ASSESSING THE ANTHROPOGENIC THREATS TO VULTURES IN THE COMMUNAL FARMLANDS OF NAMIBIA

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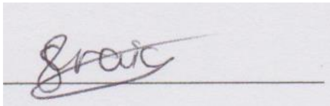

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ABSTRACT

The use of poison by farmers to control livestock predators is a major threat to vulture populations across Africa. In Namibia, there is now some understanding of poison use on commercial farms, but the situation in the communal farmlands is still poorly understood. Using a series of 36 questions, I interviewed 367 communal farmers to assess the prevalence of poison use across the north-west, north and eastern communal land. I found that 18% (SE 2.8) of farmers had killed a predator in the last year and 1.7% (SE 2.1) used poison to do so. I mapped the probability of poison use across the communal regions surveyed and found that poison use is predicted to be higher (up to 7% of farmers using poison) in some areas of the upper north-west. In contrast to previous research, those living adjacent to protected areas did not experience greater losses to predators and as a result were not more inclined to use poison. I found that those using poison are more likely to own greater numbers of livestock, particularly large livestock. Overall, my study suggests that poison use is approximately 12 times lower in the communal areas than on commercial farms. A number of farmers expressed that it is dangerous to use poison on communal land as the risk of non-target impacts is much higher where the land is not fenced and is communally used. Nonetheless there are communal farmers who are using poison and this poses a risk to already threatened vulture populations. Lastly, I did a survey to look at the farmers' local knowledge about vultures, their attitudes towards them and any cultural value that vultures hold. Overall vultures were viewed positively by farmers. The cultural use of vulture parts appeared fairly uncommon, with 9.5% of farmers reporting that they knew of uses. Many farmers indicated that the cultural use of vulture parts was something practiced by previous generations. Feathers were the most commonly used part, mainly for decorations and making arrows. From my assessment, it appears that anthropogenic threats to vultures in communal areas are fairly low. The cultural use of vulture body parts is rare. In addition, poison is used but this practice is not nearly as common as it is on commercial farms. Since poison can have such devastating impacts on vulture populations, I nonetheless advise that reactive and preventative measures are put in place to reduce poisoning and minimise the impact when poison is used. The identified 'hotspots' of poison use will assist local authorities to focus their poison mitigation efforts.

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Lastly, I would like to thank my family, my fiancé and my best friend. Travelling out of the country for the first time and doing work that was unfamiliar to me was certainly challenging and I would not have been able to do it without your love and support.

INTRODUCTION

Evidence suggests that we could be heading into the sixth global mass extinction, which is primarily driven by human exploitation (Ceballos et al. 2015). Extinction rates are not equal across all taxonomic groups, with some taxa being more at risk than others. One such threatened group are the vultures (Buechley & Şekercioğlu 2016). Today 73% of all vulture species are listed as extinction prone (Buechley & Şekercioğlu 2016). Vulture populations are declining globally, but especially in Asia due to the use of the veterinary anti-inflammatory drug, Diclofenac which was revealed to be highly toxic to vultures (Green et al. 2004). Rapid declines in the populations of African vulture species have led researchers to declare that Africa is now also facing a continental vulture crisis, of similar proportions to the one in Asia (Green et al. 2004; Ogada et al. 2016). Based upon a review of various population surveys and assessments, Ogada et al. (2016) recommended seven of Africa's vulture species be up-listed on the IUCN Red List, six of which subsequently were.

Certain life history traits are thought to make vultures predisposed to extinction. They have a specialised diet, a trait which has been known to be linked to extinction risk in many other species (Clavel et al. 2011; Buechley & Şekercioğlu 2016). Delayed sexual maturation, slow reproductive rate and low population density also make them more susceptible to extinction when populations experience high mortality due to human impacts (Purvis et al. 2000; Buechley & Şekercioğlu 2016). Poisoning, electrocution on powerlines, disturbance of nests, the use of vulture parts in traditional medicine, reduction in food availability and hunting vultures for food threaten populations to varying degrees globally (Bamford et al. 2009; Boshoff et al. 2011; Botha et al. 2012; Ogada et al. 2012a; Angelov et al. 2014; Williams et al. 2014). This wide range of threats provides challenges to fully understand these threats and mitigate their impact on affected populations.

Vultures are efficient scavengers, providing an effective disposal service for carcasses unrivalled by any other vertebrate scavenger (Devault et al. 2016). Carcasses tend to decompose much slower when only generalist scavengers are present, which gives bacteria more time to multiply and spread as these scavengers take longer to detect carcasses (Ogada et al. 2012b). In the absence of vultures, generalist scavengers such as feral dogs and rats are known to increase (Butler & du Toit 2002; Markandya et al. 2008). These animals are known disease vectors and an increase in their populations will have implications for the transmission of diseases such as rabies (Markandya et al. 2008). A Kenyan study showed that in the absence of vultures, mammal numbers at carcasses tripled, which increased the chance for diseases to be spread between individuals (Ogada et al. 2012b). In the absence of the disposal service provided by vultures, generalist scavengers such as rats and crows can reproduce quickly when resources are plentiful, and have the potential to become invasive (Buechley & Şekercioğlu 2016).

Dietary toxins, including veterinary drugs, lead ammunition and poisons, were identified as the main cause of decline in 86% of the world's vulture species (Buechley & Şekercioğlu 2016). Using data from the last 50 years, poisoning accounted for 61% of African vulture deaths, including cases of both deliberate and unintentional poisoning (Ogada et al. 2016). Deliberate vulture poisonings are related to the recent upsurge of poaching for ivory and rhino horn. Poachers lace carcasses with poison to kill the vultures that may alert the authorities to their illegal activities (Ogada et al. 2015). Unintentional poisoning results from farmers lacing carcasses, or small pieces of meat, with poison to attract and kill predators like jackals, caracals, hyenas and lions that threaten their livestock (Ogada 2014). Vultures that feed opportunistically on the contaminated meat are then poisoned. Vultures typically feed in large flocks, and a single incident can result in hundreds of individuals being poisoned (Anderson 1994, Ogada et al. 2012).

At the 2012 Pan-African vulture summit, Namibia was identified as a poisoning 'hotspot' in Africa (Botha et al. 2012). Poisoning is the main factor which contributed to the recent up-listing of six vulture species, five of which occur within in Namibia. Furthermore, vultures traverse great distances across the continent (Bamford et al. 2007; Urios et al. 2010; Phipps 2011), therefore one poisoning hotspot can have devastating impacts on the southern African vulture population as a whole. This study aims to gather information which will help the all stakeholders better understand the prevalence and context of poison use by farmers in Namibia.

Namibian commercial farmers could historically access poisons such as arsenic and strychnine on prescription from vets for controlling predator populations (L.Komen & C.Brown, pers.comm). This ceased in 2001 but some farmers still have stores of these poisons and in addition many also poison predators with pesticides intended for insects and rats which are available freely at agricultural retail shops (Santangeli et al. 2016). In the 1980s, between 30% and 80% of commercial farmers were using poison (Simmons et al. 2015). The highest prevalence of poison use was in the south of the country where small livestock farming is dominant (Simmons et al. 2015). A 2015 survey (Santangeli et al. 2016) found fewer commercial farmers (about 20%) were using poison, compared to the previous survey. Most farmers reported that they used small pieces of meat and left them for predators, with a minority of farmers poisoning whole carcasses (Santangeli et al. 2016). The latter poses a much greater threat to vultures because a whole carcass can be more easily detected by many vultures. However small pieces of meat can be equally problematic as vultures can be secondarily poisoned if they feed on the poisoned predator. Farmers who admitted to using poison typically had large farms with a large number of small livestock (typically farmers in the south) and high losses to predators (Santangeli et al. 2016). While the use of poison has been comprehensively surveyed in the commercial, freehold land of Namibia, little is known about this practice in the communal farmlands.

Incidental reports indicate that poison is used occasionally by communal farmers (Sullivan 2016; Komen, pers.comm; Hoth-Hanssen.pers. comm). This is unsurprising given that conflict between communal farmers and wildlife remains an issue with the cost to all of Namibia's communal farmers once estimated to be at N$7 million per annum (Jones & Barnes 2006). Poverty is rife in the communal farming areas (Namibia Statistics Agency 2010) and these losses have inordinate impacts on farmers' livelihoods. Human-wildlife conflict is not uniform across the landscape, for example farmers adjacent to protected areas appear to experience higher losses due to their proximity to higher densities of predators (Brown 2011). In 2011 a scheme was set up to compensate communal farmers for losses due to wildlife (Morrison 2012). However this scheme has faced challenges, primarily due to difficulties in securing funding and in the timely processing of claims (Morrison 2012).

Legislation that allowed rural communities to form a local common property resource management institution, or conservancy was enacted in 1996 (Jones 2010). The goal was to conserve depleted wildlife populations in these areas and to improve local livelihoods, through the sustainable utilisation of wildlife resources. The formation of a conservancy is voluntary and the requirements are that community members form a committee, develop a management plan and decide on borders (Jones 2010). The committee then has rights to make decisions, in democratic consultation with members, about tourism, joint-ventures, hunting, the use of wildlife and conflict between people and wildlife. The logic is that if communities receive tangible benefits from wildlife, they are more inclined to see value in wildlife and to take steps to conserve it (Adams & McShane 1992). The first communal conservancy in Namibia was registered in 1998 and since then 82 conservancies have been formed, covering large portions of the communal land (NACSO 2016a). While community based natural resource management initiatives have been globally controversial (Distefano 2005; Degeorges & Reilly 2009), Namibia's communal conservancies are typically reported as one of the success stories in Africa and worldwide (Jones 2010). In many areas conservancies have allowed wildlife populations to recover, but this success has caused increased conflict as wildlife, particularly predator and elephant, numbers have increased (Stander 2006; Naidoo et al. 2011a, 2011b). Despite this conflict, conservancy membership may improve farmer perceptions towards predators, this has been demonstrated with commercial farmers in Namibia who belong to conservancies (Schumann et al. 2008).

In many cases, conflict with predators will result in retaliatory killing which may include the use of poison. According to the national laws, farmers may only kill a carnivore if it poses an immediate danger to a human or to livestock (Ministry of Environment & Tourism 2009). If a farmer kills a predator that does not pose an immediate danger, the act is considered illegal and the perpetrator can be apprehended for poaching. Additionally, using poisons to kill predators is illegal under all circumstances, and if caught, the person responsible can be arrested.

Assessing illegal behaviour in an interview setting can be particularly difficult as the answers given can be subject to social desirability and non-response bias (Nuno & St John 2015). To minimise this, interview techniques have been developed to explore such sensitive topics. One of the most popular ways to assess people's relationships with predators is to measure their attitudes, however this method is fairly indirect and may not be a good predictor of peoples' behaviour. More direct approaches are available which have been especially formulated for sensitive questions. For example, asking people about their peers' behaviour may give an indication of their own behaviour via a psychological phenomenon called the 'false consensus effect' (see Methods). However, in some cases it is desirable to ask interviewees directly about their behaviour, and a number of techniques were designed to provide a degree of anonymity when answering sensitive questions (Warner 1965; Nuno & St John 2015). These techniques work by adding a degree of uncertainty to the individual's answers, which makes it impossible to know the actual answer of the individual respondent with certainty. The prevalence of the behaviour can nevertheless be estimated based on the known probabilities of the uncertainty introduced by the method (Nuno & St John 2015).

With this study, I aim to gain a better understanding of poison use by farmers in the communal land of Namibia. I will use the methods discussed above to quantify the prevalence of poison use. I will then map this prevalence to identify poisoning 'hotspots'. In addition, I seek to understand the socio-ecological context that supports the use of poison and the lethal control of predators. This information will not only allow government and conservancies to target their mitigation strategies to 'hotspot' areas, but it will also allow them to develop effective strategies which take into account the main drivers of poison use.

METHODS

Study landscape and farming context

This study focused on the communal areas located in central and northern Namibia, excluding the Caprivi and Kavango regions (Fig. 1). Most field sampling was concentrated within communal conservancies that host communities that practise subsistence herding and agriculture (Fig. 2). Some people living within communal conservancies are employed through hunting and tourism operations and/or receive monetary or in-kind benefits from these activities. Overall, the rainfall in Namibia is variable and unpredictable which makes farming in Namibia especially difficult. For the four years prior to this study, Namibia experienced a severe drought (Schnegg & Bollig 2016) and many farmers have been forced to move to other areas in search of adequate grazing. During the drought, many farmers were losing animals due to starvation, and additional losses due to predators were particularly damaging in this time.

Namibia has a very low population density with just 2.6 people per square kilometre with roughly half of the population living on communal land (Kafidi 2011; Mendelsohn et al. 2011). During the colonial period, different ethnic groups were allocated to certain areas or homelands (Fig. 1). These homelands were declared communal land following independence in 1990 but the spatial distribution of ethnic groups across the country is still distinct (Mendelsohn et al. 2011). Communal land is, for the most part, not fenced (unlike the commercial farmland). The combination of many farmers grazing in one area has led to some areas becoming severely overgrazed (Mendelsohn 2006).

