AN INVESTIGATION INTO THE ROOT OF TWO OF THE MAIN VULTURE THREATS: POISONING AND BELIEF-BASED USE OF VULTURE BODY PARTS IN SOUTHERN KENYA.

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ABSTRACT

Vultures are crucial scavengers, removing carcasses, and maintaining the healthy and clean environments. However, their populations are rapidly declining. Six of eight Kenyan vulture species are currently listed as 'Endangered' or 'Critically Endangered' on the IUCN Red List. Poisoning caused by human-wildlife conflicts is a major threat to vultures after belief-based use of their body parts. A total of 1387 interviews were administered within Maasai Mara pastoral community. We used the 'Unmatched Count Technique' to estimate the prevalence and distribution of poison use, and direct questions to characterize poison types, usage and sources, as well as belief-based use of vulture body parts. We found that 54% of respondents reported Carbofuran poison, whereas nearly half (48%) of respondents pointed to agrovets as a major source of all poisons and popularly (84%) smeared on carcasses. The vast majority (75%) particularly use vulture feathers for arrows. Further, 22% fence off their livestock against predatory wildlife. We further explored how predation protection measures used predict individual poisoning likelihoods. None of the five main predation protection measures significantly influences poison use. Both fencing and the use of lights as predator control measures attenuate the poisoning risk. However, herding indicated weak signals for poison use amongst pastoralists. We proposed that an effective vulture poisoning risk reduction should be multi-faceted and collaborative. Regulating and monitoring of the import, local trading and use of poisonous substances. Building partnerships and engagements for more support for local livelihoods. Lastly, upscaling fencing and expanding the communal conservancies. These strategies would curb retaliatory human-wildlife conflicts and poison use against wildlife and vultures in Southern Kenya.

Key words:

Vultures, human-wildlife conflicts, wildlife, poison use, vulture body parts, belief-based use.

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INTRODUCTION

Compelling evidence is fast developing that we are headed for the modern global biodiversity collapse, largely influenced by humans appropriation of nature (Ceballos et al. 2015; IPBES 2019; WWF 2020; Pincheira-donoso et al. 2022). Extinction rates differ across taxonomic groups, with some taxa facing imminent extinction; vultures are one such group (Buechley and Şekercioğlu 2016; Ters 2020). According to Buechley and Şekercioğlu (2016), 73 percent of all vulture species are currently in danger of going extinct. This is largely due to the widespread use of the veterinary anti-inflammatory medicine Diclofenac, which has been shown to have a harmful impact on vultures, whose populations are dropping everywhere, but mainly in Asia (Green et al. 2004; Ogada et al. 2016). Vulture threats worldwide are frequently related to human-wildlife conflicts, mainly poisoning as a counter response (Ogada et al. 2012; Ogada et al. 2016). Research, however, indicates that urgent reversal of threats can create a vulture population rebound (Buechley and Şekercioğlu 2016; Santangeli et al. 2019). As a result, it is crucial to stop indiscriminate poisoning that imperil vultures' survival and population persistence.

Life history traits explain vulture's predisposition to extinction. They feed on a specific form of diet, a survival-limiting character that has been linked to extinction risk in many other species (Buechley and Şekercioğlu 2016). Vultures are obligate scavengers (Buechley and Şekercioğlu 2016); organisms which have evolved to depend on carcasses as their sole dietary intake. In addition, vultures have other traits such as "delayed sexual maturation, slow reproductive rate and low population density" (Buechley and Şekercioğlu 2016). Vulture population growth is biologically constrained by these characteristics in relation to changing environmental circumstances. Additionally, their inherently low reproductive resilience to environmental changes or shocks increases the chance of population collapse. These

factors make vultures more prone to extinction in the face of human-induced mortality rate (Buechley and Şekercioğlu 2016; Purvis et al. 2000).

Vultures are also vulnerable to several non poison-based threats. Electrocution on power lines and collision into unsafe energy infrastructures claim large numbers of vultures (Carrete et al. 2012). In Swaziland, for instance, population decline in three vulture species were specifically linked to electrocution (Monadjem and Garcelon 2005). The illegal trade in vulture body parts for traditional medicine is increasingly a growing concern. Vulture body parts have long been prized and connected to luck and clairvoyance in African societies (Boakye, Wiafe, and Ziekah 2019; McKean et al. 2018). Others frequently hold the belief that vultures boost children's intelligence, heal mental and physical diseases, and enhance business and gambling success. (McKean et al. 2018). Also, the disturbance of nests, reduced availability of suitable food and vultures being hunted for food, all of which globally threaten their population, differently (Bamford et al. 2007; Boshoff et al. 2011; Ogada, Keesing, and Virani 2011; Angelov, Hashim, and Oppel 2013). As a result, vulture population declines are caused by natural survival-limiting characteristics and socio-economic developments, which add to their ultimate existential threat of dietary poisoning.

Vulture dietary toxins, such as poisons, veterinary drugs and lead ammunition have in the past been pointed to as the main causes of vulture mortality accounting for an 86% decline in vultures worldwide (Buechley and Şekercioğlu 2016). In addition, existing records of the past 50 years indicate that poisoning alone is responsible for 61% of mortality of African vultures, including both deliberate and accidental poisoning incidents (Ogada et al. 2016). The purposeful poisoning of vultures is linked to the recent increase in rhino horn and ivory hunts. Poachers poison animal carcasses, potentially killing large numbers of vultures. This

is done to avoid detection signals given by vultures circling overhead a carcass, revealing poachers' presence to authorities and allowing for quicker anti-poacher response times (Ogada, Botha, and Shaw 2015; Ogada et al. 2016).

Vulture and wildlife poisoning often stem from unintentional poisoning by farmers that are chiefly targeting predatory wildlife, a consequence of retaliation in human-wildlife conflicts (HWC). This negative relationship between humans and wildlife is widespread in human-dominated landscapes. Human-wildlife conflicts are not only major detractors of biodiversity conservation globally, but also destructive and costly, limiting achievements for both socio-economic aspirations and sustainable development (Redpath et al. 2013; Acharya et al. 2016; Anand and Radhakrishna 2017; WWF and UNEP 2021). Despite limited attention to climate variation as a key factor, Mukeka et al. (2019) notes that most human-wildlife conflict cascades are primarily influenced by deteriorating habitat quality because of climate variation, and human and livestock population growth. In response to climate variation, humans further disrupt wildlife habitat integrity. This leads to habitat loss, conversion, degradation, and reduced habitat connectivity, which eventually trigger human-wildlife conflicts (Acharya et al. 2017). This in turn, promotes strayed wildlife movements in search for resources. As the proximity of wildlife to humans grow, so does the "friction" caused by clashes as both increasingly compete for common life-support resources (Acharya et al. 2017).

Human-wildlife conflicts are particularly prevalent in Kenya with over 65% of wildlife dwelling outside PAS, mostly occupying privately owned and communal lands (Mukeka et al. 2019). Similarly, Narok County alone is home to 30% of Kenya's wildlife, the majority of which is found on community and private land as well as in wildlife conservancies. These areas are not part of the Maasai Mara National Reserve, which is under the protection of the

government (Mukeka et al. 2019). Akin to many developing countries, Kenya's human population growth has recently continued exponentially from 31 million people in 2000 to nearly 55 million people in 2021 (https://data.worldbank.org/country/kenya). The population of Maasai Mara was estimated at 1 million people in 2021 (dominated by Maasai people). This presents a considerable demand for land for housing, pastoralism or food production and other developments. These growing human pressures increase competition for resources between livestock and wildlife. It has further decimated available resources and restricted wildlife into the Maasai Mara National Reserve and bordering conservancies (Mukeka et al. 2019). Livestock has particularly increased in Narok County (Ogutu et al. 2016), and so are the human-wildlife conflicts, with escalating incidences of pastoralists' retaliation by poisoning offending wildlife.

Despite the magnitude of this threat to vultures, poisoning has received only limited research attention in the past. However, Ogada (2014) partly explored aspects related to poison-laced carcasses or poisoned meat pieces used as baits spread across the landscape. This attracts livestock-eating predators such as jackals, caracals, hyenas, lions and leopards. Eventually, vultures feed opportunistically on poisoned meat or poisoned carcasses leading to their death. Vultures are mostly gregarious feeders, and a single poisoning incident can lead to the massive death of individuals poisoned (Ogada, Keesing, and Virani 2012). For instance, in 2013, an elephant poisoned carcass killed 600 vultures in Namibia (Buechley and Şekercioğlu 2016).

The vulture crisis looms across Africa's iconic Savannahs (Ogada et al. 2016). Following the recent Africa-wide vulture species survey and assessment, the same study revealed eight of eleven species were declining at an average of 62% to over 80%, over three generations

(Ogada et al. 2016). Similarly, it further recommended the up-listing of seven of eleven Africa's vulture species on the IUCN Red List (Ogada et al. 2016), six of which subsequently were, as Critically Endangered or Endangered. However, there is a need to reverse vulture declines, as they are largely human-mediated by the different drivers of development within the socio-ecological environment. This study builds an understanding about people. It draws attention to and quantifies the types and the availability of poison, where they are sourced and how they are used in human-wildlife conflicted Maasai Mara. It further investigates if the use of specific livestock protection measures could aid in reducing poison use by pastoralists. Finally, it explores Maasai's attitudes, actions, and underlying motives for harvesting vulture body parts.

