Research

IDENTIFYING BARRIERS TO THE UPTAKE OF INNOVATIVE SOLUTIONS

A CASE STUDY WITH LIONS IN ZIMBABWE

Lovemore Sibanda[1], Courtney Hughes[1,2], Esther van der Meer[3], David W. Macdonald[1], Andrew J. Loveridge[1]

[1] Wildlife Conservation Research Unit, Department of Zoology, The Recanati-Kaplan Centre, University of Oxford, OX13 5QL, UK.
[2] University of Alberta, Department of Renewable Resources, Edmonton, Alberta, Canada.
[3] Cheetah Conservation Project Zimbabwe, Box 204, Victoria Falls, Zimbabwe

1. Introduction

Wildlife impacts on humans are complex conservation problems 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 wildlife including 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 and 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 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. Most lion attacks on livestock occur at night, when livestock are left to freely graze instead of being secured overnight in protective enclosures (Kuiper et al., 2015).

Attitudes and perceptions towards lions in the area are strongly negative, and are influenced by the geographic location in which farmers live as well as the farmers' 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, to safeguard the local lion population in the future, as well as to raise awareness and build knowledge and skills amongst farmers (Sibanda et al., 2020a).

In 2012, we developed the Long Shields Community Guardians (hereafter "Long Shields") programme in the HMPAC: a non-lethal, community-based, human-lion conflict intervention (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 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 (Woodhouse et al., 2015). These included: (a) implementing educational outreach amongst local farmers to encourage and train for optimised adoption of conflict mitigation techniques (e.g. livestock herding); (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 our ToC model (Fig. 1) 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 and 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.

