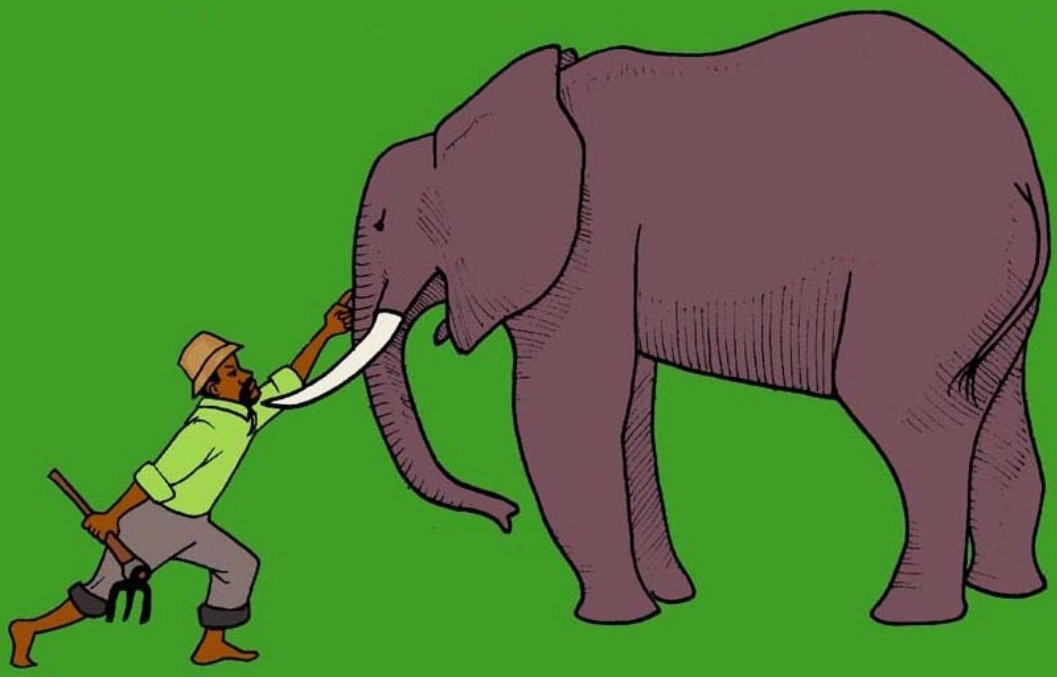

Trials of Farm-Based Deterrents to Mitigate Crop-raiding by Elephants Adjacent to the Rumuruti Forest in Laikipia, Kenya

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Trials of Farm-Based Deterrents to Mitigate Crop-raiding by Elephants Adjacent to the Rumuruti Forest in Laikipia, Kenya

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Executive Summary

Human-elephant conflict, in particular the damage that elephants cause to smallholder crops, undermines rural livelihoods and represents a major challenge to the conservation of elephants in Africa. Traditional methods for addressing this problem such as lighting fires, beating tins and throwing stones are often ineffective. So too are some of the more expensive centralised mitigation methods such as electrified fences, translocation and the destruction of problem elephants. HEC practitioners have recently called for a community-based approach that involves supporting small-scale farmers to use simple, affordable farm-based elephant deterrents such as early warning alarms, the use of hot chillies, loud noise makers, watchtowers and spotlights.

Understanding of the efficacy of the farm-based deterrents that have been promoted is limited due to the absence of trials and published studies on their use. In 2007 we provided materials and training for the use of several farm-based deterrents among 23 farmers living near the Rumuruti Forest on the Laikipia Plateau. The individual deterrents that were applied include: 1) Chilli rope fences; 2) Early warning trip wire bicycle alarms; 3) Chilli dung briquettes; 4) Loud home-made noise makers and; 5)Watchtowers and solar charged spot lights. Uptake of these deterrents varied due to problems over theft, resource constraints and opposition within the local administration over the misuse of noisemakers.

There were more attempts by elephants to raid crops on trial farms, after the application of farm-based deterrents in 2007, compared with over the same period in 2006. However the extent of cultivation damaged per farm by elephants did reduce on trial farms. On control farms there were fewer attempts by elephants to raid crops over the trial period compared with the trial farms and compared with the previous year. However on control farms overall damage to cultivation per farm increased. It is likely therefore that the overall farm-based mitigation approach reduced the amount of damage caused per trial farm if not actual pressure by elephants to raid crops. The more deterrents that were used during crop-raiding attempts by elephants the less damage that elephants caused to crops. In addition the more frequently chilli grease was applied to perimeter rope fences, the less damage elephants caused to crops on trial farms. Furthermore the farmers interviewed were positive that the deterrents helped in reducing crop damage by elephants. However they were most positive about the chilli dung briquette, which required the lowest investment of labour, compared with other more labour intensive deterrents.

