogers, 2004), which categorises people into different cohorts of innovation adopters (Hubbard & Sandmann, 2007) to understand better how an innovation spreads through a social system. We did this by exploring the characteristics of two farmer groups: (a) those who had persistent or higher livestock losses even after the implementation of the Long Shields programme; and, (b) those that did not, and looked at characteristics that might explain these differences in terms of early- or late-adoption of the Long Shields intervention. We hypothesised that persistent or higher livestock losses, and related to this, economic loss and increased risk to personal safety might be predicted by late adoption by farmers of the Long Shields interventions. Farmers who had persistent or higher livestock losses after the implementation of the Long Shields programme; and those that did not, would therefore differ in their: (a) frequency of communication with their Community Guardians; (b) levels of participation in specific programme activities such as lion tracking and chasing; (c) active involvement in the early-warning system WhatsApp group; (d) confidence in the programme's effectiveness, and; (e) trust in their Community Guardians. Our results provide insight into the utility of a ToC for programme design and evaluation, as well as the factors that can limit or advance human-carnivore coexistence interventions through the use of DoI theory.

5.3: Methods

Theoretical Framework

The DoI is a behavioural theory that systematically seeks to explain why and how new ideas or practices (i.e., innovations) are adopted (or not) by different members of a social system (Rogers, 2004). This theory has been used in health-care (Scott et al., 2008) and agriculture (Rogers, 2004), and increasingly in conservation efforts (Mbaru & Barnes, 2017) to provide valuable insight into the barriers and motivations to adopt or reject new ideas or practices (Hubbard & Sandmann, 2007). A hallmark of the theory is 'diffusion', referring to the rate at which an innovation spreads through a social group over time, and 'innovation', which refers to the novel idea or practice that is to be adopted. As suggested by Hubbard and Sandmann (2007), 'the diffusion framework is a fairly involved framework that includes several "sub-theories" or concepts [which] provide insight into human and social nature, including how new information is accepted (or not accepted) by potential users'.

According to DoI, several factors can help or hinder how and why people adopt innovations, including: (a) innovation characteristics; (b) socio-ecological contexts; and, (c) adopter characteristics (Rogers, 2004; Mohammadi et al., 2018). Innovation characteristics refer to the relative advantage or the superiority of the introduced intervention relative to other interventions as perceived by the adopters. The theory postulates that clear, coherent and relatable innovations, which align with an individual or groups' values, experiences and needs, are more likely to be adopted (Rogers, 2004).

Socio-ecological characteristics refer to factors such as cultural context, government policies, land settlement and use patterns, or, in our study, conflict with wildlife species, all of which can affect the adoption of an innovation (Rogers, 2004; Mascia & Mills, 2018). Additionally, social relationships and networks among people can affect the adoption of innovation, including how and what information about the innovation is communicated, level of trust in the source, and the channels through which information is shared (Mbaru & Barnes, 2017).

Adopter characteristics refer to the personal traits of adopters, such as demographics, risk orientation (whether or not the adopters feels they are at high risk), perceptions of and confidence in the innovation, familiarity with and the level of connectedness amongst other adopters, all of which can influence the rate of adoption (Rogers, 2004; Mohammadi et al., 2018). Adopters can be characterised as innovators, early-adopters, early-majority adopters, late-majority adopters and laggards, represented by an S-shaped or bell curve indicating the cumulative number of adopters across categories and resulting normal distribution (Rogers, 2004).

Study area

The Long Shields programme was introduced in three separate rural communities situated in communal lands in northwestern Zimbabwe: (a) Tsholotsho (Matupula and Siphoso Chieftainships: 2,171 km^2); (b) Mabale (Dingani Chieftainship: 480 km^2); and, (c) Victoria Falls (Mvuthu and Shana Chieftainships: 655 km^2) (**Figure 14**). Tsholotsho and Mabale communities are situated adjacent to the Hwange National Park (HNP), while Victoria Falls community is located adjacent to the Zambezi National Park (ZNP). Both HNP and ZNP are part of the HMPAC (Sibanda et al., 2020a). While the programme was implemented in these three communities, for our retrospective study we only selected Tsholotsho, as this community had less interaction with other research organisations which may have affected their attitudes or behaviours towards lions outside of our Long Shields programme.

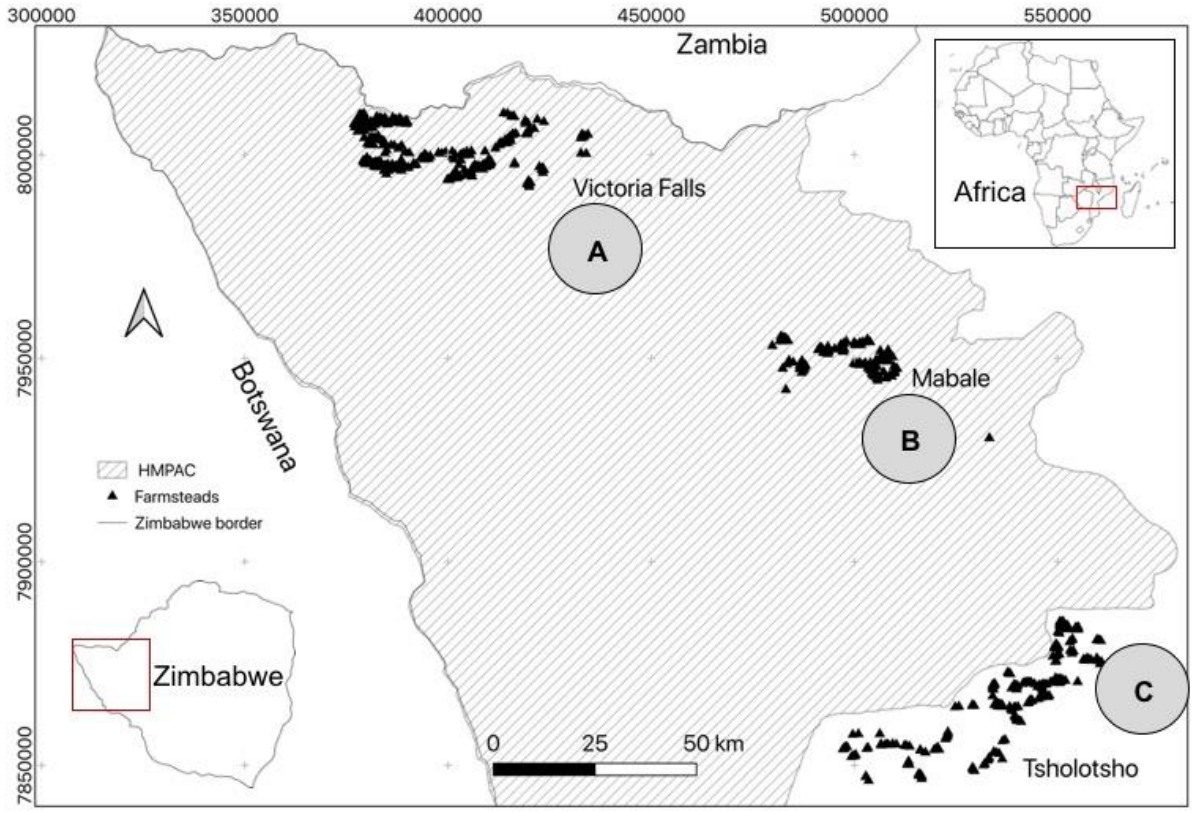


***Figure 14**: A map of our study area in northwestern Zimbabwe*

Ecologically, the area is semi-arid (annual rainfall: 550-600 mm) (Guerbois et al., 2013), with three distinct seasons, a cold-dry season (May-August), a hot-dry season (September-November), and a wet season (December-April) (Loveridge et al., 2017). Livestock rearing and crop farming are the primary sources of livelihood, with cattle (*Bos taurus*), donkey (*Equus asinus*), sheep (*Ovis aries*) and goats (*Capra hircus*) as the primary livestock, and maize (*Zea mays*), millet (*Pennisetum glaucum*) and sorghum (*Sorghum bicolor*) as the main crops (Sibanda et al., 2020a). Livestock depredation of high-value livestock, such as cattle and donkeys, commonly occurs by lions and spotted hyaenas, with leopards (*Panthera pardus*), African wild dogs (*Lycaon pictus*), cheetahs (*Acinonyx jubatus)* and black-backed jackals (*Canis mesomelas*) occasionally preying on smaller, lower-value stock such as sheep and goats (Loveridge et al., 2017). Conflict with wild carnivores is seasonal and peaks during the wet months when farmers herd their livestock in areas closer to the national park, further away

from the human communities, exposing livestock to high depredation risk (Kuiper et al., 2015). Farmers do not receive any financial compensation from the Government for any losses to wild animals (Sibanda et al., 2020a).

Description of the Long Shields programme

In consultation with local traditional leaders, the ToC guided the development of a logic model illustrating the Long Shields programme and its intended outcomes (Sibanda et al., 2020b)). We recruited 14 local farmers (women = 2, men = 12; mean age: 21 - 65 years old) to be trained as Long Shields Community Guardian (hereafter: *Community Guardians*) based on recommendations from community leaders and using the following criteria: geographic location, physical fitness, English literacy, respectability and trust amongst their community, and previous direct experience with lions (e.g., physically chased a lion). Community Guardians were then trained by the Trans-Kalahari Predator Programme (WildCRU, University of Oxford) in lion tracking, the use of radio-telemetry and GPS equipment, data collection protocols (e.g., livestock depredation assessment), and conflict mitigation techniques (e.g., herding, enclosure fortification). Additionally, Community Guardians were trained to use the lion early-warning system through the WhatsApp (WhatsApp.Inc, 2009) smartphone platform. As part of this system, we identified and collared 23 lions (Female = 6, Male = 17) selected because their home ranges significantly overlapped with the local farming communities outside the protected areas. These lion satellite collars took one location every two hours. Whenever lions were within three kilometres of the park boundary, a warning message was sent via the Community Guardians to a network of farmers within the treatment villages. Lions that crossed the park boundary and approached human settlements were hazed by the Community Guardians plus volunteers from the treatment villages with the use of a

'*vuvuzela',* a plastic horn that produces an irritating sound of about 127 decibels (dBA) (Petracca et al., 2019).

Data collection

Sampling

The list of participants to be interviewed for this study were sampled based on their reported livestock losses to lions after the implementation of the Long Shields programme. We used a conflict register held by the WildCRU's Trans-Kalahari Predator Programme (WildCRU, University of Oxford) to select a total of 50 farmers living in villages in the Tsholotsho communal area whom participated in the Long Shields programme. Specifically, we selected for individuals (n = 25) who reported persistent or larger livestock losses post-intervention implementation (i.e., mean loss after ≥ mean loss before) as well as individuals (n = 25) who reported a decrease in livestock losses post intervention (i.e., mean loss after < mean loss before). The calculated mean livestock loss prior to implementation was 3.07 ± SD= 1.58 per household (Sibanda et al, submitted).

Survey instrument

We began our study in February 2019, using in-depth face-to-face interviews consisting of closed and open-ended questions (**Appendix III**). Semi-structured interviews were preferred over structured techniques because they are flexible and allowed the conversation to flow freely (Schensul et al., 1999). We attempted to interview males and females (self-reported head of households) as equally as possible. Recognising the importance of ethics in conservation (Brittain et al., 2020), we fully explained the purpose of the study before commencing each interview, with all respondents giving verbal free and informed consent to voluntarily participate. All farmers were told they were allowed to stop the interview at any time if they did not feel like continuing. To help minimise response bias (e.g., social desirability), we did

not provide monetary compensation to participate. Each interview lasted *ca.* 45 minutes and was conducted in *isi*Ndebele, and the responses were recorded in English. We also recorded the interviews using a mobile smartphone to facilitate effective translation.