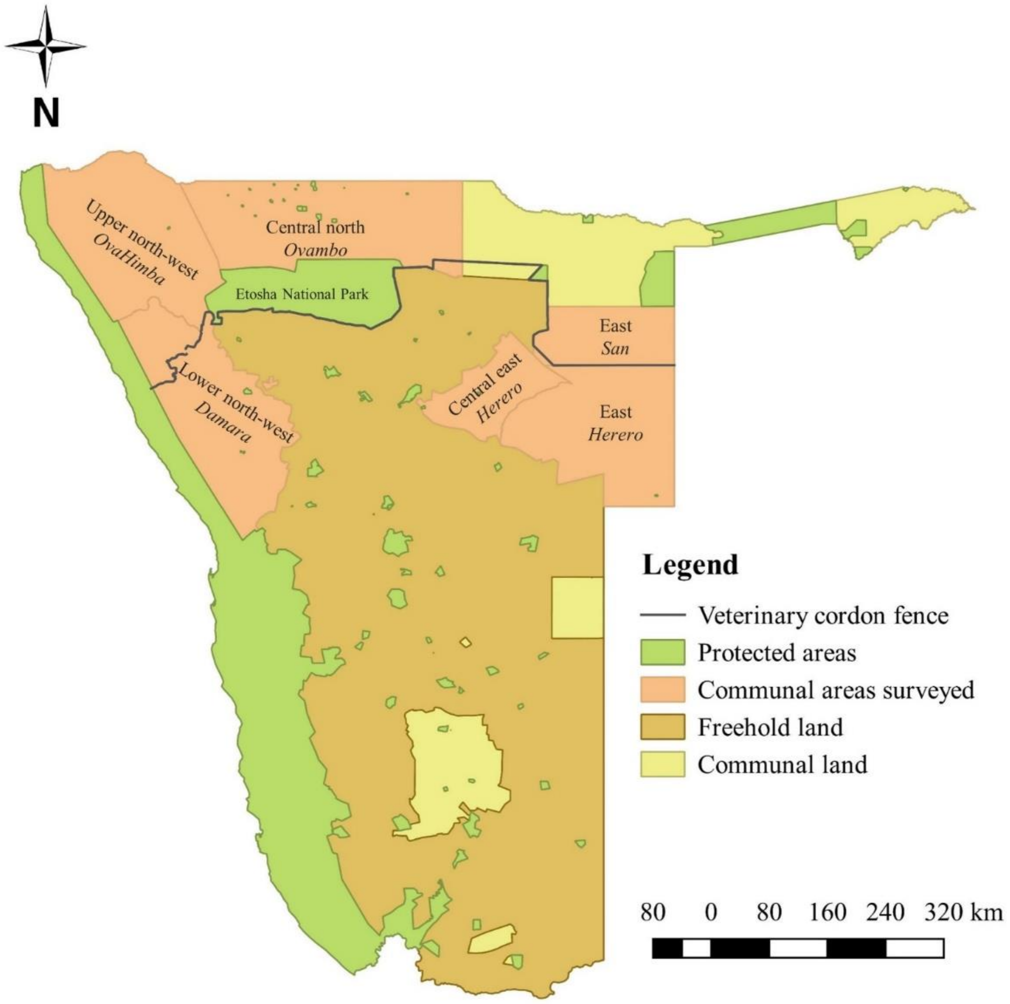


Figure 1: The land allocation (communal, protected and freehold) in Namibia and the communal regions that I surveyed (the ethnic group which was allocated to each region or homeland prior to independence is presented in italics). Spatial layers from Mendelsohn et al. (2003), accessed from EIS (2016)

Farming in the communal areas is largely for subsistence, however some farmers sell livestock. The type of livestock that people farm differs according to geographic location. The upper north-west and eastern regions receive higher rainfall and the savanna vegetation here can support cattle farming (Mendelsohn et al. 2003). The lower north-west is much drier and the Karoo vegetation is better suited to goat and sheep farming (Mendelsohn et al. 2003). The north central region is the only area surveyed which receives enough rainfall to support widespread crop farming, people living there cultivate mainly maize (*Zea mays*) and mahangu (pearl millet *Pennisetum glaucum*) (Mendelsohn et al. 2003).

Respondent selection

Surveys were conducted between September and December 2016, with the study unit for the survey being the household. The location of the homestead was recorded at the farm or pointed out by the farmer on a map if I was not at the farm. Locations have been kept confidential in order to protect the identity of the farmers, however I provide an indication of sampling density to show the coverage of the area (Fig. 2). In some cases, myself and the research assistants would interview one person representing the household and in other cases the whole household was present and all members contributed to the interview. Interviewing some households as a group poses challenges as people's answers may influence each other. However, I found that people were more willing to speak when surrounded by their peers so on the whole such interviews enhanced the data collection, especially when broaching sensitive topics. On average, interviews took 21 minutes, ranging between 7 and 53 minutes. Overall 367 farmers were interviewed. The majority (n = 267) of the farmers were interviewed on their farms. Farmers were selected using a systematic approach, a route was chosen and approximately every 10 kilometres I would stop to speak to a farmer (Kelley et al. 2003). Often, I would drive off the main road to reach a farm. The remaining interviews not conducted at the farm (n = 100), took place at agricultural shops, using a convenience sampling technique (Kelley et al. 2003; Santangeli et al. 2016).While this approach is not random and systematic like driving to farms, it did allow me to bolster my sample size, by gathering data quickly while minimising travel costs. I believe this benefit to outweigh the costs of non-random sampling.

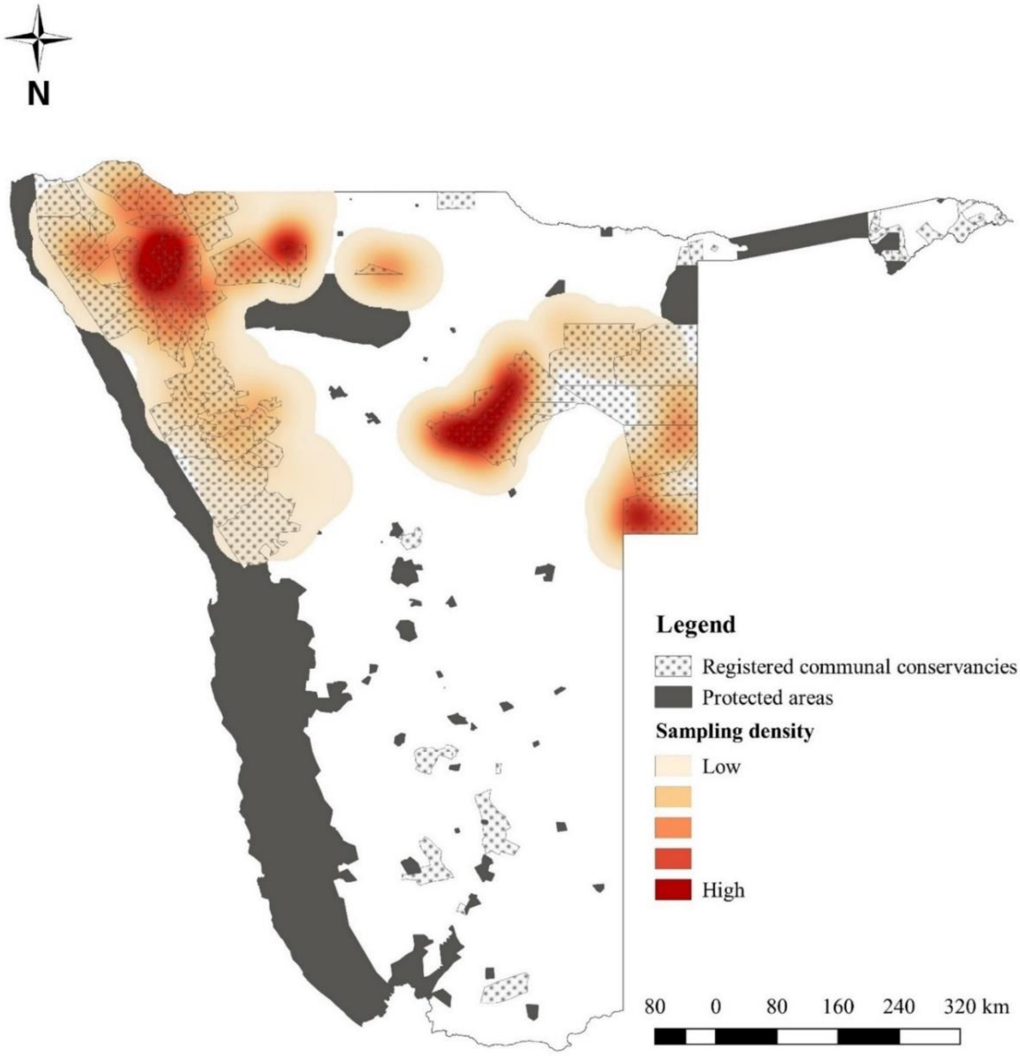


Figure 2: The density of the households sampled across the study region and the location of all registered communal conservancies. Spatial layers from NACSO (2016b), accessed from EIS (2016)

Interviews were conducted in Afrikaans, Damara, Otjiherero, Oshiwambo and English. The same local field assistant translated for me during most interviews. While sampling in the central north, Oshiwambo translation was facilitated by a second field assistant more familiar with the language than the primary field assistant. When approaching farmers at farms, almost all agreed to participate in my survey, those who declined did so because they were not involved with the farming or because they did not own livestock. Farmers in the agricultural shop declined to participate more often, mainly because they were busy. I explained the research topic to each farmer and told them that all their responses would be kept anonymous. Their consent was given verbally, when their consent was translated back to me, I would sign the consent form on their behalf. This study protocol was approved by the UCT ethics committee (Approval code: FSREC 044 – 2016).

Survey design and method

Our survey included a set of 36 structured questions, with a mixture of close ended and open-ended questions (Appendix 1). The survey was divided into seven sections. The first section covered basic demographic information about the household. The two potentially sensitive questions, about ethnicity and age were asked after the interview was completed, once a relationship had been established (Babbie et al. 2014).

The second section dealt with questions about their livestock and losses to predators. The number of livestock lost to predators can be important in predicting whether farmers will resort to killing predators (Santangeli et al. 2016). When I asked farmers what livestock they owned many would omit chickens, horses and donkeys as farmers do not value them as much as cattle, sheep and goats. I make the assumption that those who did report them placed value on them. Since farmers are only likely to consider killing predators that have predated upon livestock that are valuable to them, for the purposes of this research it is sufficient that farmers reported only livestock that they valued.

In the third part, I asked questions to gain insight into what the farmers thought was the best way to protect their livestock against predators, and how long ago they lost livestock. This was to assess whether people who have lost livestock more recently have different attitudes towards predators than if they had lost livestock a long time ago. I also asked farmers about damages to their crops or infrastructure by wildlife. The extent to which people experience damage due to wildlife may influence their attitudes to wildlife.

In order to better understand the relationship between farmers and wildlife, predators and lethal predator control I did an assessment of their attitudes, using a five point Likert scale. To distinguish between wildlife and predators, I would refer to wildlife as those animals that eat plants and predators as those who eat meat.

The assessment of attitudes, to better understand human behaviour, stems from early psychological theories that attitudes determine behaviour (Armitage & Christian 2003). However, debate remains whether attitudes can accurately predict behaviour (Armitage & Christian 2003; Ajzen & Fishbein 2005; Waylen et al. 2009a; Nuno & St John 2015). The translation of attitudes into behaviour is mediated by a number of factors including the societal norms around the behaviour as well as the person's perceived control over their behaviour (Armitage & Christian 2003). Additionally, the actual measurement of attitudes can be skewed due to people wanting to give a good impression to the interviewer (Ajzen & Fishbein 2005). Nevertheless, in order for a behaviour to take place it needs to be supported by the appropriate attitude, for example in order for a farmer to kill a predator they would need to have a positive attitude to lethal predator control, whereas someone opposed to lethal predator control will not kill a predator (Kansky et al. 2014). Therefore, measuring attitudes can still be informative, but when assessing the prevalence of a behaviour, it is not advisable to rely solely on the measures of attitudes.

Sensitive questions

The first way in which I assessed poison use was asking farmers about their peers' behaviour. Using this information, I can then make deductions about the farmers behaviour, based on a psychological theory called the false consensus effect. This effect describes the tendency for people to assume that their peers think and behave similarly to themselves and has been demonstrated to be a fairly robust method for assessing illegal behaviours (Ross et al. 1977; Petróczi et al. 2008; St John et al. 2012). In order to directly assess poison use, I asked four questions using the randomised response technique (RRT). The technique has been widely used in the conservation context and has been shown to be effective with people with limited literacy levels, as in the case of this study (Solomon et al. 2007; Blank & Gavin 2009; St. John et al. 2010; St John et al. 2012; Nuno & St John 2015; Santangeli et al. 2016).