Importance of vultures and threats to their conservation.

Vultures are crucial ecosystem service providers and are renowned for being among the animal kingdom's most effective scavengers (Carucci et al. 2022). Without vultures, carcass decomposition becomes inefficient and reliant on facultative scavengers. Ogada, Keesing and Virani (2012) reported that carcasses remaining in the environment coupled with the high activity of such facultative scavengers also increase the potential of zoonotic disease – Infections potentially transmittable, causing debilitating or ill health conditions in both wildlife and humans. For example, the decline of vultures in Asian countries is thought to have released populations of feral dogs and rats (Prakash et al. 2003), aiding the spread of diseases such as rabies. Africa and Asia, for example, already account for 95% of the annual 60,000 human death cases of rabies reported globally by the World Health Organization (WHO 2015). The vast majority (99%) of these cases are caused by infected dog bites, which are estimated to cost at least US$ 8.6 billion per year in lost productivity and healthcare treatments (WHO 2015).

Besides balancing nature's intricate human-wildlife health relationships, vultures also remain both culturally and economically important. Reson (2012) and Pfeiffer, Venter and Downs (2015), in particular, have provided some insights into the cultural ecosystem services that vultures provide within the Maasai and Xhosa cultures, respectively. However, these cultural values are widely underappreciated, despite the fact that they are an important factor to consider in context, as they can determine the success of conservation goals (Anthwal et al. 2010; Colding & Folke, 2001). In Africa, the continued harvesting of vulture body parts for cultural uses further threatens vulture populations (Ogada et al. 2016; Craig, Thomson, and Santangeli 2018). For example, witchdoctors in Namibia obtain a magical stick from vulture nests (Craig et al. 2018). Today, in Kenya's Maasai community, warriors known as *Morans* sing songs to vultures in preparation for raids and attacks on their enemies (Reson 2012). Economically, McKean et al. (2018) discovered that vultures are either hunted or poisoned in South Africa, and their body parts are illegally traded for use in traditional medicines. Their main business is clairvoyance, foresight, and increased intelligence, among other things (McKean et al. 2018). Similarly, traditional healers use vulture parts to treat headaches, boost betting and gambling business success, predict election results and winning national lotteries, and increase intelligence in school-aged children (McKean et al. 2018). Total annual sales from vulture end users in South Africa were estimated to be ZAR 1.2 million (US$ 120,000) (McKean et al. 2018). However, the traditional medicinal use of vultures, combined with current indiscriminate poison use, is considered unsustainable. It is leading to their rapid decline and eventual disappearance of their associated traditional benefits to South Africa in years to come (Brink et al. 2021; McKean et al. 2018).

The vulture crisis is distinguished by multifaceted impacts and causes of decline. This necessitates interdisciplinary research efforts that extend beyond ecological sciences. People-centred approaches would be critical in addressing these threats, preventing further species declines and extinctions, as well as biodiversity loss, given the increasing human-driven pressures on ecosystems. This approach will provide an understanding of the changing dynamics in human behaviours and attitudes, as well as the key incentives or solutions that may influence a behavioural shift toward sustainable practices.

Motivations for human behaviour to address sustainable conservation.

Understanding the factors that influence people's attitudes and behaviours toward vultures is important. It informs conservation strategies and may ultimately help reduce the vulture decline. Within human-dominated systems such as Kenya's Maasai Mara, where people, livestock and wildlife overlap, as noted by Mukeka et al. (2019), such human-wildlife conflicts will inevitably increase in the future. This emphasizes the importance of understanding human behaviour. Recent research has concentrated on community conservation to better understand local communities in order to inform conservation strategies (Fabricius et al. 2000; Shahabuddin 2020). Community conservation strategies are interventions that include public participation and result in mutually beneficial outcomes that are critical for natural resource management. This approach builds on the growing traction of evidence that biodiversity conservation, or protected areas are inseparable from the dynamic and complex socio-ecological systems (Gatiso Tsegaye 2022). For such community conservation programs to be successful, Adams and Hulme (2001) recommended that such interventions should be implemented in accordance with the interests of local people who bear the costs of wildlife conservation.

To date, attitudinal studies are used to evaluate the effects of conservation programs on communities near protected areas (Kideghesho 2007). Daily and Ehrlich (1999) had previously emphasized the importance of interdisciplinary approaches to developing long-term conservation strategies. Similarly, natural scientists have finally realized that conservation is primarily about people and the decisions they make, all of which impacts conservation (Balmford and Cowling 2006). As a result, social scientists have developed and applied methods in collaboration with conservationists to robustly quantify human behaviours, attitudes, and cultural practices as they relate to nature and the environment (Nuno et al. 2013; Madden and Mcquinn 2014; Nuno and St John 2014).

Nonetheless, significant gaps in knowledge, awareness, and acceptance of social sciences in conservation remain. This limits effective human-wildlife conflict management at the individual, community, and institutional levels, as well as at all scales (Bennett et al. 2016). According to Reson (2012), community support is only possible if people's interests and well-being are prioritized. Furthermore, conservation based on community resentment is unsustainable because it regularly results in sabotage. Human-wildlife conflict prevalence is triggered during highly competitive conditions, such as drought, or because of lost revenue from crop damage and livestock loss (Mukeka et al. 2019). As a result, this narrative necessitates continued research efforts to determine local communities' perceptions and attitudes toward conservation. Conservation interventions will be limited in their success unless local communities are consulted to understand their needs in terms of socio-ecological reality.

How policy shapes community behaviour

Behavioural change is crucial for inspiring community-centred and sustainable conservation. One of the most effective ways is still suggestively by providing resources to support livelihoods and other financial incentives, where it is especially possible to utilize positive incentives to promote behaviour change (Casey and Scott 2006; Bennett et al. 2016). Conversely, Cooney et al. 2016 argues that heavy enforcement of rules undermines rather than upholds community rights. Such interventions, which rely heavily on negative incentives, limit a resource's access and use rights (Cooney et al. 2016; Didarali et al. 2022). According to Cooney et al. (2016), when people lose benefits and feel the pinch of neighbouring protected areas, this can lead to anger and resentment. Some studies link this to poaching (Twinamatsiko et al. 2014). Poaching of iconic species such as African elephants (Burn, Underwood, and Blanc 2011) and rhinos (Biggs et al. 2013) has prompted enforcements such as state-imposed legal sanctions. According to the Kenya Wildlife Act of 2013, for example, engaging in illegal behaviour such as poisoning or hunting wildlife is punishable by heavy fines charged against the violator (Didarali et al. 2022). Criminal justice policies seek to increase deterrence and, ultimately, reduce crime rates by increasing the severity of sanctions.

Shifts in conservation strategies in Kenya.

Maasai are an ethnic group who live in Northern Tanzania and Southern Kenya, in an area known as the Maasai Mara (Reson 2012). However, the early influx of British settlers in the 1900s, combined with Kenya's post-independence population growth, resulted in vast lands, mostly within the Maasai Mara, being subdivided, planned, and exclusively secured for commercial agriculture and wildlife reserves (Bravman 1994; Collett 1987; Goldman 2011). This marginalized the previous occupants, the Maasai (who culturally revered vultures and wildlife), limiting their traditional pastoral lifestyle and livelihoods that is based on livestock

(Hughes 2005, 2006). New relationships and recent changes were reinforced as Maasai's socioeconomic lifestyles were influenced by outsiders to conform to modern standards (Reson 2012). In recent years, livestock farming in the Maasai Mara has become more of a business than a proud cultural practice (Reson 2012). This confluence of factors has gradually increased competition for land resources to meet the needs of livestock and wildlife since the 1960s (Reson 2012). As a result, both Reson (2012) and Didarali et al. (2022) agree that the dominant Maasai perception of wildlife changed. Increased extractive and aggressive behaviours have replaced previously sustainable and protective cultural ones. Human-wildlife conflict and poaching incidents have increased as a result.

Increased poaching activity in 1970 resulted in Kenya's first comprehensive legal framework, the Wildlife Act, which was enacted in 1976 to protect wildlife. This coincided with the establishment of the Kenya Wildlife Service, the primary government agency in charge of wildlife resource protection and management. In response to the increasing threats posed by humans to wildlife, the Kenya Wildlife Act, assented on 24 December 2013, imposes harsher penalties (Weru 2016; Didarali et al. 2022). For example, using poison with the intent to kill wildlife is punishable by 5 million Kenya Shillings (approx. US$ 42,000) or five years in prison or both (The Kenya Wildlife and Conservation Management Act, 2013). Under the same Act, Individuals who have lost livestock or crops because of wildlife or predators may be compensated. This is subject to perpetrators making a reasonable effort to defend life or property in order to avoid such a loss (Didarali et al. 2022). Nonetheless, development pressures have exacerbated human-wildlife conflicts, putting wildlife conservation strategies at the community level to the test. As a result, early human-wildlife relationships, as well as human behaviour and predictability, have gradually evolved. According to two theories, cognitive dissonance and motivation crowding of attitudinal shifts,

a more negative attitude change toward wildlife has recently been reported among Maasai pastoralists of the Amboseli Ecosystem in Southern Kenya (Fernández-Llamazares et al. 2020).