Factors that influenced the continuance of higher livestock losses to lions

Factors that influenced the continuance of higher livestock losses to lions were investigated by asking a series of questions that explored farmer's knowledge about and adoption of the Long Shields programme. This included questions about: (a) their awareness of the programme; (b) their knowledge of the programme; (c) how often they communicate with their Community Guardians; (d) the frequency of communication, (e) their participation in specific programme activities; (f) their confidence in the programme's effectiveness, and; (h) the relative importance of the programme to farmers and lions. A full list of factors tested and questions asked are listed in **Table 11**.

Evaluating factors that influenced the continuance of higher livestock losses to lions

Factors that influenced a farmer's losses to lions were analysed using ordinal regression models in R-statistical software (R Core Team, 2019). We fitted the models using the '*clm*' function in the 'ordinal' package (Christensen, 2015). The response variable was the farmer's losses to lions, i.e. (a) those who had persistent or larger livestock losses and (b) those that did not. 'Village ID' was included as a random variable to control for possible clustering of similar responses. Our final model evaluated the explanatory power of the following eight explanatory variables: communication frequency; early-warning system participation; responsiveness to warnings; confidence in the intervention; self-reported behaviour change; perceived risk; and trust (full explanations listed in Table 11). We tested for multiple collinearity between explanatory variables using the function '*lm'*. We used the package '*MuMIn*' (Bartoń, 2019) for model averaging and ranking of the candidate models using the Akaike Information

Criterion (AIC) value (Burnham & Anderson, 2002). Possible non-linear effects in the ordinal predictors were explored graphically using the package '*sure'* (Liu & Zhang, 2018). To support our analysis, we also include key quotes from the interviews to highlight farmer perspectives in their own voice.

Table 13*: A list of factors thought to be influencing the adoption of the Long Shields programme resulting in the continuance of higher livestock losses to lions*

Factor	**Question asked**	**Response code**
Knowledge	• Have you ever heard of the Long Shields programme? (Yes/No)	Categorical
	• What is the role of the Long Shields programme to you?	Descriptive
Communication	• How often do you communicate with your community guardian? (response: *rarely, daily, weekly, monthly, never*)	Categorical
	• What communication channel do you use to communicate with your Community Guardian? (*mobile phones, none, community guardians come in-person, both, neighbours*)	Categorical
	• Are you or someone in your house part of the Long Shields WhatsApp group and why? (Yes/No)	Categorical
	• If yes, do you respond to messages from the Community Guardians and if so how?	Descriptive
Participation	• Have you participated in the Long Shields programme activities? If yes, which activities?	Categorical
Early-warning system	• Are you or anyone in your household part or the Long Shields WhatsApp group and why? (Yes/No)	Categorical
Confidence	• Do you feel the Long Shields programme could help you reduce livestock losses and why (Yes/ No)?	Categorical
Perception	• How important is the Long Shields programme to you? (*very unimportant, unimportant, neither, important, very important*)	Likert
Risk orientation	• Do you feel your livestock are vulnerable to lions when there are out grazing? (*very invulnerable, invulnerable, neither, vulnerable, very vulnerable*)	Likert
Trust	• How much do you agree with this statement and give a reason: I don't trust the Community Guardians (*strongly disagree, disagree, neither, agree, and strongly agree*)?	Likert

5.4: Results

We interviewed a total of 50 farmers (response rate = 100%), 54% of whom were men and 46% were women, with equal representation between those that continued to experience similar or larger livestock losses to lions post-intervention and those that experienced a decrease in livestock losses. Eight interviews were excluded in the final analysis because they lacked clear answers to our primary questions, leaving us with a total of 42 responses for final analyses (52% men, 48% women).

***Table 14**: Model estimates of factors that influence a farmer's losses to lions*

Factor	**DF**	**AIC**	χ^2	**Pr(>Chi)**
Communication freq.	4	46.45	16.63	.00*
Early-warning system	1	46.64	10.82	.00*
Responsiveness to warnings	1	55.92	20.10	.00*
Participation in activities	1	39.04	3.22	.07
Confidence	1	44.90	9.08	.00*
Behaviour change	1	39.25	3.43	.06
Relative Risk	3	32.50	.68	.88
Trust	4	42.81	12.99	.01*

Factors that influenced the continuance of higher livestock losses to lions

The following variables were associated with persistent or higher livestock losses to lions: (a) the frequency of communication with Community Guardians (χ^2 = 16.63; df = 4; $P < 0.001$); (b) whether or not the farmer received warning messages of approaching lions via the Long Shields early-warning WhatsApp group (χ^2 = 10.82; df = 1; $P < 0.001$); (c) farmer responsiveness to warnings (χ^2 = 20.10; df = 1; $P < 0.001$); (d) whether or not a farmer had confidence in the Long Shields programme (χ^2 = 9.08; df = 1; $P < 0.001$), and; (e) whether or

not a farmer had trust in their Community Guardian (χ^2 = 12.99; *df* = 4; *P* = 0.01) (**Table 12**). We further describe these factors below, to highlight the differences between farmers who continued to report persistent or larger livestock losses post-intervention compared to those that experienced a decrease in livestock losses.

Characteristics of farmers who experienced a decrease in livestock loss to lions after the initiation of the programme

Farmers who experienced a decrease in livestock loss to lions after the implementation of the Long Shields programme lost an average of 1.27± *SD* = 0.67 animals per year which is lower than what they lost prior to programme implementation of 3.07 ± *SD* = 1.58. These farmers had characteristics of early-adopters, i.e., they were aware of the Long Shields programme and programme activities, and 73% indicated that they frequently communicated with their Community Guardians, at least once a week. For example, one male farmer said: *"These people [Community Guardians] assist us villagers protect our livestock against lions. [Community] Guardians send us messages via WhatsApp daily to remind us to herd our cows, and sometimes come in-person to warn us when the lions move outside of the park towards our villages".*

Sixty-two per cent of these farmers mentioned they actively use and heed the Long Shields programme's early-warning WhatsApp group, while the remaining 38% said they were not formally part of the group but relied on their neighbours who were formally engaged in the Long Shields WhatsApp early-alert system for their daily warnings. For example, one farmer mentioned that: *"I do not have a smartphone compatible with WhatsApp myself [nor anyone in this household], but we always hear of these warnings from our neighbour, who happens to be a relative, and is part of the lion guardian WhatsApp group".*

Another farmer (female) mentioned that though she was not part of the WhatsApp group, their son, working elsewhere, was part of the WhatsApp group and made sure his mother received

all critical messages concerning lions: "*The only person who is part of the group is my son in South Africa, and if there is any important warning he always rings me to make sure I got the warning*".

When asked whether or not they participate in the Long Shields programme activities, the majority of farmers (70%) in this group indicated they actively participated in tracking and chasing lions. For example, one male farmer mentioned: "*When we hear of lions, we quickly gather our livestock and bring them close to home, and we go on to assist Guardians to chase the lions back into the park*".

When asked if they thought the Long Shields programme was essential to them or not, 100% of these farmers felt the Long Shields programme was important and was confident the programme assists them to deal with problem lions. One male farmer mentioned: *"These people [Community Guardians] are critical; we used to herd our livestock in fear, not knowing if the lions were outside the park or not. Today, we have [Community] Guardians who give us a regular update of lions and alert us when lions with collars are close to the fence, and we move our livestock to safety. [Community] Guardians are doing a good job, especially with the collared lions, and it is now the non-collared lions that cause us problem".*

When asked about trusting their Community Guardians, 70% of the farmers who experienced a decrease in livestock losses to lions indicated they trust the competence of their Community Guardians. One female farmer mentioned: "*Community Guardians have helped us protect our livestock from lions since they started, incidents with lions have gone down. Had it not been for these people [Community Guardians], we could be counting our losses"*.

Characteristics of farmers who experienced persistent or larger livestock loss to lions after the initiation of the programme

Farmers who reported persistent or higher livestock losses post-intervention implementation lost an average of 3.56 ± *SD* = 2.01 animals per year which is higher, to what they lost prior to programme implementation (3.07 ± *SD* = 1.58). Further, farmers in this group had characteristics of late-adopters, i.e., although they were aware of the Long Shields programme, the majority (83%) did not clearly understand the roles and aims of the programme. Notably, one female farmer mentioned: "*We know they are called Guardians, but I am not entirely sure what they do".* As a result, these farmers did not participate in the programme. For example, one farmer said: "*I do not participate in their activities because I do not know what they do, and they have never invited me".*

When asked, 50% of farmers who experienced persistent or higher losses of livestock to lions indicated they do not communicate with their Community Guardians and cited the challenges of acquiring a mobile smartphone as the main reason. The remaining 50% mentioned they sometimes (less than once a month) communicated with their Community Guardians, but specified they did not have a mobile phone compatible with the WhatsApp SMS platform. Unsurprisingly, none of the farmers in this group participated in the Long Shields programme's early-alert WhatsApp group. However, when asked whether they participated in other Long Shields programme activities, such as tracking and chasing lions, 26% mentioned they did. That said, 67% of these farmers indicated they did not think the Long Shields programme was essential to them, and did not think the programme would help them deal with problem lions. For example, one male farmer mentioned: "*The programme is important to me because I am still losing to lions like before…nothing has changed. I don't perceive any change in the future unless the government fences the national park".* When asked about the level of trust they had in their Community Guardians (e.g., competence), 87% of the farmers indicated they did not trust them, with one male farmer mentioning they lost all trust and respect for their Community Guardian after he got divorced. Asked to explain further, the respondent, said: *"The woman*

that was married to the guardian is my relative and the bad divorce changed the way I view, including all the respect I had for this Community Guardian".

5.5: Discussion

For human-wildlife conflict interventions to be effective, they first need to be adopted (Eklund et al., 2017). Factors that limit or advance participation and adoption of human-wildlife conflict intervention programmes have received very little attention (Graham & Ochieng, 2008) yet, they enable researchers to learn from their mistakes and prevent them from continually testing 'square wheels', i.e., ineffective methods (Gunaryadi et al., 2017). As part of a broader case-study, we explored the possible reasons why a minority of farmers engaged with the Long Shields programme continued to suffer persistent or higher livestock losses to lions. We hypothesised that late adoption by farmers was a predictor of continued livestock depredation and we chose to investigate this question using the Diffusion of Innovation theory (Rogers, 2004), which categorises people into different cohorts of innovation adopters.

Our results from this exploratory study indicate that those farmers who experienced a decrease in livestock loss to lions after the implementation of the Long Shields programme had characteristics of early-adopters. For example, they were familiar with the programme including the roles of this programme. They expressed confidence in the programme and were eager to use this intervention programme. Further, they were actively involved in the programme's activities such as tracking and chasing lions. In contrast, those farmers who had persistent or larger livestock losses even after programme implementation had characteristics of late-adopters. They were less familiar with the roles of the programme, less confident about the programme and less eager to use the intervention programme.

The underlying reasons for early or late adoption of our intervention programme are not apparent but others have found that factors such as age, social status, level of education, cultural

norms and local politics influence an individual's rate of adoption (Rogers, 2004). For example, others have shown that older people are less inclined to engage with the latest technology because of anxiety and the fear of making mistakes and therefore may not own or be able to use the latest technology (such as a smartphone) (Berkowsky et al., 2018; Knowles & Hanson, 2018). While Kotzé et al. (2016) found that women were more technophobic than men. Additionally, Morawczynski and Pickens (2009) found that poorer people are more likely to be late adopters because they may not own the necessary technology. In Laikipia, Graham and Ochieng (2008) found that the reason for late adoption of farm-based treatment to deter crop-raiding elephants (*Loxodonta africana*) was because farmers feared that participation in the intervention would compromise their ability to receive government support. However, this is less likely to be a problem in our area given that the local farmers do not receive any compensation for any losses incurred from wildlife. Further, it also seems unlikely that benefits from the CAMPFIRE programme contribute to late adoption as they do not seem to reach the community and are not received at an individual level; therefore are unlikely to offset the individual costs of livestock depredation. We recommend further research on this subject to explore in-depth the underlying socio-cultural, political and economic factors that influence late adoption of human-wildlife conflict intervention programmes.