There are variations of the randomised response technique, I used the forced response design (Blair et al. 2015). Here a randomising device is used to dictate a response to the participant, this can be a dice or a selection of marked balls. I used a set of coloured balls. To introduce some uncertainty into the answers, the randomisation produces three options. The first option (white ball) requires the participant to answer honestly to a yes/no question, the second option (yellow ball) forces the respondent to say yes and the third option (blue ball) forces the respondent to say no irrespective of what the truth is. I chose a ratio of 8:1:1 for these options which introduces a 20% uncertainty in the answer. The technique gives the respondent protection as only they will know what colour ball they picked. For example, if the participant answers yes to a sensitive question, the interviewer will not know if they were forced to say yes or if they answered honestly. The results can then be analysed using the probability that 10% of the answers were a forced 'no' and 10% were a forced 'yes' (Blair et al. 2015; Nuno & St John 2015). I can then make deductions about the prevalence of the illegal behaviour in the sample. This technique allows the respondent to answer honestly without detection, and it has been proven to be effective in eliciting truthful answers from people (St. John et al. 2010; Cross et al. 2013). Given the sensitive nature of these questions, they were placed at the end of questionnaire to allow time for the interviewees to become comfortable with me (Babbie et al. 2014). I asked four RRT questions: whether they had killed a predator, whether they had used poison, whether they would use poison and whether they had accidentally killed a vulture (Appendix 1).

When I administered the RRT questions some interviewees either did not understand the technique or did not want to use it. Of the 353 interviews included in the analysis (see Results), 138 (39%) did not use the technique. Since there seemed to be a lack of understanding in some cases, I would give the interviewee the opportunity at the end of the interview to tell me the colours of the balls that they drew, if they wished. This allowed me to check whether the interviewee had followed the 'rules' of the technique.

Sixty-one (17 %) of the interviewees did not follow the rules. Understandably when someone drew a yellow ball, they were reluctant to say yes if they had not done what the question was asking. When someone had not used the RRT or had not followed the rules I would assume their answers to be true. For the sake of consistency, I would draw the balls ourselves afterwards and defined the answers according to which colours I drew.

For most questions, I asked specifically about events that occurred within the last year. This one year period would be a sufficient time period for people to recall events fairly accurately. Twelve of the farmers interviewed had lived in the area for less than one year. In these cases, they would answer the questions pertaining to others' behaviour based on knowledge they have from their neighbours. When answering the RRT questions, they would recall from the last year even if they had not been living in the area. For these farmers, I make the assumption that a person's tendency to use poison would not change based upon their location alone. A longer time period of five years was used for the questions involving vulture mortalities and the vulture population trend. If people had been farming in the area less than five years I did not consider their answers to the vulture population question. I included reports of vulture mortalities from people who had lived in the area for less than five years.

After the first 90 interviews, I decided to add two questions. I asked about vaccination of livestock to assess disease risk in these communities. During drought, many people struggle financially and may choose to forgo vaccinations if they cannot afford them. Given that vultures are important for controlling infectious pathogens, a decreasing vulture population as well as a reduction in the number of people vaccinating could result in outbreaks in disease such as anthrax. The last question was added as I began to notice that reported poison use appeared lower in the communal areas than on commercial farms. I asked the farmers why they thought this was the case, their opinion on this could shed light on why communal farmers choose not to use poison.

Statistical analysis

Analysis of attitudes to lethal predator control

In order to understand which socio-ecological variables explain farmers' attitude to lethal predator control I fitted three Generalized Linear Models (GLMs). The response variable, attitudes to lethal predator control, was coded as one indicating a positive (somewhat or strong) attitude towards lethal predator control and zero indicating a negative (somewhat or strong) attitude towards lethal predator control. The five respondents who had neutral attitudes towards this practice were removed from this dataset for these analyses. The error structure was assumed to be binomial with a logit link function.

I first used the full dataset (n = 350) to explore which socio-ecological variables explained farmers' attitude to lethal predator control. I considered six explanatory variables. These included: percentage of livestock lost in the last year (continuous variable), whether the household depends on livestock for their primary income (binomial, yes or no), location (x and y coordinates) of the household (continuous), how far the household is from a protected area (continuous), and lastly whether the farmer was registered with a conservancy (binomial, yes or no). The location of a farmer may influence their attitudes towards lethal predator control as certain areas experience a greater number of losses to predators. Farmers living within conservancies may succeed in conserving wildlife (i.e. game), but this may attract predators, causing increased conflicts. At the same time, these farmers may need to comply with the conservancy rules, thereby refraining from killing predators, which may also shape their attitude to lethal control of predators.

I then used a sub-set of the dataset (n = 302) where farmers who did not live within a conservancy were excluded. This subset of the data was analysed in order to quantify the impact that the benefits derived from belonging to a conservancy has on farmers' attitude to lethal predator control. In this model, I used the same set of predictors used in the above model, with the addition here of a variable (binomial yes or no) depicting the benefits from belonging to a conservancy (namely meat from hunts and in some conservancies monetary pay-outs from tourism activities). The subset of the data used for this analysis also included surveys from farmers who physically lived within the boundaries of a conservancy but were not members of it. This is because such farmers occasionally reported receiving benefits from the conservancy.

Lastly, I used another subset of the data (n = 267) including only farmers who lost livestock to predators in the last year. This subset of the data was used to test whether the time elapsed since last losing livestock to a predator impacts a farmers' attitude to killing predators. I considered six predictor variables: percentage livestock lost in the last year, reliance on livestock for primary income, location of the household, distance from the nearest protected area and time elapsed (in months) since the household last lost livestock to predators. I expect that those who lost livestock more recently would be more likely to be in favour of lethal predator control.

Prior to fitting the models, I used a variance inflation factor analysis to check for collinearity amongst the chosen variables. No variables were found to be correlated ($r < 2$) so I ran all model combinations, ranking the models according to the Akaike Information Criterion (AIC). No clearly superior models were identified based on AIC, therefore I used a model averaging and multi-model inference approach based on all models within the 95% confidence set. I calculated the relative importance of each variable based on the sum of the AIC weights over all models considered during model averaging.

Analysis of poison use

In order to calculate the proportion of farmers answering yes to the RRT questions, I used the following formula detailed in Hox & Lensvelt-Mulders (2004):

$$\text{Prevalence of behaviour} = \frac{\text{Proportion of 'yes' answers in the sample - probability that a 'yes' answer was forced (0.1)}}{\text{Probability that an answer was true (0.8)}}$$

Of the 367 interviews, six were excluded for this analyses due to missing data, one because of translation issues, four because they were resettled farmers, two because they obviously exaggerated their livestock numbers (over 1000 cattle for one household) and livestock losses (close to 100% of livestock lost) and one household because their distance to protected area was a clear outlier (68m with the next closest being 770m). The latter household was not removed because of an inaccuracy in data collection (the household in question lived right on the border of Etosha) but because this outlier skewed the data, making it difficult to model. The final data set included 353 interviews. Among all available variables resulting from the questions, I *a priori* chose 14 socio-ecological variables as predictors of poison use, I chose variables that I deemed relevant and had no missing data. I used a variance inflation factor analysis to check for collinearity amongst the chosen variables. One variable, ethnicity, was excluded as it was strongly correlated with the spatial information, this is as a result of the spatial separation of ethnic groups in Namibia.

I included distance to protected area because I expected that farmers living closer to protected areas experience greater conflict with wildlife (Newmark et al. 1994; Gillingham & Lee 2003; Brown 2011; Karanth et al. 2012). The spatial variables were included in order to account for spatial trends in poison use (Santangeli et al. 2016). I included household size as large households may be less tolerant to losses as resources need to be spread among more people. I included conservancy membership as a predictor with two levels: conservancy member and non-conservancy member (both those who live within a conservancy and those who live outside of conservancy boundaries). I expect farmers who are members of the conservancy to be less inclined to use poison as they are committed to the conservation principles of the conservancy. This was seen in research with Namibian commercial farmers, where those who belonged to conservancies were more inclined to be tolerant of carnivores on their farms (Schumann et al. 2008).

Another set of explanatory variables included in the model were based on attitudes of the farmers to wildlife, predators and vultures (see Appendix 2 for information on the data collected about attitudes to vultures). I had seven items in the survey which assessed these attitudes. In order to reduce these items into a few attitude variables, I did a spearman's correlation to test for correlation between these items. The correlation between the wildlife attitude items (Question 13a & b) (Spearman's rho = 0.6, $n = 353$, $p < 0.01$), two of the predator attitude items (Question 13c & d) (Spearman's rho = 0.6, $n = 353$, $p < 0.01$), and the vulture attitude variables (Question 21 & 22) (Spearman's rho = 0.7, $n = 353$, $p < 0.01$) was sufficient to include just responses to question 13a, 13c and 21a as variables in the analysis. Those with positive attitudes towards wildlife, predators and vultures may be less inclined to use poison as these attitudes indicate that they value biodiversity. The correlation between the item, "Predators that kill livestock should be killed" and the the other predator attitude items (Question 13c & d) was poor (Spearman's rho = -0.4 ($n =353$, $p < 0.01$) and -0.3 ($n =353$, $p < 0.01$) respectively). This item was therefore included as a separate variable, attitude to lethal predator control. Those who have a positive attitude to lethal predator control may be more inclined to use poison.

The number of large livestock and the number of small livestock owned by the household were also included. I expect those owning more livestock, especially small livestock, to experience more conflict with predators and therefore be more inclined to use poison (Schumann 2009; Santangeli et al. 2016). I also included the number of large and small livestock lost in the last year. Farmers are known to exaggerate the number of livestock lost (Oli et al. 1994; Marker et al. 1996), however in this study the farmers' perception of loss is more informative than their actual losses. In Namibia communal and resettled farmers who *perceived* higher losses to predators removed more predators than those who perceived lower losses (Rust & Marker 2014). A study from the U.S. came to similar conclusions (Wywialowski 1994). I separated large and small livestock as small livestock tend to be predated more often (Rust & Marker 2014) and therefore may be more important in predicting poison use, as in the study by Santangeli et al. (2016).

The relationship between poison use and the 13 predictors was analysed using Generalized Linear Modelling (GLM). The error structure associated with the model was assumed to be binomial with a link function appropriate for randomized responses. This consists of a modified logit link function that incorporates known probabilities of the forced RRT responses (van den Hout et al., 2007). I ran all model combinations using the 13 predictors. The models were ranked using the Bayesian Information Criterion (BIC). An initial analysis lead to many non-converging models (over 70 %). This problem was solved through a Monte Carlo resampling approach, computing all model combinations on 50 resampled datasets. In each resampled dataset, the number of zeroes and ones in the response variable was kept equal. This lead to a total of 144 495 models, reaching convergence across the 50 datasets. Model averaging was performed on each resampled dataset, computed as the average of all the regression coefficients weighted by their BIC weights. A coefficient for each variable was obtained by taking the mean of the coefficients from the 50 averaged models. For each dataset, a measure of relative importance as calculated using the ratio of absolute values of the t statistics for unstandardized predictors. The model averaged predicted values from the 95% confidence set were used to map the probability of poison use across the communal regions surveyed. An interpolated map of these modelled data was created using the inverse distance weighting interpolation method.

All models were fitted using R 3.3.2 (R Core Team 2016). To fit the attitude models I used the MuMin package (Barton 2016). To fit the poison use models, the RReg package was used (Heck & Moshagen 2016). Inverse distance squared weighting interpolation was performed using the v.surf.idw GRASS GIS module (Neteler & Mitasova 2013). All maps were created using QGIS (2.18.3) software (QGIS Development Team 2016).

RESULTS

Socio-ecological information about the interviewed farmers

The majority of the farmers interviewed were men (78%, n = 353). Most of the farmers interviewed identified as Himba (30%), Herero (26.3%), Damara (14.1%) or Ovambo (13.9%). The remaining farmers identified as Ovazemba (4.8%), San (2.5%), Riemvasmaker (1.7%) and Kavango (1.1%). A small percentage of the farmers (totalling 5.6%) identified as Baster, Caprivian, Damara-Nama, Nama and other minority groups. On average the households interviewed housed 9 people (SD 9, range 1-60). Himba (mean 13, SD 11), Ovazemba (mean 12, SD 12) and San (mean 11, SD 15) households had, on average, twice as many people as Damara (mean 7, SD 8), Ovambo (mean 6, SD 5) and Herero (mean 8, SD 7) households. The mean age of the interviewees was 42 (SD 16, range 18-86). Most households were registered with a conservancy (59%), 29% of households lived within a conservancy but were not members. In total, 28% of households reported that they received benefits from the conservancy, mainly in the form of meat which is distributed after a hunt. The mean length of time that households had been farming in the area was 24.7 years (SD 19.6, range 0.08-90).

Drought was the predominant cause of livestock loss for 79% of the farmers, followed by predators (11%), disease (4.8%), poisonous plants (3.4%) and theft (1.4%). Of those I asked (n =263), 83% of farmers had vaccinated their animals in the last year and many farmers reported that the government helped them with vaccinations. While drought was the main cause of livestock loss, 80% of farmers had lost livestock to predators in the last year. A total of 47% of farmers had lost more than a tenth of their livestock (Fig. 3). Just six per cent of farmers who had lost livestock in the last year (n = 281) reported that they received compensation from the conservancy for their loss, compensation for cattle amounted to roughly half the average value and for a goat the compensation given was about a quarter of its average value.