Aims of this thesis

The purpose of this research is to quantify the main reasons for poison use, the types of poison used, how poison is used, and where it is obtained. That is, it investigates the various sources and types of poison, as well as how and why they are used against predators. The study also attempts to investigate the use of vulture body parts in Maasai culture, as well as the underlying reason for their use. It finally establishes whether and which kinds of livestock protection techniques—such as herding, fencing, guard dogs, or lighting—may reduce the use of poison.

METHODS

Study environment.

The study was conducted across the Southwestern and South-central parts of Kenya, running along the Tanzanian border and surrounding several protected areas such as Maasai Mara and Amboseli National Parks. This is where Narok County (17,944Km^2), a semi-arid region is located between 34°45´E - 0°45´S and longitudes 0° 45´S - 2°00´S (Ojwang 2014). The region receives an average annual precipitation between 500 to 1800mm. Temperatures range from 7.3°C to 28.5°C and has recently increased by an average of 2.5° C between 1965 and 2015 (Mukeka et al. 2019). Trends of rising temperatures and declining rainfall have been linked to recurrent droughts and floods (Bartzke et al. 2018). The semi-arid conditions make livestock production a predominant source of livelihood, and a key contributor to the social settings of pastoralists (Chege, Kimiywe, and Ndungu 2015).

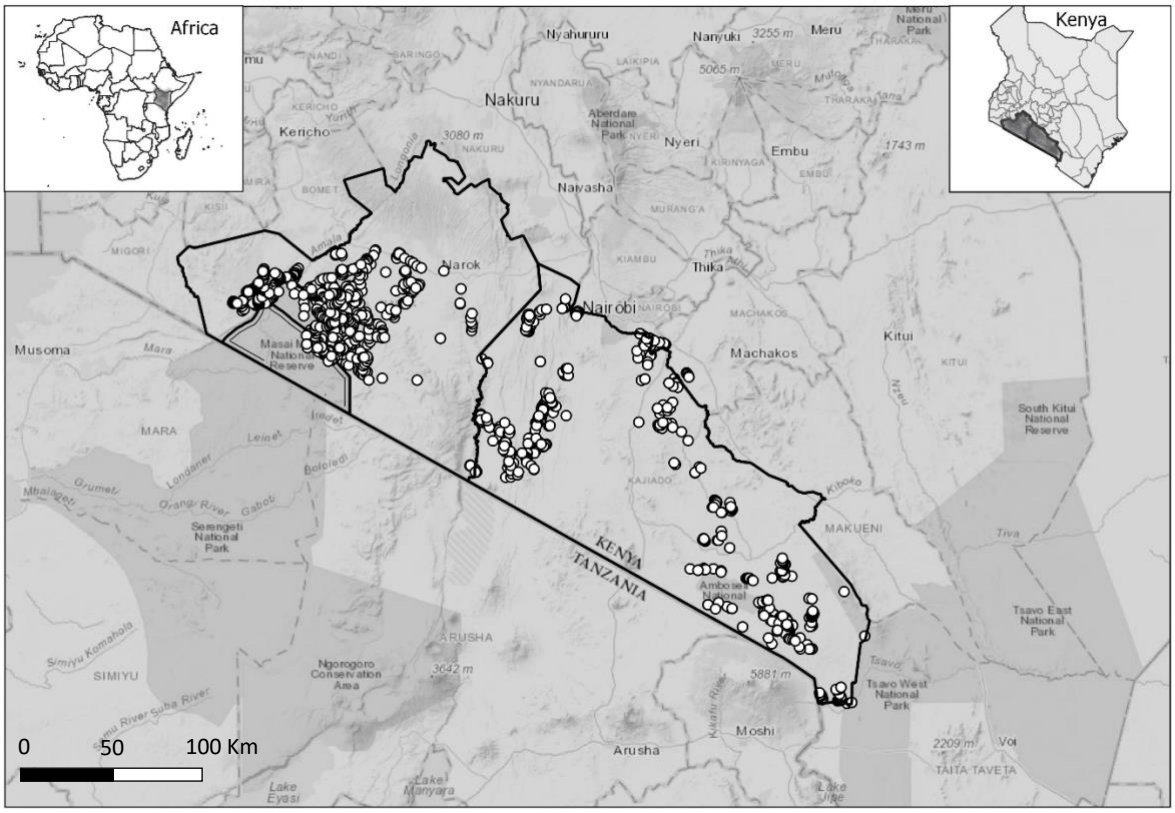

Figure 1: Map showing the approximate location of the 1,424 households (white dots) across Maasai Mara, Southwestern Kenya that participated in the research survey.

Crop production is a rare practice. The region is punctuated with several communal conservancies. Communal conservancies are areas owned, administered and managed by individuals, local communities or a corporate group aimed at wildlife conservation, among other compatible land uses for better livelihoods. Under the Kenya Wildlife Act, conservancies are a recognised land-use option, making it an attractive alternative for landowners and communities as they offer incentives and land resource rights. Kenya has 15 wildlife conservancies in this region. These connect landscapes that augment the role of National Parks and reserves and simultaneously provide benefits of wildlife management to communities.

The Maasai Mara is primarily composed of grasslands, which provide important grazing grounds for large herds of wildebeest, Zebras and other grazing animals during the annual great migration (Anderson and Horwitz 1979). The grassland is composed mainly of different types of grasses such as red oat grass, star grass, buffalo grass, and others (Anderson and Horwitz 1979). Small areas of acacia woodlands also form part of the ecosystem, which provide important habitat for a variety of bird species and other wildlife, such as baboons, bushbuck, and bush pigs (Anderson and Horwitz 1979). Wetlands complement the ecosystem where the Mara River and other seasonal rivers and streams flow through the Maasai mara, creating a network of wetlands that are important for waterfowl, crocodiles, and other aquatic species (Anderson and Horwitz 1979). The wetland also play an important role of maintaining the hydrological balance of the Mara ecosystem (Mukeka et al. 2019). These conditions support high biodiversity estimated at over 95 species of mammals, amphibians, reptiles and over 400 bird species (Anderson and Horwitz 1979). The ecosystem is also home to endangered species, including the black rhinoceros, the Rothschild's giraffe, and the wild dog and serves as a critical habitat for the wildebeest, zebras, and other migratory species (Ottichilo et al. 2000).

Narok County generally supports large masses of migratory browsers, and grazers and in turn hosts a diversity of predators such as lions, hyenas and jackals. Ultimately, this makes the region a suitable foraging area for avian scavengers such as vultures in East Africa (Ottichilo et al. 2000). Six vulture species (*Gyps ruepellii, Gyps africanus, Torgos tracheliotos, Necrosyrtes monachus, Trigonoceps occipitalis, Neophron percnopterus*) occur here at different densities (Anderson and Horwitz 1979). These species are Endangered or Critically Endangered according to IUCN, to the extent that the area represents a priority hotspot for vulture conservation (Santangeli et al. 2019). The study area is rife with human-wildlife conflicts, involving a range of predatory species and intensifying

with increased occurrence over the past decade (Ogutu et al. 2016; Mukeka et al. 2019). Amid the fast-rising human-wildlife conflicts, pastoralists are increasingly resorting to use poison as a corresponding measure to suppress predators. This has resulted in mass mortalities, involving hundreds of vultures in recent years (Ogada, Keesing, and Virani 2012; Ogada 2014).

Data access protocol.

This study used secondary data provided by the Peregrine Fund, a non-profit organisation that conserves endangered and threatened birds, and later authorised for secondary use by the University of Cape Town Scientific Research Committee. The data were previously collected in 2018 as part of a research project completed in 2021 (Didarali et al. 2022). The questionnaire survey covered the study area and targeted livestock owners. It explored the belief-based use of vulture body parts and poison use within human-carnivore conflicted pastoral communities. All interviews were conducted in-person by local field assistants who were extensively trained prior to the data collection exercise. Verbal consent was used owing to logistic challenges such as varying literacy levels. In cases where consent was denied, interviews were not taken. Interviewers moved across a predefined region, approaching pastoralists and selecting respondents encountered. This respondent selection was opportunistic, given logistic constraints, while optimizing the spatial extent of sampling. In practice, interviewers arrived in one location, searched for livestock farmers, and then selected one at random. Interviews lasted between 10 to 60 minutes in either Kiswahili or other local language, depending on the respondent's preference. A total of 1,424 interviews were undertaken in order to characterise and quantify the use of poison against vultures and wildlife, and the belief-based use of vulture body parts. However, 1,387 consistent interviews were finally analysed after eliminating 38 of them that had missing information in some questionnaires.

Interview design.

The original questionnaire included many questions related to socio-demographic, human-wildlife conflict and solutions to avert that, and knowledge and perceptions of vultures and of the new Kenya Wildlife Act of 2013 (Didarali et al. 2022). For this study, I only used data resulting from the following questions (Appendix, page 47). Questions about various sections focus on factors associated with the respondents' motive behind poison use, type of poison used, method of applying and spreading poison, as well as questions related to the knowledge and use of vulture body parts. The belief-based use of vulture body parts was asked as a categorical variable, where different beliefs and uses were clustered based on common responses falling into community's specific needs such as singing and dancing class into traditional use. Questions related to livelihoods such as farming context were asked, for example; the main source of income, type and number of livestock on the farm and the number of livestock lost to predators. Other questions relate to livestock protection measures and their perceived effectiveness as the preventive alternatives against predatory wildlife.