The participatory nature of our project made it difficult to control for factors that might have been excluded with an experimental design, complicating the interpretation of our results. However we would cautiously suggest that our results and experiences are sufficient to highlight the critical role of labour availability in farm-based defence of crops from elephants. We therefore propose that in future trials and applications of the community based approach to HEC mitigation that farmers are supported to access sufficient labour to defend their farms. We believe this will improve the performance of farm-based deterrents and reduce levels of crop damage on vulnerable farms.

Introduction

Human-elephant conflict, where elephants damage crops and property and occasionally injure and kill people, and where people retaliate by injuring and killing elephants, has emerged as the greatest challenge to the conservation of elephants in Africa in the absence of commercial poaching for ivory (Thouless 1994; Kangwana 1995). The problem of human-elephant conflict is complicated in that elephants can be extremely destructive pests while at the same time they are listed as endangered under CITES, and are therefore afforded considerable protection by national governments (Hoare 2000). This creates tension between human victims of human-elephant conflict on the one hand and conservationists on the other, including national wildlife authorities, undermining wider programmes of biodiversity conservation and community support (Lee and Graham 2007).

A number of approaches have been used to address human-elephant conflict including destroying problem elephants, the construction of various barriers (moats and electrified fences) and translocation of elephants (Hoare 1995; Thouless and Sakwa 1995). Alongside these centralised interventions, there are also traditional methods that farmers use to defend their crops from elephants such as lighting fires, making loud noises and throwing various kinds of missiles (Sitati et al. 2005; Ochieng 2008). Due to the expense and frequent failure both the sophisticated and traditional methods used for HEC mitigation (Hoare 2001), HEC researchers have recently called on practitioners to focus efforts on supporting small-scale farmers to take up and implement simple and affordable farm-based crop-raiding deterrents that enhance and compliment traditional deterrents used (Osborn and Parker 2003). While there is some evidence to suggest that such simple farm-based crop-raiding deterrents can be effective (e.g. Sitati et al. 2005; Sitati and Walpole 2006), there are still very few studies published on trials of such deterrents and it is possible that enthusiasm for this approach has outpaced scientific and social understanding of its efficacy (though see Hedges and Gunaryadi 2009).

With a view to better understanding the effectiveness and uptake of farm-based deterrents, trials were conducted in three sites suffering from crop-raiding by elephants on the Laikipia plateau, in north-central Kenya between 2002 and 2006 (Fig.1). The positive responses from the farmers involved, together with levels of uptake of some of the deterrents used, suggests that this approach does indeed have merits (Graham and Ochieng 2008, Nyumba 2009). However the results from the trials in terms of actual numbers and levels of damage were not entirely conclusive, largely as a result of the trial design which was participatory rather than experimental.