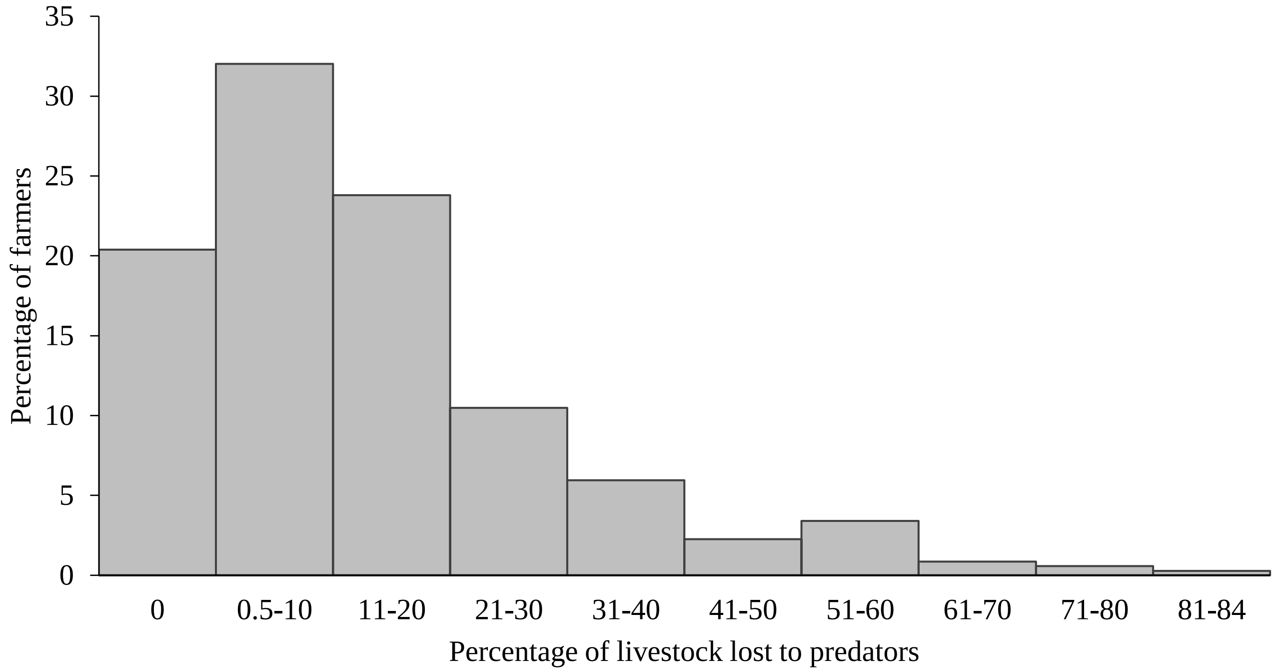


Figure 3: The percentage of farmers interviewed who reported losing livestock to predators, grouped by the percentage livestock lost

Farmers in the central east were the wealthiest in terms of livestock capital, mainly because they owned more cattle than farmers in other regions (Table 1b). This wealth was evident, with many farmers in these regions having houses and fenced land which resembled commercial farms. In contrast farmers in the lower north-west and central north were poorest with regards to livestock capital (Table 1b). However, a number of farmers in the central north did not rely primarily on livestock and instead grew crops. Farmers in the upper north-west lost the greatest percentage of livestock to predators, compared to the other regions. There was no correlation between the number of livestock owned and the percentage of livestock lost (Pearson's correlation coefficient: small (goats, sheep, chickens) = -0.2 ($n = 353$, $p < 0.01$) and large (cattle, donkeys, horses) = -0.2 ($n = 353$, $p < 0.01$). In contrast, there was a weak positive correlation between the number of livestock owned and the number of livestock lost (Pearson's correlation coefficient: number of large livestock vs. number of large livestock lost = 0.4 ($n = 353$, $p < 0.01$); number of small livestock vs. number of small livestock lost = 0.4 ($n = 353$, $p < 0.01$)). The percentage of goats and sheep lost to predators was three times higher than the percentage of cattle lost (Table 1a). In monetary terms capital loss due to predation of cattle was double that of capital loss due to predation of sheep and goat (Table 1b). There was no relationship between percentage livestock lost and distance to protected area (Pearson's correlation coefficient = -0.2 ($n = 353$, $p < 0.01$)). Herding, herding dogs and keeping livestock in kraals were cited by 83% of farmers as being the best means to protect their livestock from predators.

Table 1a: Total percentage of livestock lost to predators by all farmers surveyed in each region (Fig. 1); **b:** Mean livestock capital* owned and mean livestock capital* lost to predators, per region, with the standard deviation of these means and the number of farmers (n) in each region (Fig. 1) that owned, and lost, the specified livestock (zero values were excluded when calculating means)

a.		**Cattle**	**Sheep & Goats**	**Donkeys & Horses**	**Chickens**	**Total livestock**
Central east	% livestock lost	3.4	16.0	0.0	0.0	9.6
East	% livestock lost	2.4	12.1	2.2	0.0	5.5
Central north	% livestock lost	4.8	12.7	1.5	29.4	9.7
Upper north-west	% livestock lost	7.9	17.0	46.2	-	14.5
Lower north-west	% livestock lost	7.7	13.7	9.4	24.6	12.5
All regions	% livestock lost	5.8	15.4	7.3	22.9	12.1

b.		**Cattle**			**Sheep & Goats**			**Donkeys & Horses**			**Chickens**			**Total livestock**	
		Mean (N$)	**SD**	**n**	**Mean (N$)**	**SD**	**n**	**Mean (N$)**	**SD**	**n**	**Mean (N$)**	**SD**	**n**	**Mean (N$)**	**SD**
Central east	Livestock capital owned	281 099	311 298	45	34 858	39 025	65	6 017	3 526	5	443	0^*	1	128 843	229 757
	Livestock capital lost	40 228	54 092	11	8 752	7 500	49	-	-	0	-	-	0	14 522	26 316
East	Livestock capital owned	270 842	326 009	29	23 509	22 589	31	4 314	2 524	12	1 292	261	2	116 724	237 790
	Livestock capital lost	17 339	14 908	11	5 605	4 062	18	1 500	0^*	1	0	0	0	9 771	11 007
Central north	Livestock capital owned	121 950	175 388	32	36 309	54 571	38	9 503	10 206	14	886	313	2	62 988	121 325
	Livestock capital lost	19 455	15 412	10	12 585	12 859	16	2 047	0^*	1	738	0^*	1	14 239	13 964
Upper north-west	Livestock capital owned	160 353	236 245	112	52 522	63 872	168	3 582	724	2	-	-	0	95 002	165 263
	Livestock capital lost	22 225	26 437	69	12 878	18 132	141	6 140	0^*	1	-	-	0	15 902	21 569
Lower north-west	Livestock capital owned	148 660	279 216	68	39 263	43 075	142	9 341	13 097	37	1 292	902	21	59 902	153 053
	Livestock capital lost	26 464	17 412	32	8 250	7 729	107	4 085	2 325	8	20 915	1 381	6	11 569	12 860
All regions	Livestock capital owned	183 478	268 365		42 283	52 061		8 110	10 747		1 099	826			
	Livestock capital lost	24 121	26 763		10 361	13 462		3 851	2 287		1 213	1 278			

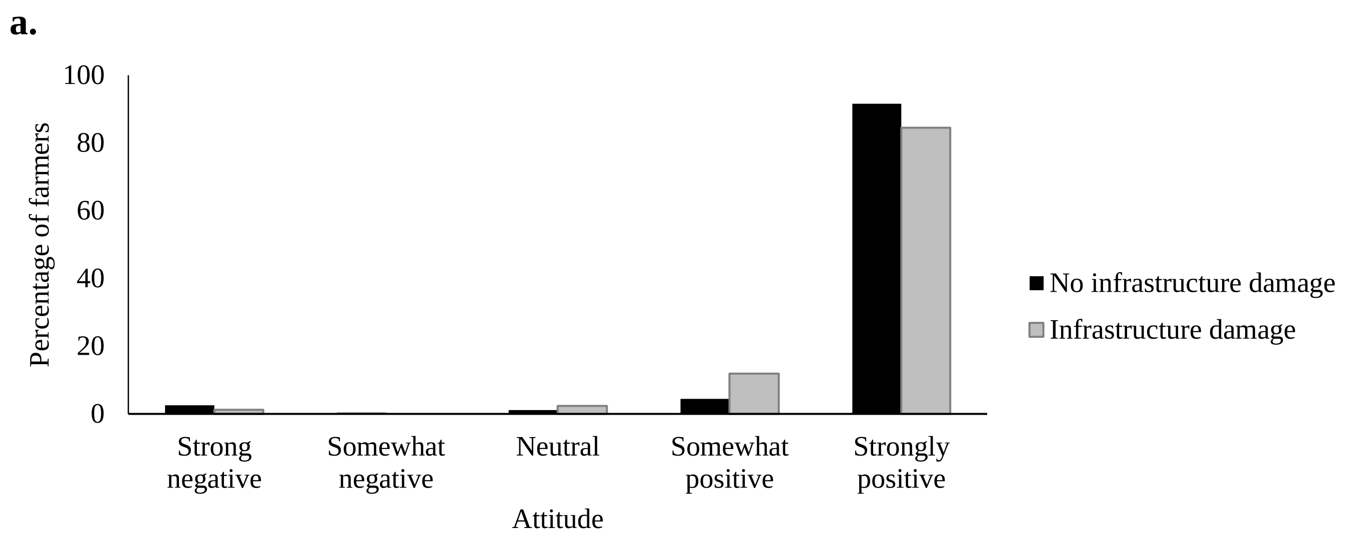
* capital was calculated using the mean of approximate livestock values as reported by the farmers (Cattle N$ 3 814 (SD =1 775), Sheep N$ 742 (SD =323), Goat N$ 823 (SD = 574), Donkey N$ 1 023 (346), Horse N$ 1 500 (SD = 707), Chicken N$ 74 (SD = 21);* SD could not be calculated as there was only one farmer in the sample, the corresponding value in the mean column is the value of that single farmer's livestock, in lieu of the mean

The majority (over 60%) of farmers who had lost goats or sheep reported that jackals were responsible. Spotted hyenas and leopards were primarily responsible for large livestock predations. There were some regional differences in these trends, for example farmers in the central east region reported that wild dogs were the main predator responsible for cattle predations. Eagles (thought to be black eagles *Aquila verreauxii)* were primarily responsible for chicken mortalities. Farmers living along the Kunene river reported that crocodiles were primarily responsible for their livestock losses. There were 11 instances of people losing goats and sheep to baboons.

Attitudes to wildlife, predators and lethal predator control

Ninety per cent of farmers interviewed had strongly positive attitudes towards wildlife. Farmers stated that wildlife were important because of their intrinsic value and also for their value to the tourism and hunting industry. Twenty-four per cent of the farmers had had their infrastructure damaged by wildlife in the last year. Elephants were almost solely responsible for these damages, which were mainly to water pipes and pumps. This damage did not have an obvious impact on the farmers' attitudes towards wildlife (Fig. 4a). Twenty-one per cent of farmers reported damage to crops by wildlife, this damage also did not have a major impact on their attitudes towards wildlife (Fig. 4b).

Conversely 73% of farmers held strongly negative attitudes towards predators. The minority (20%) who had positive attitudes towards predators valued them because of their role in the tourism and hunting industry and for their intrinsic value. Seven farmers emphasized that predators should be in the communal areas so that their children could see them. The majority (82%) of farmers had positive attitudes towards the lethal control of predators that kill livestock.



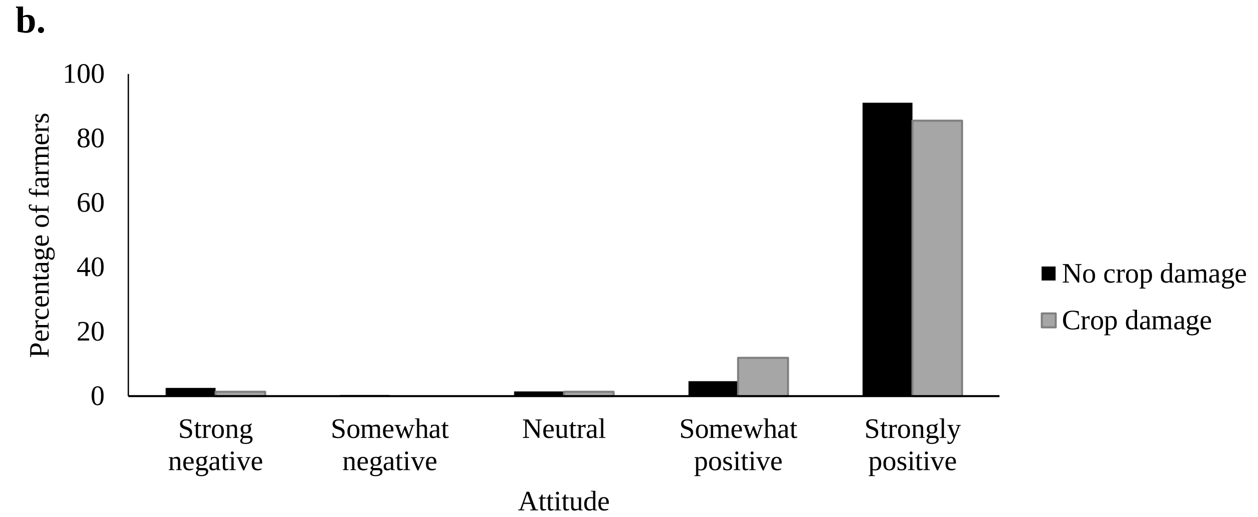


Figure 4: Comparing the attitudes of communal farmers to wildlife **a.** who have and have not experienced infrastructure damage from wildlife in the last year; **b.** who have and have not experienced crop damage from wildlife in the last year

Households who are primarily reliant on livestock for their income, and those who have lost a large percentage of their livestock to predators, were most likely to be in favour of lethal predator control (Table 2a). In comparison, household location, the distance of the household to a protected area and whether the household belongs to a conservancy were less important in predicting farmers' attitudes to the lethal control of predators (Table 2a).When I only considered households within conservancy land (registered members and non- members), those who rely primarily on livestock for their income and have lost a higher percentage of their livestock to predators were more likely to favour lethal predator control (Table 2b). Receiving benefits from the conservancy has some effect on people's view on lethal predator control i.e. those who receive benefits are somewhat less likely to be in favour of lethal predator control (Table 2b). Conservancy membership, location and distance to protected area were less important in predicting farmers' attitude towards lethal predator control (Table 2b).