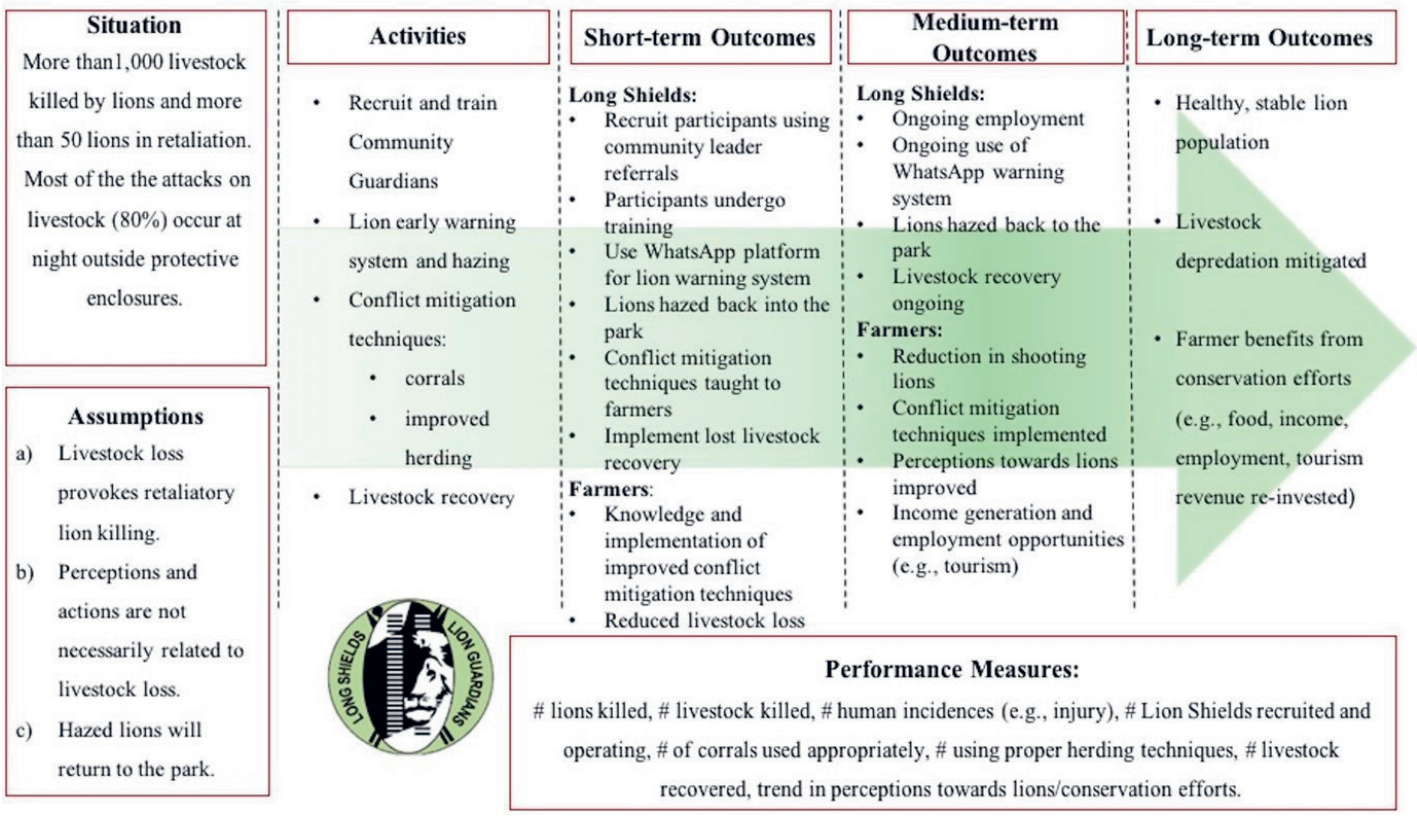

Fig. 1 The community-based programme's Theory of Change.

We 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 programme, and those that did not, would therefore differ in their: (a) frequency of communication with 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.

2. 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), agriculture (Rogers, 2004) and, increasingly, in conservation efforts (Mbaru and Barnes, 2017) to provide valuable insight into the barriers and motivations to adopt or reject new ideas or practices (Hubbard and 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's or group's 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, as in our study, conflict with wildlife species, all of which can affect the adoption of an innovation (Rogers, 2004; Mascia and 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 and 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) (Fig. 2). 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 outside our Long Shields programme

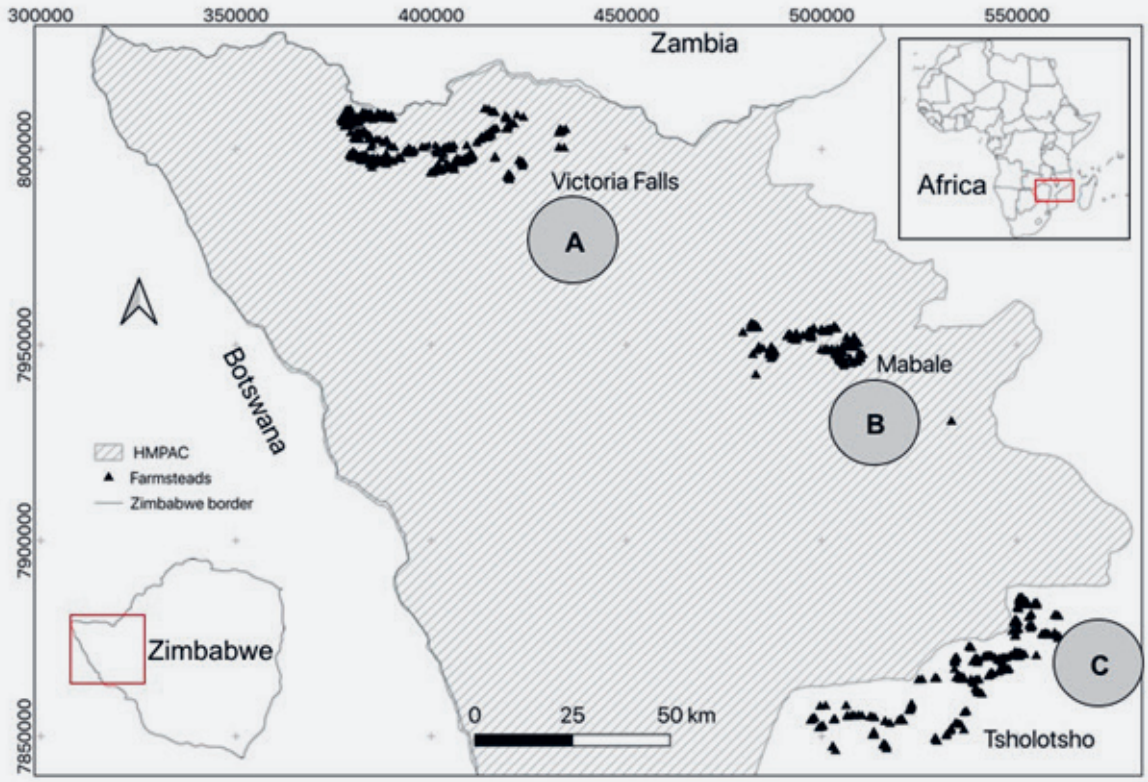

Fig. 2 A map of our study area in northwestern Zimbabwe.

which may have affected attitudes or behaviours towards lions.