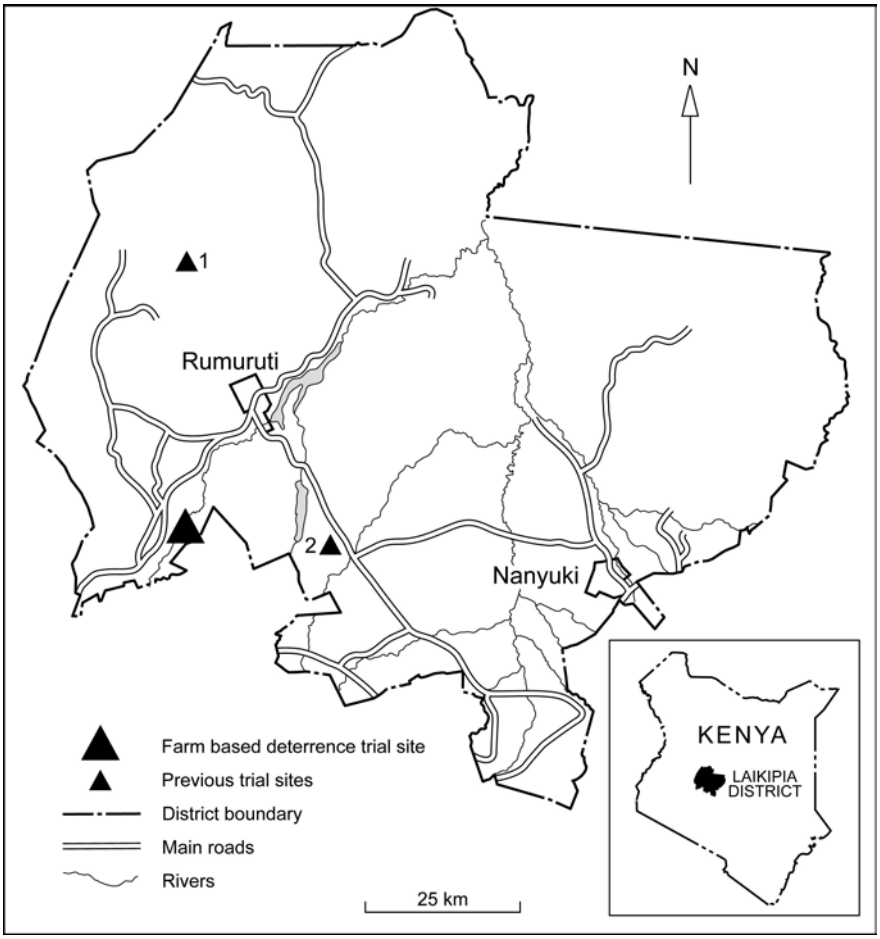

Figure 1 Deterrence Trial Site 2007
Previous Trials:
1. Ol Moran (Feb to Nov 05)
2. Mutara (June to Dec 02)

This paper describes an extension of the farm-based deterrent trials implemented in Laikipia, carried out over a crop-raiding season in 2007, at one of the original three trial sites. The extension of the trials was carried out as part of a UK Darwin Initiative funded project (15/040), 'building capacity to alleviate human-elephant conflict in north Kenya', implemented by the University of Cambridge in collaboration with local partners. The purpose of the extended trial was to demonstrate the merits of farm-based deterrents in partnership with local farmers and to facilitate inclusive learning as much as it was to understand the efficacy of the deterrents used. Here we share the results from this extension of our trials of farm-based deterrents and our experiences with their application in a community context on the Laikipia Plateau.

The Study Area

The Laikipia Plateau (9,700km2), comprising three administrative districts, is located in north-central Kenya, at an elevation of 1700- 2000m above sea level, in between the Aberdare Mountains and Mt Kenya. Rainfall falls in two seasons, the long rains, between April and June, and the short rains, between October and December. Annual rainfall varies along a steep gradient from 750mm per annum in the southern part of the plateau near the massifs of Mt Kenya and the Aberdares to 300mm in the lower northern part (Berger 1989; Gichuki et al. 1998).

The variations in altitude and rainfall across the plateau has contributed to marked variation in land use, from protected upland forest, through a belt of smallholder cultivation to savannah under large-scale commercial ranching, traditional transhumance pastoralism and wildlife conservation. There is extensive commercial wheat and irrigated horticulture in Eastern Laikipia, near the growing urban centre of Nanyuki. Unusually for a landscape without government gazetted wildlife areas, Laikipia hosts the second highest densities of wildlife in Kenya after the Maasai Mara, including the country's second largest population of elephants (Georgiadis et al. 2007; Omondi et al. 2002). Tourism based on this wildlife resource plays an increasing role in the local economy. Today there are wildlife-based tourism enterprises on 18 of the 41 large-scale ranches (2,000 to 93,000 acres) which cover 42% of the plateau, and 5 of the 9 community owned group ranches which collectively cover 11% of the district (Graham et al. 2009).

An aerial survey carried out in Laikipia and Samburu in 2008 recorded over 7,000 elephants (KWS, unpublished data). Some of these elephants contribute to high levels of human-elephant conflict, particularly crop-raiding on smallholder farms in the south of the plateau (Thouless 1994; Graham 2007). In 2007 funds were secured by a local conservation NGO, the Laikipia Wildlife Forum, to construct a 163 km electrified elephant fence across the plateau with the intention of separating smallholder cultivation where elephants are not tolerated from large-scale ranches where elephants are tolerated.

Methods

Human-Elephant Conflict Enumeration

Ten local enumerators, 'elephant scouts', systematically collected data on crop-raiding and other forms of human-elephant conflict across the study area from 2002. Scouts were trained on data collection protocols, using an adapted version of the IUCN's training package for enumerators of elephant damage (Hoare, 1999). HEC enumeration involves canvassing a designated area for HEC incidents, visiting the location of the incident and filling in a standard data collection form on the basis of direct observation and measurements, including GPS locations.

Crop Raiding Deterrents

A smallholder farming area known as Salaama, located adjacent to the Rumuruti Forest in south-west Laikipia was selected as the site for this trial of farm-based deterrents. This site was one of three used for farm-based deterrent trials 2002-6 (See Figure 1). Salaama was chosen as a site to trial farm-based deterrents under UK Darwin Initiative project 15.040 because 1) farmers here were relatively settled and farming was less transient compared to the other two sites previously used; 2) uptake of the farm-based deterrents had been better in Salaama. Crop-raiding by elephants is a major problem in Salaama, because elephants leave the nearby Rumuruti Forest at night to raid crops on the surrounding smallholder farms.