I found that the time elapsed since last losing livestock to predators had a strong effect on farmers' attitudes towards lethal predator control (Table 2c). Those who had more recently lost livestock were more likely to be in favour of lethal predator control. The latitude of the homestead correlated to some extent with their attitudes to lethal predator control (Table 2c). Those living further north were more likely to have positive attitudes towards lethal predator control. However, longitude and distance to protected area were poor predictors of farmer attitudes towards lethal predator control (Table 2c).

Table 2. Predictors of farmers' attitude to lethal predator control as obtained from three separate Generalised Linear Models (GLMs) considering in turn **a)** livestock factors, location and conservancy membership (using the full dataset); **b)** livestock factors, location, conservancy membership and conservancy benefits (using a subset of the data where farmers outside of conservancy land are excluded); **c)** time since last predation, location and livestock factors (using a subset of the data where only farmers who lost livestock in the last year are included). Predictors are ranked according to their relative importance in the model. The variables considered to have a strong effect are those where the confidence intervals (CI) do not include zero

	Coefficient	Lower CI	Upper CI	Relative importance
a.				
Intercept	0.90	-2.38	4.18	
Rely on livestock	1.00	0.40	1.60	1.00
% of livestock lost	0.29	0.06	0.52	0.98
Distance to protected area (km)	0.00	0.00	0.00	0.38
Latitude of homestead	0.03	-0.14	0.21	0.34
Member of conservancy	0.06	-0.32	0.45	0.32
Longitude of homestead	0.00	-0.09	0.09	0.27
b.				
Intercept	1.23	-2.47	4.92	
Rely on livestock	0.99	0.35	1.63	1.00
% of livestock lost	0.22	-0.08	0.51	0.82
Receive benefits from conservancy	-0.40	-1.23	0.42	0.64
Member of conservancy	0.23	-0.48	0.93	0.46
Latitude of homestead	0.04	-0.15	0.23	0.33
Longitude of homestead	0.00	-0.10	0.11	0.28
Distance to protected area (km)	0.00	0.00	0.00	0.27
c.				
Intercept	8.29	0.88	15.71	
Months since last livestock predation	-0.67	-1.14	-0.19	0.99
Latitude of homestead	0.32	-0.08	0.72	0.85
% of livestock lost	0.23	-0.28	0.74	0.61
Rely on livestock	0.35	-0.46	1.17	0.59
Longitude of homestead	-0.02	-0.16	0.12	0.33
Distance to protected area (km)	0.00	0.00	0.00	0.28

The perceived behaviour of other communal farmers

When asked about how their peers controlled predators, most reported one dominant method but 28% reported on more than one method. Twenty-three per cent of farmers interviewed reported that other farmers did not kill predators and 11% said farmers would call the MET or conservancy to deal with them. Farmers also reported the use of snares and traps (32% of farmers), dogs (26%), firearms (21%), poison (10%) and bows and arrows (1%). The highest number of people reporting that they were aware of poison use in their area was in the central east (21%) and the lower north west (15%), the lowest was in the central north (5%). Most (93%) farmers did not know what poisons farmers use, or did not what to divulge this information. The farmers who were able and willing to give me this information, described a wide range of different substances which are used. Three farmers reported the use of traditional poisons, made from euphorbia milk and parasitic plants, one person said that they used red shoe polish. The remaining farmers reported a number of different chemicals being used, including termite poison and a variety of liquids and powders which they did not know the name of. The poisons were referred to as jackal poison or 'wolf-gif' (hyena poison in Afrikaans). Based upon how farmers described these chemicals, they could be a number of different poisons such as arsenic, strychnine, carbamate pesticides, organo-chloride, sodium monofluoroacetate and ethylene glycol. Some farmers were aware of the methods used for the poisoning of predators, 78% of them reported that farmers would put poison into small pieces of meat. Others said that farmers poison whole carcasses. Some said that farmers take measures to prevent non-target effects, such as putting the poison out at night and then removing it in the morning and burning the poisoned carcasses. The poison that the farmers used was reportedly sourced from shops, pharmacies and from commercial farmers. One farmer believed that poison was being sourced from Angola, and then transported to Namibia disguised in a packet of mielie meal.

Sensitive questions on lethal predator control

I calculated the prevalence of retaliatory killing, poison use, intention to use poison and accidental vulture killing in the total sample group. Overall, 17.6% of farmers admitted that they had killed a predator in the last year, and 1.7% of the farmers had used poison (Table 3). More farmers in the lower north-west indicated that they had killed a predator, than in other regions (Table 3). Based on farmers' reports of their peers' preferred lethal predator control methods, gin traps were popular amongst farmers in this area. Farmers in the upper north-west and central east used poison more frequently than farmers from other regions (Table 3). Thirty-six per cent of farmers said that they would use poison if they experienced losses to predators (Table

3). The regions where poison use and lethal predator control were more prevalent coincided with the areas where a high proportion of people indicated that they would use poison. When asked whether they had killed a vulture accidentally (by poisoning or other means), 0.3% of farmers said they had (Table 3). Given that so few people had killed a vulture, it does not make sense to compare the incidence between regions as any differences are likely due to chance.

Table 3: The prevalence (%) of retaliatory killing, poison use, intention to use poison and accidental vulture killing as assessed used the RRT, grouped by region with the sample size (n)

	Killed predator	**Used poison**	**Would use poison**	**Killed vulture**
Central east (n = 48)	21.4	5.7	52.6	0.5
East (n = 33)	0.0	0.0	40.5	0.0
Lower north-west (n = 95)	24.3	0.0	25.7	0.0
North central (n = 41)	0.0	0.0	5.8	2.7
Upper north-west (n =136)	22.4	5.9	45.4	1.3
All regions (n = 353)	17.6	1.7	36.0	0.3
Standard error	2.8	2.1	3.2	2.0

I found that there were slight differences in the prevalence of each behaviour between farmers who used the RRT and farmers who did not (Fig. 5). I do not think that this difference is attributed to the technique itself but rather to the regional differences in the percentage of people that used the RRT. For instance, poison use was found to be highest in the central east and upper north-west, where 40-45% of people used the RRT (Fig. 5). On the contrary, poison use was found to be lowest in the lower north west, where a higher percentage of farmers used the RRT (60%) (Fig. 5). Therefore, the group of farmers who used the RRT had a lower incidence of poison use because this group contained more people from areas where poison use was lower, while the group of farmers who did not use the RRT contained more people from areas where poison use was highest.

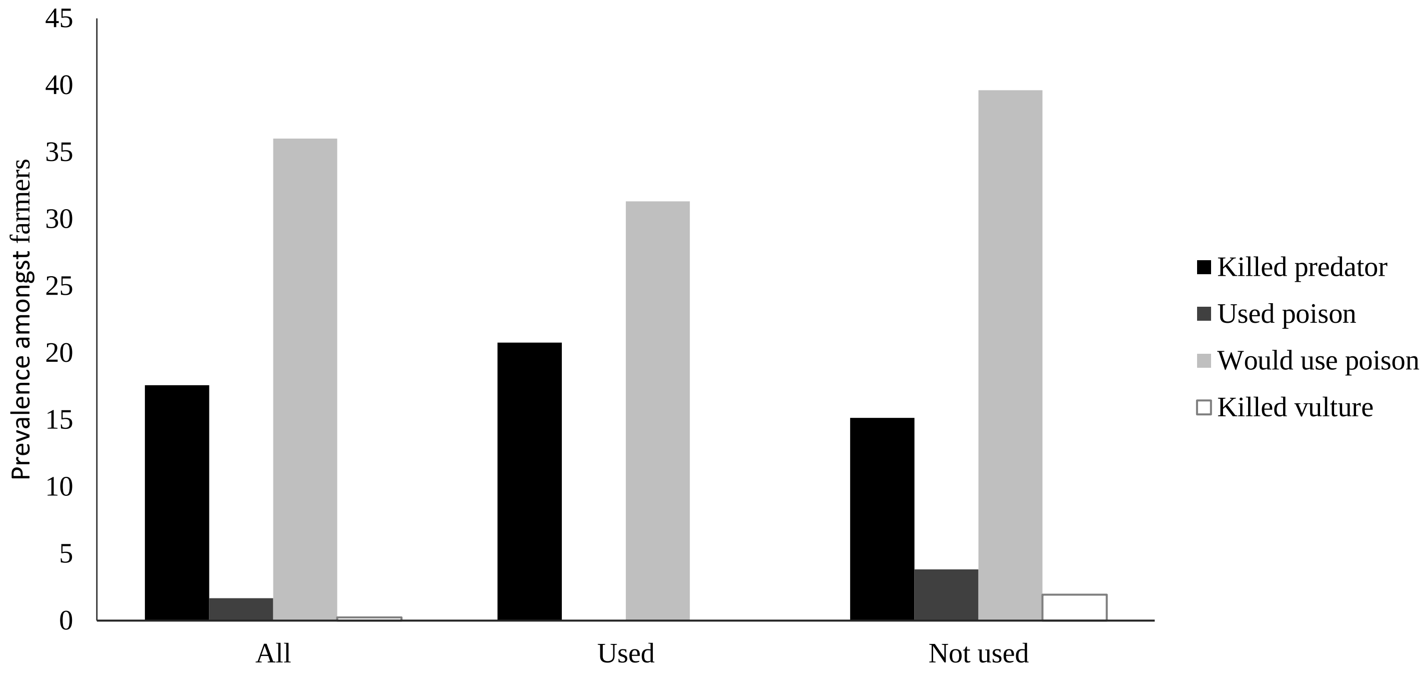


Figure 5: The prevalence of retaliatory killing, poison use, intention to use poison and accidental vulture killing amongst all communal farmers, those who used and understood the RRT, and those who did not use or understand the RRT.

Of those who used and understood the RRT (n =154), 123 interviewees (80%) were willing to tell me the colour of the balls that they drew. Since I know the colours for those who did not use or did not follow the RRT (because I drew them myself), I know the colours for 90% of the interviews. With this information, I can look at what the 'actual' percentage of forced responses was in the sample, compared to the 10% of forced responses I would expect given the 10% probability. I found the 'actual' percentage of forced responses to be as follows: killed a predator (8%), used poison (6%), would use poison (7%) and killed a vulture (7%). These percentages are somewhat lower than expected, given the 10% probability of a forced 'yes' response. If I were to use the 'actual' percentage of forced responses to calculate the proportion of each behaviour in the sample I would find that 19% of farmers killed a predator, 6% used poison, 37% would use poison and 4% killed a vulture.

The model of poison use found that the most important predictor of poison use was the number of large livestock that the household owned (Table 4) i.e. households with many large livestock were more inclined to use poison (Table 4). The latitude of the homestead was the second most important predictor of poison use, with poison use tending to be higher in the north than in the south (Table 4). The third most important predictor of poison use was the number of small livestock owned by the household (Table 4). A positive attitude towards the lethal control of predators was important for predicting poison use (Table 4). However, attitudes to wildlife, vultures and predators were poor predictors of poison use (Table 4).

Table 4: The relationship between poison use and 13 socio-ecological factors, with the relative importance of the variables calculated as the ratio of absolute values of the t statistics for unstandardized predictors

Variable	**Coefficient**	**SE**	**Relative importance**
(Intercept)	-4.89	3.63	
Number of large livestock owned	1.20	1.00	0.27
Latitude of homestead	1.19	1.03	0.21
Number of small livestock owned	1.09	1.63	0.18
Attitude to lethal predator control	0.90	1.28	0.14
Longitude of homestead	-0.24	1.98	0.12
Number of large livestock lost	0.80	0.91	0.12
Conservancy membership (not a member)	-1.78	2.74	0.11
% livestock lost	-1.05	1.44	0.10
Distance to protected area (km)	-0.48	0.96	0.10
Size of household	-0.65	1.05	0.09
Attitude to vultures	-0.21	0.87	0.08
Attitude to wildlife	0.33	1.62	0.06
Attitude to predators	0.14	0.49	0.03

The interpolated map derived from the model further demonstrated that poison use is not uniform across the communal farmlands. The probability of poison use is highest in the upper north-west with 4-7 % of farmers predicted to be using poison in parts of this region (Fig. 6). The model predicted one poison use ‘hotspot’ in the lower north-west and highlighted two parts in the central east and east regions where poison use is predicted to be slightly more prevalent than surrounding areas (4-5% of farmers; Fig. 6).

