

Article

“Smelly” Elephant Repellent: Assessing the Efficacy of a Novel Olfactory Approach to Mitigating Elephant Crop Raiding in Uganda and Kenya

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Abstract: Human–elephant conflict is increasing across many parts of Asia and Africa. Mitigating elephant crop raiding has become a major focus of conservation intervention, however, many existing methods for tackling this problem are expensive and difficult to execute. Thus, there is a need for more affordable, farm-based methods. Testing these methods is key to ensuring their effectiveness and feasibility. In this study, we tested a novel olfactory deterrent, the “smelly elephant repellent”, a foul-smelling organic liquid, on 40 farms in Uganda and Kenya. Our results show that the repellent was effective at deterring elephants from crop raiding. Over the study period, 82% of 309 elephant crop raids were deterred in Uganda. In Kenya, the repellent deterred 63% of 24 crop raiding incidents, and there was a significant effect of the repellent on test sites compared with control sites. The smelly repellent could be a helpful crop raiding mitigation tool for farmers, as this study showed it to be effective, relatively cheap, quick to produce from locally available ingredients, and communities have a positive attitude towards using it. Ongoing work is exploring the potential for a market-based approach to take this to scale in a financially sustainable way.

Keywords: African elephants; human–elephant conflict; crop raiding; olfactory mitigation; elephant repellent



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1. Introduction

Human activities have modified and transformed over half of the Earth’s land surface [1], causing extensive habitat loss and fragmentation and leading to a global decline in species [2–5]. This land-use change has expanded the interface between farmland and natural habitats, creating agricultural frontiers that increase interactions and resource competition between humans and wildlife populations [6–8]. The resultant human–wildlife conflict is one of the most complex issues facing conservation today [7,8].

Human–wildlife conflict can have negative impacts on people through damage to crops and property, livestock depredation, and potential human injury or loss of life [9,10]. This can lead to retaliatory killing of wildlife [11,12] and strongly undermines support for conservation efforts [13–15].

African and Asian elephants are particularly prone to conflict as they often range outside the boundaries of protected areas into places inhabited by people [16]. Damage to cultivated food crops by foraging elephants is one of the most widespread forms of human–elephant conflict, and farming communities can incur substantial costs. People

living around wildlife frequently cite elephants as a critical factor in their lack of support for conservation [8], and in turn, these attitudes can lead to behaviours that negatively impact elephants and other wildlife [7,10]. Elephants can fall victim to retaliatory killings, and the general attitude of society may accept behaviours such as poaching and bush meat hunting.

As the magnitude of conflict between humans and elephants increases across many parts of Africa, mitigating crop raiding has become one major focus of conservation intervention [14,17]. In the past, culling was used as a conflict mitigation tool, and more recently, translocation of “problem” elephants has been implemented, to varying degrees of success [18,19]. Compensation schemes for elephant crop damage have been introduced in some places but have proven expensive and difficult to execute [20,21]. These interventions are both controversial and costly, and there is a need for more affordable, farm-level methods on the front-line of this challenge. Farm-based mitigation measures can be broadly grouped into four classes: acoustic, visual, physical and olfactory interventions. Testing mitigation methods is key to ensuring effectiveness and feasibility, as it is widely recognised that placing the responsibility with communities and assisting them with application may be the most sustainable option [22].

Acoustic elephant deterrents include traditional methods such as shouting, banging pots and pans or iron roofing sheets, scare shooting and other gunshot-like sounds, air horns, and even playback of predator calls, such as lions or tigers [13,23]. However, these exhibit varying efficacy and are found to lose their effectiveness due to the habituation of elephants over time to the sound [13]. Visual deterrents, such as fire and lights, including torches or solar-powered spotlights, can be effective [13], but again, habituation in the longer term is a possible issue [24].

Physical barriers, which include trenches and fences, are some of the most popular interventions as they appear to be an easy way to prevent conflict. Fencing elephants into areas using regular wire fences is difficult and has been achieved only in a few places [24]. Electric fences can be effective [25,26], but major challenges exist with both regular wire and electrified wire fences, with issues around cost, ownership, maintenance responsibility, and vandalism, with wire being deliberately cut to allow access into fenced areas or for use as snare traps [19,24,27,28]. Moreover, due to the high intelligence of elephants, they can find weaknesses in fences and break through or find their way around [29].

One method that is an acoustic, visual, and physical deterrent is beehive fences. This method uses the elephant’s innate fear of honeybees as a crop protection method by placing beehives strung on simple wire perimeter fences at intervals around farm plots [30]. Studies in Kenya have shown that beehive fences can prevent up to 80% of elephant crop raids. However, issues of hive occupancy rates have been noted [30], there may be a saturation point for the number of bees an environment can support [27], the fences require significant up-front investment, and encouraging bees may not be appropriate in all contexts.

