A neglected aspect of human-elephant conflict: fence damage by elephants in the Trans Mara, Kenya

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Abstract

Human–elephant conflict (HEC) is one of the most complex issues for elephant conservation today and is on the increase. Incidents involving elephants can have severe consequences for people who co-exist with them, creating negative attitudes. While there has been a great deal of research on crop raiding, other forms of conflict including fence damage are poorly documented, but could still give rise to significant costs for households. In this study, we investigated the frequency, severity and patterns of fence damage caused by elephants in communities of the Trans Mara District, Kenya in 2014–2015 and compared these to patterns of crop raiding. In total there were 792 incidents involving fence damage only, 517 incidents involving crop and fence damage, and 72 incidents involving only crop damage. While the majority of fence damage incidents occurred between 18:00 and 06:00, some damage continued until 09:00. Fence damage occurred in every month of the study period and peaked when the frequency of crop damage decreased, highlighting the year-round nature of HEC in this region. The persistent occurrence of HEC in the Trans Mara, on both a daily and an annual timescale, becomes much more apparent when incidents of fence damage are considered as well as crop raiding. Such constant conflict could have significant implications for effects on human wellbeing and consequently, on local attitudes towards elephants and conservation efforts. This research highlights the need for more attention to be paid to the patterns and perceptions of all types of HEC, not just crop raiding, across elephant ranges in order to plan effective mitigation strategies.

Additional key words: Human–wildlife conflict, property damage, social impacts, conservation costs, poverty, agricultural communities, fencing.

Résumé

Le conflit homme-éléphant (CHE) est l'un des problèmes les plus complexes pour la conservation des éléphants aujourd'hui et est en augmentation. Les incidents impliquant des éléphants peuvent avoir de graves conséquences pour les personnes qui coexistent avec eux, créant des attitudes négatives. Bien que de nombreuses recherches aient été menées sur les pillages des cultures, les autres formes de conflit, y compris les dommages aux clôtures, sont mal documentées, mais pourraient néanmoins entraîner des coûts importants pour les habitants. Dans cette étude, nous avons enquêté sur la fréquence, la gravité et les types de dommages aux clôtures causés par les éléphants dans les communautés du district de Trans Mara, au Kenya, en 2014–2015, et nous les avons comparés aux modèles de pillage des cultures. Au total, il y a eu 792 incidents impliquant uniquement des dommages à la clôture, 517 incidents impliquant des dégâts aux cultures et aux clôtures et 72 incidents impliquant uniquement des dommages aux cultures. Bien que la majorité des dommages aux clôtures se soient produits entre 18:00 et 06:00, certains ont continué jusqu'à 09:00. Les dommages aux clôtures se sont produits tous les mois durant la période d'étude et ont atteint leur maximum lorsque la fréquence des dommages aux cultures a diminué, soulignant la nature tout au long de

l'année des CHE dans cette région. La présence constante de CHE dans le Trans Mara, sur une échelle de temps quotidienne et annuelle, devient beaucoup plus apparente lorsque les incidents de dommages causés aux clôtures ainsi que les raids sur les cultures sont pris en compte. Ce conflit permanent pourrait avoir des conséquences importantes sur le bien–être et, par conséquent, sur les attitudes locales à l'égard des éléphants et les efforts de conservation. Cette recherche souligne la nécessité de prêter plus d'attention aux schémas et aux perceptions de tous les types de CHE, et pas seulement aux pillages de cultures, à travers les aires de répartition des éléphants afin de planifier des stratégies d'atténuation efficaces.

Mots-clés supplémentaires: conflit homme–faune sauvage, dommages aux propriétés, impacts sociaux, coûts de la conservation, pauvreté, communautés agricoles, clôtures.

Introduction

Human–elephant conflict (HEC) is projected to increase in intensity as human populations continue to expand into natural habitats, leading to increased competition between humans and elephants for space and resources (Naughton-Treves et al. 1999). Elephants can inflict direct costs on households though crop damage, fence damage and the injury or death of humans and livestock. Indirect costs include the resources used and/or the opportunities forgone while preventing conflict or repairing property (Woodroffe et al. 2005). Due to their large size, elephants can cause severe damage and elicit strong feelings of fear, anger and hopelessness amongst residents living in their presence (Naughton-Treves et al. 1999; Mariki et al. 2015). Despite this, elephants are protected because of their threatened conservation status and so tension between local residents and conservationists can be high (Acharya et al. 2016). This tension can lead to retributive killing of elephants, hampering conservation efforts and affecting local elephant populations (Mariki et al. 2015; Acharya et al. 2016; Pant 2016; Suba et al. 2017). This is why HEC is considered one of the greatest threats to elephant conservation across their range (Naughton-Treves et al. 1999).