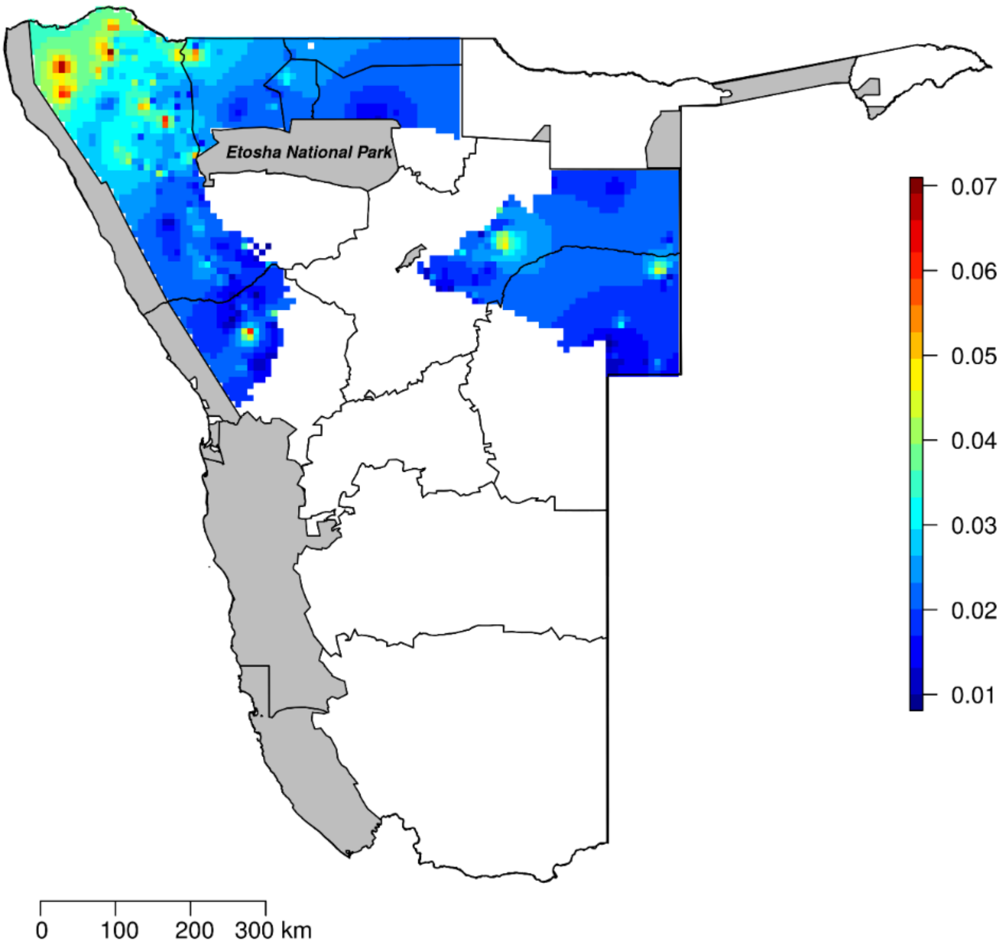


Figure 6: The predicted prevalence of poison use in the communal farmlands of Namibia. This interpolated map was derived from the model averaged predictions from the 95% confidence set relating poison use as reported by farmers using the Randomised Response Technique to 13 socio-ecological variables

DISCUSSION: SYNTHESIS AND SOLUTIONS

This study documents that conflict between humans and livestock predators is still high in most of Namibia's communal farmlands. As a result, just under a quarter of farmers interviewed report using lethal predator control. However, the use of poison to control predators is not widespread. Nonetheless the few poison use hotspots that I identified pose a risk to wildlife, especially already depleted vulture populations. Since farmers' relationship with predators is the primary driver of poison use, it is important to have a thorough understanding of this.

Communal farmers' relationship with predators

In my assessment, I found that communal farmers believe wildlife belongs on the farmlands but most do not like to share the land with predators. These viewpoints were similar to those expressed by Namibian commercial farmers in a similar study by Santangeli et al. (2016). A smaller percentage of communal farmers, 11% reported predators as their primary source of livestock loss compared to commercial farmers, 50% (Santangeli et al. 2016). Nevertheless, communal farmers lose (relatively) more livestock to predators than commercial farmers (Santangeli et al. 2016). Forty-eight per cent of communal farmers reported losing more than a tenth of their livestock to predators, compared to 27% of commercial farmers (Santangeli et al. 2016). This difference may be because commercial farmers have fewer predators on their land as a result of lethal control or because communal farmers' livestock are more vulnerable to predation.

The negative effects of the drought on communal farmers seemed to exceed the effects on commercial farmers. The majority of communal farmers reported that drought was the primary reason for their livestock losses, a much greater percentage than the commercial farmers surveyed in 2015 (Santangeli et al. 2016). This is likely due to the fact that a greater proportion of commercial farmers can afford to feed their livestock when grazing is poor, as in the case of prolonged droughts. Additionally the effect of the drought would have worsened during the year between the Santangeli et al. (2016) study and my study. This combined impact of drought and predators illustrates how communal farmers are comparatively more vulnerable to the effects of both, compared to commercial farmers. Therefore, it is not unexpected that the majority of communal farmers were in favour of killing predators that killed their livestock.

I found that farmers who relied on livestock as a primary income source were more likely to be in favour of lethal predator control. This trend is intuitive given that these farmers experience an imminent threat to their livelihood when predators attack their livestock. Unsurprisingly this finding is not unique, other studies have found that poor communities who rely on livestock are less tolerant to losses from predators (Mishra 1997; Romañach et al. 2007). Providing opportunities for farmers to supplement their income will reduce farmers' reliance on livestock which will reduce their vulnerability to adverse effects such as drought and livestock predation. This may in turn result in fewer farmers being in favour of lethal predator control.

One way that farmers can generate alternative income is through their conservancy. I found conservancy membership to be a rather poor predictor of attitudes to lethal predator control and tendency to use poison. This is in contrast to previous research in Namibia with commercial farmers (Schumann et al. 2008) and Kenya with communal farmers (Blackburn et al. 2016) that found that farmers who belonged to conservancies showed greater tolerance to predators than non-conservancy members. However, I found that farmers that received *benefits* from the conservancy were somewhat less likely to favour lethal predator control. While the effect of this variable was small, it suggests that profitable conservancies that provide benefits to their members could be important role players in reducing human-wildlife conflict. The vast majority of farmers stated meat from hunting as the benefit that they received from the conservancy. This is in line with what Naidoo et al. (2016) observed, hunting is integral to the income generation in conservancies and the benefits arising, in the form of meat, are distributed to the community at large. Tourism can be highly profitable in areas which have good game viewing opportunity and are accessible, however benefits from tourism typically do not go to the whole community but rather go to the few individuals employed (Naidoo et al. 2011b, 2016). The benefits derived from both tourism and hunting instil a sense of pride in local wildlife amongst local farmers, which is the main reason for the success of the conservancy movement (Naidoo et al. 2011b). I observed this sense of pride in many of the farmers I interviewed. Similarly, Romañach et al. (2007) found good evidence in Kenya that income from tourism increases community tolerance of losses to predators. These results are encouraging for the CBNRM (Community based natural resource management) movement in Africa, given the controversy around whether conservancies are meeting their conservation goals (Distefano 2005; Degeorges & Reilly 2009). However, it appears that conservancy membership alone is not sufficient to affect people’s attitudes towards predators, people need to get tangible benefits from the conservancy for these effects to come into play.

I found that households who lost a higher percentage of their livestock to predators are more inclined to favour lethal predator control. A similar trend was observed in previous studies (Dickman 2005; Holmern et al. 2007; Hazzah et al. 2009). This suggests that the severity of livestock predation is one of the primary factors influencing farmers' attitudes towards lethal predator control. Innovative techniques to reduce the severity of livestock predations would then intuitively result in fewer farmers being in favour of lethal predator control. In turn, fewer farmers would resort to lethal predator control methods such as trapping and poisoning which threaten wildlife, particularly vultures, in the case of poisoning. I learnt of one such innovative idea while visiting Torra conservancy. Torra conservancy generates large incomes from the joint-venture that they have with the lodges in the area (Hoole & Berkes 2010). Part of this income is used to invest in improved kraals for those who are most affected by livestock predations (Romen. pers.comm). These kraals have high fences with shade cloth so that cattle cannot see predators outside of the kraal and therefore do not panic and try to escape (Fig. 7). These kraals also have motion sensor lights which deter predators at night.

Figure 7: An example of a kraal built in Torra conservancy to reduce livestock predations at night

Lastly, I found that the time elapsed since last losing livestock has an effect on farmers' attitude to lethal predator control. Having lost livestock recently increases the likelihood that a farmer would be in favour of lethal predator control. Numerous studies have looked at attitudes, how they form and how they affect behaviour (Schwarz & Bohner 2001; Armitage & Christian 2003; Ajzen & Fishbein 2005; Waylen et al. 2009b). Attitudes tend to be stable over time when the person has direct experience with the attitude object (in this case a predation event) on a regular basis (Schwarz & Bohner 2001). In turn, stable attitudes are more consistent in predicting behaviour (Ajzen 1996; Ajzen & Fishbein 2005). From a theoretical point of view this indicates that if farmers experience fewer losses to predators, their positive attitude towards lethal predator control will weaken which will reduce retaliatory killings. This is intuitive and has been observed in a number of studies (Dickman 2005; Romañach et al. 2007; Schumann et al. 2012; Kansky & Knight 2014). The value of assessing attitudes to lethal predator control is to gauge the potential for the associated behaviour i.e. killing predators. While many studies question whether attitudes consistently translate into behaviour (Armitage & Christian 2003; Ajzen & Fishbein 2005; Waylen et al. 2009a; Nuno & St John 2015), my poison use model indicates that reported attitudes to lethal predator control are a good predictor of actual poison use.

Poison use in the communal farmlands

With this study, I surveyed poison use by farmers over most of the communal land in Namibia. I found the prevalence of poison use in the communal farmland to be about 12 times lower than on the commercial farms (Santangeli et al. 2016). It must be noted that this figure should be taken as an estimate and not as a precise measurement. The nature of the Randomised Response Technique is that it uses random effects and probability to create 'noise' in the data which provides the user with anonymity in their answers. The benefits of this technique have been demonstrated in others studies, it has been shown that the RRT elicits a greater proportion of honest answers than direct questioning (Lensvelt-mulders et al. 2004; St. John et al. 2010). A drawback of these random effects is that the standard errors are somewhat larger, as discussed by Lensvelt-mulders (2004, 2005). I demonstrated these drawbacks in my study, I found the 'actual' proportions of forced responses to be lower than the predicted 10%. Considering this error margin, figures presented from the RRT data should be taken with this uncertainty in mind. Even though the exact level of poison use is uncertain, this study provides information on the spatial pattern of poison use and sheds lights on the drivers of poison use. While I cannot give a precise count of poison users in the communal farmlands, I can be reasonably certain that poison use in the communal farmlands is lower than on the commercial farmlands.

When I asked communal farmers why they thought that poison use was less prevalent on communal farmland, compared to commercial farmland, a number of insights were given. Many farmers brought up the issue of land tenure, they believed that because commercial farmers owned their land they had the right to do what they wanted with the animals on their land. A number of farmers raised the issue of non-target effects, very few communal farms are fenced and therefore any poisoned meat put out for predators could end up killing their neighbours dogs or livestock and may even be picked up by other community members. Some farmers pointed out that if they decide to poison it has to be a community effort to avoid these non-target effects. Additionally, many interviewees said that it was difficult for communal farmers to access poison because of the cost or because they did not know where to get it. Lastly many communal farmers expressed fear of retribution from law enforcement authorities if they were to use poison. These anecdotes allow me to better understand what prevents communal farmers from using poison. It must however be acknowledged that this question was only added to my questionnaire after the first 90 interviews, after I had surveyed the lower north-west region, so these farmers did not contribute to this particular aspect of the survey.

While my survey suggests that poison use is less prevalent in communal farmland, it is by no means non-existent and it is important to understand what drives farmers in ‘hotspot’ areas to resort to poisoning. To some extent the predicted poison use ‘hotspots’ in the communal farmland can be explained by the higher number of predations experienced in these regions. It is well known that the farmers in these regions lose a large proportion of their livestock to predators (Brown 2011). It is thought that these high losses are largely due to the proximity of these farmers to protected areas (Brown 2011), studies have shown that those living closer to protected areas often experience greater conflict with wildlife (Newmark et al. 1994; Gillingham & Lee 2003; Brown 2011; Karanth et al. 2012). However, I found no evidence that farmers closer to protected areas lost more livestock to predators. As a result, proximity to protected area did not affect a farmers' attitude towards lethal predator control or their tendency to use poison. Interestingly poison use is predicted to be low in the lower north-west where livestock predations were high, and more farmers reported killing predators than any other region. Anecdotal observations from this study suggest that farmers in this region prefer to kill predators using traps, snares and dogs as opposed to poison.