Given elephants’ high intelligence and relatively quick habituation to acoustic and visual barriers [20,26], understanding their sensory perception may be key to finding ways to mitigate conflict. Elephants have an excellent sense of smell [31], and possess nearly 2000 olfactory receptors—five times more than humans [32]. In recent years, the use of olfactory deterrents has gained traction, and among these, the use of chilli pepper (*Capsicum* spp.) is one of the most widely tested.

Various studies have trialled chilli-based methods, including fences of chilli oil-soaked cloths and briquettes, to test the efficacy of the chemical compound capsaicin in chilli to deter crop raiding [22,33–35]. Positive efficacy of these methods has been realised in some contexts (e.g., [36]), but in others has shown low efficacy when compared with easier and cheaper methods such as community guarding [37]. Positive results suggest that chilli can play an important role in mitigating elephant damage to crops, although there has been criticism levelled at the difficulty, expense and labour required for application, and its uptake by farmers.

The “smelly” elephant repellent tested in this study is a novel olfactory method for mitigating elephant crop raiding. Initially formulated by Henry Latigo, a lecturer

and farmer from northern Uganda, it is a foul-smelling organic liquid designed to deter mammals using a combination of smell and taste. The repellent is a mixture of common farm ingredients, including chilli, garlic, ginger, neem leaves, cooking oil, dung, and rotten eggs, that are widely grown or available in East Africa. After preparation of the solution, the mixture is left to mature for a strong, unpleasant odour to develop. The first trials looking at the smelly repellent's efficacy on elephants were conducted in Uganda in 2017 [38].

In this study, we present the results from the first full field trials of the efficacy of the smelly elephant repellent on wild African elephants (*Loxodonta africana*). We specifically measure the effectiveness of this method as an elephant crop raiding deterrent and assess the perceptions of the communities in Uganda and Kenya that tested the method on their farms.

2. Materials and Methods

2.1. Study Area

The smelly elephant repellent was tested in Uganda and Kenya between 2018–2021.

2.1.1. Uganda

Latoro is a farming area in Got Apwoyo Sub-County in Nwoya District, northern Uganda. It comprises six villages: Latoro Central, Aringokec, Barlyec, Pajengo-Lolim, Paminolango, and Tegot, which lie within a 6 km belt north of the Karuma–Arua national highway (Figure 1). This highway forms a “hard edge” separating the community from the northern boundary of Murchison Falls National Park, which, along with Bugungu and Karuma wildlife reserves, makes up Murchison Falls Protected Area (MFPA), Uganda's largest protected area, home to approximately 1300 African savanna elephants [39].

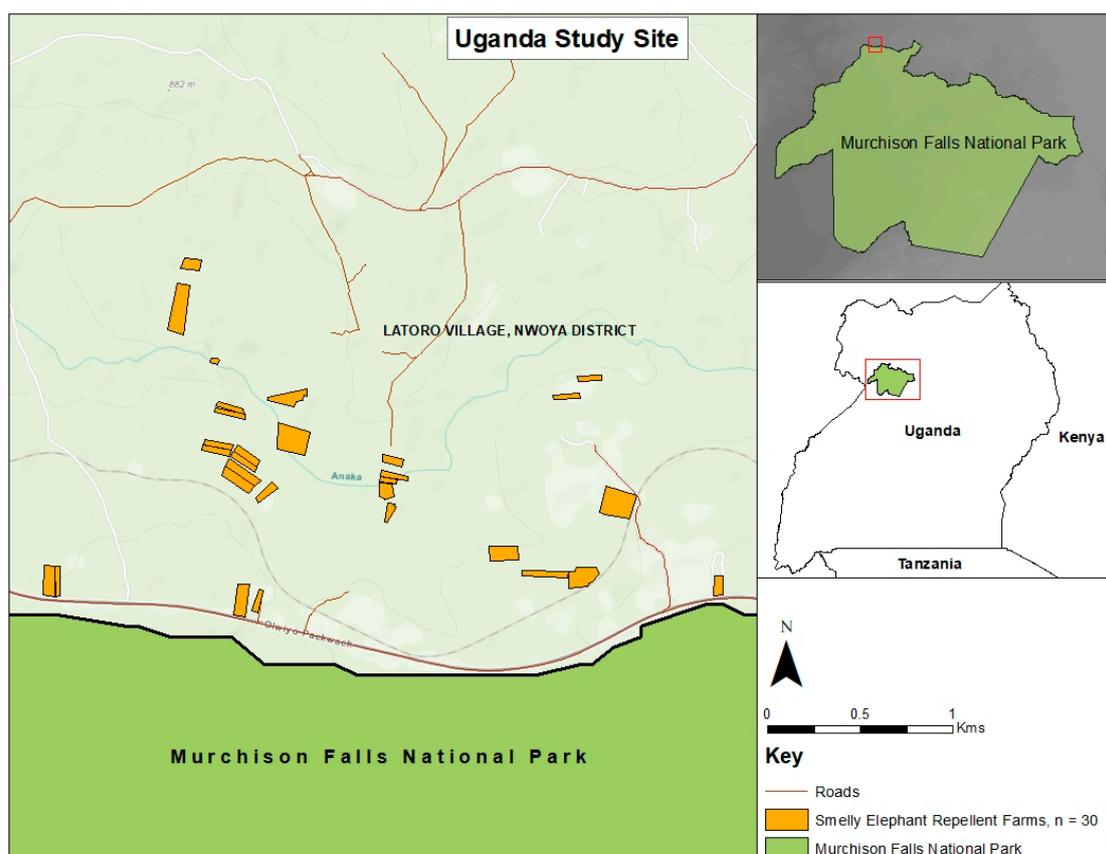


Figure 1. Location of the 30 smelly elephant repellent test farms in Latoro, Got Apwoyo Sub-County, Nwoya District, Uganda.