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, donkeys, sheep and goats as the primary livestock and maize, millet and sorghum as the main crops (Sibanda et al., 2020a). High-value livestock, such as cattle and donkeys, is commonly depredated by lions and spotted hyaenas (*Crocuta crocuta*). Leopards (*Panthera pardus*), African wild dogs (*Lycaon pictus*), cheetahs (*Acinonyx jubatus)* and black-backed jackals (*Canis mesomelas*) occasionally prey 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 and further away from 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., in review; Morehouse et al., 2020). We recruited 14 local farmers (two women and 12 men, aged 21–65 years) to be trained as Long Shields Community Guardians (hereafter "Community Guardians") based on recommendations from community leaders and using the following criteria: geographic location, physical fitness, English literacy, respectability and trust within 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 reinforcement). Additionally, Community Guardians were trained to use the lion early-warning system through the WhatsApp smartphone platform (WhatsApp Inc., California, USA).

As part of this system, we identified and collared 23 lions (6 females and 17 males across 9 prides), selected

because their home ranges significantly overlapped with local farming communities outside protected areas. Collars were set to record 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 participating villages. Lions that crossed the park boundary and approached human settlements were hazed by the Community Guardians plus village volunteers with the use of a *vuvuzela*: a plastic horn that produces an irritating sound of about 127 decibels (dBA) (Fig. 3).

Fig. 3 Long Shields Community Guardians blowing a *vuvuzela* during a lion chase event. *Photo: L. Mathe*

3. Data collection

Sampling

Participants were selected for interview 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 to select a total of 50 farmers living in villages in the Tsholotsho communal area who participated in the Long Shields programme. Specifically, we selected 25 individuals who reported persistent or larger livestock losses post-intervention (i.e. mean yearly loss after implementation ≥ mean yearly loss before) as well as 25 individuals who reported a decrease in livestock losses post-intervention (i.e. mean yearly loss after implementation < mean yearly loss before). The calculated mean livestock loss prior to implementation was 3.07 ± SD = 1.58 per household (Sibanda et al., 2020b).

Survey instrument

We began our study in February 2019 using in-depth face-to-face interviews consisting of closed and open-ended questions. Semi-structured interviews were preferred over structured techniques because they are flexible and allow the conversation to flow freely (Schensul et al., 1999). We attempted to interview men and women (self-reported heads of households) as equally as possible. Recognising the importance of ethics in conservation activities (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 c.45 minutes and was conducted in *isi*Ndebele; 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 farmers' knowledge about and adoption of the Long Shields programme. This included questions about: (a) their awareness of the programme; (b) the purpose of the programme; (c) how often farmers communicated with their Community Guardians; (d) frequency of communication; (e) participation in specific programme activities; (f) confidence in the programme's effectiveness; and (h) relative importance of the programme to farmers and lions. A full list of factors tested and questions asked are given in Table 1.

Evaluating factors that influenced the persistence 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

Table 1 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*)	Categorial
	What communication channel do you use to communicate with your Community Guardian? *(mobile phones, none, community guardians come in-person, both, neighbours)*	Categorial
	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?	Categorial
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 they 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

Table 2 Model estimates of factors thought to influence farmers' losses to lions.

Factor	Df	AIC	χ^2	Pr (>Chi)
Communication frequency	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	0.68	.88
Trust	4	42.81	12.99	.01*

Lions in Hwange National Park, Zimbabwe. *(Photo: WildCRU TransKalahari Predator Project)*

of the following eight explanatory variables: communication frequency; early-warning system participation; responsiveness to warnings; participation in activities; confidence in the intervention; self-reported behaviour change; perceived risk; and trust (full explanations listed in Table 1). 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 and Anderson, 2002). Possible non-linear effects in the ordinal predictors were explored graphically using the package '*sure*' (Liu and Zhang, 2018). To support our analysis, we also include key quotes from the interviews to highlight farmers' perspectives in their own voices.

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).