Sensitive Questions: Assessment of poison use.

The list experiment technique.

Surveying poison use is sensitive since using poison is illegal in Kenya. An indirect questioning technique that provides anonymity to respondents was employed to assess poison use. The method does not necessitate respondents admitting to any illegal activity. Hence, it reduces the biases inherent in direct questioning of sensitive subjects (Nuno and St John 2014). This technique is known as the list experiment or unmatched count technique in this context. It has been used successfully to quantify the prevalence of illegal hunting in African communities (Nuno et al. 2013), as well as the prevalence of vulture poisoning in South Africa (Brink et al. 2021). The technique works when the target pool of respondents is divided into a control and treatment group. In the same context, respondents in the control

category were each presented with a list of four non-sensitive behaviours, or the control items: livestock herding (common behaviour), crop farming, trading, teaching (the rare behaviour). In the case of the treatment group a fifth behaviour, the sensitive one of research interest (use of poison) was included in the list. The order of listed items was randomized to eliminate the order effect. The Indirect questioning technique provides a high degree of privacy by asking the total number of items that respondents engage with, rather than pointing out specific items (Imai 2011).The expected results on non-sensitive questions would be the same both for the control and treatment groups. However, any detectable mean number of behaviours reported between the two groups would result from the sensitive item (poison in this case) on the list of the treatment group (Imai 2011).

Statistical analysis.

All analyses were performed in R version 4.1.0 (R Core Team, 2021), with figures produced using the package ggplot2 (Wickham, 2009). For modelling the list experiment data aimed to quantify the effect of livestock protection measures on poison use, I used the item count technique from the "list package" (Blair and Imai, 2010), a tool specifically designed for analysing list experiments (Blair and Imai 2012). I used the same recommended modelling framework as recently followed by Brink et al. (2021) and Didarali et al. (2022) to estimate poison prevalence and correlates from list experiment data similar to those of this study. The dependent variable is the count of behaviours as declared by each respondent in either the control or the treatment group. I tested my model with Non-Linear Squares (NLS) estimator for assumptions inherent to list experiments, including design and floor effects. All assumptions of the unmatched count technique were met. (1)The treatment group was randomly selected, (2) no list experiment design effects were detected (tested using the item count technique function, and the Bonferroni-corrected p-value = 0.605, for the sensitive Item), implying that all responses were honest, and (3) the number and responses too, did

not change with the inclusion of the sensitive item (poison). All predictors were tested for collinearity, and no correlated variables ($r > 0.7$) were detected. The model included eight variables (*Table 1, page 48*). Among these, three were included in order to control for their known effect on poison use: income source (categorical with two classes: main source coming from livestock farming vs other sources), cause of loss (categorical with two classes: whether the main cause of livestock loss is attributed to predators vs other causes), and proportion of livestock predated (continuous variable).

The five predictors of interest represented each specific livestock protection measure commonly used by Maasai Mara farmers to protect their livestock from predation (*Table 1, page 46*). (1) Herding; the daytime open-field rearing of herds of livestock. (2) Fencing; where structural enclosures as either live fencing materials such as thorny hedge plants or those made out of dead materials such as poles and barbed wire, and electrified fences. (3) Guarding; patrolling livestock, particularly at night when carnivores are publicly suspected of wandering into human and livestock territories. (4) Using dogs to protect livestock at any time and (5) lights as an alternative method of scaring away carnivores, using one or a combination of fencing, lion lights, solar security lights, torches and fire. Due to sample size and ease of results interpretation, I only tested the single effect of each of the five above variables in a separate model, whereby the main model structure was the same (e.g. the response type and the three variables to control for), but in turn we included each of the five predictors of interest. Here, I intentionally ignore the joint effect of the application of multiple measures by the same respondent, while I acknowledge that testing also some of the most popular combinations of methods could be informative.

RESULTS

Reasons for using poison as control against problematic wildlife and vultures

A total of 292 households provided answers about the reason that poison is mainly used by farmers in the Maasai Mara community. These reasons fell into five categories. About half (48.6%; *n* = 142) of households surveyed associate poison use with its ability to kill many predators, whereas 29% (*n* = 85) reported that it is easy to use. A minority of respondents also revealed their preference to poison because it is a cheap and secret method, accounting for 9% (*n* = 27 and 25 respectively) of total responses in each case. Only 4.4% (*n* = 13) of farmers reported they choose poison because it is safe to use.

Types of poison used to kill wildlife and vultures.

Only 19% (*n* = 257) of total households (*n* = 1,387) chose to answer questions about the types of poison used to trap and kill wildlife within Maasai Mara (Fig. 2). Five types of poison were reported as carbofuran, strychnine, potassium powder, rodenticide and herbicide. Among these, carbofuran is the most widely used poison, with over half of all households who responded to this question using this poison. Strychnine was used by about one of four of the respondents to this question, while other poisons were far less commonly mentioned (Fig. 2).

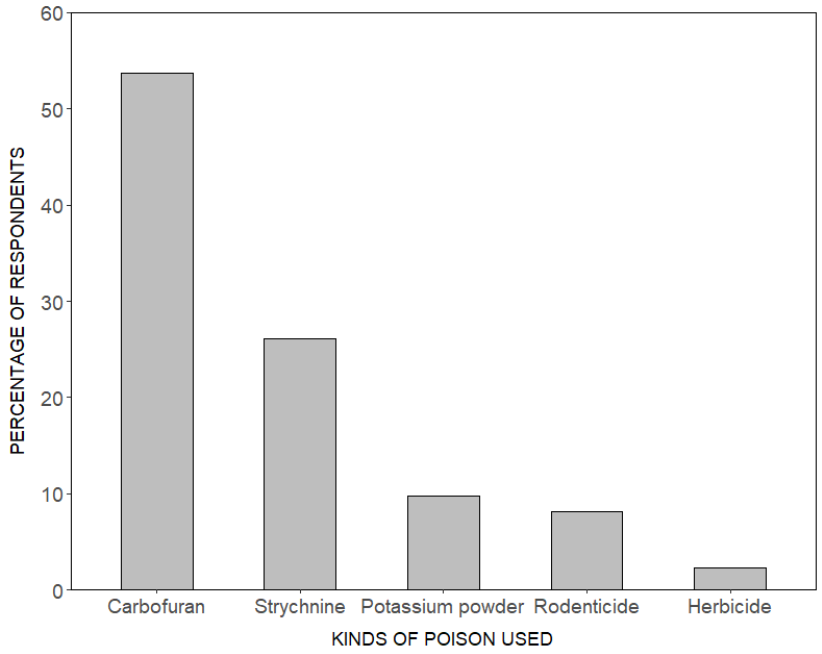

Figure 2: Percentage of different types of poison identified by respondents as being used to kill wildlife and vultures within Maasai Mara.

How poison is used against wildlife.

A total of 300 households responded about the ways in which poisons is used to achieve the desired lethal effect on predators, which fell in three main ways (Fig. 3). The majority, 84% (*n* = 252) smear the poison on carcasses as a paste, poison powder sprinkles, or as a liquid spread on dead livestock or wildlife. Fewer households reported injecting poisons into carcass baits. In this case, liquid poison is injected intravenously into the carcasses of dead livestock or wildlife. Finally, those who use 'small' poisoned baits were extremely rare (Fig. 3). Poisoned baits are pieces of fresh or dried meat curated with poison that are scattered across the landscape.

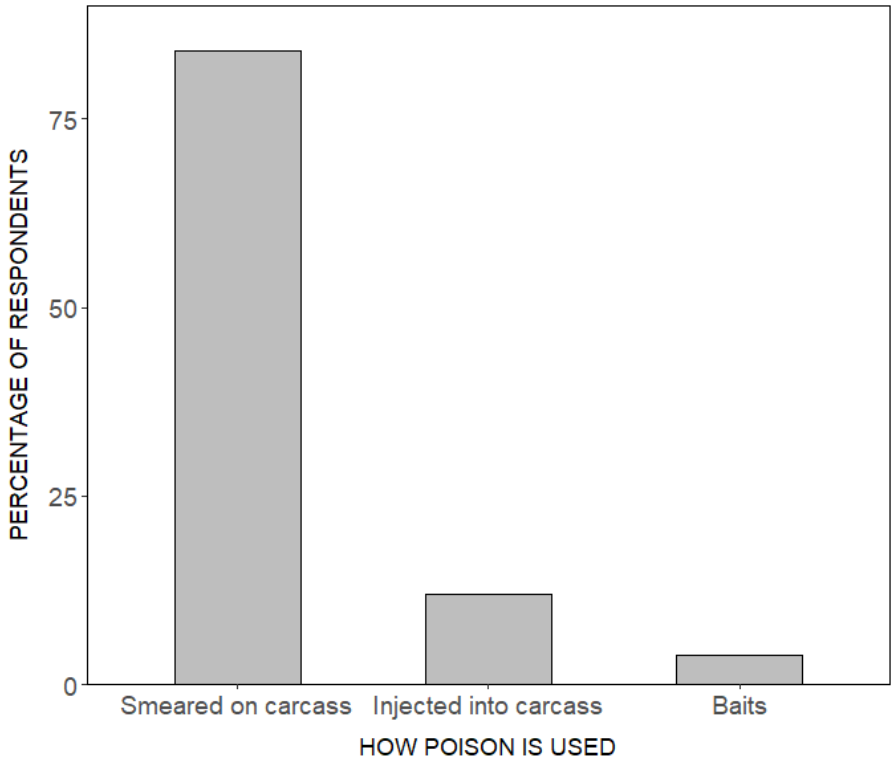

Figure 3: Popularity of different ways as revealed by respondents on how poison traps are set against wildlife and vultures in Maasai Mara.