The study area was formerly part of the Aswa-Lolim wildlife reserve and elephants freely roamed its range (see the name of the village, Barlyec, “lyec” meaning elephants and “bar” meaning a place where they roam in the local language, Acholi). The reserve was degazetted in 1972 [40] and remained largely uninhabited until recently due to the civil unrest that plagued northern Uganda from 1987 until the end of the war. From 2006, people began to resettle the area, and farming communities now inhabit the land up to the edge of the highway. The landscape on the edge of the park has become fragmented into commercial farms, smallholder farms, pine plantations, tracts of deforested grassland, and remnants of scrub bush, grassland, and woodland.

The presence of crops on the other side of the unfenced road encourages elephants to cross the highway from MFPA, and crop raiding is an almost-daily occurrence during crop harvesting seasons, of which there are two in this region. The first growing season runs from February to July, with maize, cassava, ground nuts, beans, and soya beans primarily grown, and the second season runs from July to November/December, with rice, sesame (“simsim”), maize, ground nuts, beans, and soya beans as the main crops.

Until the recent construction of 20 km of “short fence” deliberately targeting elephants to the east of the study area, there were no fences around MFPA, and elephant conflict mitigation methods primarily involved noise-making, guarding/chasing, and the use of fire. Uganda Wildlife Authority rangers are frequently called out to intervene, and to participate in the weekly “elephant herding” activity, where animals on the community side are guided back to the national park. Human fatalities are not uncommon, and elephants are regularly killed by speeding vehicles travelling along the highway.

2.1.2. Kenya

Lower Sagalla is a rural farming community in Taita-Taveta County that consists of four villages that lie at the eastern base of Sagalla Hill. The county is part of the Tsavo Conservation Area (TCA), which is 42,000 km² and comprises three national parks (Tsavo East, Tsavo West, and Chyulu Hills), human settlements, small-scale farms, private ranches, and wildlife conservancies. The area is home to Kenya’s single largest elephant population of approximately 14,964 individuals [41].

Lower Sagalla is only 3 km from the boundary of Tsavo East National Park (Figure 2). To the south of Sagalla, between Sagalla Hill and Mount Kasigau, is a historical corridor used by elephants to migrate out of Tsavo East into the ranches and Tsavo West National Park. However, in the last decade, this movement has led to conflict between people and elephants. Farms along the edge of Tsavo East are the hardest hit, with crop raiding being common [30]. Small-scale farming of crops such as maize, beans, and green grams in Lower Sagalla provides critical livelihood support and income. There are two rainy seasons within TCA, typically between October and December, and March to May, ranging from 250–700 mm, with an average of 550 mm annually [42]. The rains coincide with the crop farming seasons from November–January and April–May. The main elephant conflict mitigation methods primarily involved noise-making and torches. Additionally, beehive fences are used by over 50 farmers [30].