Crop raiding alone can inflict obvious and significant economic costs on households (Woodroffe et al. 2005; Jadhav and Barua 2012; Mackenzie and Ahabyona 2012; Sitienei et al. 2012) and is the most common type of conflict studied and reported. Crop raiding follows relatively predictable patterns, typically occurring at night and peaking when crops ripen (Wilson et al. 2013; Sitienei et al. 2014), and commonly occurring closer to forest cover where elephants can take refuge (Sitati et al. 2003; Graham et al. 2010; Gubbi 2012) and along migration routes (Acharya et al. 2017). However, while elephants are also known to cause damage to trees, homes, water and livestock infrastructure, crop stores and fences (Gubbi 2012; Sitienei et al. 2014; Pant 2016; Neupane et al. 2017), research on the prevalence and patterns of these types of damage is lacking.

Available research in Asia shows that fence damage can occur year-round and that such conflict could potentially have an equal or greater economic impact on farmers compared to crop raiding (Wilson et al. 2013; Pant 2016). In addition to direct economic costs, the time and effort required to repair such damage can take resources away from other important tasks, including agriculture, or other areas of income generation, which could affect health and education (Mackenzie and Ahabyona 2012; Barua et al. 2013). If strategies for mitigating conflict are based on an incomplete understanding of the full extent of conflict, mitigation efforts may not be sufficient to alleviate impacts, which could further create negative attitudes and actions towards elephants (Woodroffe et al. 2005). Therefore, it is important to understand all aspects of conflict in order to develop effective mitigation efforts that foster coexistence between elephants and people.

This is particularly important in the context of the Trans Mara District of southwestern Kenya, which is considered a significant HEC hotpot in Africa (Litoroh et al. 2012). This region lies next to the world famous Masai Mara National Reserve and is undergoing changes that are typical of trends across much of Kenya and East Africa. These include: (1) high human population growth (Sitati 2003); (2) rapid land-use change and shifting land-use practices (Tiller 2018); and, consequently, (3) high levels of human–wildlife

conflict (Tiller 2018). In a landscape becoming increasingly dominated by agriculture, privatized livestock grazing and fenced land (Løvschal et al. 2017), it is essential to expand our understanding of HEC beyond just crop raiding, as this is just one of many ways that communities could be affected. To this end, this study assessed the frequency, severity and temporal and seasonal patterns of fence damage in the Trans Mara District during 2014–2015 and compared these patterns to incidents reported patterns of crop raiding over the same time period. It also determined the elephant group types involved in fence damage events and whether this was linked to event severity.

Materials and methods

Study site

The Trans Mara District covers an area of 2,900 km^2 and is located in southwestern Kenya along the western border of the Masai Mara National Reserve. The landscape is a mosaic of agricultural land, afro-montane, semi-deciduous and dry deciduous forests and acacia savannah woodlands (Tiller 2018). The region experiences two rainy seasons, with 'long rains' occurring between February and June and 'short rains' occurring between November and December. The Trans Mara and Masai Mara are connected by natural pathways which act as important dispersal routes for various wildlife including elephants (Sitati 2003). The region hosts a resident elephant population of 200–300 individuals alongside a migrating elephant population from the Masai Mara (Sitati et al. 2003). The largest ethnic group in the District are the Maasai, whose major livelihoods are based on livestock grazing and subsistence farming. However, there is an increasing shift from pastoralism to agriculture, similar to patterns across much of Africa (Ogutu et al. 2016).

Data collection

Data on conflict incidents were collected from June 2014 to November 2015. Ten enumerators were trained to use an adapted version of IUCN's training package for enumerators of elephant damage (Hoare 1999). Enumerators were selected from 10 locations across the Trans Mara which covered the entire elephant range. The location of any incident that occurred within an enumerator's assigned area was visited to verify the incident. Each incident was considered an independent conflict event and information was collected on the date of the incident, the time of the incident to the nearest half hour, the GPS location, the type of damage, the number of elephants involved, the elephant group type involved and the type of fence damaged and the extent of damage, where possible. Elephant group types were classified as lone/bull groups ('bull'), family groups including females and young ('family'), or family groups including one or more bulls ('family + bull(s)').