The predicted poison use map, taken in conjunction with the similar map for commercial farmers (Santangeli et al. 2016) provides a unique resource for targeted mitigation measures. However, the map of predicted poison use should be interpreted with the study's sampling limitations in mind. Two-thirds of the farmers interviewed came from the upper north-west and lower north-west, with fewer farmers interviewed in the north central, central east and east. I believe that more interviews in the central east and east could reveal more widespread poison use than my data suggest. However, this is unlikely to be the case in the north central region. Here predators are rare due to the high human population density and fewer farmers in this region own livestock (Mendelsohn et al. 2003; NACSO 2016c). Therefore, the farmers there have little incentive to use poison.

Looking at poison use at an individual level, I found the number of small livestock owned to be the third most important predictor of poison use for communal farmers, similarly this factor was one of the most important for predicting poison use amongst commercial farmers (Santangeli et al. 2016). It makes sense that the number of small livestock owned is an important predictor of poison use, as small livestock are taken more frequently by predators, and therefore small livestock farmers face greater losses to predators. I found this to be the case in my study, as did two other Namibian studies (Schumann et al. 2012; Rust & Marker 2014).

Interestingly the percentage of livestock lost was unimportant in predicting poison use in the communal farmland. On commercial farms, in contrast, this was one of the most important factors driving poison use. This indicates that there are different factors at play for poison users in communal land versus commercial land. Commercial farmers who use poison are primarily driven by the magnitude of livestock losses, while for communal farmers it seems that socio-economic and cultural factors drive poison use. The most important predictor of poison use for communal farmers is the number of large livestock owned, namely cattle. Cattle have high cultural value, particularly to Herero and Himba communities (see Fig. 8) (Jacobsohn 1995). Cattle not only provide income and sustenance but are also central to the society's cultural customs, and are important for defining wealth and social prestige (Jacobsohn 1995; Dickman 2005). I surmise that those who own many cattle, namely the Himba and Herero tribes, (Jacobsohn 1995) are less tolerant of losses as losing cattle is akin to losing wealth and social standing. As poison is seen as one of the quickest, easiest and most efficient ways to reduce predator populations (Ogada 2014) they use poison to mitigate these losses in spite of the ecological consequences. To reframe this in a western perspective, farmers with cattle wealth can be compared to the capitalists of the market economy. Many capitalists make decisions based on what will increase their wealth (and consequently power and social standing) in the short term rather than making decisions based on long term issues such as environmental sustainability.

Figure 8: The importance of cattle to Himba and Herero people is immediately evident from how the women dress. Left: The Herero people came into contact with European settlers, which is evident in the women's traditional dress. The older women wear colonial style dresses and matching headdresses which are shaped like cattle horns (Wikimedia commons 2017), Right: The Himba are a sub-group of the Herero, women wear cattle skin skirts and when married adorn their heads with a cattle skin headdress to signify their marital status (Photographer Unknown 2017)

Our finding that wealthier individuals are more likely to use poison contradicts previous work which found that those who own more livestock are more tolerant to predators (Dickman 2005). It seems that particularly in the Namibian context, those with more livestock are *less* tolerant of predators (Schumann 2009; Santangeli et al. 2016). Another factor to consider, aside from the socio-economic and cultural factors, is that farmers who own more livestock tend to lose greater numbers of livestock (Hazzah et al. 2009; Hemson et al. 2009; Schumann 2009). As a result, these farmers who are losing greater numbers of livestock to predators become less tolerant of predators and therefore more inclined to use poison. In addition, because farmers who own many cattle are wealthy, they can afford to buy poison.

In combination with the study from Santangeli et al.(2016), we now have a better understanding of of poison use in both the commercial and communal farmlands. We also have a better understanding of the socio-ecological context which characterises poison use in the communal farmlands, and how this differs from the commercial context. This information will be instrumental when planning mitigation strategies and prioritising areas to implement these. The first step to reduce the prevalence of poisoning is to reduce the incidence of predation on livestock as this is the fundamental reason that farmers use poison. Keeping livestock in kraals at night, using trained guard dogs and herdsmen are some of the most effective and widely used methods to prevent livestock predations (Smith et al. 2000; Ogada et al. 2003). These methods can be improved upon by creating better kraal deigns as well as breeding and training dogs which are good at guarding livestock. In some cases the selective removal of a predator which is repeatedly killing livestock is effective in reducing livestock predations and in ameliorating irate farmers (Treves & Naughton-Treves 2005). These planned removals can be outsourced to trophy hunters which results in income coming back to the conservancy.

In addition to reducing livestock predations, poison use can be mitigated by increasing awareness in communities about the dangers involved, both to humans, livestock and wildlife. This has been achieved to some extent, as many of the farmers interviewed were aware of these dangers. However, less than a quarter of farmers are aware that vulture populations are declining, a further step would be to inform communal farmers of the crisis facing vultures. My study highlights that 63% of farmers like vultures and 68% find them useful (see Appendix 2). In addition, some farmers acknowledge the value of having vultures in conservancies for the benefit of tourism and disposing of carcasses. This indicates that communal farmers may respond well to awareness campaigns highlighting the plight of vultures in Namibia and the ecological role that they play in disease prevention.

Research shows that broad conservation messages like ‘save species *x* from extinction’ often fail to inspire people to change their behaviour (Costanzo et al. 1986; Stern 2000; Schultz 2012). Evidence shows that if the conservation message includes a motivational message which appeals to the community it will be much more effective in affecting behavioural change (Costanzo et al. 1986; Stern 2000; Schultz 2012). Appealing to farmers to refrain from poison use for their own well-being, to protect wildlife populations that help them generate income, and to retain the ecosystem services that vultures provide, may be sufficient motivation for many farmers. In order for this campaign to be well received, it should be presented by respected community members (Santangeli et al. 2012), conservancy staff are well positioned for this. However, awareness may have limited potential to affect behavioural change, especially when predators are threatening farmers' livelihood, and poison is viewed as one of the most effective ways of reducing predator numbers. Thus, awareness and education should always go in tandem with measures to reduce the frequency of livestock predations and the impact of these on farmers.

Poison use is illegal and as such the legal system has an important role to play in challenging the prevailing social norms in 'hotspot' areas. Research has shown that anti- and pro- conservation behaviours are strongly influenced by perceived social norms about what is, and is not, acceptable behaviour (Cialdini et al. 2003, 2006; Marchini & Macdonald 2012). I found evidence for this in my study, in the regions of high poison use many farmers indicated that they would use poison and many reported that they knew of others using poison. This suggests that in areas where more people were using poison, this practice was viewed as more acceptable than in areas where poison use was rare. At present, even though using poison is illegal in Namibia, it is poorly enforced. The timely and effective prosecution of those who use poison is a key mechanism for challenging the social norms which support poison use in 'hotspot' areas. At the 2014 International workshop on poisoning and vultures, a response protocol was presented by Namibian conservation authorities which detailed the steps to be followed at a poisoning incident (Ministry of Environment & Tourism et al. 2013). This protocol should improve the enforcement of poisoning laws. However, many poisoning incidences go undetected, which allows ample time for vultures and other scavengers to feed on the poisoned meat. Conservancy staff, particularly the game guards, are well positioned to monitor and respond quickly to any poisoning activities within their conservancy. Provided they are sufficiently trained to intervene when poisoning happens, they can be key role players in reducing the impact of poisoning on vultures and other scavenging carnivores (Murn & Botha 2017).

Poisoning as a method to control predators is nonspecific and therefore has the potential to decimate wildlife populations (Ogada 2014). This is particularly concerning for Namibia's communal farmlands as the rural economy is driven primarily by income derived from wildlife i.e. through hunting and tourism (Naidoo et al. 2016). The poison use 'hotspots' highlighted by my study correspond with areas where conservancies have been particularly profitable and have provided upliftment for the local communities (Naidoo et al. 2016). If poisoning is to continue, or to increase, in these areas, 'popular' species such as lion, leopard, hyena and jackal would decline and as a result income generation through hunting and tourism would suffer. While poisoning affects a wide range of predators and scavengers, the impact on already depleted vulture populations is disproportionately greater. Vultures are not only valuable for the tourism industry but the ecosystem services that they provide to farmers are indispensable, particularly the service of carcass disposal. The effect of reduced or depleted vulture populations on the spread of disease has been demonstrated both experimentally and in natural systems (Butler & du Toit 2002; Markandya et al. 2008; Ogada et al. 2012b; Devault et al. 2016). Poorer farmers cannot always afford to vaccinate their livestock against infectious diseases such as anthrax, and therefore the rapid disposal of diseased livestock carcasses is vital for preventing transmission of these pathogens to livestock and wildlife. This disposal service becomes especially important during times of drought when many livestock are dying and the potential for the spread of bacteria is high.

CONCLUSION

Prior to this study little was known about the use of poison in the communal farmlands of Namibia. My study suggests that poison use in the communal farmlands is less widespread than on commercial farmland. However, any level of poisoning is a threat to dwindling vulture populations. With the map of predicted poison use, authorities can be more effective by better targeting their resources to poison use 'hotspot' areas. My study not only identified areas of concern but also identified the socio-ecological drivers of poison use. The social factors are particularly important to consider, as Schultz (2012) wrote "conservation is a goal that can *only* be achieved by changing behaviour". Enlightened with a better understanding of the socio-ecological context of poison use, conservation authorities can devise strategies to reduce this practice.

Strategies need to address many aspects of this issue. These include reducing livestock depredations and the impact of these on farmers, affecting social norms in hotspot areas through monitoring and enforcement, and raising awareness around poison use and vulture conservation. Failing to address poison use in the communal areas will result in knock on effects on the viability of conservancies in areas where poison use is high, because they are so reliant on healthy wildlife populations. In addition, losing the ecosystem service of carcass disposal provided by vultures will have ramifications for disease transmission in these areas.

APPENDIX 1: INTERVIEW QUESTIONS

Interview number__________________ **Interviewer______________________**

Date____________Time______ - ______ **Consent given ____________________**

1.) Gender: Male____Female____ **Consent translated________________**

2.) Ethnic group

Damara	Himba	Ovambo	Mixed
Nama	Herero	Kavango	Other
San	Caprivian	Tswana	

3.) Age________

4.) How long have you farmed in this area?___________

5.) How many people are in your household? ________________________

6.) What is your household's main source of income?__________________

7.) Do you belong to a conservancy? Yes____ No____

If yes: 8.) Do you and your household benefit from belonging to the conservancy? Yes____ No____

,*If yes*..how do you benefit (a)?_________________________

Livestock

9.)In the last 12 months what is the main cause of livestock loss?

Drought	Disease	Injury	Other
Stolen	Lost	Unknown	
Predator	Stillborn	Fell down hole	

10.) Livestock numbers and losses to predators (in the last 12 months)?

Type of Livestock	Number lost	Replacement cost	Predator	Compensation (Yes/No)?

a.) Were you able to vaccinate your animals this year? If not what prevented you from vaccinating?

11.) When last did you lose livestock?____

12.) What is the best way to prevent livestock from being predated?__________________________________

13.) I am going to say a statement: Strongly agree, somewhat agree, neutral, somewhat disagree, strongly disagree

a.) Game animals are a valuable resource to my community___________

b.) Game belong in national parks and not in the farmlands___________

c.) Predators are a valuable resource to my community______________

d.) Predators belong in national parks and not in the farmlands__________

e.) Predators that kill livestock should be killed_________________________

Crops

14.) In the last year were any of your household's crops damaged by wildlife? Yes____ No____

15.) Which crops?__________________________

16.) What animal was mainly responsible?___________________

17.) Did you get compensation for these damages? Yes____ No____ Not Yet_____

Infrastructure

18.) In the last year were any of your household's infrastructures (water pipes, buildings,fences) damaged by wildlife?

Yes____ No____

19.) What infrastructure?______________________

20.) What animal was mainly responsible?__________________

Vultures: beliefs, knowledge and attitudes

I am going to say a statement: Strongly agree, somewhat agree, neutral, somewhat disagree, strongly disagree

21.) I like to see vultures in this area __________________

a.) "Can you tell me why you agree/disagree with this?"_________________________

22.) Vultures are useful to have in this area___________________________

a.) "Can you tell me why you agree/disagree with this?"_________________________

23.) Are there any beliefs about vultures in your culture?____

24.) Do vulture body parts have any uses in your culture? _______________________________

a.) If yes… What for?____

25.) What is the main thing that you see vultures eating?_______________________________________

26.) In the last five years have the number of vultures in this area:

Decreased:______ Increased:____ Stayed the same:____

a.)Why do you think this is?_____________________________________

27.) In the last five years have you seen any dead vultures in this area?

a.) Yes____ No_______ b.) How many?_______ c.) How did they die?____________________

Other farmers in your province

28.) In your province what do you think is the most popular method used by farmers to control predators?