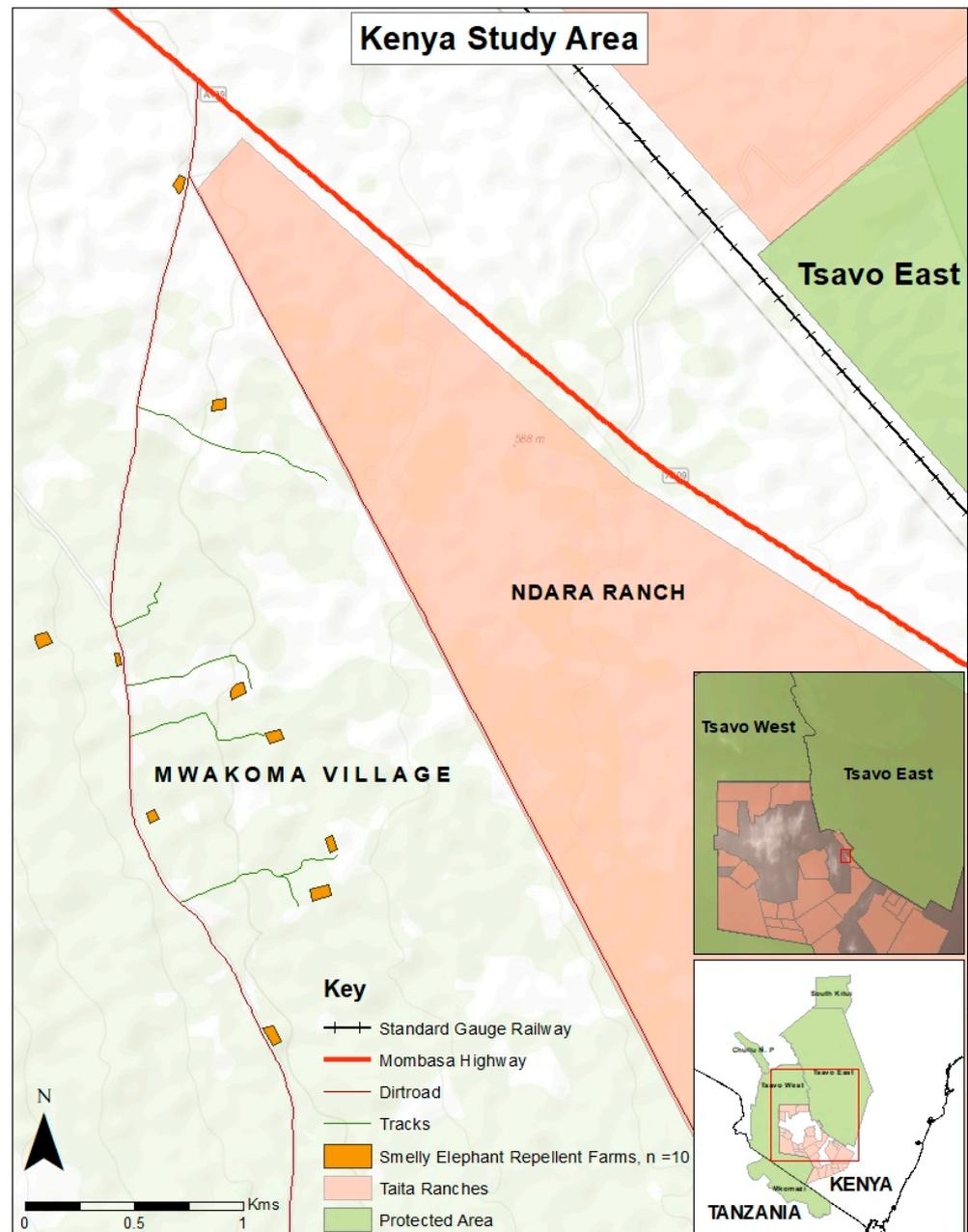


Figure 2. Location of the 10 smelly elephant repellent test farms in Mwakoma Village, Lower Sagalla, Taita-Taveta County, Kenya.

2.2. Farm Selection

The repellent was trialled on 30 farms in Uganda and 10 farms in Kenya. In Uganda, two of the authors were working with an existing group of community wildlife scouts on a human–elephant conflict mitigation programme prior to the commencement of data collection for this study. In order to select the study participants, we called a community meeting to explain the research plan to the scouts and asked them to select 30 participants either from within their group or from their neighbours. The only requirements were that the participants were actively farming at least one acre of land, and that the farm was within the Latoro locale. Scouts selected study participants using these requirements and through identifying farmers who they perceived to experience a high frequency of crop raiding by elephants.

In Kenya, Save the Elephants has been working with farmers for 10 years on human–elephant conflict mitigation. During a participatory community meeting, farmers were

selected from a pool of 110 farms, where the community identified the farms most affected by elephant crop raiding. Farms that did not receive any other support for deterring crop-raiding elephants, such as beehive fences, were selected.

2.3. Smelly Elephant Repellent

The production process of the repellent for both the Uganda and Kenya studies was conducted either by the study farmers themselves or by community wildlife scouts with supervision from teams at non-governmental (NGO) conservation organisations, WildAid (in Uganda) and Save the Elephants (in Kenya). The ingredients (chilli, garlic, ginger, cooking oil, eggs, neem leaves, and dung) were purchased from nearby towns or collected locally and were provided by the NGOs.

The ingredients for the repellent were pummelled before being cooked together and left to mature for four weeks. The repellent was distributed to farmers in advance of the usual crop raiding seasons (May–July and October–December in Uganda and during the main crop raiding season in November–January in Kenya). In Uganda, farmers were asked to use either the spray or fence-line method to distribute the repellent on a one-acre plot of their crops. The spray method involved directly applying the repellent to crops using a commercially available knapsack sprayer that was provided to them (see Figure 3), or, as some farmers preferred, using a local spraying method involving dipping a grass broom into the liquid and dispersing the liquid with a flick of the wrist. The fence-line method involved erecting a rudimentary fence from commonly available bush-poles with sisal, nylon, or wire strung between the poles, forming a single-strand fence-line. From the string or wire, reclaimed plastic drinks bottles were hung, each containing about 200 mL of repellent. For waterproofing, bottlecaps were placed on the bottles and holes perforated in the sides of the bottles to allow the repellent's scent to disperse (Figure 3). In Kenya, all farmers used the fence method.