Data analysis

Characteristics of elephant conflict

We classified incidents according to the main type of damage that occurred: (1) crop only; (2) crop and fence; (3) fence only; (4) fence and livestock boma (i.e. a fenced enclosure); or (5) 'other'. 'Crop only' refers to damage to only field crops whether or not a fence was present. 'Livestock boma' refers to damage to fenced in areas reinforced with mesh wire used to protect livestock, while 'fence' refers to damage to any other fence fully encircling a farmer's property, field of crops and/or livestock boma. All fences were at least 1.5 m high. We classified incidents resulting in death or injury to humans or livestock, and those involving damage to other property, such as homes, as 'other'. Incidents involving multiple types of damage were classified according to the most prominent type of damage that occurred. For example, an incident involving crop damage and damage to a tree was classified as 'crop only'. We then calculated the number of incidents and further classified all incidents involving any amount of fence damage according to the type of fence damaged, i.e. as local, live or barbed wire (Fig. 1; see colour plates: page ii). Local fences are typically constructed from dead branches while live fences consist of shrub species that have grown up over time, most commonly Mauritius thorn (*Biancaea decapetala*). When incidents involved damage to more than one type of fence, we classified them under '>1 type of fence'.

Severity of conflict

To investigate the severity of conflict, we classified all incidents involving fence damage according to the severity of damage reported. We used the number of openings created or the number of sides damaged from an incident as proxies for severity of damage. We classified incidents in which damage details were reported as follows: 1–5 openings, 6–10 openings, ≥11 openings or ≥1 sides damaged or destroyed. We assumed that more openings created would take more resources to fix, and so would be perceived as more severe by individuals. We also assumed that entire sides of fences requiring repair represented the most severe form of fence damage. We then summed the number of incidents falling into each severity category for comparison. We performed a chi-square test at the 5% significance level to assess if the frequency of incidents of differing severity were related to the elephant group type involved.

Temporal and seasonal patterns of conflict

To investigate the temporal trends in elephant conflict, we calculated the start, end and duration of each incident for each incident category. We then summed the number of incidents within each incident category for each hourly block. If an incident lasted longer than an hour, it was assigned to the hourly block when the incident began. To investigate seasonal trends in elephant conflict, we summed the number of incidents for each incident category for each month of study. We then compared our results to the temporal and seasonal patterns of crop raiding in the same area reported by Tiller (2018).

Results

Characteristics of elephant conflict

In total, there were 1,385 reports of elephant conflict over the study period, with 37% of reports involving crop and fence damage, 34% involving fence and livestock boma damage, 23% involving fence damage only and 5% of reports involving crop damage only (Fig. 2; Table 1). Grouping together the categories 'fence only' and 'fence and livestock boma', in total there were 792 incidents involving fence damage only, 517 incidents involving crop and fence damage, and 72 incidents involving only crop damage. Out of all conflict reports that provided information on the deterrent type used (n = 1366), only 4% (n = 55) did not use fencing as a deterrent. Four incidents categorized as 'other' included one report each of human death, human injury, sheep house damage and sheep death. There was no significant difference in the frequency of reports within incident categories between elephant group type ($x^2 = 11.244$, df = 6, p = 0.081; Table 1).