Our findings suggest that persistent or higher livestock losses to lions was influenced by various barriers grouped together into three main categories: (a) poor communication; (b) negative attitudes toward the innovation, and; (c) lack of trust in the programme itself, as well as in programme personnel. Acting together, these barriers negatively influenced participation and adoption of the Long Shields programme by this minority, resulting in persistent or higher livestock losses to lions.

Poor communication

The Long Shields programme was designed in conjunction with local communities and one key role of this community-based programme is to directly involve farmers in mitigating the human-lion conflict situation in the area through regular communication using the WhatsApp SMS platform, which serves to: (a) educate, (b) encourage farmers to herd their livestock as well as to, (c) alert farmers of approaching lions (Sibanda et al., 2020b). Between 2013 and 2017, more than 2,000 WhatsApp messages were sent to farmers warning them of approaching lions (Sibanda et al., 2020b). Further, Sibanda et al. (2020b) show that participating farmers mentioned that this was the most critical role of the programme because it enabled them to move their livestock to areas of lower depredation risk. Using the WhatsApp SMS platform for communicating with villagers has several advantages, for example, WhatsApp is open-source cheap software and allows a single message to be broadcast to several users within a short space of time (WhatsApp.Inc, 2009).

However, our results indicate that the WhatsApp platform was not sufficient to communicate with the farmers with late-adopter characteristics. We found that 50% of farmers with late adopter characteristics did not own mobile phones while the remaining 50% owned phones, but their phones were not compatible with WhatsApp. Consequently, compared to those farmers with early-adopter characteristics, we found that the majority (83%) of farmers with late-adopter characteristics did not fully understand the role of the Long Shields programme. Other studies have established a similar link between communication and appreciation of an innovation (Graham et al., 2011; Mohammadi et al., 2018). Moreover, adoption is often linked to the simplicity of the innovation, and the ease at which people can participate in or enact the innovation (Mascia & Mills, 2018). Additionally, more of those farmers with early-adopter characteristics than those with late-adopter characteristics were part of the Long Shields early-warning WhatsApp group, and received warning of approaching lions either directly from the Community Guardians (62%) or their peers (38%). In contrast, 100% of those farmers with

late-adopter characteristics and their immediate neighbours were not part of the Long Shields early-warning WhatsApp group. Farmers with late-adopter characteristics mentioned they were not part of the WhatsApp group because they did not own, or could not afford, a smartphone-compatible with WhatsApp, and thus they relied on face-to-face communication with Community Guardians to warn them. Indeed, innovations can be spread through a diversity of pathways, whether passive or active, highlighting the importance of social networks (Barnes et al., 2016; de Lange et al., 2019). This suggests that there is a need to improve methods of communication and to design a channel of communication that can reach all relevant farmers, including, for example, those that do not have WhatsApp compatible smartphones. to ensure that the programme's message and purpose is clear (Madden, 2004).

The poor communication, and associated poor understanding of the intervention programme, explains why the majority of those farmers with late-adopter characteristics did not participate in the Long Shields programme activities, such as tracking and chasing lions. Certainly, the DoI theory suggests that knowledge and understanding influence participation and ultimately, the decision to either adopt the innovation or not (Rogers, 2004; Mohammadi et al., 2018). For example, in Uganda, Webber et al. (2007) found that lack of knowledge and understanding was one reason why a primate live-trap programme was less often adopted by farmers. Therefore, we suggest that communicating via various channels, including 'old fashioned channels' (e.g. community meetings, face-to-face, sending SMS, a 'phone tree' i.e., where those who are part of the WhatsApp group inform their immediate neighbours) is likely to solve the problem. Moving forward, those identified as having characteristics of late-adopters could be engaged by the Long Shields programme through other means, such as social marketing tools to educate farmers on the roles of the Long Shields programme as well as the benefit associated participation.

Negative attitudes

Perceptions refer to how an individual observes, interprets and evaluates an experience, object, action or other social entity (Pickens, 2005). Indeed, attitudes can influence how an individual assesses the value of a conservation action and, ultimately, the decision to either adopt the innovation or not (Bennett, 2016b). In this study, we found that compared to those farmers with early-adopter characteristics, farmers with late-adopter characteristics held negative attitudes of, and were less confident in, the Long Shields programme. Elsewhere, lack of confidence in the intervention was the reason why methods of mitigating human-elephant conflict using chilli as a deterrent in Indonesia and Laikipia (Kenya) were less adopted by local farmers (Graham & Ochieng, 2008; Gunaryadi et al., 2017). We suggest this was because these farmers did not fully understand, or misunderstood, the objectives of the Long Shields programme and that at root this illustrates the hazard of failed communication. We, therefore, recommend demonstrating the effectiveness of the interventions to farmers before implementation to increase confidence as this has been shown to improve intervention uptake in other areas (Webber et al., 2007; Gunaryadi et al., 2017). Though others argue that this might not always be the case (Sitati & Walpole, 2006).

Lack of trust

Trust in humans results from the judgment that one individual is trustworthy, and that, the individual will perform in a certain way in risky situations (Mayer et al., 1995). This judgement is based on the perception as well as the integrity of the individual (Tams et al., 2018). In this study, we found that those farmers with late-adopter characteristics tended not to trust their Community Guardians. One example illustrates the intricacy of the interpersonal relationships involved: the social ramifications of the divorce of one Community Guardian jeopardised the programme's impact in parts of the community. This finding parallels examples in marketing

where sales have fallen when the behaviour of a brand ambassador incurs disapproval (Ogunsiji, 2012). This episode highlights the importance of trust, and societal mores, in the outcome of community-based interventions, and therefore the necessity of sensitive mindfulness of inter-personal relationships in the design and delivery of such programmes (Madden, 2004; Hughes et al., 2020).

Though small sample sizes are not uncommon in non-random purposive sampling (Rust, 2016; Morehouse et al., 2020), we acknowledge that our sample size was small and our findings will therefore need to be confirmed in subsequent studies. Nonetheless, our findings provide a framework within which to evaluate conservation programmes mindful of the perspective of the people expected to adopt them.

5.6: Conclusion

We used a Diffusion of Innovation theory to explore reasons why a minority of farmers engaged with the Long Shields programme continued to suffer similar or higher livestock losses to lions than did others in the same treatment group. We found that: (a) poor communication; (b) negative attitudes toward the innovation, and; (c) lack of trust in the programme itself as well as programme personnel were important barriers that negatively influenced participation and adoption of the Long Shields programme by a minority of community members. With the cattle of the farmers who adopted the intervention not being available for depredation it seems the remaining cattle of late adopters to be more vulnerable to lion depredation and we suggest this resulted in persistent or higher livestock losses to lions. Results of our work provide insight into barriers, several of them, intangible (e.g. trust and confidence) that can limit or advance human-carnivore coexistence programmes. Our study highlights that the DoI theory provides a way to explore how people adopt (or reject)

conservation interventions, and in turn, can help identify paths forward for enduring actions (Mascia & Mills, 2018).

Ethics Statement:

The study was approved by the Social Science and Humanities Interdivisional Research Ethics Committee of the University of Oxford ref. R52851/RE001, Research Council of Zimbabwe ref. 02786 and the Zimbabwean Ministry of Rural Development ref. P/13/3. We declare no conflict of interest.

Contributions

Lovemore Sibanda conceived the experiment assisted by Esther van der Meer. Lovemore Sibanda reviewed the literature, analysed the data and wrote the final manuscript. Esther van der Meer, Courtney Hughes, David W. Macdonald and Andrew J. Loveridge commented on the draft manuscript. Esther van der Meer, David W. Macdonald and Andrew J. Loveridge supervised the doctoral study.

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Chapter Six: General Discussion and Conservation Implications



Cecil's pride, Ngweshla, Hwange National Park

6.1: Background

Using an experimental design, I evaluated the effectiveness of a community-based, non-lethal human-lion conflict intervention programme that we implemented in Zimbabwe's Hwange-Matetsi Protected Area Complex. The goal of this intervention programme was to protect both lions and livestock (a primary source of livelihood for many families in the area) while the goal of this research study is to critically evaluate the effectiveness of this conservation intervention programme. As part of the Long Shields programme, several pro-active measures were implemented, most of which were traditional conflict mitigation tools rebranded and reintroduced as if there were new: "*the old wine in new bottles*". A ToC framework was developed in collaboration with local communities' to define outcomes of interest (i.e., reduction in stock losses and lion killing) and illustrate how the Long Shields programme will bring about the desired change. Drawing insights from the Elaborate Likelihood Model of Persuasion (Petty & Cacioppo, 1986) and the Theory of Reasoned Action (Fishbein & Ajzen, 1975), when developing the ToC, I hypothesised that: (a) a decrease in livestock losses to lions would be observed after implementing this programme; (b) the decline in losses would then motivate a positive shift in attitudes towards lions; and, (c) subsequently lead to a reduction in lion retaliatory killing by farmers. This study therefore, test the above assumptions as part of impact evaluation. Below, I review the key findings including the advantages and disadvantages of the Long Shields model of conflict intervention. I also contextualise the implications of our findings to species conservation including recommendations and suggestions for future research priorities. Although I focus on lions here, my experimental design can be used to evaluate other human-carnivore conflict interventions in other areas.

6.2: Impact of the community programme on attitudes

Before the Long Shields programme was implemented, farmers' attitudes towards lions were strongly negative and seemed to be influenced by the perceived threat that lions pose to humans and their livestock, including the farmer's ethnic group and the geographic location where the farmer lived (Chapter 2). However, since the introduction of the Long Shields programme in 2013, I detected a positive shift in attitudes towards lions for those farmers that were part of the programme (i.e., treatment). This is also true for those farmers that were part of the control group but exchanged information through social discourse with their peers in the treatment group (Chapter 3). Further, my findings reveal an overall positive attitude towards the Long Shields programme. More than 90% of farmers that participated in the Long Shields programme felt it was very important and it has helped them avoid problems with lions (Chapter 3). The majority (> 90%) of farmers that participated in this community programme expressed desire for the programme to continue (Chapter 3). I therefore conclude that community intervention programmes can be used to influence a positive shift in attitudes towards species that are threatened with population decline and yet prone to conflict with local livestock farmers.

6.2: Impact of the community programme on livestock attacks and retaliatory lion killing

As predicted, this study revealed that farmers that participated in the Long Shields programme experienced a significant reduction (up to 40%) in livestock losses to lions since the start of the programme in 2013. By warning farmers of approaching lions, famers mentioned that they moved their livestock to safety and thereby avoid any potential losses (Chapter 3). Moreover, the number of lions killed directly by farmers in retaliation for livestock dropped by 41% and we hypothesised this to be attributed to a reduction in stock losses to lions as a result of the

effective mitigation of stock losses (Chapter 4). Overall, these results reveal that the Long Shields model is an effective conflict tool that can be used to safeguard both lion populations and human sources of livelihoods.

While these findings are encouraging, I detected that a minority of farmers living in villages part of the programme continued to suffer higher livestock losses to lions than did others. The continuance of higher livestock losses to lions, despite all efforts from the programme personnel, seemed to be influenced by various barriers such as poor communication, negative attitudes towards the programme and lack of trust in the programme itself, and in some cases, programme personnel. Together, these barriers negatively influenced participation and late adoption of the Long Shields programme by a minority of farmers resulting in continuing livestock losses to lions (Chapter 5). Wes strongly recommend others to evaluate the rate of adoption of conflict intervention programmes as we have done.