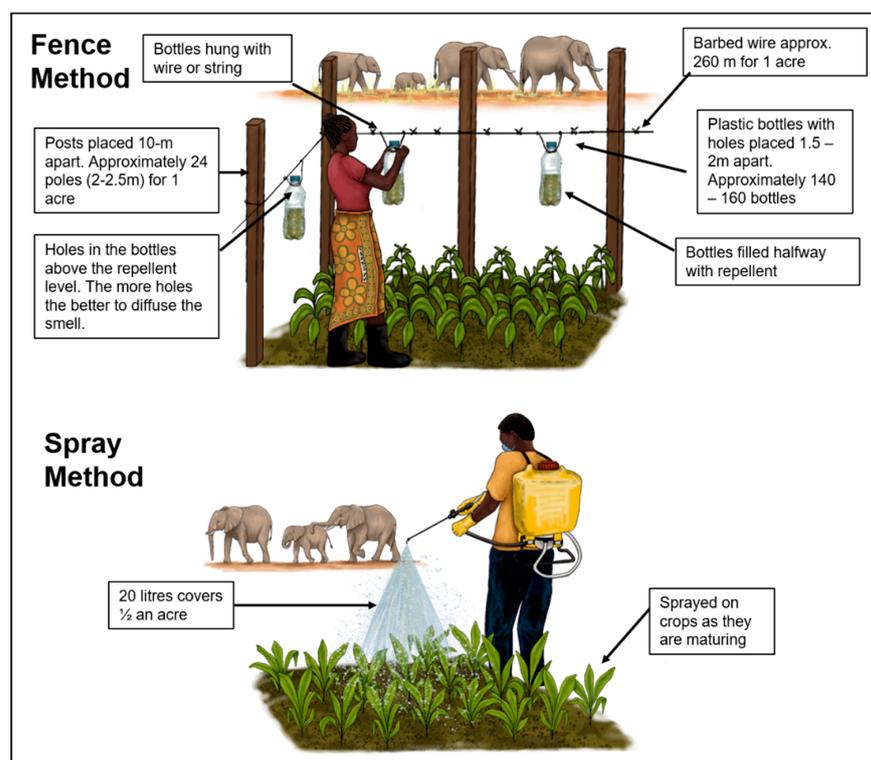


Figure 3. The two different methods that were used for dispersing the smelly elephant repellent. The fence method, where repellent is hung in bottles, and the spray method, where the repellent is sprayed directly on the crops. Illustrations: N.Heath/Save the Elephants.

2.4. Data Collection

Farmers were asked to self-report incidents of attempted crop raiding or crop raiding to the WildAid and Save the Elephants teams in Uganda and Kenya, respectively. Upon receiving information about an incident, staff members or community wildlife scouts were deployed to farms to collect data on the incident time and date, weather, location, size and composition of the elephant group, type of damage, type of crop damaged and its stage of growth, severity of the damage, and whether any action in addition to repellent deployment was taken during the incident.

For the Kenya study site, a test site and a control site were implemented at each farm. The test site was an acre in area and was where the repellent fence was set up. The control site was adjacent to the test site and constituted a one-acre plot with crops but no crop raiding deterrents. If an elephant approached the farm at any time, data collectors later visited the farm and collected the same data as in Uganda, but in addition, they gathered data such as whether the elephants ate crops in the test site, control site, or both, and information about the age of the repellent.

At the end of the study at both sites, we conducted semi-structured interviews with 16 of the farmers (eight from Kenya and eight from Uganda) to understand more about their perception of the repellent. Each interview took 30–45 min, and respondents were selected randomly from the repellent trial farmers.

2.5. Data Analysis

We conducted descriptive statistics on the data to calculate the percentage of crop raiding incidents in which the repellent deterred elephants. To compare successful raids between the test sites and control sites, we used a Fisher's exact test, which is useful for small sample sizes and gives an unbiased and more accurate probability compared to the chi-square test [43]. We also carried out simple logistic regression to determine the factors that best predicted if the repellent deterred or did not deter elephants. All analyses were conducted in the statistical software program R [44].

3. Results

The smelly repellent deterred a high percentage of elephants that approached the trial farms to crop raid at both study sites. In Uganda, during the four-season study period, there were 309 recorded incidents at the 30 farms, with a mean elephant group size of 6. Of these incidents, 82% of elephants were deterred by either the sprayed crops or fence treatment, with the consequence that no crops were eaten by elephants and no part of the fence was damaged by elephants breaking through. In Kenya, during the two-year study period, there were 24 recorded incidents at the 10 trial farms, and 63% of elephants approaching the protected farms were deterred (Figure 4). The mean elephant group size was 2 (Table 1).

In Uganda, the fence method had a significantly higher impact in deterring elephants from the study farms than the spray method (Fisher's exact test, $p = 0.001$), despite both methods preventing a high number of crop raiding incidents (Figure 5). There was no significant predictor variable in the binomial logistic regression model looking at the influence of elephant group size.