Twenty-five farms were identified to trial farm-based deterrents. Farms were selected on the basis of the willingness of their owners/occupants to participate in the trials and previous experience of human-elephant conflict. Of these 25 farms originally identified, the owners of 2 farms moved to a different area before materials and training for farm-based deterrents could be provided and so these two farms were not involved in the trial. From August to November of 2007 the remaining 23 farms were provided with materials, training and ongoing outreach support to trial the following deterrents, adapted from Osborn and Parker (2002):

(1) Chilli rope fences:
two strand fences made from sisal string with any available timber used as posts were erected around cultivated plots (Figure 2). Squares of white mutton cloth were stretched and tied between the two strands of string at regular intervals. A mixture of ground dried hot chillies and engine grease was applied to the strings and squares of cloth.

(2) Bicycle alarms:
alarms emitting a loud noise were rigged up to a trip wire that surrounded the perimeter fence so that when broken the alarm would sound, waking up the farmer. Because of resource constraints materials and training were provided to 20 farmers so that they could erect bicycle alarms.

(3) Chilli smoke briquettes:
These are mixtures of elephant or cow dung mixed with hot chillies and a little water, then placed in a mould to dry in the sun (Figure 3). The briquettes were added to small fires placed on the perimeter of farms to create a noxious smoke that preferably blew into the direction elephants were likely to raid from.

(4) Noise makers:
'Banger sticks' were provided to participating farmers so that if an elephant did enter their fields they could scare them away by creating a very loud noise, similar to a gun shot ((Figure 4). Banger sticks are made by placing match stick heads into a hollow pipe with one solid end. A solid piece of pipe is then placed part way into the hollow pipe and cocked with rubber tubing fastened to a long stick. When the stick is smashed with force onto a hard object, the solid pipe hits the matchstick heads in the bottom of the hollow pipe, creating a very loud noise.

(5) Watchtowers and solar powered torches:
Watchtowers (6-9 m high) were constructed on farms located close to the Rumuruti Forest and the farmers who volunteered to man these watch towers were provided with powerful solar charged torches. Because of resource constraints only 5 watchtowers could be constructed.

Twenty-five nearby farms were also selected to provide a control but only 19 of these were occupied and in use over the trial period and could be included in the analyses.

Figure 2 Preparing a Chilli Rope Fence

Figure 3 Chilli Smoke Briquette burning

Figure 4 'Banger stick' in action

Questionnaire survey

A semi-structured questionnaire was used to assess experiences among farmers of using the farm-based deterrents provided and perceptions of their effectiveness. Twenty-two farmers involved in the trial were interviewed. The questionnaire comprised a mixture of closed and open questions. Questions were asked by a trained research assistant in the presence of one of the project leaders, in Kikuyu or Kiswahili, depending on the ethnicity of the respondent. Responses were coded and entered into a spreadsheet prior to analysis.

Data Analysis

Dependent variables used to assess the performance of farm-based deterrents were: 1) The number of crop-raiding incidents on individual farms; 2) the average area damaged per farm and; 3) the average proportion of crops planted that were damaged per incident and overall per farm. Following methods used in previous analyses (Graham and Ochieng 2008), the individual farm was used as the sampling unit rather than an individual foray by an individual or group of elephants. Values for dependent variables were compared between trial and control farms for the trial period in 2007. Values for variables among trial and control farms were also compared between the trial period (August to November 2007) and the same period in the previous year (August to November 2006). Only those trial and control farms that were under cultivation in both 2006 and 2007 were used these 'before and after' comparisons. Frequency of use of individual deterrents over the trial period was calculated by summing data collected by trained enumerators on the use of deterrents during each attempt by an elephant to raid a trial or control

farm. Questionnaire results are presented as response frequencies. Data analyses were carried. out using SPSS v. 12 (SPSS, Chicago, USA). Data were not normally distributed and so standard non-parametric tests were used for statistical comparisons.

Results

Characteristics of crop-raiding incidents

Elephants tried to raid crops on all 23 trial farms between August and November 2007, successfully raiding 20 of these farms. Seventy-seven incidents were recorded where elephants damaged crops on trial farms and a further 12 incidents where elephants attempted but failed to raid crops on trial farms. Elephants only attempted to raid 8 of the 19 farms selected as a control, with 7 control farms experiencing damage to crops during the trial period. There were a total of 11 crop-raiding incidents recorded among control farms with just one incident were elephants tried but did not succeed to raid crops on a control farm. Maize is the main subsistence crop grown in the area and in 99% of the crop-raiding incidents recorded among trial and control farms over the trial period, maize was damaged. There were other crops damaged, including pumpkins, potatoes, oranges, beans and sweet potatoes, but relative to maize these other crops were only available on a small number of farms and damage to these crops was relatively small.