Sources of poison to Maasai Mara pastoralists.

Almost half of the respondents to the poison source question (48%; *n* = 152) admitted that poison is sourced from agricultural and veterinary shops (Agrovets), with other sources being far less common (Fig. 4).

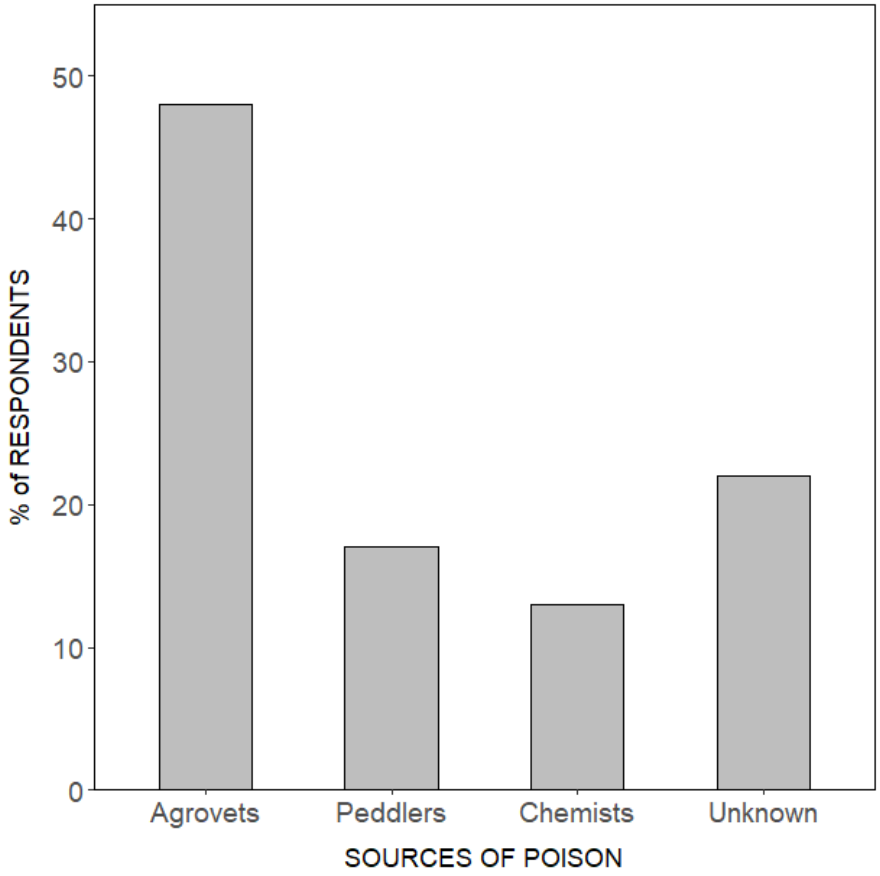

Figure 4: Sources of poison reported by respondents used to kill wildlife within Maasai Mara.

Use of vulture body parts

In total, 58% (799 of 1387 respondents) revealed how vulture body parts are used in their community (Fig. 5). The vast majority (75%; *n* = 603) of respondents reported that vulture body parts are used for arrows, making it the largest consumptive cultural use. Use of vulture body parts for decoration and traditional purposes were far less common. The “other” category represents a case when only one respondent revealed that vulture body parts are used for meat consumption (Fig. 5).

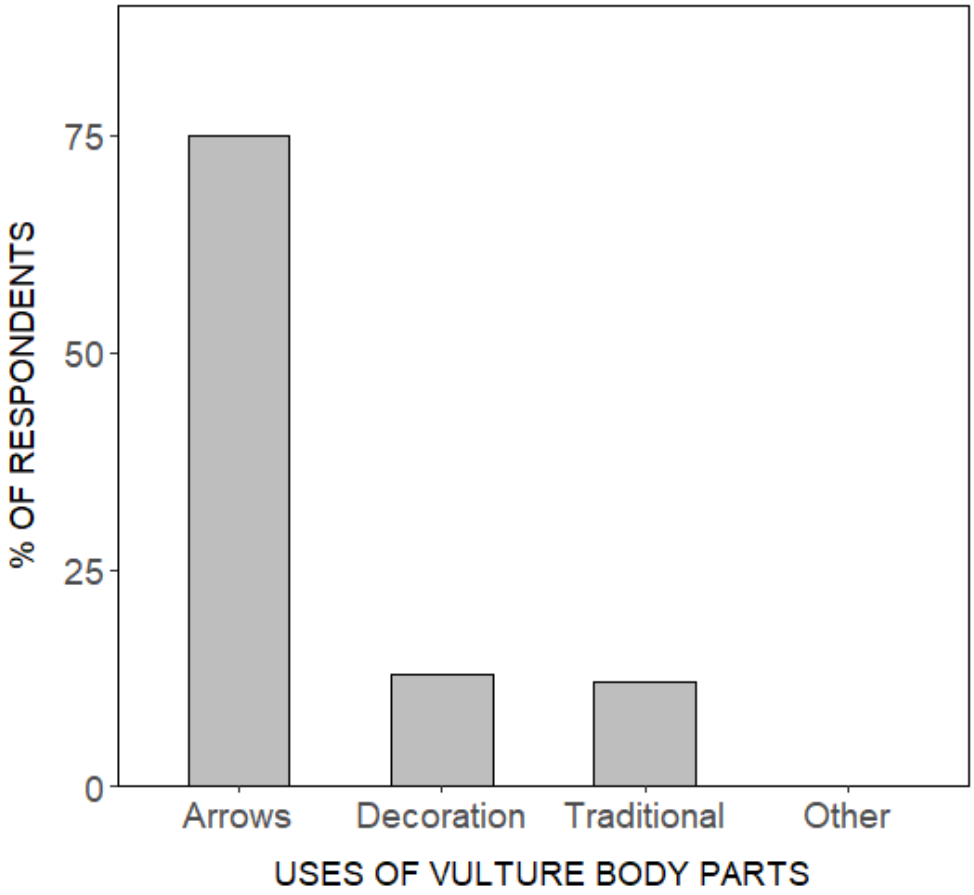

Figure 5: Percentage of the different uses of vulture body parts reported by respondents within the Maasai Mara community.

Livestock protection measures used by Maasai pastoralists

Respondents reported five livestock protection measures against depredation by wildlife. In their respective order of popularity, these included fencing, guarding, lights, dogs and herding (Fig. 6). Fencing was the most commonly used predator-proofing measure by 1 in 5 Maasai pastoralists (22%, *n* = 306), guarding at 5% (*n* = 70), lights at 2% (*n* = 27), whereas dogs and herding were the least used methods at 1% (*n* = 27 and 17 respondents respectively). Protection measures were reported from 440 respondents, where nearly half of all the respondents combine fencing with other livestock protection measures.