In Kenya, the repellent demonstrated a significant deterrent effect on the test site when compared to the control sites without deterrents (Fisher's exact test, $p = 0.001$) (Figure 6). Of the two potential predictor variables (elephant group size and age of repellent) used in the logistic regression analysis, only the age of the repellent was significantly and positively correlated with whether the test site was raided or not ($\beta = -2.654$, 95% confidence intervals = 0.07, 0.16).

Table 1. Descriptive statistics from the total number of crop-raid events testing the smelly elephant repellent trials in Kenya (n = 24) and Uganda (n = 309).

	Study Site	
	Kenya	Uganda
Number of farmers	10	30
Trial seasons	Nov. 2019–Jan. 2020 Dec. 2020–Jan. 2021	Oct.–Dec. 2018 May–Jul. 2019 Oct.–Dec. 2019 May–Jul. 2020
Crops grown	Cowpeas, green grams, maize, pigeon peas	Cassava, ground nuts, maize, millet, rice, sorghum, soya beans, sweet potatoes
Average number of elephants	2 (± 0.43)	6 (± 0.38)
Percentage of incidents where crops were eaten (%)	37 (n = 9)	18 (n = 55)
Percentage of incidents where crops were not eaten (%)	63 (n = 15)	82 (n = 254)

**Figure 4.** Camera trap images taken in December 2020 of a bull elephant approaching the smelly repellent fence at a farm in Kenya.

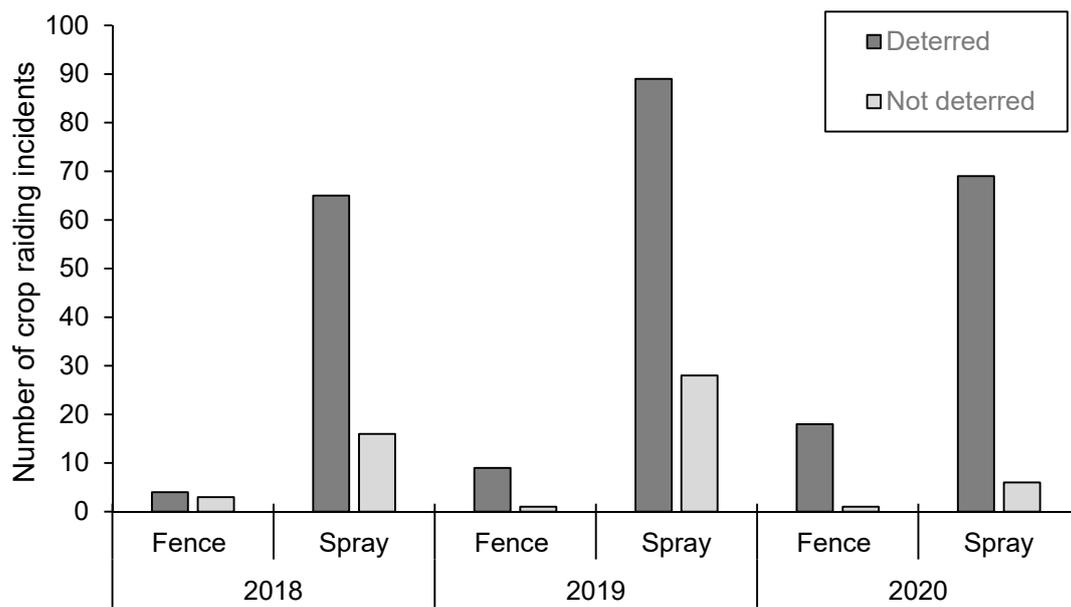


Figure 5. Number of crop raiding incidents (n = 309) deterred and not deterred using the two different smelly elephant repellent methods (fence and spray) across the study period in Uganda.

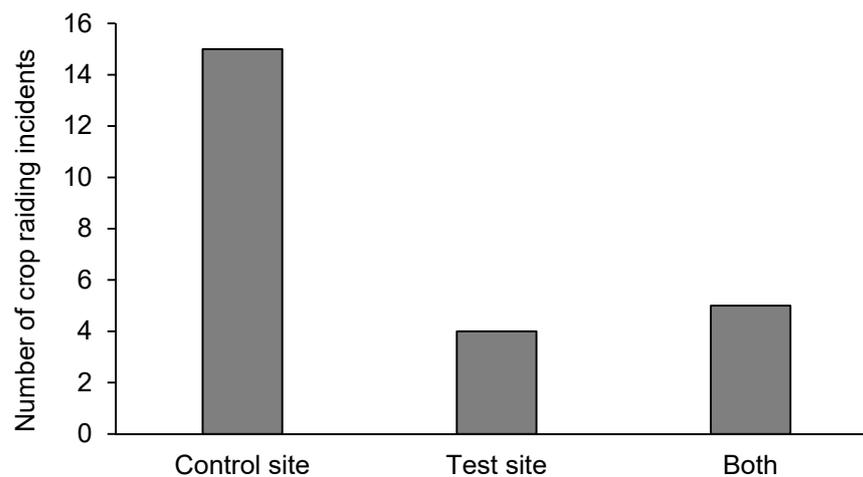


Figure 6. Total number of crop raiding incidents that occurred at the control site and test site across the study period in Kenya.