The average size of the elephant herds that attempted to raid trial and control farms over the trial period was 7, with individual males or groups of males implicated in 74% of incidents and mixed sex groups, that included females, implicated in 26% of the incidents (n=97). Lone bull elephants were implicated in 26% of crop-raiding attempts on trial and control farms.

Use of crop-raiding deterrents among trial farms

Elephants were detected during 85 % of the incidents on trial farms. The most common method of detection was by the sounds of elephants raiding (38%), followed by dogs barking (37%). Other methods of detection included alarms (4.4%) and directly seeing the elephants (5%). On control farms elephants were detected during 50% of the incidents.

Among the 23 trial farms chilli fences were used during 75% of the 89 incidents where elephants raided (n=77) or attempted to raid (n=12) crops and was the most frequently used deterrent. The next most frequently used of the deterrents provided was the chilli dung briquettes (55%) and the use of a watch tower and spot light (22 %). Banger sticks (13%) and bicycle alarms (6%) were the least frequently used deterrents during crop-raiding attempts. There were five incidents among trial farms where none of the deterrents provided were used at all. Between one and three deterrents were used during half the incidents recorded, with four or more deterrents used among the remaining incidents. There was a strong negative correlation between proportion of area damaged and the number of deterrents used by farmers when elephants raided or attempted to raid crops on trial farms (Spearman's rank correlation: $r_s = -.423$, $P < 0.001$, $n=83$). There was also a strong positive correlation between the proportion of crops damaged and the length of time in days that chilli was last applied to the chilli fence ($r_s = 0.455$, $P < 0.001$, $n=56$).

Comparison of trial and control farms before and after the provision of farm-based deterrents

The performance of the farm-based deterrents, based on the difference in crop-raiding between trial and control farms and before and after the trial was not entirely conclusive (Table 1).

Table 1: Crop raids and crop damage on trial and control farms before (August to November 2006) and after the provision of materials and training for farm-based defence (August to November 2007).

Farm Type (n)	Time	Average cultivated area per farm (m2)	No. of raid attempts (No. raids successful)	Average crop damage per farm (m2)	Average proportion of cultivated area damaged per farm (%)
Trial (16)	Before	19,825	46 (26)	9,400	78 %
Trial (16)	After	22,039	99 (77)	7,751	53 %
Control (12)	Before	6,567	18 (14)	3,001	53 %
Control (12)	After	15,930	12 (11)	4,224	21 %

Among the 23 farms provided with materials for farm-based deterrents, only 16 were cultivated in 2006 and could therefore be used in a comparative analysis between the two time periods. Owners of these 16 trial farms planted on average 22,039 m2 of crops in 2007 when materials and training for farm-based deterrents were provided compared with 19,825 m2 of crops over the same period in 2006. In contrast, owners of the 12 control farms cultivated on average 15,930 m2 of crops over the trial period, compared with an average of 6,567 m2 during the 2006 season.

In 2006 there were 46 attempts by elephants to raid crops among these 16 trial farms, 26 of which were successful. Elephants damaged on average 9,400 m2 of crops per trial farm, an average of 78% of the area under cultivation per farm. Ten of the 16 trial farms lost 100% of their crops to elephant damage in 2006, prior to trial of farm-based deterrents. In 2007, after materials and training were provided for farm-based defence, there were 99 attempts by elephants to raid crops on trial farms, of which 77 were successful. On average 7,751 m2 of crops were damaged per trial farm, 53% of the area under cultivation per farm. Five of the trial farms lost 100% of their crops in 2007. The reduction in the area damaged by elephants among trial farms after the provision of materials for farm-based deterrents approached significance (Median damage on trial farms: before treatment = 6995.5 m2, IQR = 10558; after treatment = 2319, IQR = 4534; Wilcoxon signed ranks test $Z_{16,16} = -1.81$, $P = 0.07$). The reduction in the proportion of damage to crops also approached significance. (Median proportion of damage on trial farms: before trial = 100%, IQR = 27%; after trial = 43%; IQR = 79%; Wilcoxon signed ranks test $Z_{16,16} = -1.88$, $P = 0.06$).

Among the 19 control farms selected, only 12 were cultivated in 2006 and could therefore be used in a comparative analysis between the two time periods. Between August and November in 2006 elephants attempted to raid crops among the 12 control farms 18 times of which 14 were successful. Over the same period in 2007, there were 15 attempts on control farms of which 10 were successful. Damage among control farm was on average higher over the trial period compared with the same period in 2006, increasing from 3001.7 m2 to 4224 m2 of cultivated fields, though the proportion of the cultivated area damaged actually reduced on average from 53% in 2006 to 21% in 2007. The difference in the area damaged between the two time periods was not significant (Median damage on control farms: before trial = 1263, IQR = 5139.7; after trial = 294, IQR = 1662.7; Wilcoxon signed ranks test $Z_{12,12} = -.70$, $P = 0.48$). However the difference in the proportion of the area damaged was significant (Median proportion of damage on control farms: before trial: 63%, IQR = 50%; after trial = 9%; IQR = 27%; Wilcoxon signed ranks test $Z_{12,12} = -2.49$, $P = 0.013$).