Factors that influenced the persistence 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 ($\chi^2 = 16.63$; 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 ($\chi^2 = 10.82$; df = 1; $P < 0.001$); (c) farmer responsiveness to warnings ($\chi^2 = 20.10$; df = 1; $P < 0.001$); (d) whether or not a farmer had confidence in the Long Shields programme ($\chi^2 = 9.08$; df = 1; $P < 0.001$); and (e) whether or not a farmer had trust in their Community Guardians ($\chi^2 = 12.99$; df = 4; $P = 0.01$) (Table 2).

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.

Community Guardians tracking lion spoor along the protected area-community interface. *(Photo: L. Mathe)*

Characteristics of farmers who experienced a decrease in livestock loss

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 compared to 3.07 ± *SD* = 1.58 prior to programme implementation. These farmers had characteristics of early-adopters, i.e. they were aware of the Long Shields programme and its 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 to protect our livestock against lions. 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 the park towards our villages."*

Sixty-two per cent of these farmers mentioned they actively use and heed the Long Shields early-warning WhatsApp group, while the remaining 38% said they were not formally part of the group but relied on their neighbours who engaged in the Long Shields WhatsApp early-warning 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 mentioned that, although she was not part of the WhatsApp group, her son, working elsewhere, was part of the 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 Long Shields programme activities, the majority of farmers (70%) in this group indicated that they actively participated in tracking and chasing lions. For example, one 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 were confident the programme assists them to deal with problem lions. One 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 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. Guardians are doing a good job, especially with the collared lions, and it is now the non-collared lions that cause us problems."*

When asked about trusting their Community Guardians, 100% of the farmers who experienced a decrease in livestock losses to lions indicated they trust the competence of their Community Guardians. One farmer mentioned that, "*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, we could be counting our losses".*

Characteristics of farmers who experienced persistent or larger livestock loss

Farmers who reported persistent or higher livestock losses to lions post-intervention implementation lost an average of 3.56 ± *SD* = 2.01 animals per year compared to 3.07 ± *SD* = 1.58 prior to programme implementation. 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 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 platform. Unsurprisingly, none of the farmers in this group participated in the Long Shields early-warning 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 farmer mentioned, "*I don't think the Long Shields 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 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 him, including all the respect I had for this Community Guardian"*.

5. Discussion

For wildlife impact 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, even though this enables 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 its roles. They expressed confidence in the programme and were eager to participate. Further, they were actively involved in programme 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, older people tend to be 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 and Hanson, 2018). Kotzé et al. (2016) found that women were more 'technophobic' than men. Additionally, poorer people are more likely to be late adopters because they may not own the necessary technology (Morawczynski and Pickens, 2009). 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 compensation for losses incurred due to wildlife (Sibanda et al., 2020a). 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, so are unlikely to offset the individual costs of livestock depredation (Sibanda et al., 2020a). We recommend further research on this subject to explore in-depth the underlying socio-cultur-

al, political and economic factors that influence late adoption of human-wildlife conflict intervention programmes.

With regards to livestock losses, our findings suggest that persistent or higher livestock losses to lions were influenced by various barriers grouped together into three main categories: (a) poor communication; (b) negative perceptions towards 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 Messenger platform, which serves to (a) educate, (b) encourage farmers to herd their livestock and (c) alert farmers of approaching lions (Sibanda et al., in review). Between 2013 to 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 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 which 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. 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).

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' means (e.g. community meetings, face-to-face, sending SMS) as well as 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 benefits associated with participation.

Negative perceptions

Perceptions refer to how an individual observes, interprets and evaluates an experience, object, action or other social entity (Pickens, 2005). Indeed, perceptions can influence how an individual assesses the value of a conservation action and, ultimately, the decision to either adopt the innovation or not (Bennett, 2016). In this study, we found that compared to those farmers with early-adopter characteristics, farmers with late-adopter characteristics held negative perceptions of, and were less confident in, the Long Shields programme. We suggest this was because these farmers did not fully understand, or misunderstood, the objectives of the Long Shields programme, which illustrates the hazard of failed communication. 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 and Ochieng, 2008; Gunaryadi et al., 2017). 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), although

some authors have argued that this might not always be the case (Sitati and 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 work provides a framework within which to evaluate conservation programmes mindful of the perspective of the people expected to adopt them.

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 perceptions 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 cattle of late adopters became 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 and 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.

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