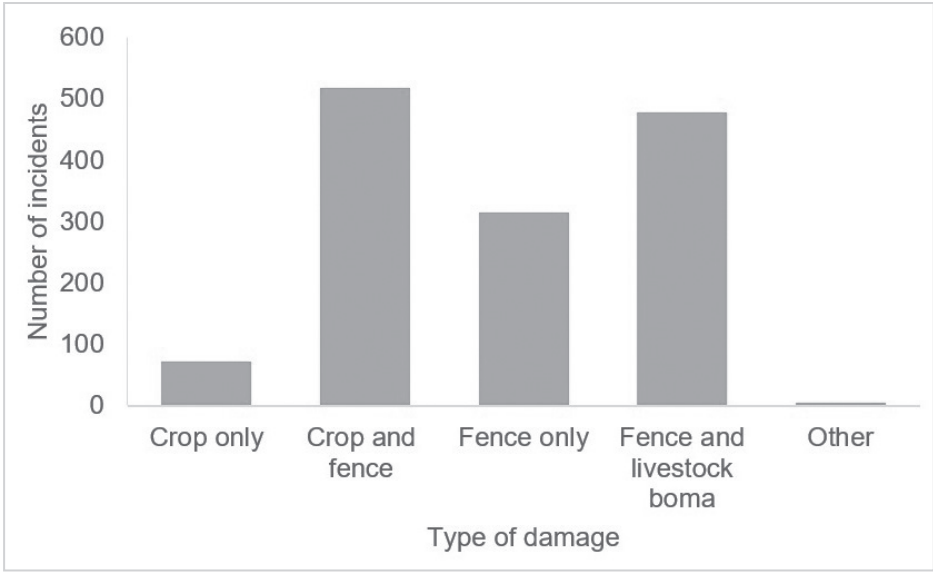

Figure 2. Number of different types of conflict incidents in the Trans Mara during 2014–2015.

Table 1. Types of damage caused by elephants in the Trans Mara 2014–2015.

	Elephant group type	Crop only	Crop and fence	Fence only	Fence and livestock boma	Other
Number of Incidents	Bull	5	62	21	34	0
	Family	10	129	69	71	0
	Family + Bull(s)	25	143	93	98	
	Unknown	32	183	132	274	4

Table 2. Fence damage characteristics reported within 'crop and fence', 'fence only' and 'livestock boma and fence' damage categories.

	Fence type			
	Local	Live	Barbed wire	>1 type of fence
Number of incidents	963 (83%)	85 (8%)	50 (4%)	58 (5%)
Median number of openings	3	4	2	4.5
Range number of openings	1–37	1–14	1–10	1–18
Median number of sides	1	N/A	1	1
Range number of sides	1–3	N/A	N/A	NA

Local fences were damaged more frequently and more severely compared to live and barbed wire fences (Table 2).

Severity of fence damage by elephants

Out of the incidents involving fence damage and which reported damage details (n = 1157), 74% had 1–5 openings (n = 857; Fig. 3). Although more severe damage occurred much less frequently, 279 incidents involved more than six fence openings and 21 incidents involved one or more sides being damaged or destroyed. Incidents involving family + bull(s) groups were significantly more likely to result in more severe damage (≥6 openings) compared to

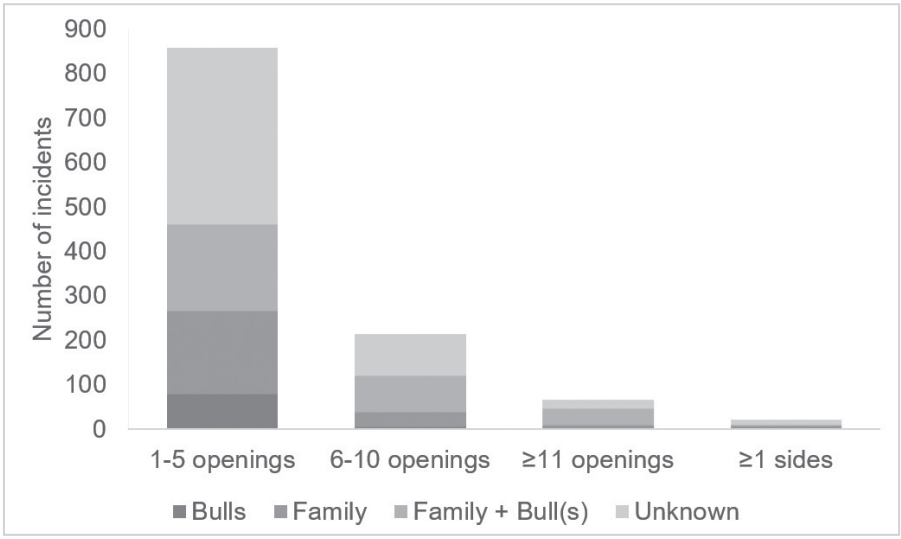

Figure 3. Number of fence damage incidents of different severity categories caused by different elephant group types in the Trans Mara 2014–2015.

family groups and bull groups ($x^2 = 46.494$, df = 4, $p < 0.001$; Fig. 3). There were insufficient reports of elephant group type for incidents involving damage to ≥1 sides for analysis.