6.3: The advantages of the community-based models of conflict mitigation

There are several advantages associated with community-based interventions such as the Long Shields programme. Importantly, this pro-active programme is made up of a suite of non-lethal tools, such as hazing lions using a *vuvuzela*, and this makes it more suitable intervention for addressing conflict involving a species threatened with population decline. As others have shown, conservation interventions that target both the wild animal and the human behaviour are likely to be effective in the long-term (Miller et al., 2016). Similarly, results reveal that this programme has been effective in long-term and we suspect this is because it targets both lions and human behaviour. We recommend others to consider this model as an effective intervention in addressing human conflict with lions.

The Long Shields programme is flexible and has the potential to be replicated in other areas with similar problems. For example, this programme was initially implemented in two rural

communities i.e., Mabale and Tsholotsho and three years later it was scaled up to a third community (i.e., Victoria Falls) including other sites in Botswana in 2017. Anecdotal evidence from expansion sites reveal a reduction in livestock losses to lions.

Beyond assisting local farmers avoid economic impacts from lions, this programme empowers local people through conservation-related employment, training and community assistance (e.g. provision of canvas mobile bomas). Another strength of this programme is that it attempts to mitigate conflict by directly involving local communities; such collaborative approaches have been found to be beneficial to species conservation and therefore highly recommended (Redpath et al., 2017). This is because involving local communities, ensures that the aims, actions and outcomes of intervention programmes are relevant across stakeholders and aligned with the interest of the community (Osborn & Parker, 2002). It also ensures that the intervention is locally appropriate and consistent with the norms and customs of local people (Chase et al., 2004). Moreover, it increases levels of trust and fosters a sense of stewardship towards carnivores (Infield et al., 2017).

6.4: The disadvantages of community-based models of conflict mitigation

The main disadvantage of this presented programme is that, like most community participatory programmes, it requires long-term funding commitments to remain viable (Webber et al., 2007). In worst case scenarios, if funding were to stop, and the programme terminated, one risks losing the trust of the community (Hughes et al., 2020). Additionally, this programme, like most participatory programmes, is sensitive to social ramifications or challenges. In our case, the divorce of one Community Guardian jeopardised the programme's impact in some parts of the community (Chapter V). Therefore, sensitive mindfulness of inter-personal relationships in the design and delivery of such programmes is necessary.

Another potential challenge is that local people need to fully adopt the programme as their own. Failure to achieve this ownership risks raising expectations, and cause local people to think external organisations will bring a solution to their problem. In the event that those expectations are not fulfilled, there is a risk of frustrated tensions (Graham & Ochieng, 2008). For example in Uganda, Webber et al. (2007) found that the primary reason the primate live-trap programme was unsuccessful was because the local people did not accept responsibility for the live-traps and did not feel it was their responsibility to repair the traps when they broke down. Therefore, I conclude that it is crucial to collaborate with local people, and for them to assume full responsibility for any conflict mitigation programme that is designed for their benefit.

6.5: Recommendations on how to design effective community-based models of conflict mitigation

Based on my findings, I make the following recommendations on how to design and evaluate community-based conservation interventions. Most importantly, a good design is necessary for effective evaluation and therefore, I strongly recommend the following:

Stagger treatment to promote spill-over effects

I observed that certain farmers that were not part of the Long Shields programme exchanged information, thorough social discourse (stories that people exchange in a society), with their peers who were part of the programme. This interaction influenced a positive change in their attitudes to match their peers through 'spill-over' effects (Chapter 3). This particular result implies that, in situations when funding is limited, it may be an advantageous for researchers to stagger treatment to promote spill-over effects. I therefore, recommend others to consider staggering treatments as a means of promoting social 'spill-over' effects.

The Theory of Change: a useful conceptual guide for designing conflict interventions

The Theory of Change is a useful conceptual guide that has been used elsewhere in diverse conservation contexts (Washington et al., 2014; Milner-Gulland et al., 2020; Morehouse et al., 2020). This conceptual guide is particularly useful for structuring data collection and prioritising the activities and goals of future programmes (Balfour et al., 2019). In this case, the ToC enabled me to model the Long Shields programme as well as to conceptualise its impact pathway including recruiting the Long Shields Community Guardians. This research study revealed that the Theory of Change is a useful conceptual guide and I recommend those establishing future conservation activities to adopt this methodology.

Incorporate indigenous knowledge in the design

In most developing countries, collaborative approaches which directly involves stakeholders in the design and implementation of interventions are likely to be beneficial to species conservation and therefore highly recommended (Redpath et al., 2017). As others have shown, this direct involvement increases trust and fosters a sense of stewardship towards carnivores (Infield et al., 2017; Morehouse et al., 2020). When the Long Shields programme was set up, local farmers were involved in designing the intervention, e.g. developing the logic model illustrating the inputs, outputs and measures of success. This is likely to have contributed to the successful adoption of this programme. By and large, I recommend that others developing conservation intervention programmes should not only focus on addressing predator and human behaviours but also building relationships with the people (Miller et al., 2016; Snijders et al., 2019).

Let them choose the messenger

When the Long Shields programme was implemented, local farmers and their traditional leaders were encouraged to identify respected and influential men and women as Community Guardians. This is important because identifying a 'good messenger' is key in disseminating conservation related information and influencing a positive behaviour change (Marchini & Macdonald, 2019). Community Guardians acted as messengers relaying information in the event that lions were closed to the villages and therefore acting as the interface between the conservation project and the community. In this study, farmers mentioned that this aspect of the programme was the most important because it enabled them to avoid confrontations with lions (Chapter III). I recommend to others seeking to encourage community involvement, that they give special attention to selecting suitable representatives, to ensure that they are both highly connected and well-received in the community, in order to achieve desired programme outcomes (Marchini & Macdonald, 2019).

Identify and act on adoption barriers early

Results from this study indicate that poor communication with a minority of farmers influenced negative attitudes towards the intervention, and a lack of trust in the intervention programme (Chapter V). These factors resulted in minimal participation in the Long Shields programme by these farmers. Poor communication arose because those farmers with higher losses (as well as their immediate neighbours) were not able to access WhatsApp messages alerting them about lions and encouraging them to herd their livestock. Access to warnings was limited because they did not own a smartphone. In turn, this oversight affected their attitudes as well as their confidence in the programme. I therefore recommend that others carefully consider channels of communication that engage all people including those that are most disadvantaged.

6.6: Study limitations

This research had several notable limitations discussed below:

Non-random control and treatment allocation

Treatment randomisation is not always possible when tackling real-world problems that involve human subjects affected by potentially life-threatening situations (Treves et al., 2019). As is often the case in those situations, treatment is allocated to individuals who need it the most (Woodhouse et al., 2015). Likewise, the allocation of villages to the Long Shields programme was not random. The programme was focused on villages that had sustained the highest livestock depredation in the past. An obvious fear is that, non-random treatment allocation could result in regression-to-the-mean, a statistical phenomenon that makes natural variations in data appear like real change (Barnett et al., 2005). In my study, while alert to this risk, is less likely to be problematic because the villages that suffered high livestock depredation by lions have endured this high level of conflict for several years; it was not a transitory phenomenon that happened to coincide with the study.

Panel attrition

Panel attrition is a situation where participants drop out of a study during follow-up surveys. This is a common limitation in long-term studies that involve human participants (Lugtig, 2014). In this research study, 47% (n = 294) of the farmers that participated in the 'before' survey did not participate in the 'after' survey due to absence, sickness, death or relocation (Chapter III). However, in my case, the number of participants that remained (i.e., n = 328) was enough to accurately determine the impact of the programme on farmers' attitudes toward lions.

Small sample size

Small sample sizes are not uncommon in non-random purposive sampling (Rust, 2016; Morehouse et al., 2020). Although our findings on the factors that influenced continued losses

to lions despite the Long Shields programme implementation (Chapter V), are informative, I acknowledge the small sample-size and also the need to confirm these findings in subsequent studies.

6.7: Suggestions for future research and improvements to the programme

Ritual palliative, the invisible enemy to threatened wildlife populations

Robust interventions alone cannot ensure long-term population recovery of threatened species such as lions, tigers and jaguars. The decisions that authorities chose to enact (or not) are also important. In this study, I found possible evidence of 'ritual palliative', a situation where officials shoot wild animals to appease affected communities (Hoare, 1995). Ritual palliative is a common problem not only in HMPAC but also in other systems and species. Others examples of ritual palliative in others areas include, wolf culling in North America and Europe (Chapron & Treves, 2016), badgers (*Meles meles*) in Britain (Woodroffe et al., 2005a) and red deer (*Cervus elaphus*) in Scotland (Nilsen et al., 2007). An important question, therefore, is how much is this a problem to species conservation and what can be done to stop it? Although evidence indicates ritual palliative can improve relations between officials and the community, the truth is: it can undermine conservation efforts (Chapter IV). I therefore suggest further research into this aspect of species management including examining the barriers and opportunities to adopting policy change, and related capacity-building for behavioural change, amongst wildlife managers.

Identifying barriers that limit the adoption of conservation interventions

Conservation interventions are only effective if fully adopted by end users, but literature on factors that limit or enhance adoption has so far received very little attention (Eklund et al., 2017). In the fifth chapter, I revealed that it was possible to explore these barriers using the

Diffusion of Innovation framework and that careful planning was essential (Chapter V). I therefore, suggest future research to collaborate with social scientists and explore this aspect of conservation interventions deeply to maximise the impacts of interventions.

The role of social networks and communal channels in conflict mitigation

Information shared within social networks can influence attitudes and behaviours such as whether to adopt or not to adopt conservation interventions (Bennett, 2016a). Very little research has explored these communication channels and how they can benefit species conservation. For example, little is known on how information is shared through farmer social networks. Therefore, I suggest future research to explore this idea in-depth as it has the potential to expand the impact of conservation interventions given that research funding is scarce.

The effects of the Long Shields programme in long-term

Information on how long conservation interventions remain effective is scant. In this study I demonstrated the effectiveness of the Long Shields programme on livestock losses as well as lion retaliatory killings five years since implementation, but whether or not this programme will still be effective after 10 years or so is an important conservation question? What will be informative and beneficial would be to continue to monitor the programme to answer this important question. I recommend further research to explore how long such conservation interventions remain effective.

6.8: Study contribution

In this study, I contributed a baseline dataset for future applied research in HMPAC, and also provided insight into developing locally-meaningful conservation interventions, including the type of information to be shared, channels for communication, and the benefits derived from

participating in wildlife conservation (Chapter II). Additionally, I contributed to the growing literature on impact evaluation and I demonstrated that people's attitudes are valuable for assessing the impact of conservation programmes as well as informing conflict intervention strategies in other areas (Chapter III). Furthermore, I demonstrated the effectiveness and conservation benefits of conflict interventions that are developed in collaboration with local communities (Chapter IV. Similarly, I contributed insight into barriers, several of them not only intangible but also very remote from lions and lion behaviour, that can limit or advance human-carnivore coexistence programmes. This includes a framework within which to evaluate conservation intervention programmes, mindful of the perspective of the people expected to adopt them (Chapter V).