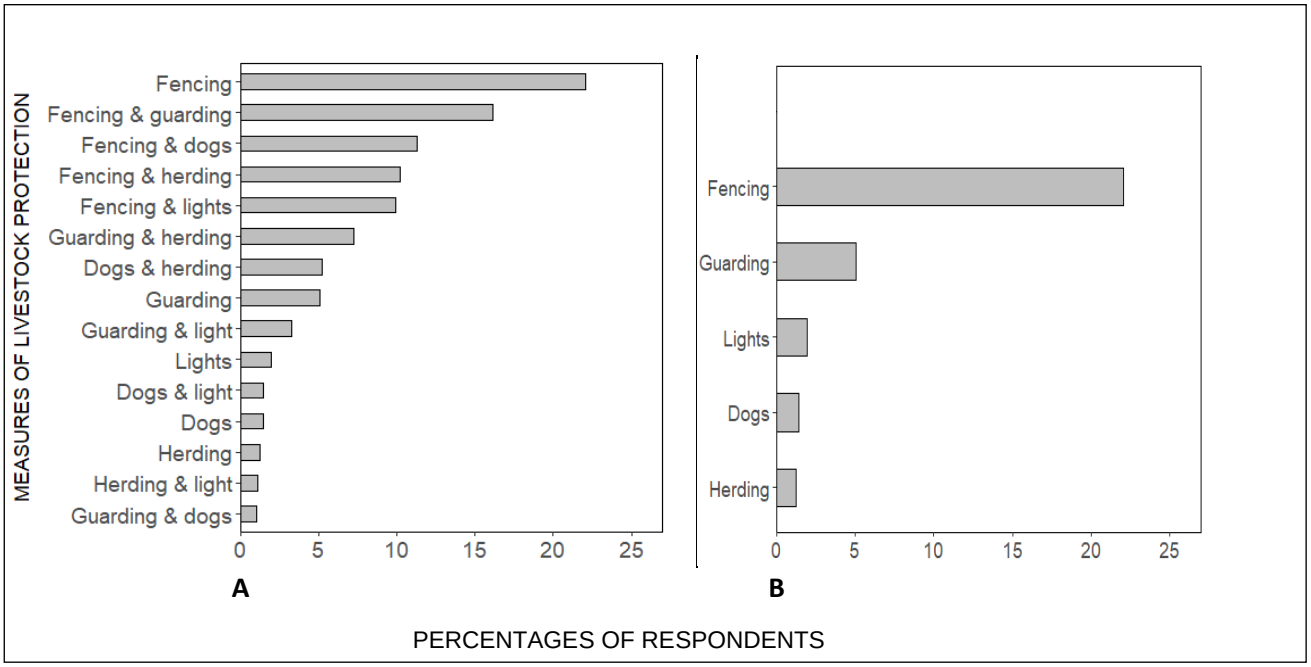

Figure 6: Relative use of (A) one or a combination of two of five livestock protection measures and (B) the main livestock protection measures predominantly used against predators reported by respondents within Maasai Mara. These responses combined discrete methods of livestock protection (Fig. 6A) with other measures reported by 90% of respondents in this whole study. Similarly, five main categories of livestock protection measures (Fig. 56) were isolated from all the responses provided (Fig. 6A).

Livestock protection methods' effect on poison use prevalence.

The results of the list experiment model (*Table 1, page 46*) indicate that none of the livestock protection methods significantly affects the likelihood of poison use (Fig. 7). However, we found weak signals that the use of fences, or lights, might reduce the likelihood of using poisons (Fig. 7).

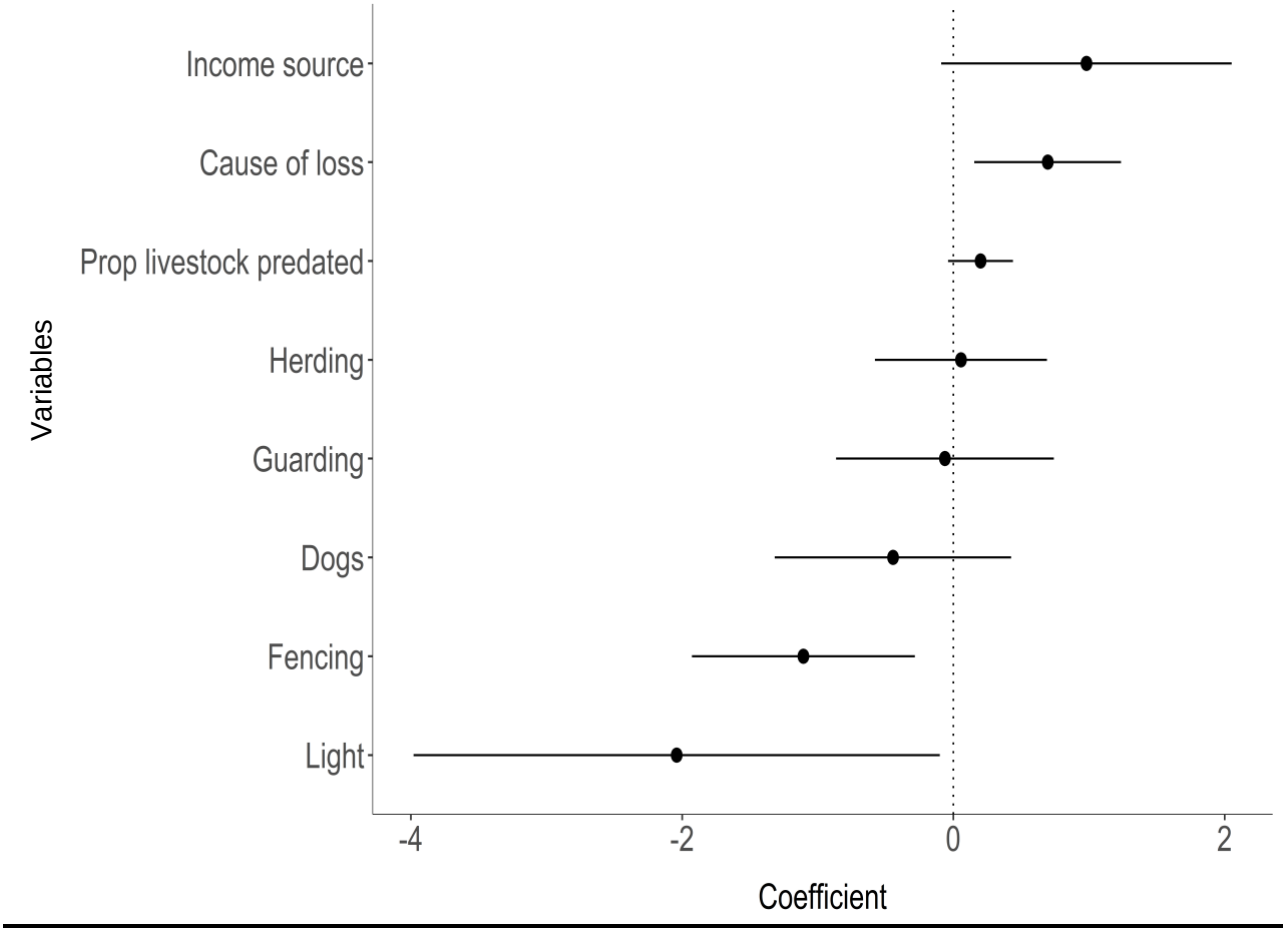

Figure 7: Coefficients of the eight variables (predictors) on poison use prevalence in Maasai Mara. Dark horizontal lines in each prediction show the level of the 95% confidence interval, while the midpoint denotes the median. Significant variables are interpreted as those whose 95% CI does not cross zero. Variables were quantified using the list experiment and tested with non-linear least squares estimator (see methods for details). A score from 0 to -4 signifies no poison use, whereas from 0 to 2 indicates an increasing likelihood of using poison by pastoralists either relying on each of the bottom five livestock protection methods or affected by the top three predictors. Cause of loss refers to predators with other causes set as reference.

DISCUSSION

My study reveals that a high proportion of the Maasai pastoralists are familiar with poison being used to kill carnivores. Communities were readily aware of the types of poison used, and how to use these, with somewhat lower proportions knowing where these were sourced. It also finds that, Maasai culture uses vulture body parts, mostly vulture feathers, largely used for ornamentation among other purposes. Currently, fencing remains Maasai's preferred and predominantly used livestock protection method against predatory wildlife. However, a least proportion of the Maasai pastoralists still entirely rely on herding their livestock, signalling future human-wildlife conflicts and the associated poisoning risks to wildlife.

Reasons for poison use.

Poisoning is regarded as the most effective and simple method of predator control by pastoralists in Maasai Mara. These results complement earlier findings on poison prevalence and environmental law from both Reson (2012) and Didarali et al. (2022). Nearly half of households who poison wildlife prefer this method for its simplicity and effectiveness (simple to use, available, and can kill many predators). Past baseline studies particularly on reasons for poisoning, remain scanty and unquantified for comparison. Earlier ethnographical studies suggest that Maasai pastoralists primarily depend on livestock for their subsistence (Bravman 1994; Little 1998). Currently, pastoralists possibly tolerate predators most often begrudgingly due to the increasingly conflicting needs of humans. Thus, they may aim for effective "eco-cidal" reprisal in the worst-case scenarios. Poison is also widely used against predators in other pastoral communities, as it is in Namibian freehold areas (Santangeli et al. 2016).

Maasai households further revealed other aspects about their choice of using poison against carnivores such as its ease of use, safety and the secrecy to evade prosecution. However, they reported these as minority considerations. This prioritizes poison's effectiveness amongst pastoralists and remains the main driver for its use. Anecdotal evidence also suggests that pastoralists are very much pragmatic, as their main interest is to effectively achieve their target of killing predators. Basically, they place little consideration on other factors, like the price of poisons or the fact that they can secondarily kill other animals, like vultures. In addition, they are less concerned of potentially harming other elements of the environment such as polluting the water sources. Presumably, pastoralists instead only avoid being found by authorities. Therefore, pastoralists seemingly want to effectively achieve their goal of eliminating predators. Unlike other reasons, the effectiveness of poison use matches Maasai's primary interest of eliminating carnivores. It is also visible, because poisoning often kills masses of predatory or scavenging wildlife in a single event (Ogada et al. 2016).

Poison sources, types and ways of application.

The most common sources of poison are agrovets and local open markets reported by almost half of households sampled in Maasai Mara. Agrovets include a combination of agricultural input shops and veterinary drug shops operated by business people within Kenyan local markets. I presume that Mara compares with other fast-developing agro- and purely nature-based settings, where this retail category could be more abundant and accessible to many community members, yet less regulated with regards to sensitive chemicals. Typically, Mara's goods distribution and supply system could still occasionally characterize the hypothetically less regulated, free and open market kind for all utility products. Based on Maasai household responses, peddlers are people covering distances selling poison products (among other items) by hawking them to community members, some

of whom might be interested in getting rid of predatory wildlife. Whereas, chemists specifically entails specialist traders whose stores and chain of supplies is predominantly focused on trade in agricultural, industrial and domestic chemicals. All poison sources that were “unknown” to Maasai households mainly relate to other unauthorised sources external to the Kenyan local markets. Based on their mentions of foreign place names, it broadly includes the rest of poisons and poisonous products, mostly, those smuggled from the southern neighbouring country, Tanzania.