During interviews conducted at the end of the trials with repellent farmers, all stated that the repellent was effective at reducing elephant crop raiding. 81% of the respondents mentioned unprompted during the interview that they wanted to continue to use the repellent to protect their farms, and 38% commented that they would like to expand their fence to protect more of their farm. A number of respondents (44%) noted that the repellent had pesticide and fertiliser qualities, and 31% observed that the repellent also deters other wildlife and domestic animals, including cattle, buffalo, and squirrels. All of the Kenyan respondents mentioned that they had been approached by other farmers enquiring about the repellent. It was mentioned in five of the interviews that the repellent smell faded over time, but that if the wind was blowing in the right direction, it could help spread the repellent scent further.

The average cost of the smelly elephant repellent fence across the Uganda and Kenya test sites was USD 281 for bottles spaced at 2 m. This included the cost of the fence materials (posts spaced at 5 m and simple wire), which was USD 180 for 1 km, and the repellent ingredients. Spraying a 2 m-wide 1 km stretch cost USD 88, including the cost of the sprayer

at USD 20 and repellent ingredients. Compared to the cost of olfactory deterrents, the repellent spray method comes out as one of the cheapest interventions. After the repellent spray method, chilli fences are the next cheapest, followed by the repellent fence (Table 2).

Table 2. Comparison of the costs of different human-elephant conflict mitigation methods, including the costs of the smelly elephant repellent fence and spray.

Method	Description	Cost per km (USD)	Notes	Source
Smelly repellent fence	1 km linear fence—bottles at 2 m spacing	281	Low maintenance, smells fades after time	
Smelly repellent spray	1 km at 2 m width band of spray	88	Additional pesticide and fertiliser benefits, needs reapplication, coating food products not desired	
Chilli fence	1 km linear fence	149–197	Labour intensive, high variability in efficacy	Snyder and Rentsch 2019
Beehive fence (Langstroth hives)	1 km linear fence	3800	High setup cost, low maintenance cost, suitability of environmental conditions, moderate to high efficacy	Save The Elephants
“Smart/short” electric fence	1 km linear fence	1082–30,090	Very high setup cost, perpetual maintenance costs, suitability to community, high efficacy if maintained	Snyder and Rentsch 2019

4. Discussion

Our study found that the novel olfactory deterrent, the “smelly elephant repellent”, was effective at deterring elephants from crop raiding in both Uganda and Kenya. Over the study period, 82% of 309 elephant crop raids were deterred by the repellent in Uganda. In Kenya, the repellent deterred 63% of 24 crop raiding incidents, and there was a significant effect of the repellent on the test sites compared with control sites. Results from Uganda also showed that the fence method had more impact in deterring elephants compared to the spray method, even though both methods prevented a high percentage of crop raiding incidents. This may be due to the fence providing two sensory deterrents: the smell of the repellent and the fence structure itself providing an additional visual deterrent.

The effectiveness of using an olfactory-based deterrent, such as the smelly elephant repellent, may lie in the elephant’s trunk. Reasons for this might include, firstly, chilli peppers. Chilli is one of the main ingredients of the repellent and its effectiveness at deterring elephants due to its active compound (8-methyl-*N*-vanillyl-6-nonamide) has been well documented. This compound can cause irritation to elephants’ eyes and noses, and stimulate olfactory receptors [33,45]. Secondly, the repellent emits an extremely unpleasant smell, to which elephants may be averse, regardless of the chilli factor. Anecdotal evidence collected from trial farmers suggests that elephants were seen spitting out crops sprayed with repellent that they had attempted to eat. Elephant aversion to other scents, for example, bee pheromones [46] and predator scents [47], has also been documented. Thirdly, we must consider the smell from an elephant’s perspective. To the human nose, the repellent smells very strong and unpleasant. This smell is extremely likely to be much stronger for elephants, as they have more genes for olfaction than any other mammal [32], and their brains have a greater capacity dedicated to olfaction than to any of their other senses [48].

Finally, the smell of ripening food crops may be masked by the unpleasant smell of the repellent [31], resulting in fewer elephants approaching farms protected by this method.

There were incidents during the study when the repellent was not effective. Either elephants broke through fences, or they ate crops that were sprayed with repellent. Our analysis of the factors determining whether the repellent did or did not deter elephants found that in both Uganda and Kenya, elephant group size did not influence this. The number of elephants recorded at incidents was generally low (Uganda mean elephant group size = 6, Kenya = 2, see Table 1). In Kenya, where data on this were collected, the age of the repellent was a significant factor in determining its effectiveness; the older the repellent, the more likely that elephants were not deterred. Interview respondents commented that the smell of the repellent faded after around 7–8 weeks, and in some cases where temperatures were high, the repellent dried out in the bottle containers, which was when elephants broke the fence and crop raided. Scent fading is a factor seen in other olfactory deterrents, for example, chilli oil on chilli rope fences has to be reapplied every 20 days if conditions are dry, and every 7 days if there is heavy rain [49]. In this study, we only applied one round of repellent, which was used for the entire crop raiding season (2–3 months). In future applications of the repellent, it would be advisable to apply the repellent twice during the crop season (at least every 8 weeks) to ensure effectiveness. This time, labour and cost investment are lower than for other methods, such as chilli rope fences. However, more research is needed to understand the exact duration of efficiency of the repellent, including factors such as temperature and humidity gradients that may influence drying and evaporation rates, which will vary from site to site.