6.9: Conclusions and implications

Globally, conflict between humans and large carnivores over livestock is a major threat to most carnivore populations. Critical evaluation of conservation interventions to test where they are effective or not is important, and stops conservationists reinventing 'square circles' (Gunaryadi et al., 2017). Although important, studies on impact evaluation have until recently, have uncommon because they are difficult to design and implement (Margoluis et al., 2009). In the face of increasing human-wildlife conflict as a result of the increase in world human population density and footprint, this study provided us an opportunity to develop and evaluate the effectiveness of the community programme in successfully mitigation the human-lion conflict situation in northwestern Zimbabwe. Not only was the Long Shields programme well-perceived, findings reveal that since the introduction of the programme in 2013, there has been a *ca*. 40% decrease in livestock losses to lions for those farmers that were part of the programme, while, livestock losses increased for farmers that were not part of this programme. The study dictated the Long Shields programme has conservation benefits: the number of lion

retaliatory killing by farmers has also reduced by 41% since the implementation in 2013. Additionally, this study afforded us an opportunity to explore reasons why a minority of farmers living in villages part of the programme continued to suffer higher livestock losses to lions than did others. Continuance of higher livestock losses to lions, despite all efforts from the programme personnel, was influenced by various barriers such as poor communication, negative attitudes towards the programme and lack of trust in the programme itself, and in some cases, programme personnel. This work demonstrates that it is possible to effectively mitigate the conflict between people and large carnivores such as lions using locally developed interventions, without significant ecological or economic costs to either party. We recommend others to develop site specific and non-lethal conservation toolkits to safeguard wild carnivores, livestock and humans within shared landscapes. This study contributes literature on impact evaluation of conservation interventions and also presents an invaluable opportunity to learn and contribute knowledge to broader human-carnivore conflict mitigation.

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Appendix I

[All instructions to interviewer are given within square brackets]

[Introduce the study and the questionnaire. Refer to separate notes.]

Interviewer name: _____ Date of interview: _____

SECTION 1: Personal information

1a.What is your name? _____
1b. What is your position in the household? _____
1c. What is your age? _____
1d. What is the name of the village? _____
1e. How long have you lived here? _____
1f. What is your first language? _____
1g. Level of education [None, Primary, Secondary, Tertiary]_____
1h. Record names of all people present at interview: _____
[Record GPS location of household: _____]

2a. How many people are in your household?

Position in household	Age	Sex	Living at home?
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

2b. How many houses make up the household? _____
3a. How many of the children attend school? _____
3b. How many meals does the household usually eat per day? _____
3c. How many times per week does the household eat meat? _____
4. What are the household's sources of livelihood? Please list all, giving the largest/most important first.
[List responses in code, using key below] _____

1 = Livestock 2 = farming of crops 3 = Regular employment (please specify) 4 = Casual labour (please specify)	5 = Arts and crafts 6 = Other small business (please specify) 7 = hunting 8 = photographic tourism	9 = money sent home from abroad 10 = Other (please specify)

5. What do you think is the greatest threat to your livelihood? _____

[code using key below]

1 = Crop raiding 2 = Predators killing livestock 3 = Disease of livestock 4 = Natural deaths of livestock	5 = Accidental deaths of livestock 6 = Drought 7 = Lack of government assistance 8 = Theft of livestock	9 = Malnutrition of family 10 = Disease of family 11 = Other (specify)

SECTION 2: Crop husbandry

[ignore this section if crops not listed as source of income in question 4]

6a. Which crops do you grow?

[List all in the table below, using key below]

1 = Maize 2 = Cotton	3 = Millet 4 = Vegetables (specify which)	5 = Other (specify)

6b. What quantities of each crop do you grow? [use information to complete table below]

6c. When do you plant each crop? [use information to complete table below]

6d. When do you harvest each crop? [use information to complete table below]

6e. What measures do you take to protect each crop?

[List all in the table below, using key below]

1 = Fences 2 = Children guarding	3 = Adults guarding 4 = Repellents (specify)	5 = Other (specify)

Response grid

a. Crop	b. Amount (bags)	c. When planted	d. When harvest	e. Steps to protect	Comments [use if code 5 appears in grid]

7. In what months is it most important to protect your crops?

_____

_____

8a. How do you till your land?

Tractor		Hand hoe		Plough		Other (specify):	
- own		- own		- own		- own	
- hire		- hire		- hire		-hire	

8b. Who is responsible for tilling the land? _____

SECTION 3: Livestock husbandry

[ignore this section if livestock not listed as source of income in question 4]

9. What livestock does your household own?

Cattle: _____ Oxen: _____ Donkeys: _____ Goats: _____ Sheep: _____
Poultry: _____ Dogs: _____Other (specify): _____

10. What livestock has the household acquired in the last 12 months, and how was it acquired?

	Bought	Born	Traded	Gifts	Other (specify)
Cattle					
Oxen					
Donkeys					
Goats					
Sheep					
Dogs					
Poultry					
Other (specify):					

11a. What do you do to protect your livestock? [Encourage respondent to list all measures]
_____
_____
_____
11b. Where do livestock drink? [include distance from homestead] _____

12a. How do your livestock usually graze: [use code below to record response for each type of livestock kept]

Cattle		Goats		Poultry	
Oxen		Sheep		Other (specify):	
Donkeys		Dogs			

1 = Unattended 2 = Herded by children (go to Q12b)
3 = Herded by adults (go to Q12b) 4 = Guarded by dogs (go to Q12c)

12b. Are the guards armed in any way? [circle appropriate answer]
No / Yes If yes, what are they armed with _____
12c. If guarded by dogs, how many? _____
12d. If guarded by dogs, do you use your dogs for any other purpose?
No/ Yes If yes, what purpose(s) _____

13. Do you have a boma?
No (go to Q17) Yes (go to Q14)

14a. What livestock do you put into your boma? [circle all that apply]
1 = Cattle 2 = Oxen 3 = Donkeys 4 = Goats
5 = Sheep 6 = Dogs 7 = Other (specify)_____

14b. What are the reasons for using your boma in the wet season? [list all reasons in order of importance]
_____
_____
_____

14c. What are the reasons for using your boma in the dry season? [list all reasons in order of importance]

_____
_____

15a. Do you use your boma more: [circle appropriate answer]
1= in the wet season than in the dry season
2= in the dry season than in the wet season
3= use same amount in wet and dry season

15b. How often do you put your livestock into your boma in the wet season? [circle appropriate answer]
5 = Every night (Go to Q16)
4 = More than once a week
3 = Less than once a week
2 = Rarely
1 = Never

15c. How often do you put your livestock into your boma in the dry season? [circle appropriate answer]
5 = Every night (Go to Q16)
4 = More than once a week
3 = Less than once a week
2 = Rarely
1 = Never

16. Can we see the boma?
[Inspect boma and complete all sections of Q16 – do not ask respondent]

16a. What is the distance to the nearest human habitation in meters? _____
16b. Where is the boma situated in relation to village? _____
16c. What is the boma made of?
1 = Poles 2 = Thorn bushes 3 = Piles of sticks
4 = Wire 5 = Other
(specify)_____

16d. Write a brief description of the boma, detailing how it is constructed and mentioning the complexity of the design.

_____
_____
_____
_____
_____

16e. How big is the boma, in terms of internal area? [circle closest answer]
Small (5 x 5m) Medium (10m x 10m) Large (20m x 20m)
16f. Are there gaps in the boma?
No If no, go to Q16f
Yes If yes, go to Q16e

16g. Approximately what size are these gaps?
Small (10 cm – 20 cm) Medium (20 cm – 50 cm) Large (50 cm – 100 cm)

16h. How tall is the boma at its lowest point (in meters)? _____
16i. How thick are the boma walls on average (in meters)? _____
16j. What is the visibility through boma? [circle closest answer]
5 = No visibility
4 = 25% vis
3 = 50% vis
2 = 75% vis
1 = 75%+vis

16k. Which of the descriptions below best matches the construction of the boma?
5 = Strong poles
4 = Thick branches
3 = Medium branches
2 = Small branches
1 = Small hedge

16l. What is the condition of the poles? [circle as appropriate]
Treated / Untreated
Brittle / Strong

16m. How stable are the poles? [circle as appropriate]
Stable / Unstable

16n. If constructed of wire, please specify construction:
1 = Diamond mesh on poles
2 = Barbed wire (specify number of strands)_____
3 = Other (please specify) _____

[questions below to be directed to respondent]

17. If you don't bring livestock home at night, do you have: [circle appropriate answer]
1 = Armed adults sleeping with them
2 = Unarmed adults sleeping with them
3 = Armed children sleeping with them
4 = Unarmed children sleeping with them
5 = Dogs guarding them
6 = Satellite bomas
7 = No protection (left to roam)
8 = Other (specify) -
_____

18a. What is the furthest distance from your homestead that you graze the following livestock in the wet season? (km)
Cattle _____Oxen _____Donkeys _____ Goats _____
Sheep _____Other (specify) _____

18b. What is the furthest distance you graze the following livestock in the dry season? (km)
Cattle _____Oxen _____Donkeys _____ Goats _____
Sheep _____Other (specify) _____
18c. Do you graze your livestock in wildlife areas?
No / Yes If yes, which livestock? _____
In what months? _____
And, where and how far? [distance from homestead] _____

19. Do you graze all your livestock in one herd?
No / Yes

20. Do you group your livestock with other people's livestock?
No / Yes If yes, with how many livestock? _____

21. Do you dip your livestock?
No / Yes If yes, which livestock? _____
How frequently? _____

22. Do you vaccinate your livestock?
No / Yes If yes, which livestock? _____
How frequently? _____
And, against what? _____

23. Do you collect and dry maize/grass for winter stock feed? No / Yes

24. How often do you count/take stock of your livestock?

5 = every day	4 = More than once a week	3 = Less than once a week	2 = Rarely	1 = Never

25. Do any of your livestock wear bells?
No / Yes If yes, what livestock and how many?
_____
_____
26. How did your forefathers look after their livestock?
_____
_____
_____

27. Do you think that practices have changed?
No / Yes If yes, why?
_____
_____
_____

SECTION 4: Wildlife in the area

28. Please tell me all of the wild animals that live in this area that you can think of:

1	2	3	4	5

6	7	8	9	10
11	12	13	14	15

[Show each animal picture card and ask the following questions:]

29a. What animal is this? [If identified incorrectly, record response]
29b. How regularly do you see this animal in your village?
29c. When was the last time you saw it?

[Use the table below to record responses]

Species	ID?	X response	1= Daily	2= Weekly	3= Monthly	4 = Rarely	5= Never	Last seen
Hyaena								
Elephant								
Lion								
Leopard								
Baboon								
Bush pig								
Genet								
Serval								
Caracal								
Python								
Wild dog								
Jackal								
Cheetah								
Kudu								
Buffalo								
Tiger								
Vervet								
Porcupine								

[Show each spoor picture card and ask the following questions:]

30a. What animal spoor is this? [If identified incorrectly, record response]
30b. How regularly do you see the spoor of this animal in this village?
29c. When was the last time you saw it?

[Use the table below to record ALL responses]

Species	ID?	X response	1= Daily	2= Weekly	3= Monthly	4 = Rarely	5= Never	Last seen
Hyaena								
Elephant								
Lion								
Leopard								
Baboon								
Bush pig								
Genet								

Serval								
Caracal								
Python								
Wild dog								
Jackal								
Cheetah								
Kudu								
Buffalo								
Tiger								
Vervet								
Porcupine								

31. How much do you like the following animals, and why?

Species	5 = strongly like	4 = quite like	3 = neither like nor dislike	2 = quite dislike	1 = strongly dislike	Why?
Hyaena						
Elephant						
Lion						
Leopard						
Baboon						
Bush pig						
Genet						
Serval						
Caracal						
Python						
Wild dog						
Jackal						
Cheetah						
Kudu						
Buffalo						
Vervet						
Porcupine						

32. What would you like to see happen to the numbers of the following animals in the area around your village, and why?

Species	Increase	Decrease	Stay the same	Don't know	Why?
Hyaena					
Elephant					
Lion					
Leopard					
Baboon					
Bush pig					
Genet					

Serval					
Caracal					
Python					
Wild dog					
Jackal					
Cheetah					
Kudu					
Buffalo					

33. How important do you think it is to protect wildlife in Hwange National Park?

5 = very important	4 = quite important	3 = neither impt or unimpt	2 = quite unimportant	1 = very unimportant

34. How important do you think it is to protect wildlife in the communal lands?

5 = very important	4 = quite important	3 = neither impt or unimpt	2 = quite unimportant	1 = very unimportant

35. How do you feel about having predators in your area?

5 = very positive	4 = quite positive	3 = indifferent	2 = quite negative	1 = very negative

36. Why do you feel this way?_____
37. How often are you bothered by each of the following?
37a. When was the last time you were bothered by each of the following?