Perceptions of farmers on the performance of farm-based deterrents

Twenty-two farmers involved in trials of farm-based deterrents were interviewed. Of these 90% reported that the materials provided helped to keep elephants out of their farms and were able to achieve a harvest, even if in some cases this was small. One farmer claimed that the deter-

rents did not help at all and the elephants still destroyed his entire crop. The level of reported use of the different individual deterrents varied, as did perceptions over their effectiveness and issues associated with their use (Table 2).

Table 2: Use of different deterrent types (n= number of attempts by elephants to raid crops on trial farms), perceptions of effectiveness (n=number of trial farm respondents who reported using the deterrent) and summary of the costs and benefits of using each deterrent on the basis of interviews with trial farm owners/occupants. Percentage figures show the frequency of incidents in which a deterrent was used on the basis of farm monitoring data and the frequency of positive responses to questions on the effectiveness of individual deterrents, respectively.

Deterrent Type	Use % (n)	Effective % (n)	Costs/benefits of use
Chilli Fence	75 (89)	90 (22)	Labour intensive; chilli grease needs to be reapplied on a weekly basis; irritating and painful to apply; Advantage of this deterrent is that it is passive and doesn't require active night time guarding
Chilli Dung Briquette	55 (89)	100 (22)	Can cause irritation, pain and nausea if chilli dung smoke blows in the wrong direction; Very cheap and simple to implement
Watch Tower & Spotlight	22 (89)	100 (9)	Expensive and labour intensive to construct; requires ability to climb a ladder thereby demanding able labour; Provides guard with the ability to see across entire farm and if equipped with a powerful torch can be an effective active deterrent
Bicycle Alarm	6 (89)	90 (10)	Awkward to erect; components not easy to locate and vulnerable to theft; trigger wire broken by livestock and people and needs regular replacement; Can be a good early warning if well maintained
Banger Stick	12 (89)	92 (12)	Needs to be repaired after each application; Misuse has led this being banned by local administration; creates an extremely loud noise; cheap and simple to make.

Ninety percent of respondents reported that the chilli fence helped deter elephants. Five farmers reported applying grease on a weekly basis, twelve farmers claimed to apply chilli grease to the fence after every two weeks and five farmers reported applying chilli grease after every month or less frequently. Over half of respondents complained that the chilli grease was painful when applying this to the fence. Several farmers reported that elephants would break the fence posts or simply walk around the fence to raid crops so as to avoid the chilli grease fences. Three farmers reported abandoning the chilli fence altogether.

Chilli dung briquettes were used by all farmers with the exception of one who complained he did not have access to enough chillies. Almost all farmers reported burning chilli dung briquettes on the perimeter of their farms every evening until they harvested their crops with just four farmers reporting that they only used the briquettes when they heard the elephants nearby. All farmers who used the chilli dung briquettes reported that it was effective. Over half of the farmers complained that the chilli smoke generated from burning the chilli dung briquettes made them cough with one complaining that the chilli smoke caused him to vomit.

Reported use of the other deterrents by farmers selected for the trial was limited. Ten farmers reported trying the bicycle alarm and of these nine claimed it was helpful. However there were problems associated with its use including the difficulty in setting it up and with the strings that triggered the alarm being either broken regularly or in some cases, stolen. Nine farmers claimed to have tried using watchtowers with bright torches and of these all reported that this deterrent was helpful. However some complained that it was windy and cold when using the watchtower

and others reported that elephants charged on seeing the spotlight. There were also difficulties reported with finding power sources to charge up the batteries of the spotlights provided. The banger stick was tried by 12 farmers but its use was discouraged by the local administration because of concerns over security in the area and the potential for the abuse of this deterrent to intimidate victims during theft of livestock and property. The parts used in making banger sticks, in particular the hollow metal pipes, needed regular replacement, interrupting recurrent use. While farmers were asked to rank the different deterrents provided, these cannot be used for comparative purposes because of the variable level of use and uptake. However as use of chilli fences and chilli dung briquettes was high among all trial farms, these can be compared. The chilli dung briquette was ranked higher than the chilli fence by 17 respondents. Only one respondent ranked the chilli fence higher than the chilli dung briquette.