Temporal and seasonal patterns of elephant conflict

The majority of fence damage occurred between 18:00 and 06:00, rising to a peak at 22:00–23:00. There were a few cases of damage later in the morning, until 09:00, with isolated incidents later, at 13:00 and 15:00. In comparison, incidents of crop damage only were restricted to 21:00–03:00 (Fig. 4).

Conflict incidents occurred every month of the study period (Fig. 5). Incidents involving both crop and fence damage occurred relatively consistently across the study period, while incidents of crop damage alone peaked in June–July 2014, March–April 2015 and in

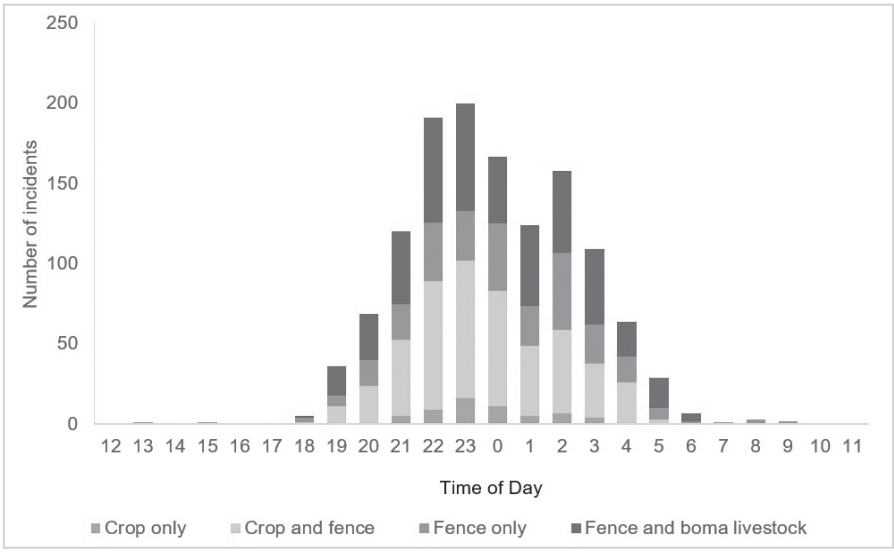

Figure 4. Temporal patterns of the different types of conflict incidents in the Trans Mara during 2014–2015, showing the total number of incidents recorded in each one-hour block.

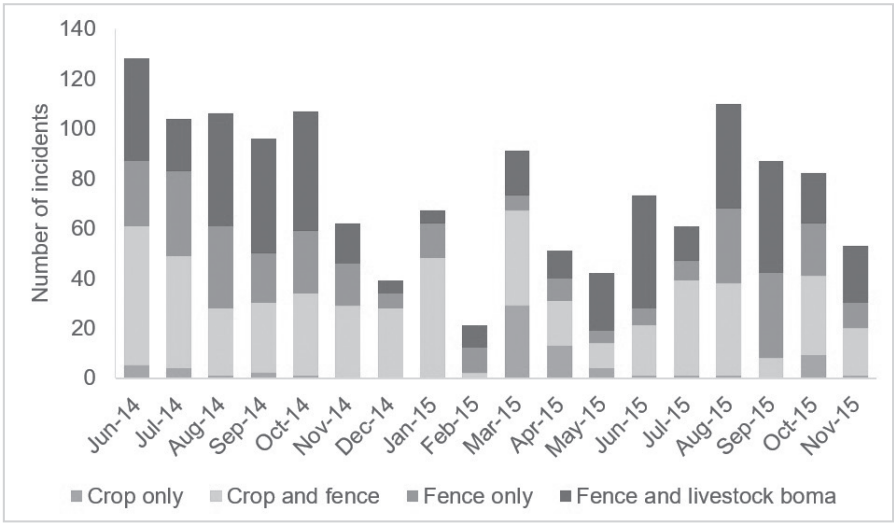

Figure 5. Seasonal patterns of the different types of conflict incidents in the Trans Mara during 2014–2015, showing the total number of incidents recorded in each month of the study period.

October 2015. Incidents involving fence and/or livestock boma damage peaked shortly after peaks in crop damage. Overall, fence and/or livestock boma damage continued even when crop damage frequency was low.