Species	1=Daily	2=Weekly	3=Monthly	4 = Rarely	5= Never	Last bothered
Hyaena						
Elephant						
Lion						
Leopard						
Baboon						
Bush pig						
Genet						
Serval						
Caracal						
Python						
Wild dog						
Jackal						
Cheetah						
Kudu						
Buffalo						

38a. Can you tell me all the ways that each animal bothers you? [record answers in table below]

38b. Is the problem better in the wet season or dry season? [record answers in table below]

Species	Destroys crops	Kills livestock	Disrupts humans	Scavenges food	Damages property	Injures humans	Other (specify)	Wet vs Dry
Hyaena								
Elephant								
Lion								
Leopard								
Baboon								
Bush pig								
Genet								
Serval								
Caracal								
Python								
Wild dog								
Jackal								
Cheetah								
Kudu								
Buffalo								

SECTION 5: Livestock losses

39a. How many livestock have you lost to each of the following causes in the last 12 months? [for each loss reported, please record which month loss occurred]

Species	Cattle	Oxen	Donkeys	Goats	Sheep	Dogs	Poultry	Month(s)
Predators								
Disease								
Natural deaths								
Accidental deaths								
Slaughter								
Sold								
Used in transaction								
Stolen								
Given as gift								
Other (specify								

39b. Can you tell me a bit about the animals you lost to predators?
[please complete table below – one row for each animal lost to a predator:]

Animal lost	Age of animal	Sex of animal	Predator	Month of loss	GPS of incident
1					
2					
3					
4					
5					
6					
7					
8					
9					

40. Do you think that killing of livestock by predators has increased, decreased or stayed the same over the past 12 months?

Increased	Decreased	Stayed the same

41. How many of each animal would you be willing to lose to predators in a year before you would take action against the predator responsible?

Cattle	Oxen	Donkeys	Goats	Sheep	Dogs	Poultry

42. Who do you think is responsible for your losses to predation, and why?

_____
_____
_____

43. How do you think livestock can be better protected against predation?

_____
_____
_____

44. Do you use these methods?
No / Yes If no, why not? _____

45. What action do you think should be taken after livestock predation has occurred? Who do you think should take such action?

_____
_____

Section 6: Human injury

46. Has anyone in your household ever been attacked by a wild animal?
No / Yes If yes, please give details.

[please try to record the following information: name of person attacked, age of person attacked, when and where the attack happened, what the person was doing at the time, nature of the injury, type of predator, what happened to the predator]

_____
_____
_____
_____
_____
_____
_____
_____

47. Do you think that attacks of humans by wild animals has increased, decreased or stayed the same over the past 5 years?

Increased	Decreased	Stayed the same

SECTION 7: Crop losses

48a. How much of each crop have you lost to each of the following causes in the last 12 months (in bags)? [for each loss reported, please record which month loss occurred]

Crop	Maize	Millet	Cotton	Veg	Other (specify)	Month(s)
Trampled by animals						
Eaten by animals						
Disease						
Drought						
Theft						
Other (specify)						

48b. Can you tell me a bit more about the crops you lost to animals, through being eaten or trampled?
[please complete table below – one row for each crop (or part of crop) lost:]

Crop	Amount Damaged	Trampled or eaten	Animal responsible	Month of loss	GPS of incident
1					
2					
3					
4					
5					
6					
7					
8					
9					

49. Do you think that the number of crops lost to animals has increased, decreased or stayed the same over the past 12 months?

Increased	Decreased	Stayed the same

50. How much of each crop would you be willing to lose to animals in a year before you would take action against the animal responsible?

Maize	Millet	Cotton	Veg	Other (specify)

51. Who do you think is responsible for your crop losses to animals, and why?

_____

_____

52. How do you think crops can be better protected against animals?

_____

_____

53. Do you use these methods?
No / Yes If no, why not?

_____

54. What action do you think should be taken after crops are lost to animals? Who do you think should take such action?

_____

_____

SECTION 8: Conservation

55a. Are you aware of the existence of Hwange National Park?
No / Yes If yes, what do you think of it?

5=Strongly like	4=quite like	3=neither like nor dislike	2=quite dislike	1=strongly dislike

55b. Why?

_____

_____

_____

56. What is the purpose of Hwange National Park? Why does it exist?

_____

_____

_____

57. Have you ever had someone from Hwange National Park come and talk to you about the Park?

No / Yes If yes, describe the encounter:
_____
_____
_____

58. Do you benefit from the presence of Hwange National Park?
No / Yes If yes, how? _____
59. Have you heard of the CAMPFIRE scheme?
No / Yes
60. What is the function of this scheme?
_____
_____
_____
_____

61. Have you ever benefited from the CAMPFIRE scheme?
No / Yes
If yes, when/how often:
_____
How: [select from options below]

	Amount	When? [Year]	Where?
Financial (specify when & amount)			
Meat (specify when & amount)			
Building schools (When? Where?)			
Building roads (When? Where?)			
Drilling boreholes (When? Where?)			
Other (specify, include amount, when & where)			

62. Have you ever received compensation for the loss of livestock?
No / Yes If yes, from whom?: _____
When?: _____
How much?: _____
For what loss?: _____

63. How much compensation (in US $) do you think is appropriate for the loss of a:

Cattle	Oxen	Donkey	Goat	Sheep	Dog	Poultry

64. Have you ever received compensation for the loss of crops?
No / Yes If yes, from whom?: _____
When?: _____
How much?: _____
For what loss?: _____

65. How much compensation (in US $) do you think is appropriate for the loss of an acre of:

Maize	Millet	Cotton	Vegetables	Other (specify

66. In your opinion, are there any positive aspects of having wild animals in your area?

No / Yes If yes, what?

_____

_____

67. In your opinion, are there any negative aspects of having wild animals in your area?
No / Yes If yes, what?

_____

_____

68. Do you feel the benefits of having predators in your area outweigh the negative aspects?
No / Yes Why?

_____

69. Do you think it is necessary to control the predation of livestock by wild animals?
No / Yes If yes, which of the following methods do you think are appropriate?
[if more than one, please rank your choices, 1 for the most preferred and so on]

Method	Rank
Improving methods for protecting livestock	
Avoiding areas with high risks	
Financial compensation	
Removing problem animals	
Eradication of predators	
Fencing the Park	
Other (specify):	

70. Do people in this household ever need to take action to control wild animals?
No / Yes If yes, what action? _____
How often? _____
If no, why not? _____

71. Have you ever killed a wild animal yourself?
No / Yes If yes, what kind? _____
How many? _____
When? _____
Where? _____

72. Has anyone else in the household ever killed a wild animal?
No / Yes If yes, what kind? _____
How many? _____
When? _____
Where? _____

[Thank the respondent and give information about how and when he will know the results of the study – refer to separate notes]

Appendix II

Long Shields Lion Guardians programme evaluation 2017

Date of interview: _____Questionnaire reference: _____
Name of the interviewer: _____
Introduction
We would like to understand how the situation in your area has been in the last 5 years. We kindly like to ask you questions and collect your opinion in writing. The interview is strictly voluntary and Information collected will be used for research purposes only. This means that this study is completely anonymous, and it will not be possible for anyone to trace the replies to you. We will appreciate your honest opinion and will be grateful if you could participate. Thank you!
Sizacela ukuxoxa lani sizwisisa ukubana isimo sokuphila besinjani emnyakeni emihlanu edlulileyo, silibuza imibuzo njalo siloba impendulo zenu. Asibambi muntu ngamandla njalo linkulumo iphathelane le research kuphela hayi okunye, ngakho sizacela likhululeke. Singajabula kakhulu nxa lingakhuluma kuphela okuliqiniso, Siyabonga.
Are you willing to participate in this interview (Yes/No) _____?
Likhululekile na ukubana singaxoxa? (Yebo/Hatshi) _____
Section A: Personal Information

Age (Lileminyaka emingaki yokuzalwa?): __ (*if below 18 don't interview* Sex (M/F): __
What is your position in the household (Liyini lapha ekhaya)? _____
GPS Homestead: _____/_____
Level of education (lifunde lafika kuliphi ibanga): (None/Primary/Secondary/Tertiary)
Name of village (Lapha elihlala khona kuthiwa kungaphi)? _____
What is your first language (Lapha ekhaya likhuluma luphi ulimi)? _____
1h. Record the number of all people present at interview and age:
Males ____ Adults (+18 y) ___Sub Adults (12-17 y) __Juv. (< 12 yrs.) __
Females____ Adults (+18 y) ___Sub Adults (12-17 y) __Juv. (< 12 yrs.) ____
How many people are in your household Lapha ekhaya lihlala libangaki, abavuka khonapha hayi abavakatshileyo noma abahlala ezikhiweni)? _____
Section B: Livelihood related questions
2. What are the household's sources of livelihood? Please list all, giving the largest/most important first
Lapha ekhaya liziphilisa ngani? Okokudla lokokugqoka likuthola njani? Liqambe liqalisela kokubaluleke kakhulu

Most important	Second	Third	Fourth	Fifth

[List responses in code, using key below]

1 = Livestock rearing Sifuyile 2 = farming of crops Siyalima 3 = Regular employment (please specify) siyavukela emsebenzini/ukhona osebenzayo 4 = Casual labour (please specify) Siyasebenza ama piece-job	5 = Arts and crafts Siyenza imisebenzi yezandla yokuthunga lokubaza 6 = Other small business (please specify) Ngilebhizimusi elincinyane 7 = hunting Siyazingela 8= Photographic tourism Siyenza i Photographic tourism	9 = money sent home from abroad Silezihlobo labangane abasithumezela imali abakwanye amazwe 10 = Other (please specify) Okunye, kuchasise

3. What do you think is the greatest threat to your livelihood? Please exhaust all
Elingathi yikho okulikhathazayo sibi-sibili ekuphileni kwenu yikuphi? Ngicela liqambe konke elingakucabanga

Most important	Second	Third	Fourth	Fifth

1 = Crop raiding 2 = Predators killing livestock 3 = Disease of livestock 4 = Natural deaths of livestock	5 = Accidental deaths of livestock 6 = Drought 7 = Lack of government assistance 8 = Theft of livestock	9 = Malnutrition of family 10 = Disease of family 11 = Other (specify)

4. What livestock does your household own Yiziphi izifuyo elilazo lapha ekhaya?
Cows: ____ Oxen/Bulls: _____ Donkeys: ____ Goats: _____ Sheep: _____
Other (specify): _____
>>>>>>>>>>>>>>>>>>>IF THEY DONOT OWN ANY LIVESTOCK GO TO Q28
12a. How do your livestock usually graze?
Izifuyo zenu nxa zise madlelweni, ziyeluswa kumbe hatshi, liyabe lilezinja loba hatshi?
[use code below to record response for each type of livestock kept]?