Discussion

Comparisons of crop-raiding incidents between the trial period and control period suggest that the farm-based deterrents introduced did little to reduce pressure from elephants, in terms of attempts to raid crops. Indeed there was even an increase in the number of attempts by elephants to raid crops on trial farms in contrast to a decrease in the number of attempts on control farms. This may possibly reflect the study design which relied on individual farmers who were willing to volunteer their time and resources to trial the farm-based deterrents provided rather than a randomly selected sample as would be needed in a more robust experimental design. This was consistent with the participatory nature of the project, which aimed to build local capacity and facilitate participatory learning, rather than undertake strictly independent research. However the problem with this approach is that the farms involved in trials could be inherently more vulnerable to crop-raiding by elephants than the control farms because of their geography and/or the socio-economic background of their owners/occupants. Previous research has shown that farms are more likely to be raided if they have been raided in the past (Sitati et al. 2005). This might make their owners more willing to trial new deterrents out of desperation. Our results highlight the difficulty in conducting trials within community contexts where controlling for external factors and outside influences is not always possible or practical. However the level of damage caused by elephants to crops did reduce on trial farms in 2007 when compared with the level of crop damage experienced in 2006, whereas levels of damage experienced on control farms increased between the two time periods. This was corroborated in interviews with the farmers involved in the trial with the majority suggesting that the measures introduced did have a deterrent effect, allowing a significant proportion of the planted crops to be harvested, in contrast to previous years when little or none of the planted crops were harvested on many of the trial farms. We would therefore cautiously suggest that the overall farm-based crop-raiding mitigation approach did have an impact on the ability of farmers to protect their crops from elephants.

The role of individual deterrents in contributing to the reported increase in harvests among trial farms was difficult to establish due to the variable levels of application and uptake. This is disappointing given that the trial area was selected on the basis of previous strong performance in terms of farmer uptake. However uptake of the deterrents provided over the trial period may have been less a consequence of the willingness of the farmers to apply deterrents and more a result of other factors. This was the case with banger sticks which provided to each and every farmer but could not be used because of an edict issued by the local administration over security concerns in the area. Watchtowers were expensive and difficult to build and therefore only five were constructed due to resource constraints. Lastly the trip alarms were not practical to use because of problems of maintenance and theft. The high uptake of chilli fences which require significant investments in labour further demonstrates that it was not the willingness of farmers alone that led to low uptake of the other deterrents. Despite these setbacks in the trial design, there were two results from this study that were interesting and merit further discussion.

The significant relationship between the number of deterrents applied and levels of crop damage highlights the importance of using a suite of deterrents to deter crop-raiding elephants. It also

highlights the issue of labour availability in reducing vulnerability to crop-raiding by elephants. The issue of labour availability is also intrinsic to the significant relationship identified in this study between the frequency with which chilli grease is applied to perimeter rope fences and levels of crop damage experienced during elephant attempts on trial farms. The latter result is also interesting as it appears to contradict the recent results generated by a well designed trial of farm-based deterrents undertaken in Indonesia (Hedges and Gunayadi 2009). In their study Hedges and Gunaryadi (2009) found that chilli grease was not an effective crop-raiding deterrent but that collective guarding was. Given that labour availability is clearly a key factor in the regular application of chilli grease (Sitati and Walpole 2006; Graham and Ochieng 2008), it may be that the trial farms that were better at regularly applying chilli grease could also be more effective at guarding their farms at night due to greater access to household labour and this may have been key in reducing crop damage rather than the deterrent effect of the chilli grease alone. Labour availability may also explain the high rank allocated to burning chilli dung briquettes by farmers interviewed in this study. Creating and burning chilli dung briquettes is very simple and cheap to do. The reported preference of chilli dung smoke among the deterrents provided is consistent with the previous trials undertaken in Laikipia (Graham and Ochieng 2008).

Conclusion

Human-elephant conflict is a major problem for rural farmers and conservationists in both Africa and Asia and therefore identifying appropriate mitigation tools is critical if elephants are to have a future in many of their current ranges. The emergence of a community-based approach (Osborn and Parker 2003) for alleviating human-elephant conflict has been an important landmark in the ongoing challenge of developing effective mitigation strategies. However the application of this approach in the field has outpaced understanding of the efficacy of the individual deterrents promoted and the conditions under which the overall approach can work. While the participatory and non-experimental design of the trial described in this paper compromised our ability to generate sufficient independent data to enhance understanding of the performance of the individual deterrents, we do think that the identification of labour availability as a key factor in uptake and performance of farm-based deterrents in Laikipia is relevant to future trials and applications of the community-based approach to HEC mitigation. The role of labour availability identified here is consistent with previous trials of farm-based deterrents in Laikipia (Graham and Ochieng 2008). Greater guarding effort was also found to reduce the likelihood of elephants successfully raiding farms in Transmara District, also in Kenya (Sitati et al. 2005). In the recent study undertaken in Way Kambas National Park in Indonesia improved guarding significantly reduced the impact of crop-raiding by elephants among trial farms (Hedges and Gunaryadi 2009). We would therefore cautiously propose that ensuring labour is available for guarding crops be the primary focus of future farm-based HEC mitigation interventions in rural African contexts.