Discussion

Characteristics of elephant conflict

The results from this study show a much higher frequency of fence damage compared to crop damage caused by elephants in the Trans Mara. Fence damage also represented a higher proportion of conflict reports relative to crop raiding in Nepal (Pant 2016); however the majority of available research shows that property damage, including fence damage, occurs less frequently than crop damage (Mulonga et al. 2003; Wilson et al. 2013; Neupane et al. 2017). In India, despite property damage occurring at lower frequencies, the financial losses associated with such damage were comparable to losses associated with crop damage (Wilson et al. 2013). The results from this study show the majority of damage occurred to local fences, with less damage occurring to barbed-wire fences. Available research on how fence damage is perceived shows context-dependent results, with households in Botswana perceiving only damage to high quality fences as inflicting significant economic costs (Mayberry et al. 2017), while households in India perceived repairs to traditional (or 'local', as defined here) fences to be a significant financial burden (Orga 2008). We recognize that we lack quantitative data on the costs of fence damage versus crop damage and acknowledge that the cost of fence upkeep could be worthwhile in the long term if crops are protected from damage. However, it is possible that the high frequency of fence damage occurring alongside other forms of conflict could result in fence damage being perceived as a significant economic concern by affected households.

Severity of fence damage by elephants

Aside from the potential economic costs of fence damage, the time required to fix repairs would also represent significant indirect costs. Although the majority of incidents involving fence damage in this study fell into the 'lowest' damage category, almost 300 incidents involved the creation of more than six openings. This represents a large amount of damage that would need to be repaired by households, reducing the time available for other important activities. Moreover, such repairs would likely be required during times when people were also incurring indirect costs in the form of time spent guarding crops. Repairs of traditional fences were reported to take multiple days for households in India and, at times, required wood to be illegally harvested from local forests (Orga 2008). We recognize that the resources available and the subsequent time and effort required for such repairs would be context dependent; however, research in the Trans Mara showed a decrease in forest and grazing land and subsequent increase in agricultural land between 2000 and 2015 (Tiller 2018), suggesting a decrease in resources available to households for repairing traditional fences.

Furthermore, the results of this study found family + bull(s) groups to cause more severe damage relative to lone family or bull groups. It is common sense that larger groups would likely cause more damage. However, it is notable that Tiller (2018) found family + bull(s) groups were a new group type found crop raiding in the Trans Mara in 2014–2015, that had been absent from the area 15 years earlier. The author suggested this could be attributed to a decrease in natural forage availability and the need for family groups to adopt more risk-taking behaviour, which is assumed to benefit from the help of less risk-averse bulls. This could explain the high prevalence of livestock boma damage, as bomas often have preferred forage inside, such as kikuyu grass (Sitati 2003). If elephants continue to become less risk averse as natural habitats shrink and forage availability declines, the severity of HEC incidents, including fence damage, could increase, leading to increased local economic and opportunity costs.

Temporal and seasonal patterns of elephant conflict

With the focus on crop raiding in the conflict literature, it is often reported that the majority of conflict occurs during the night and during crop planting and harvesting seasons (Sitati et al. 2003; Graham et al. 2010; Wilson et al. 2013; Pant 2016; Tiller 2018). However, results from this study show that occurrence of HEC in the Trans Mara is much more consistent, on both a daily and an annual timescale, when fence damage incidents are considered alongside crop

raiding. Not only did fence damage incidents occur over a longer period of the night relative to crop raiding incidents, they also occurred during the day. Moreover, fence damage peaked in the months following the peak months for crop damage in the area reported by Tiller (2018). This is the first study to look at the daily temporal variation of fence damage; however, other studies have found similar seasonal patterns as found in our study, with fence damage and crop raiding peaking during different times of the year (Wilson et al. 2013; Pant 2016).

The seasonal patterns found here could correlate with post-harvest periods and attempts to access food stores (Tiller 2018). It is also possible that increased guarding effort, and thus human presence, during crop maturation could divert damage elsewhere and/or force elephants to engage in more risky behaviour in order to obtain food, for example by coming out during the day. Furthermore, the peak in fence and/or livestock boma damage coincides with the dry season in the Masai Mara National Park (Sitati 2003) and the subsequent peak in corridor use by elephants moving into the Trans Mara (Tiller 2018). It is possible that a significant number of fences are present along their natural migration routes and/or blocking resources such as water, contributing to increased damage. However, it is also possible that elephants in the region are just becoming increasingly tolerant of human presence, as already suggested by comments made by local residents in 2000 (Sitati 2003). If elephants are becoming less risk averse, this could exacerbate conflict.