Cattle		Goats		Poultry	
Oxen		Sheep		Other (specify):	
Donkeys		Dogs			

1 = Unattended 2 = Herded by children 5= both children and adults
3 = Herded by adults 4 = Guarded by dogs 0= There do not own this livestock

13. Do you have a boma? Lilesibaya yini? No (go to Q26)/ Yes (go to Q14)
14a. What are the reasons for using your corral in the wet season? [list all reasons in order of importance]
Yiziphi izizatho ezenza lisebenzise isibaya ngesikhathi sezulu? Ngicela liqambe zonke izizatho ngokuqakatheka kwazo)
Reason 1 _____

Reason 2_____
Reason 3_____

14b. What are the reasons for using your boma in the dry season? [List all reasons in order of importance]
Yiziphi izizatho ezenza lisebenzise isibaya ebusika? Ngicela liqambe zonke izizatho ngokuqakatheka kwazo
Reason 1 _____
Reason 2_____
Reason 3_____

15a. Do you use your boma more: [circle appropriate answer]?
Livalela kanengi nini, ebusika noma ngesikhathi sezulu?
1= in the wet season than in the dry season
2= in the dry season than in the wet season
3= use same amount in wet and dry season

15b. How often do you put your livestock into your boma in the wet season? [circle appropriate answer]
Ngesikhathi sezulu livalela kangaki ngeviki
5 = Every night
4 = More than once a week
3 = Less than once a week
2 = Rarely
1 = Never

15c. How often do you put your livestock into your boma in the dry season? [circle appropriate answer]
Ebusika ke, khona livalela kangaki ngeviki
5 = Every night
4 = More than once a week
3 = Less than once a week
2 = Rarely
1 = Never

18a. What is the furthest distance from your homestead that you graze the following livestock in the wet season? (km)
Kungumango ongakanani lapho elihambisa khona izifuyo lezi ezilandelayo emadlelweni ngesikhathi sezulu

Cattle	Oxen	Donkeys	Goat/sheep	Other, specify

18b. What is the furthest distance you graze the following livestock in the dry season? (km)
Kkungumango ongakanani lapho elihambisa khona izifuyo lezi ezilandelayo emadlelweni ebusika?

Cattle	Oxen	Donkeys	Goat/sheep	Other, specify

18c. Do you graze your livestock in wildlife areas? No / Yes
(Liyelusela e Game na? (Yebo/Hatshi)
If yes, which livestock (Nxa impendulo yakho kungu yebo, yiziphi izifuyo) _____
In what months (Ngaziphi inyanga)? _____
And, where and how far? *[distance from homestead]*
ngaphi, njalo kungu mango ongakanani nxa usuka emizini) _____

19. Do you graze all your livestock in one herd? No / Yes
Liiyelusa izifuyo zenu (imbuzi, amadonki lenkomo) ndawonye na? (Yebo/Hatshi)
20. Do you group your livestock with other people's livestock? No / Yes
Lliyahlanganisa umhlambi leminye imizi nxa lisiyakwelusa na? (Yebo/Hatshi)
If yes, with how many livestock (Nxa kungu yebo, lihlanganisa lezibaya ezingaki)?
_____
21a. Do you dip your livestock? No / Yes (liyazi dibhisa na izifuyo zenu)
21b. If yes, which livestock(Ziphi)? _____
21c. How frequently(kangaki ngenyanga)? _____
22a. Do you vaccinate your livestock? No / Yes (liyazihlabisa na izifuyo zenu)
22b. If yes, which livestock (Ziphi)? _____
22c. How frequently (kangaki ngenyanga)?
_____
21d. And, against what (livikela wuphi umkhuhlane)? _____
23. Do you collect and dry maize/grass for winter stock feed (izifuyo zenu liyazigcinela amahlanga kumbe utshani njengokudla kwebusika na) ? No / Yes
24. How often do you count/take stock of your livestock (lizibala kangaki izifuyo zenu)?

5 = every day Nsukuzonke	4 = More than once a week Kanengi ngeviki	3 = Less than once a week Kabili noma kathathu ngeviki	2 = Rarely Gqo	1 = Never Ngitsho/ asizibali vele

25. Do any of your livestock wear bells (kuzifuyo zenu kukhona yini ezilama bhera)? No /Yes If yes, what livestock and how many (ziphi njalo zingaki) _____ and why(yindaba)?
_____
_____
26. How did your forefathers look after their livestock
Okhokho bakho bebenakekela njani izifuyo zabo?

_____

_____

27. Do you think that practices have changed No / Yes
Libona ngani sezantshitsha yini lezo ndlela? Nxa uthe yebo kungani lisitsho njalo?

_____

_____

_____

28. Please tell me all of the wild animals that live in this area that you can think of(Ngicela ukubakwazi ukubana yiziphi inyamazana zasendle ezihlala khonapha esigabeni senu)?

Section C: Attitudes towards wildlife

31. How much do you like the following wild animals, and please give reasons why
IInyamazana zasendle ezilandelayo zona lizithanda kumbe lizizonda kangakanani, linika lezizatho.

Species	5= strongly like Ngiyayithanda kakhulu	4 = quite like Ngiyazithanda mbijana	3= neither like nor dislike Angizithandi angizizondi	2 = quite dislike Ngiyazizonda mbijana/ ngiyazizonda	1 = strongly dislike Ngiyazizonda kakhulu	Why? Isizatho
Impisi						
Indlovu						
isilwane						
ingwe						
Indwangu						

31b. When you were deciding on whether you like or hate animals for the above question, which particular aspects did you consider/ influenced your answer
Embuzweni ophezulu lithe licabangisisa ngempendulo yenu ukubana inyamazana lezi liyazithanda noma liyazizonda, yini ebelikukhangelisisa ukuthi lithi liyazithanda kumbe liyazizonda?

_____

32b. What would you like to see happen to the numbers of the following animals in the area around your village, and why
Yikuyini ofisa ukubona kusenzakala ngenani lenyamazana ezilandelayo esigabeni senu, njalo yindaba?

Species	Increase Inani kaliqanse	Decrease Inani kalehle	Stay the same Azingaqansi azingehli	Don't know angilalwazi	Why? Isizatho?
Impisi					
Indlovu					

Isilwane					
Ingwe					
Indwangu					

33b. When you were deciding on your answer, which particular aspects did you consider/ influenced your answer
Lithe licabangisisa ngempendulo yenu ukubana inyamazana lezi liyazithanda noma liyazizonda, kuyini obelukikhangela okubangele ukuthi liphendule ngendlela eliphendule ngayo? _____

Section D: Attitudes towards protected areas

33a. How important do you think it is to protect wildlife in Hwange National Park?
Kuqakatheke kangakanani ukuvikela inyamazana ezihlala e Hwange National Park)?

5 = very important Kuqakathekile kakhulu	4 = quite important Kuqakatheke mbijana	3 = neither impt or unimpt kuphathi laphakathi kokuqatheka lokungaqakatheki	2 = quite unimportant akuqakathekanga	1 = very unimportant akuqakathekanga ngitsho!

33b Why (Yindaba)? _____

34. How important do you think it is to protect wildlife in the communal lands.
Kuqakatheke kangakanani ukuvikela inyamazana zasendle nxa ziphakathi esigabeni?

5 = very important Kuqakathekile kakhulu	4 = quite important Kuqakatheke mbijana	3 = neither impt or unimpt kuphathi laphakathi kokuqatheka lokungaqakatheki	2 = quite unimportant akuqakathekanga	1 = very unimportant akuqakathekanga ngitsho

34b Why (Yindaba)? _____

35a. How do you feel about having predators in your area and why?
Uzwanjani ngokubakhona kwezibanda esigabeni sakho, tshono lesizatho?

5 = very positive Ngiyakuthabela kakhulu	4 = quite positive Ngiyakuthabela mbijana	3 = indifferent Akula mehluko	2 = quite negative Ngiyaphatheka kubi kodwa mbijana	1 = very negative Ngiyaphatheka kubi kakhulu

35b Why(Kungani)? _____

35c. Could you please tell me how you feel about having the following predators in your area? And why?
Bengicela lingitshele ukuthi lizwanjani ngokubakhona kwezibanda ezilandelayo esigabeni sakho, tshono lesizatho?

	5 = very positive Ngiyakuthabela kakhulu	4 = quite positive ngiyakuthabela mbijana	3 = indifferent akwenzi mehluko	2 = quite negative ngiyaphatheka kubi	1 = very negative ngiyaphatheka kubi kakhulu	Why isizatho
Impisi						
Isilwane						
Ingwe						

37. How often are you bothered by each of the following
Inyamazana ezilandelayo zona zilikhathaza ngemva kwesikhathi esingakanani?

37a. When was the last time you were bothered by each of the following?
Tshono ukubana bekunini zicina ukulihlasela?

Species	1=Daily Nsukuzonke	2=Weekly Maviki onke	3=Monthly Nyangazonke	4 = Rarely Gqo	5= Never Azikaze zihluphe	Last bothered Zicine nini ukuhlasela
Impisi						
Indlovu						
Isilwane						
ingwe						
indwangu						

39a. Over the last 5 years, how many livestock have you lost to each of the following causes? *[for each loss reported, please record which year loss occurred]* Bengicela sikhangele eminyakeni engu 5 eyadlulayo, ulahlekelwe yizifuyo ezingaki ngezizatho lezi ezilandelayo?

Species	Cattle amnkomokazi	Oxen inkabi	Donkeys obabhemi	Goats/Sheep Imvu lembuzi	Year(s) Ngawuphi umnyaka qamba
Izibanda					
Umkhuhlane					
Zisifa zodwa					
Other (specify) Okunye(chasisa)					

39b. Can you tell me a bit about the animals you lost to predators? *[please complete table below – one row for each animal lost to a predator, if they can still remember ask them whether the attack was in the wet or dry season]*Bengicela ukuzwisisa ngalezo ezabanjwa yizibanda, litsho lokuthi yabanjwa ebusika noma ehlobo

Animal lost Inyamazana esalahlekayo	Age of animal ibinganani	Sex of animal M/F	Predator isibanda	Year of loss Wuphi umnyaka	GPS of incident Lapho eyabanjwa khona
1					
2					
3					
4					

Section E: Investigating the efficacy of the Long Shields Intervention

40. Please take a moment to reflect on the situation 5 years back and also take a moment to reflect on the situation now. Do you feel the killing of livestock by the following predators has increased, decreased or stayed the same at (a) your homestead and (b) at village levels?
(a) Ngicela sike sinakane ngomumo wobudli eminyakeni engu 5 eyadlulayo emzini wakho khonapha. Lokhu kusitsho kusukela ngo 2012 kuze kuzefika lamuhla. Ingabe inani lezifuyo ezidliwayo/ezilinyazwayo liyayehla, liyaqansa kumbe lokhe lifana. (a) Siqale sikhangele emzini wakho

[*Note to interviewer, please ask the respondent to say how the situation was back-then and how is the situation to date*

Predator	Household level
Impisi	
Isilwane	
Ingwe	

Use the following code for your answers: 1= Increased 2= Decreased 3= Stayed the same

(b) Ngicela sike sinakane ngomumo wobudli eminyakeni engu 5 eyadlulayo esigabeni sakho. Lokhu kusitsho kusukela ngo 2012 kuze kuzefika lamuhla. Ingabe inani lezifuyo ezidliwayo/ezilinyazwayo liyayehla, liyaqansa kumbe lokhe lifana. Kathesi

Predator	Village level
Impisi	
Isilwane	
Ingwe	

40a. What do you think are the reason(s) at household level?
Yiziphi izizatho nxa ukhangele ngobudli emziniwakho?

_____

_____

40b. What do you think are the reason(s) at village level?
Ubona ngani yindaba kusenzakala njalo ngobudli esigabeni?

_____

_____

43a. What do you do to protect your livestock from predation? *[encourage respondent to list all measures]*
Yiziphi indlela elizisebenzisayo ukuvikela izifuyo zenu ukuba zingadliwa/ zingabanjwa?
Method 1_____
Method 2_____

Method 3_____

b. Some of the methods that can be used to protect livestock against predation are given below. Using a 0-10 scale, where 0 is not efficient at all at 10 is very efficient. How effective do you think the following methods are against predation by lions?

c. Please rank the methods based on which one you consider to be important

Ezinye indlela ezingasetshenziswa ukuvikela ukudliwa / ukubanjwa kwezifuyo yizibanda, yilezi ezilandelayo. Sisebenzisa isilinganiso kusukela ku 0 kusiya 10, u 0 esitsho ukuthi akusebenzi ngitsho, u 10 esithi kuyasebenza kakhulu. Bengicela ukuzwa ukuthi libona ngani zisebenza kangakanani ekuvikeleni izifuyo ekubanjweni yizilwane?