At both study sites, there was an overall positive response towards the use of the repellent by farmers, as all farmers who were interviewed stated that the repellent was effective. Additional benefits of the repellent were observed, such as it working as an organic pesticide/insecticide and a fertiliser. These factors may also contribute to positive attitudes towards the repellent, and act as an added incentive to using it. The likelihood of communities adopting particular mitigation approaches is greatly influenced by attitudes. If a tool is perceived as effective and viewed positively by the community, then the rate of adoption is higher [50]. This, coupled with initial cost and local capacity to maintain the tool, could also influence the adoption and sustainability of the method [51].

The cost of the smelly elephant repellent is significantly lower than other deterrents such as electric fencing, trenches, or beehive fences (see Table 2). If the set-up and maintenance costs of mitigation techniques are too high, they become a significant barrier to adoption, even when deterrents are effective [51]. For many subsistence farmers, the cost of construction and materials for many deterrents makes them unlikely to be initiated unless external support can be provided [28,30]. Both electric fencing and beehive fences can be very effective at mitigating conflict, but both require large investments for purchasing materials [30]. For electric fencing, regular maintenance is also needed, which requires a high financial input. These costs are currently too high for most communities [28]. Thus, there is potential for the smelly repellent to be used as a cost-effective method for many communities at human-elephant conflict sites.

All the repellent ingredients used in Uganda and Kenya are relatively cheap and easily sourced in these places. However, for expansion into other sites and countries, costs may vary, and this could hinder the uptake. For example, chilli is an effective deterrent [22,49] but can be expensive in some places and is unlikely to be adopted by communities unless it is affordable or grown locally [22,52]. Neem (*Azadirachta indica*) is a particular tree native to the Indian subcontinent and is commonly found in East Africa, but is not widespread in West Africa or parts of Southern Africa.

Maintaining deterrent effectiveness over time can be challenging as elephants are highly intelligent and social animals. Elephants can often habituate to deterrents, finding ways to disable them [20,26] and learning from other group members how to do so [53]. Electricity, bee stings, and chilli are directly painful to elephants, whereas other methods are just “scary”, so they would more easily habituate to these. During this study, we used

the repellent only during periods of crop ripening—the primary time for elephant crop raiding—which lessens the opportunity for habituation [49]. Although repeated use of this method over four crop harvesting seasons in Uganda showed continued effectiveness, further research is required to determine whether habituation will occur over time.

Mitigation methods can be site-specific, working well in some locations but not in others [20]. This could be due to a variety of reasons, as previously discussed, such as the attitudes of the community towards adopting mitigation techniques, the cost involved and/or the specific dynamics of elephant crop raiding in an area [21,51]. Although our results are promising so far, as the repellent was effective in two different ecosystems, currently, more trials are underway across Africa and Asia. We also recommend the future development of other olfactory deterrents, as olfaction is a key sense that elephants use to navigate their world and to make foraging decisions [54–56].

The smelly elephant repellent has the potential to become a helpful crop raiding mitigation tool for farmers, as this study showed it to be effective, relatively cheap, and quick to produce from locally available ingredients, and communities have a positive attitude towards using it. Given these encouraging factors, work is ongoing by WildAid to develop this product using a market-based approach. To-date, no crop raiding mitigation method has truly cracked the issue of widespread adoption across multiple geographies. The work aims to reduce reliance on complete financial support from conservation donors and ensure that farmers can become active stakeholders in tackling crop raiding by providing them with a product that gives them agency in addressing the issue. Conversations with trial farmers, repeat demand from users, and early feedback from market research show that taking a non-conventional approach to this problem could be well received.

Mitigation methods, although short-term, are required to address the negative impacts of human–elephant conflict. Despite the effectiveness shown by the repellent, we are aware of the fact that no one single solution will prevent human–elephant conflict. Thus, providing farmers with multiple approaches, including the repellent, in combination or in rotation, could be the most impactful [13,21,51]. Conservationists should consider using project management tools, such as SWOT (strengths, weaknesses, opportunities, and threats) analysis, which could provide valuable insight when assessing the suitability of different conflict mitigation methods in varying contexts. This approach has been widely applied in strategic decision support for business management but is now also commonly applied for environmental management [57]. Ultimately, for the future coexistence of humans and elephants, we must look beyond short-term approaches and seek to reduce the underlying symptoms of human–wildlife conflict, such as land-use change, loss of wildlife corridors, and political ecology.

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