Poison types used to kill wildlife in Maasai Mara comprise carbofuran, strychnine, potassium powder, rodenticide and herbicides in their respective abuse order. Carbofuran is an extremely poisonous insecticide or pesticide, yet inexpensive, easily obtainable, and has frequently been used in Sub-Saharan Africa (Virani et al. 2011; Ogada 2014; Buechley and Şekercioğlu 2016). In this regard, our results are consistent with Ogada's (2014) findings that carbofuran is the most widely abused pesticide, based on its unparalleled toxicity in eradicating predators, followed by strychnine in Africa. According to Buechley and Şekercioğlu (2016), carbofuran is sold widely and is frequently used by Maasai herders in Kenya to kill lions. As an efficient replacement to traditional poisons, it is also by far the most common poison still illegally employed against wildlife in Namibia (Ogada 2014; Santangeli et al. 2017). Similar issues with this product have been observed in Namibia, where Bayer was able to remove it (along with strychnine) from the market but livestock producers had already acquired substantial amounts by 2003 (Buechley & Şekercioğlu, 2016; Santangeli et al. 2017). Additionally, it was also banned for use on food crops a number of years ago or their use is severely restricted in the USA, Canada and Europe (Ogada 2014; Buechley and Şekercioğlu 2016). Carbofuran also remains a commonly used pesticide in Asian and

African countries on crops (Buechley and Şekercioğlu 2016), and so it represents a threat for wildlife and the entire ecosystem.

Householders specifically reported a number of relevant pesticides frequently employed. These were collectively identified as carbofurans. They included Acaricides, insecticides, methyl-carbamate, doom powder, lanet, pyrethrin, agrinet, almatix, and blue powder were also mentioned alongside carbofuran itself. These were reported according to their major intended purpose, trade names, or main active ingredient known to locals. Santangeli et al. (2017) found that Namibian farmers who had large stocks of cattle and sheep, and had suffered losses due predatory wildlife, poisoned wildlife. Of those, carbofuran still was largely reported above strychnine, even though these were banned in 2003 yet no legislative regulation was set up. Its likely farmers still rely on residual reserves and smuggled consignments.

Strychnine was the second most popular poison reported that collectively include all white, pinkish, or bluish crystalline forms of highly toxic and acute toxins. Other white chemical powders like potassium carbamate, potassium chloride, arsenic, or DDT are examples of potassium powder. Additionally, potassium powder can be extremely poisonous and cause burning when it comes into contact with human or animal tissue (NARREC 2006). A broad group of chemical poisons intended to kill rodents is known as rodenticide. Ratrat and nearly all anticoagulant first- and second-generation rat poisons were taken into consideration. Under the same classification, we also considered tornado, redcat (Zinc phosphide), a toxic chemical by inhalation or ingestion and it is an acute toxin (NARREC 2006). Herbicides comprise a broad range of chemicals primarily employed in agricultural farmlands to eradicate weeds. Under this category, we included ‘phosphatic’ agrochemicals and copper

toxic chemicals that were reported as frequently employed by pastoralists for ecocide despite being meant to manage weeds in agricultural areas.

Depending on the nature of a pesticide, pastoralists mainly smear poisons onto dead livestock or wildlife to achieve the desired lethal effect on predators. Uncommonly our interviews showed that pastoralists inject poison into livestock or wildlife carcasses. Rarely opened carcasses or pieces of meat laced with poison (mostly odourless) are scattered as baits across the landscape. Santangeli et al. (2016) argued that by their sheer size, poisoned carcasses could stay for longer exposed in the environment than poisoned meat baits that are small and targeted. However, baits too, kill vultures given their exceptional ability to scan over landscapes for dead animal materials (Ogada 2014). Poisoned carcasses are therefore long lasting death traps with potential to kill numerous scavengers, compared to baits. These are the most commonly utilized anti-carnivore measures and of great cause for concern. Like many poisons, Ogada (2014) notes that poisoning ability depend on toxicity levels or how fast acting the pesticide could potentially be, poison load consumed by unsuspecting wildlife and vultures, prevailing weather conditions and period of poison-trap exposure. Ogada (2014) and Santangeli et al. (2017) also found that some animals succumb far from the point of poisoning. In some cases, close to or inside open water sources as most seek to neutralise poison. This not only confounds the exact estimate of poison mortality but, most importantly, it further diffuses the lethal effect of poison through space and time. Therefore, it raises the number of other animals and potentially water sources and humans at risk.

Uses of vulture body parts

Use of vulture feathers for making hunting arrows and ornamentation appears to be the most common (75 percent) belief-based use, partly for they enhance hunting success. To a lesser extent for customary uses including cultural festivities. In this regard, decorative purposes

reported included the use of vulture feathers to make ornaments, necklaces, and in some cases used as charms and for beautification. Traditional uses mentioned included ceremonial activities, boys' circumcision, traditional singing and dancing by *morans*, initiation, and witchcraft (mostly, the heads of vultures). Vulture feathers are mainly collected from the ground where vultures congregate over their nested trees and this may pose no significant threat to vulture conservation in Mara (Reson 2012). However, vulture heads used in traditional medicine are obtained by vulture poisoning, a practice also well-documented in Southern and Western Africa (Thiolla 2006; Saidu and Buij 2013; McKean et al. 2018). Henriques et al. (2020) also found that, by using poison, hooded vulture heads are harvested in Guinea-Bissau and traded in traditional medicine. The "other use" considered was the rarest purpose of vultures for meat as human food. However, given that it lacks support on a cultural, social, and economic level, this occasional intake of vulture flesh is less concerning and unexpected. Moreover, Reson (2012) poised that sourcing vulture meat is unusually a Maasai norm because it is culturally unacceptable (a taboo), and only seen from the socio-culturally deficient and morally bankrupt (insane) or the crude and outcast Maasai members.

Livestock protection measures.

The majority (70 percent) of Maasai pastoralists in Southwestern Kenya at least protect their livestock by fencing. This is based on the effective protection and security fencing provides (Sutton et al. 2017). Fences are essentially fortified or chain-linked livestock enclosures commonly known as "bomas". Sutton et al. (2017) discovered that these kinds of fences significantly reduce up to 67 percent of annual livestock depredation in Maasai Mara. From our results, it is also noteworthy that the vast majority (70 percent) of households fence in conjunction with another livestock protection strategy, and 18 percent, at least use fence lights as a livestock protection method. Despite fencing being initially labour intensive along

with associated high overhead costs to set (Reson 2012), it remains the preference and an aspiration of the pastoralists (Sutton et al. 2017). Fence lights enhance protection but equally raises the capital costs involved. Capable farmers may individually install fences. Others are partially funded on case-by-case basis, possibly on a livestock depredation event, through government compensation (consolation) program or non-governmental organizations focused in areas like Maasai Mara, where people and wildlife coexist despite conflicts (Hazzah 2007). Only 1% of pastoralists in Maasai Mara still traditionally herd their livestock. In carnivore-infested areas such as pastoral areas of Maasai Mara, herding doubles as both an open-field rearing and as a protective mode for pastoralism against carnivores (Sutton et al. 2017). Therefore, it not only grazes livestock but also ensures the monitored protection of livestock from carnivorous wildlife among other threats afield during daytime.

Vulture poisoning risk based on livestock protection measures.

Pastoralists who use fences and a few others who use lights as their livestock protection measures appear less likely to poison wildlife. This signal in our data is weak and needs further investigation. Those who herd their livestock, on the other hand, are more likely to poison predators, again based on a very weak statistical signal. This is partly due to pastoralists' low resilience to wildlife disturbance. Herders' poisoning behaviour appears to be triggered as the number of large to small livestock disproportionately increases through time and space. This illegal behaviour is further influenced, and it becomes more widespread whenever pastoralists realize that their livestock's loss resulted from carnivorous wildlife. Thus, it explains their animosity and intolerant behaviour to predators. According to our findings, this continues to be the leading cause of wildlife poisoning. Reson (2012) argues that the majority of Maasai remain dependent on livestock amidst pervasive modernization

almost completely "engulfing" their pastoral culture and lifestyle. Efforts aimed at subsidizing fencing would go a long way to solve the longstanding human-carnivore conflicts in Mara.