Trap	Shoot	Other:
Poison	Snare (wire)	

29.) How often do you think farmers in your province over the past year use poison to kill predators?

Often	Sometimes	Never	Don’t know

30.) Why do you think farmers in your province use poison rather than other predator control methods?____

31.) What poisons do they use?______________________

a.)How do they use them?___________________________

b.)Where does the poison come from?________________________

RRT

32.) In the last year did you or someone in your household kill any predator?____________

33.) In the last year did you or someone in your household use poison to kill any predator?________

34.) Would you consider using poison to kill a predator, if your household lost livestock to predators?____________

35.) In the last year did you or anyone in your household kill any vultures by accident?________

Commercial vs. Communal

36.) We conducted this study in commercial areas and found that many commercial farmers use poison. It appears that communal farmers do not use poison as often, why do you think this is?

APPENDIX 2: THE CULTURAL VALUE OF VULTURES TO NAMIBIAN COMMUNAL FARMERS

INTRODUCTION

The relationship between humans and vultures has a long history, beginning in the late Pliocene where humans used vultures when scavenging for meat (Moleón et al. 2014). Vultures have religious and spiritual value to many groups of people across the world, particularly in India (Markandya et al. 2008). The incorporation of local beliefs and knowledge into research and into conservation programs is becoming increasingly appreciated (Brook & Mclachlan 2008). Reson (2012) and Pfeiffer et al. (2014) have provided some insights into the cultural value of vultures in Maasai and Xhosa culture respectively, however little is known about the cultural importance of vultures to other rural communities of Africa.

In some African countries, vulture body parts have cultural value and are used in traditional medicine. A review by Ogada et al. (2016) found that the traditional medicine trade accounted for 29% of reported African vulture deaths. Vulture parts have a variety of uses, including bringing luck, increasing intelligence, giving the user clairvoyance and treating headaches (Beilis & Esterhuizen 2005; Mckean et al. 2013). The cultural use of vulture parts is becoming a concern for vulture populations that are already under pressure. For example in Lesotho it was estimated that the yearly harvest of 35 Cape vultures accounted for 7% of the entire breeding population of the country (Beilis & Esterhuizen 2005). Vultures are sought after in the traditional medicine markets, with hooded vultures one of the most frequently recorded species in African markets (Williams et al. 2014). In South Africa, demand is high, with many consumers specifically requesting vulture parts when at muthi markets (Mckean et al. 2013).

Little is known about the cultural use of vulture parts in Namibia. A study looked at the use of vulture parts by seventeen traditional healers in central Namibia (Hengari et al. 2004). Most of the traditional healers (9) reported that nesting material was the most popular item, followed by the brain and feathers. From this small study they calculated that at least 11 vultures had been killed by just these 17 traditional healers in the past year (Hengari et al. 2004). This suggests that traditional medicine could have a significant impact on vultures in Namibia. I did an assessment of the extent of cultural use of vulture parts in Namibia's communal farmlands. This assessment included asking farmers about their beliefs around vultures and whether they were aware of any uses for vulture parts. In addition, I asked farmers questions to assess their knowledge of vulture biology and their perceptions of vulture trends in their area. This information can be used to design vulture conservation awareness programs which are relevant and effective in the Namibian context.

METHODS

Questions relating to the cultural value and local knowledge of vultures were included in the interview questions used in the main study (Appendix 1- see Methods of main study for further details of sampling protocol). I asked a series of open–ended questions about traditional beliefs and uses of vulture parts. I assessed farmers' attitudes towards vultures using a five point Likert scale. I also asked questions about any sightings of dead vultures, the diet of vultures and the population trend of vultures in the area. These questions were asked to assess farmers' knowledge of vultures, as well as to find out whether there have been any vulture mortalities in the area and whether these may have been related to poison use.

RESULTS

Vultures: attitudes, knowledge and perceptions

In total, 361 of the households interviewed answered the section on vultures in the questionnaire. The majority (63%) of the households indicated that they liked vultures and found them useful (68% of households). With these questions, I pooled the responses for strongly agree/agree and strongly disagree/disagree as I found that that almost all farmers either strongly agreed or strongly disagreed with the statements, very few farmers (average 8.5% between the two statements) used the agree/disagree options. Of those who provided examples of vulture usefulness (n = 287), 66% used vultures to locate dead livestock, 13% valued their role in cleaning the environment and 7% thought vultures were useful for educational purposes. Of those who provided reasons for liking vultures (n = 306), 37% stated that they were harmless, 18% found them useful for spotting dead livestock and 15% liked to see them because of their intrinsic value (God's creature, beautiful creature, good for conservancy to have wildlife). The minority of households who did not like vultures reported that vultures killed their stock (9%) and got to meat before they could (6%). Sixty-six per cent of households who reported that vultures were killing their livestock reside in the lower north-west. Overall however, the majority (88%) of households interviewed reported that vultures eat dead animals only. Two per cent of households did not know what vultures were and 4% of households said they never see vultures in their area.

When I asked farmers (those who had lived there for 5+ years, n = 308) about the vulture population trend in their area, over half said they could not tell because vultures were in the area sporadically (for food) or because they had not taken note of the number of vultures. Of those who had taken note of the number of vultures over the last 5 years, 50% thought that the population had decreased, 32% thought they had increased and 18% thought the number had not changed. The main reasons given for the decrease in population were: emigration to areas with more food, drought and poisoning. Conversely reasons given for an increasing population were: nothing kills vultures and during the drought there are more carcasses for them to feed on.

Nineteen of the farmers that I interviewed reported a total of 40 vulture mortalities (33 unidentified, four lappet-faced vultures and three white-backed vultures) in the last five years. According to farmer reports, three of these mortalities were due to the vultures choking on meat, 17 were killed at a poisoned carcass, seven were uncertain but may have been due to poison (dead vultures were near a carcass), one was hit by a car, one got trapped within a carcass, one was killed by a dog and the remaining 10 died of unknown causes. Upon meeting with a number of conservancy staff across the study area I heard about a few cases of poisoned vultures but in some cases, these were not recorded adequately and had not been reported.

Cultural beliefs

The vast majority (89%, n = 327) of households interviewed had never heard of any cultural beliefs around vultures. Those who had heard of cultural beliefs usually indicated that these beliefs were more widespread in the older generations. In some cases, I heard about the same belief multiple times from different households (Table 1). Many of the beliefs appear to span different ethnic groups (Table 1).

Table 1: The cultural beliefs farmers reported about vultures, including the number of farmers reporting the belief and the ethnic group of these farmers

Belief	**No. farmers reporting**	**Ethnic groups**
Witchdoctors can procure a special stick from a vulture's nest which has many magical properties and is considered lucky. To get this stick, the witchdoctor will tie a vulture chick to the tree with a piece of string, it is believed that the adult will use a stick to untie the chick, this stick will then be collected	7	Herero, Himba, Ovambo
Vultures mean rain is coming	5	Damara, Himba, Kavango
Vultures can be a bad omen if they are behaving unusually	3	Himba, Herero, Damara
Witchdoctors use vultures as carriers for curses	2	Herero
Vultures breeding indicate that drought is coming	2	Damara, Herero
Just so story: francolins make a noise when vultures are feeding because at creation vultures were given the wings that the francolins were supposed to get	2	Himba
It is bad luck to touch a vulture and doing so can give you an incurable illness which you will pass on to future generations	1	San
The eye of a dead animal communicates with the vulture, if you do not want a vulture to find the carcass you should poke the dead animal's eye out	1	Himba

Cultural uses of vulture body parts

Few households (9.5%, n = 357) had heard of cultural uses for vulture body parts, many said it was more common in the previous generations. Half of these indicated that it is feathers that are used, mainly for arrows. The use of feathers was reported across multiple ethnic groups including: Damara, San, Herero, Himba and Ovambo. Other uses are detailed in Table 2.

Table 2: The uses of vulture parts as reported by farmers, including the number of farmers reporting the use and the ethnic groups of these farmers

Use	No. farmers reporting	Ethnic groups
Claws for decorative purposes	2	Herero
Bones, claws and beak used in traditional medicine- they have healing properties	2	Herero, Himba
Vulture claws to scratch open a sick child's skin to release the sickness	2	Ovambo
A child holding a vulture skull can predict the future	1	Ovambo
Holding a vulture kidney on a child's skin to cure disease	1	Damara
The vulture skin is worn by boys going to get circumcised	1	Ovambo

DISCUSSION

I found that, for the most part, communal farmers like vultures and find them useful. Similar observations were made in surveys with commercial farmers in Namibia and communal farmers in the Maasai Mara (Reson 2012; Santangeli et al. 2016). Those who liked vultures described them as 'harmless' as they did not pose any threat to their livelihood and in some cases proved useful to them. Many farmers made use of vultures when looking for livestock that died in the field, a service which humans have used for a long time (Moleón et al. 2014). Communal farmers in the Maasai Mara and the Eastern Cape of South Africa, as well as commercial farmers in Namibia, are also known to use vultures for this purpose (Reson 2012; Pfeiffer et al. 2014; Santangeli et al. 2016). Vultures were acknowledged by some farmers for their role in disposing of carrion. This is a service that has also been shown to be useful to Namibian commercial farmers (Santangeli et al. 2016) and Eastern Cape communal farmers, with the Eastern Cape farmers referring to vultures as their 'free municipality' (Pfeiffer et al. 2014). My study demonstrates that communal farmers in Namibia are aware of and appreciate the ecosystem services that vultures provide.

The minority of farmers who did not like vultures were concerned about vultures killing their livestock. While vultures are regarded as obligate scavengers, reports of predation are not unheard of. Similar reports have been reported by farmers in Spain and in Kenya (Zuberogoitia et al. 2010; Reson 2012). Most of the reports of vulture predation in the present study came from the Damaraland region which may either indicate a change in behaviour of vultures in this area or a community misconception in this region. It is also possible that eagles are misidentified as vultures, thereby explaining the farmers' perception that vultures predate on small livestock. Further investigation is needed to clarify this matter. It must be noted, however that these farmers represent a minority, most farmers interviewed reported that vultures eat dead animals only. Another reason that communal farmers expressed dislike for vultures was that vultures eat all the meat before they can get to it. At the time of this study Namibia had been experiencing a severe drought for the past four years and many farmers were struggling. Given the circumstances, animosity towards vultures for 'stealing' their meat may not be surprising.

Farmers' perceptions of vulture population trend were mixed. Of those who had noted the numbers of vultures, half thought that vultures were decreasing. Santangeli et al. (2016) found commercial farmers to express a similar mixture of opinions when it came to vulture population trends in their area, with over a third of farmers believing that vultures were increasing in Namibia. Based on farmers' anecdotal observations, perceived vulture population trends differ according to region and circumstances. For example, perceived increases could be due to a neighbouring vulture restaurant which draws more vultures to the area (Santangeli et al. 2016). It is clear that awareness campaigns which draw attention to the global and continental decline in vulture populations would be of value. Even though vultures may be increasing or stable in some regions, it is clear that on a broader scale vultures are in decline (Ogada et al. 2016) and it is important for farmers to be aware of this.

Cultural beliefs and the use of vulture body parts are not common amongst the farmers that I interviewed, with many seeing these beliefs and practices as outdated. Of the few beliefs that I heard about, some could be beneficial for vulture conservation. For example, the belief that touching a vulture will cause you be cursed could be seen as a protective belief for the species. On the other hand, the belief that vultures carry curses may inspire animosity towards them. This has been seen in parts of South Africa, Malawi and Costa Rica where owls are believed to be carriers of bad luck and death and as a result some people kill them out of fear (Enriquez & Mikkola 1997; Thompson et al. 2013). The cultural use of vulture body parts is an important threat to African vulture populations, particularly in West Africa (Williams et al. 2014; Ogada et al. 2016). However, in Namibia, few communal farmers had heard of cultural uses for body parts. Of those who had heard of uses for vulture body parts, feathers were the most popular part used. This is similar to what Hengari et al. (2004) found when speaking with traditional healers in Windhoek. A farmer informed me that feathers are collected from the ground at vulture feeding sites. It is uncertain whether all people procure feathers in this way but this particular method poses little threat to the vulture population. Of greater concern is the collection of the 'special stick' in vulture nests for use in traditional medicine as this could result in chick mortalities and impact on breeding success. Nonetheless, this practice seems to be rare and not likely to pose a serious threat overall.

Conclusions and implications for vulture conservation

Overall, my study shed light on farmers perceptions of vultures and the local practices and traditions that could pose a threat to vultures. The reports of poisoning mortalities are concerning, especially since the reports that I heard of were almost certainly 'the tip of the iceberg'. Conservancies need to be encouraged to record poison mortalities in detail and to report them timeously. This will help authorities to act quickly to reduce the impact of a poisoning event. Such timely interventions are particularly effective when field staff are specifically trained to respond to poisoning events (Murn & Botha 2017). Most importantly, my findings confirmed that communal farmers have an overall positive perception towards vultures, as was the case for the commercial farmers of Namibia. These findings highlight the potential for conservancies to focus on vulture conservation. Raising awareness about vulture conservation and bringing vultures into the realm of ecotourism could enhance existing tourism in communal conservancies. This will ultimately benefit local livelihoods and give vulture conservation the attention it so needs.

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