Implications for local wellbeing, elephant conservation and conflict globally

Regardless of the behavioral drivers behind fence damage, it is evident that even at times when crop damage is low or non-existent in the Trans Mara, fence damage is still occurring. This year-round conflict could have major implications not only for the livelihoods and wellbeing of local farmers (Woodroffe et al. 2005), but also for local attitudes towards elephants and, consequently, for conservation efforts (Pant 2016). The constant efforts required to repair fences, in addition to guarding crops, could represent significant indirect costs to local farmers. Furthermore, if fence damage occurs over longer hours during each day, this could further increase the indirect costs associated with guarding fields and deterring elephants. Other studies have identified opportunity costs as one of the most important hidden impacts of human-wildlife conflict (Orga 2008; Barua et al. 2013; Mayberry et al. 2017). While crop damage has an immediate impact on household income and food security, indirect costs of conflict often have delayed effects (Mulonga et al. 2003; Jadhav and Barua 2012). Delayed costs can include decreased income over time and increased debt, leading to declines in nutrition, education and physical and mental health, as a result of the fear, worry or hopelessness felt by households (Barua et al. 2013). Additionally, fences are used for protecting crops and livestock, and so damage to fences could have other indirect impacts on the two major livelihoods of communities in the Trans Mara.

Furthermore, damage from conflict is often patchy, concentrated and suffered by a minority of residents (Woodroffe et al. 2005; MacKenzie and Ahabyona 2012). Conflict events have been shown to deepen poverty of the most vulnerable social groups and aggravate pre-existing, institutionalized inequalities (Mulonga et al. 2003; Jadhav and Barua 2012). Furthermore, the broader political context affects the amount and timing of compensation for conflict damage. Lack of compensation or delays in receiving compensation can exacerbate the negative impacts of conflict on human wellbeing, and it is these impacts that ultimately shape an individual's perception of elephants (Mayberry et al. 2017). Dickman (2010) highlights that individuals with few livelihood options can be particularly antagonistic towards conflict animals, such as elephants, due to the high risk associated with their presence, and that such negative attitudes can continue long after conflict stops. Furthermore, while we recognize that fences can deter conflict locally, they have been found to do so by redirecting elephant movements, potentially introducing conflict into new areas (Osipova et al. 2018). This issue, coupled with the direct and indirect costs of continually fixing fences damaged by elephants, means that more research is needed on the cost effectiveness of fencing for HEC mitigation.

In the meantime, alternative mitigation measures could be introduced, including chili fences in place of traditional fences. Such fences are constructed out of sisal ropes soaked with chili-infused oil strung between bush poles or existing trees (Hoare 2012). Chili fences

have proven successful in deterring elephants from crop raiding in Tanzania, (Chang'a et al. 2016) and because they are a cash crop, they also provide a potential source of income (Hoare 2012). Chili fences were piloted within conflict zones in the Trans Mara in 2001, with fences fully encircling fields successfully deterring all crop-raiding attempts by elephants over a two-year period (Sitati and Walpole 2006). Beehive fences could also be potential alternatives as they have been effective at deterring large elephant groups from entering fields in Kenya (King et al. 2017). Further, income from honey production could help compensate farmers for any fence damage that could occur, making this a sustainable alternative to traditional fencing (King et al. 2017). While alternative mitigation methods could reduce instances of HEC, land-use planning to regulate where cultivation takes place will be essential for addressing the root causes of conflict (Sitati and Walpole 2006).

Our results suggest that while crop damage has significant economic impacts, fence damage may also inflict significant costs on rural households co-existing with elephants in Africa, as is has also been found by studies in Asia. Thus, strategies for mitigating conflict based only on crop-raiding research could be ineffective, thereby fueling negative perceptions towards elephants, local authorities and conservation efforts. We argue that more research is needed on fence damage when investigating HEC across elephant ranges, including studies on elephant movement patterns to reveal why such damage occurs. This should be complemented by participatory studies with affected communities to understand local perceptions of fence damage impacts and potential mitigation methods. With increased competition for space occurring between elephant populations, pastoralists and farming communities, increased levels of conflict can be expected (Naughton-Treves et al. 1999; Litoroh et al. 2012). Furthermore, as land privatization and sub-division continues, the expanse of fenced areas will also increase (Løvschal et al. 2017). Therefore, it is vital to understand the impact of fence damage, and all other forms of HEC, for mitigation efforts to be successful in fostering the coexistence of elephants and people.

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