There are of course other underlying factors that determine vulnerability to human-elephant conflict among rural farmers, such as for example farm location and size, elephant movement routes and cultivation patterns. In addition there are equally important factors that determine the ability of farmers to absorb the cost of crop-raiding by elephants (Naughton-Treves 1997). However it is the availability of labour that will allow a farm to be defended from crop-raiding elephants at night. There are many situations under which labour can be available to defend cultivated fields from crop-raiding. In many rural contexts there were and in some cases continue to be customary systems of collective farming where a group of farmers provided reciprocal labour and collectively shared the costs and benefits of farm defence. However with the transition of land ownership arrangements from communal to individual tenure more common today, cultivated fields are much more likely to be defended by individual farm owners and their families (Naughton et al. 1999). This too is becoming a challenge in the modern rural context, with men often away searching for or engaged in wage labour and children attending school (Hill 2004). The other possibility is of course the employment of guards but this requires significant surplus resources. For these reasons it is the poorest and most vulnerable within rural farming communities who are also the most vulnerable to crop-raiding. Projects that aim to improve access to labour among these vulnerable groups so that they are better able to guard their

cultivated fields from crop-raiding elephants should be a priority in future application of the community-based approach to HEC mitigation. This is corroborated by the recent crop-raiding mitigation success demonstrated in an Indonesian site as a result of improved guarding (Hedges and Gunaryadi 2009).

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Laikipia Elephant Project
Working Papers

1.The Use of Electrified Fences to Reduce Human Elephant Conflict: A Case Study of the Ol Pejeta Conservancy, Laikipia District, Kenya (2009),
Max Graham, Nathan Gichohi, Francis Kamau, George Aike, Batian Craig, Iain Douglas-Hamilton, and William M. Adams.

2.The Use of 'Push to Talk' Mobile Phone Technology to Reduce Human Elephant Conflict, Laikipia District, Kenya (2009)
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3.An Assessment of Elephant-Compatible Livelihoods: Trials of Beekeeping, Chilli Farming and the Production of Dung Paper in Laikipia, Kenya (2009)
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4.The Use of Community Drama in the Mitigation of Human Elephant Conflict, Laikipia, Kenya, Laikipia Elephant Project, Nanyuki, Kenya (2009)
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5.Trials of Farm-Based Deterrents to Mitigate Crop-raiding by Elephants Adjacent to the Rumuruti Forest in Laikipia, Kenya, Laikipia Elephant Project, Nanyuki, Kenya (2009)
Max Graham, Tobias Nyumba, Gabriel Kahiro, Martin Ngotho and William M. Adams.

Building Capacity to Alleviate Human-Elephant Conflict in North Kenya

DEFRA Darwin Initiative Grant 741

This project aims to enhance the conservation and management of Kenya's second largest elephant population (over 5,000 animals) and the ecosystem they inhabit through the implementation of an integrated and sustainable community based approach for alleviating human-elephant conflict (HEC).

The purpose of this project is to alleviate human-elephant conflict and promote tolerance of elephants in Laikipia District, Kenya.

The project works to support local partners in the following activities:

- Research on the development of systems to provide early warning of human-elephant conflict using local knowledge, Mobile phone ('push-to-talk') technologies and GPS/GSM collars;
- Dissemination of information on elephant conservation and human-elephant conflict management in vulnerable communities and local conservation organisations and land managers;
- Assess the feasibility of establishing economic activities that promote sustainable livelihoods and reduce negative human-elephant conflict;
- Promote the establishment of strategy and revenue streams to support for long term human-elephant conflict management in Laikipia;
- Support local organisations in the development of the institutional capacity to manage the West Laikipia Elephant Fence.

The project's partners are:

CETRAD
Elephant Pepper Development Trust
Kenya Wildlife Service
Mpala Research Centre
Ol Pejeta Conservancy
Rivercross Technologies
Save the Elephants
Symbiosis Trust
The Laikipia Wildlife Forum

www.laikipiaelephantproject.org
www.geog.cam.ac.uk/research/projects/heccapacity/

OL PEJETA CONSERVANCY

Laikipia Wildlife Forum

SAVE THE ELEPHANTS

UNIVERSITY OF CAMBRIDGE

KENYA WILDLIFE SERVICE

The Symbiosis Trust

ELEPHANT PEPPER

People living with elephants