Method	0	1	2	3	4	5	6	7	8	9	10	Don't know Angazi
i. Ukwelusa												
ii. i-Mobile boma (show Picture)												
iii. i-Compensation												
iv. Ucingo olula magetsi												
v. ama-lion guardians)												
vi. Problem Animal Control (PAC) Ukudubula inyamazana eziluhlupho zibulawa												
Other, specify (Okunye ,chasisa)? _____												

45. What action do you think should be taken after livestock predation has occurred? Who do you think should take such action?

Ubona ngani yiliphi inyathelo elingathathwa ngemva kokubana izifuyo sezidliwe yizibanda? Ngubani okumele athathe leli nyathelo?

_____

47. Over the last 5 years, do you think that attacks of humans by wild animals has increased, decreased or stayed the same? [Say how was the situation back-then and how is the situation to date]

Nxa sikhangele iminyaka engu 5 edlulileyo, inani labantu ababulawa/ abalinywazwa zinyamazana zasendle lona linjani? Liyaqansa/liyehla kumbe lokhe lifana? [Tshono ukuthi bekunjani kudala njalo umumo usunjani khathesi]

Increased Liyaqansa	Stayed the same lokhe kufana	Decreased liyehla

47b. if your response to the above question was 'Increased', please tell which species in particular where responsible for attacks of humans (Nxa impendulo yakhe kumbuzo odlulileyo ibingu "liyaqansa" buza ukubana yiyiphi inyamazana edala lo monakalo)

_____

Section F: Importance of wildlife conservation in protected areas

55a. Are you aware of the existence of Hwange National Park? If yes, what do you think of it and why?
i- Hwange National Park yona lilolwazi layo na? No / Yes
(Nxa kungu Yebo, uyizonda noma uyithanda kangakanani)?

5=Strongly like Ngiyayithanda kakhulu	4=quite like Ngiyayithanda	3=neither like nor dislike angiyithandi-angiyizondi	2=quite dislike Ngiyayizonda	1=strongly dislike Ngiyayizonda kakhulu

55b. (Kungani)?

_____

_____

56. What is the purpose of Hwange National Park? Why does it exist?
Iyini injongo ye Hwange National park, njalo kungani ikhona?

_____

_____

57. Do you have anyone in this household working for Hwange National Park or lion guardians or any Safari to do with wildlife
Ukhona yini omunye wenu ongabe esebenza e Hwange National Park kumbe engum' Lion Guardian loba ema Safari aphathelane lenyamazana zasendle)? No / Yes
If yes, where (Ngaphi) _____
58. Do you benefit from the presence of Hwange National Park
Kule nzuzo na eliyitholayo ngokuba khona kwe Hwange National Park)? No / Yes

If yes, how (Yinzuzobani eliyitholayo)? _____

Section G: Importance of wildlife conservation within village lands
59. Have you heard of the CAMPFIRE scheme
Selike lezwa ngohlelo lwe CAMPFIRE yini? No / Yes
60. What is the function of this scheme
lungo lwani lolu hlelo?

_____

_____

_____

61. Have you ever benefited from the CAMPFIRE scheme?
Kule nzuzo eselike layithola ku hlelo lolu lwe CAMPFIRE? No / Yes
If yes, when/how often Nini njalo kangaki: _____

_____

How: *[select from options below]*

	Amount	*When? [Year]*	*Where?*
Financial (specify when & amount) (imali)			
Meat (specify when & amount) Inyama			
Building schools (When? Where?) Ukwakhiwa kwezikolo			
Building roads (When? Where?) ukulungiswa kwemigwaqo			
Drilling boreholes (When? Where?) ukugejwa kwemi kwemigodi			
Other (specify, include amount, when & where) okunye (chasisa)			

Section H: Effects of the lion guardians programme on human predator conflict

80a. Are you familiar Long Shields Lion Guardian Programme [*show and point at the Long Shield image*]
I-Long Shields Lion guardian yona lilolwazi ngayo na? Yes/No

80b. Do you have Long Shield (lion guardians) in your village?
Lapha esigaben senu akhona yini ama lion-guardians? Yes/No
If yes, what is the role of the Long shields (lion guardians)
If yes, umsebenzi wama lion-guardians ngowani? _____

81a. Do you receive any warning messages from your local lion guardian (liyathola yini izixwayiso kuma lion guardians)? (Yes/No)
81b. If your answer is yes, how often do you get warning messages
(liyithola kangaki le imbiko ekhuluma ngezilwane ngeviki?

1=Daily nsukuzonke	2=Weekly Kanye ngeviki	3=Monthly Kanye ngenyanga	4=Rarely gqo ngemva kwesikhathi	5=Never ngitsho asikaze sithole imibiko evela kma lion guardian

81c. What do you do when you get warning messages?
Kuyini elikwenzayo nxa lingathola leyi imbiko ekhuluma ngezilwane?

82a. Personally, how do you perceive the Long Shields Lion guardian's intervention
Ngombono wenu, nxa likhangele uhlelo lwama lion guardian, lilubona njani?
5=Very Important Luqakathekile kakhulu
4=Important Luqakathekile
3=Neither important not unimportant kuphakathi laphakathi

2=Unimportant Aluqakathekanga
1=Very unimportant Aluqakathekanga ngitsho
82b.Why (kungani lisitsho njalo):_____ _____ _____
83a. Considering all aspects of your life that you consider to be very important. Please tell me if the Long Shields Lion Guardians programme improved your general well-being?
Nxa ukhangele nje ngempilo yakho, lezinto ozibona ziqakathekile ekupheleni kwakho. Bengicela ukuzwa ukubana empilweni yakho sekube lobungcono yini ngokubakhona kwama Lion guardian's esigabeni sakho? (Yes/No)
Note to interviewer please emphasise on the respondent to consider all aspects of their lives
83b. Can you please tell me of reasons why this was the case? If not, please also say why? (Nika izizatho)
……
83c. Please tell me specifically which aspects of well-being were impacted
(Ngicela ukubuza ukubana yikuphi osekuntshintshile empilweni yakho)?
……

84. Imagine if you hear that lions killed your neighbour's cow, how would you feel and why Asithi uzwe umbiko wokuthi umakhelwane wakho udlelwe inkomo yisilwane, ungezwa njani? Yindaba usizwa njalo)?
……
85. How much do you agree/ disagree on the following statements?
Livumelana kangakani lemibono le elandelayo?
86. Did other people present during the interview participate during the interview **(Yes/No)**

	1=Strongly disagree : 5=Strongly agree				
Method	1	2	3	4	5
IUzilwane zilelungelo lokuphila lazo emhlabeni					
Ngenxa yokuthi sekwaba lama Lion guardians izehlakalo zokubulawa kwenkomo zami yizilwane sezehlile					
Ngenxa yokuthi sekwaba lama Lion guardians angisazesabi izilwane ngitsho					
Ngenxa yama Lion guardians angisakhathazeki ngokubulawa kwezifuyo zami ezibayeni ebusuku					
Ngokutshelwa ngama lion guardians ukuthi izilwane zingaphi sokungisizile ukuthi ngenqabele uhlupho lwe zilwane					

Appendix III

Reference No: _____

Record GPS loc stat (*for use to calculate the distance between the homestead and the park boundary*) ……

Q1a: Have you ever heard of the Long Shields Lion Guardians program? (**Yes/No**)

Q1b: What does the LSLG do for you?

……..

……..

Q2: How often do you communicate with your lion guardian (which means do you use, please list all)? Rarely/Daily/Weekly/Monthly/Never

……..

……..

Q3: Are you or someone in this household part of the Long Shields Lion Guardian WhatsApp group? **Yes/ No**

Why?……..

……..

Q4: If yes, do you respond to messages from the Long Shields Lion Guardian, and if so, how?

……..

……..

Q5: Have you participated in Long Shield Lion Guardian activities? **Yes/No**

Which activities (Please list all)? If NOT please tell me why?

……..

……..

Q6: Do you think the Long Shields Lion Guardians program could help you reduce livestock loss? **Yes/No**

Please give reasons for your answer

……..

……..

Notes*: Maybe people that recorded a reduction in livestock loss after the intervention believed the Long Shields Lion Guardians program was important and vice-versa. Here we ask this question.*

Q7:: How important is the LSLG program to you?

5= Very important

4= Important

3= Neither important nor unimportant

2= Unimportant

1= Very unimportant

Livestock management practise

Notes*: A possible reason why some people experienced a reduction in livestock loss while other experienced the opposite is because of possible changes (or not) in livestock management. Here we want to find out if there have been any changes over the last five years.*

Q8: Has your livestock management practices changed over the last 5 years? If so, how??

……..

Q9: Over the past 5 years, do you feel your losses to lions have increased, stayed the same or decreased.

……..

If the answer is stayed the same: You say, over the past 5 years your losses to lions stayed the same, did those losses stay low or stay high?

……..

What do you think is the reason?

……..

Notes*: We notice that people tend to assign more value and protection than other forms of livestock e.g., donkeys less valued and left outside at night while cattle are brought home to safety. First, I want to understand the reasons why people think livestock is important.*

Q10a: Why are livestock important to you?

……..

Q10b: Which livestock in particular?

……..

Notes*: Another possible reason and also supported by our direct sighting records is that there is very little livestock herding done by farmers despite the presence of marauding lions in the area. What we know from our data so far is that livestock is a primary source of livelihoods (chapter 1) and equivalent to 'bank accounts' and therefore leaving livestock to graze unsupervised is taking a huge risk by local farmers (bad behaviours exposing them to lion depredation). We think this has all to do with the assumed probability of risk, where people think their chances of losing a cow to a lion (vulnerability) are less hence they herd less and vice versa.*

Q11: Do you think your livestock is very **vulnerable, vulnerable, invulnerable or very invulnerable** to lions? **Answer**: …….
Why?…….....
……..

Notes*: Sometimes people think conflict should be managed differently to how it is managed already. In such cases if their expectations are not met, they undermine existing interventions meant to assist them.*

Q12: What do you think could help reduce future livestock losses?

……..

……..

Why have you not already done that?

……..

……..

Q13: How do you think national parks could help you reduce livestock loss?

……..

……..

Q14: How do you think the government could help you reduce livestock loss?

……..

……..

Notes*: Social trust is also an important predictor of intervention uptake. Lack of trust is often associated to low uptake (when people fail to partake in a program meant to ease their problem) hence we need to determine whether this was the case.*

Q15: How much do you agree or disagree with the following statements?

Answers to choose from: **1= Strong disagree:2: Disagree, 3: Neither agree nor disagree, 4: Agree, 5 Strongly agree**

(i) I don't trust lion guardians (when they give you a response please also ask why)

……..……

(ii) I expect the LSLG roles to be different to what they are now? (when they give you a response please also ask why)

……

Thank the participant for their time and their contribution

Permission to use lion photos

RE: Lion photos for your Ph.D. Thesis

Paul Funston <PFunston@panthera.org>

Thu 30/07/2020 15:50

To: Lovemore Sibanda <lovemore.sibanda@zoo.ox.ac.uk>

Dear Lovemore

It gives me great honor and is indeed a great privilege to send you a selection of images of Hwange lions to include and use in you thesis where you so should choose. I have sent them to you using the WeTransfer platform. You will get an email to enable you to download

I am extremely proud of your fast nearing achievement and look forward to many wonderful years of lion conservation together.

Kind regards,

Dr Paul Funston | Lion Program Director and
Regional Director Southern Africa
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