From our results, Maasai herders are particularly more likely to poison carnivores. It is an unusual attitude explosion against wildlife which is periodically reflected in the retaliatory behavioural poisoning response (Didarali et al. 2022). Still, Didarali et al. (2022) found that Maasai pastoralists not only regard vultures favourably but also have a positive attitude towards wildlife. On the contrary, the same study confirmed that lingering animosities toward wildlife are occasionally stoked. This is consistent with earlier findings of Hazzah (2007) and Hazzah et al. (2014). The negative attitude was associated to a number of factors: Maasai's longstanding conflict with wildlife, the prevailingly inefficient compensation and low institutional trust (Hazzah et al. 2014). In addition, the historically coercive protective measures, alongside the updated Kenya wildlife Act of 2013, that prioritize wildlife and predators over Maasai's wellbeing are all influential to Maasai's repulsive attitude about wildlife (Hazzah et al. 2014; Didarali et al. 2022). Consequently, the Maasai pastoralists, mostly those predominantly herding afield (26 percent) may be constantly exposed to predatory wildlife and therefore more prone to livestock loss. Hence, they occasionally retaliate by poisoning wildlife to safeguard their livestock.

According to Reson (2012) and Didarali et al. (2022), Maasai pastoralists value vultures for their cultural support, cleaning services and locating carcasses. Similarly, with the majority's preference to vultures, Namibian farmers mentioned these socio-economic benefits (Craig et al. 2018). More recently, vultures are especially valued in Maasai Mara because they contribute to the region's aesthetic attractiveness. Unsurprisingly, this feature as well, makes the area a popular locus for ecotourism which further solidifies its designation as a UNESCO

World Heritage site (Virani et al. 2011). Nonetheless, due to the human-carnivore conflicted Maasai Mara, these IUCN-endangered and -critically endangered scavengers are repeatedly poisoned to death, as pastoralists fend their livestock against carnivorous wildlife. This implicates the possibility of dwindling environmental and socio-economic benefits that wildlife, and vultures in particular, provide.

CONCLUSION.

The high inorganic poison presence and use in Maasai Mara possibly thrives on relaxed regulations and inadequate law enforcement on; poison importation, distribution and accessibility to toxic pesticides and other poisonous substances. Poisons such as carbofuran and strychnine have been widely eliminated or rigorously regulated in other parts of the world. If they are commercially viable as agricultural inputs, then they should cease to be openly availed at any store. Additionally, only a number of authorized and well-trained distributors or retailers should be allowed to sell them, and only limited amounts should be distributed to interested parties. Registered retailers should regularly keep a file with the address details of the individual purchasers, as well as the amounts purchased. Any misuse of the poisons may then be traced back to the offending community members for legal prosecution.

All chemical imports with significant environmental effects should be subject to frequent regulation at ports of entry under the international agreement on hazardous chemicals. Additionally, in order to identify chemicals and record poisoning instances, the Kenyan wildlife/environment agency should work more closely with the Maasai people. Collaborations should include local agencies, donor agencies supporting pastoral livelihoods and anti-poaching efforts, as well as industries manufacturing these chemicals

to create a networked sensitization and regularisation on poison use. Other measures include developing a national vulture management plan to guide vulture conservation works, training farmers (where necessary), and field rangers on poison, poisoning data collection, and establish a national reporting channel and database on poison to focus the much needed support or preventive action.

In practice, conservancies in Maasai Mara, Southern Kenya, merit special recognition in this regard. They have been key to implement a variety of strategies to counter the looming vulture and other wildlife poisoning and poaching. These include community engagement, surveillance and security measures, and collaboration with the wildlife management authorities. They also involve educating local people about the importance of wildlife and the negative impacts of poisoning, poaching, and other illegal activities. Additionally, some conservancies have established pest and disease management programs, which can help to reduce the need for pesticides and other chemicals. Overall, the most effective approach to countering wildlife poisoning and poaching in Maasai Mara is a combination of various strategies. Based on evidence of vulture poisoning, the need for more efforts still exists.

Allocating resources where necessary to upscale fencing initiatives for pastoralists in need, impose stringent restrictions, and monitor the use of poisons. This strategy, meanwhile, is not a panacea; rather, it promotes good wildlife stewardship and a gradual transition from conflicts between people and wildlife, possibly to a mutualistic co-existence. In addition, joint efforts between local actors and the Convention on Migratory Species should build local trust and collaborations. This will maintain or enhance habitat quality and safety for the transboundary movements of vultures within their East African range states.

Similar measures must be taken to appropriately conserve vultures and other species in the Maasai Mara. More ‘pro-people’ initiatives and activities are necessary to engage in actions to support already-established social and economic well-being programs. For instance, greater funding is required for initiatives that support the creation of alternate watering holes, fencing, eco-lighting for those in need, and adequate, prompt, and effective compensation for wildlife damages. If community-centred programs that acknowledge and support local livelihoods are put into place, communities will become more resilient to wildlife and perhaps climate-related shocks. These initiatives will also inherently influence community support for conservation. In addition, interested parties can provide durable and well-regulated positive economic incentives, such as community recognition for exemplary resource usage and the straightforward redistribution of grazing land in acutely deserving areas. These would inevitably and favourably alter the Maasai's perspective on who owns, responsible for maintaining, and manage wildlife resources and conservation areas today.

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TABLE 1: Vulture poisoning risk for Maasai pastoralists using at least one of the five livestock protection methods, modelled with three confounding factors: proportion of livestock predated, causes of livestock loss, and pastoralists' source of income (*N* = 1,277*).* (*Refer to methods on Page 19 and Results, Fig. 7 on Page 26*).

	Sensitive Coefficient	Sensitive se	Sensitive p-value	Control Coefficient	Control se	Control p-value
(Intercept)	-1.491	1.351	0.270	0.017	0.123	0.890
Prop.LivestockPredated	**0.201**	0.239	0.401	-0.002	0.029	0.932
Cause of livestock loss	**0.695**	0.541	0.199	0.019	0.063	0.768
Income source	**0.982**	1.071	0.359	-0.110	0.078	0.159
Dogs	-0.445	0.871	0.609	0.062	0.088	0.484
Fencing	-1.106	0.822	0.179	0.299	0.086	**0.001**
Guarding	-0.062	0.803	0.939	0.184	0.085	0.030
Herding	0.056	0.634	0.929	0.160	0.077	0.039
Light	-2.040	1.940	0.293	0.090	0.097	0.351

APPENDIX: RESEARCH QUESTIONAIRE

Interview questions specifically analysed in this thesis from the respondent survey questionnaire tool.

1. What measures do you use to protect livestock from predators? .....
   ……
2. Do vulture body parts have any uses in your culture? .....
   Yes …… No…….
3. If yes, what for? .....
   ……..
4. Control or Treatment card? …….
5. Number of behaviours relevant?
   a) Control card (No poisoning):
   b) Treatment card (poisoning):
6. What is the most popular method used to kill predators? .....
7. Do people use poison to kill predators? Yes ……. No ……...
8. Why do they poison? .....
9. What poison do they use, how do they use and where does this poison come from?
   a) Poison type: ……..
   b) How poison is used: ……....
   c) Source of Poison: ……..…..
10. What is your main source of income? .....
11. Which is the most problematic predator? .....
12. When last did you lose your livestock? .....
13. Proportion of cattle lost to predators from the total number of cattle before loss
14. Proportion of Sheep and Goat to predators from the total number before loss
15. What was the cause of livestock's death? .....

Full questionnaire survey tool on the next page – 50

Full questionnaire survey tool used to guide this study.

Variable code	Description:
Question:	**Corresponding description.**
1. **Region**	6 regions
2. Village Name	Name of village
3. Village ID_NEW	Integer ID of the village, with some small villages lumped into larger villages for analyses
4. **Accessibility**	Market accessibility calculated at the household farm location using the market accessibility layer from Verburg et al GCB: https://iopscience.iop.org/article/10.1088/1748-9326/6/3/034019/meta
5. **DistPA_km**	Distance of the household farm to closest protected area
6. Date	Date of survey
7. X_OK	X- Coordinates
8. Y_OK	Y- Coordinates
9. Y_OLD	Y - coordinates
10. X_OLD	X- Coordinates
11. Refused to Answer	Respondents who refused to participate
12. Gender	Gender
13. Age: 3 Classes	3 classes: Young (<33), Junior Elders (34-49), Elders(>50)
14. **Age_Continuous**	Continuous numbers for Age from young to old
15. 18-33	Age between 18-33 (years)
16. 34-49	Age between 34-49
17. 50-65	Age between 50-65
18. 65-80	Age between 65-80
19. 80+	Age between 80+
20. How long lived	Age above 80 years
21. PP/HH	People per House hold
22. **Income2Classes**	Livestock vs others
23. Income Source	What is your main source of income
24. **Predation**	
25. Most problematic predator	Which is the most problematic predator
26. Proportion of sheep to goats predated	Proportion of Sheep and Goats lost to predators from the total no. before loss
27. Cause of death	What was the cause of death
28. Measure used to protect livestock	What measures do use to protect your livestock from predation?
29. Beliefs about vultures?	Are there any beliefs about vultures in your culture?
30. Any uses of vultures body parts.	Do vulture parts have any uses in your culture? Yes or No
31. What for?	If yes, what for?
32. **Control/treatment**	Control or Treatment card?
33. Number of behaviours relevant?	Number of behaviours relevant?
34. What's the most popular methods used to kill predators.	What is the most popular method used to kill predators.
35. Do people use poison to kill predators?	Do people use poison to kill predators?
36. Why poison rather than other methods?	Why do they use poison rather than other methods?
37. What poison do they use? How do they use them? Where does the poison come from?	What poison do they use, how do they use and where does this poison come from?