Biodivers Conserv (2012) 21:2569–2587
DOI 10.1007/s10531-012-0318-y

ORIGINAL PAPER

Crop protection and conflict mitigation: reducing the costs of living alongside non-human primates

Catherine M. Hill · Graham E. Wallace

Received: 17 November 2011 / Accepted: 14 June 2012 / Published online: 7 July 2012

Abstract Conflict between farmers and primates increasingly impacts conservation efforts in Africa and Asia. Field crops provide a reliable and readily-accessible source of food for primates coping with habitat loss. However, crop-raiding undermines food security and tolerance of wildlife within neighbouring human communities. Many primates consume crops regularly yet there are few accounts of systematic evaluation of techniques to deter them. Working in partnership with farmers, this study was conducted over two growing seasons within four villages adjacent to the Budongo Forest Reserve, Uganda. Using systematic observational sampling, semi-structured interviews, and focus groups, we (i) monitored primate crop-raiding behaviour prior to and after installing locally-appropriate deterrents, developed with local farmers, and (ii) explored farmers' initial responses to the methods trialled. Deterrent efficacy was assessed by comparing the frequency and characteristics of raiding events across seasons. Primates were the predominant diurnal crop-raiders; six species were observed raiding. Deterrents implemented included barriers, alarms, repellents, and systematic guarding. Incidence of raiding and crop loss decreased in almost all cases, often by shifting raiding to unprotected fields or adjacent farms. Farmers identified benefits and shortcomings for each deterrent, and considered most to be effective and valuable. Insights from the research directly inform intervention strategies to address crop-raiding issues and extend options to mitigate human–wildlife conflict.

Keywords Behaviour · Baboon · Chimpanzee · Conservation · Crop-raiding · Deterrent · Farmer · Guenon

C. M. Hill (✉) · G. E. Wallace
Anthropology Centre for Conservation, Environment and Development,
Department of Social Sciences, Faculty of Humanities & Social Sciences,
Oxford Brookes University, Gipsy Lane, Oxford OX3 0BP, UK
e-mail: cmhill@brookes.ac.uk

G. E. Wallace
e-mail: g.wallace@imperial.ac.uk

G. E. Wallace
Division of Ecology and Evolution, Imperial College London, Silwood Park,
Buckhurst Road, Ascot SL5 7PY, UK

Introduction

Conflict between subsistence farmers and wildlife due to crop-raiding is an increasingly crucial conservation issue in Africa and Asia. Raiding can compromise local food security (Hill 2000), reduces tolerance of wildlife (Sekhar 1998) and undermines management efforts (Osborn and Parker 2003). There is an extensive literature reviewing techniques to deter crop-raiding (Conover 2002; Sitati and Walpole 2006; Graham and Ochieng 2008). However, despite the prevalence of crop-raiding by non-human primates, virtually all accounts of techniques to protect crops from primates are indirect and anecdotal (Osborn and Hill 2005), without verification or structured evaluation (CARE et al. 2003; Reynolds 2005; Hockings and Humle 2009). Consequently, efforts to address raiding by these animals risk being ineffective and of little value to farmers, compromising conflict mitigation and conservation efforts (Madden 2004).

The context of crop-raiding must be understood before implementing deterrent interventions (Sitati et al. 2005), including the behavioural ecology of raiding species, crops grown on farms, and extent and frequency of raiding events (Hill et al. 2002). Farmers' perceptions about crop-raiding and raiding animals should be assessed to ensure actions and anticipated outcomes address farmer concerns (Gillingham and Lee 1999). Consultation with farmers and other key local people is imperative to agree plans and goals, and be informed about steps, limitations, local resources, or timeframes to take into account (Strum 1986; Webber et al. 2007).

We use the term 'deterrent' to refer to any technique intended to protect crops from damage by animals, irrespective of how and at what stage of a crop-raiding event the technique influences raider behaviour. An effective deterrent increases animals' perceived risks, overriding the benefits of raiding crops (Lee and Priston 2005). Because many animals habituate to deterrents, the most effective deterrents are likely to be adaptive and inexpensive rather than complex (Osborn and Hill 2005). The utility of an effective deterrent can be quantified by comparing crop-loss savings with deterrent costs over time (Wallace 2010). However, utility is also qualitative and influenced by perceptions about effort, expense, and opportunity cost to implement, use, and maintain a deterrent (Conover 2002). Accordingly, deterrent value is a function of how well it addresses the need to reduce crop-raiding, relative to the time and resources a farmer is willing or able to invest in crop protection. It is therefore productive to approach deterrent strategies as cost-benefit scenarios.

Deterrents used frequently or widely are not necessarily effective; rather, subsistence farmers may lack feasible alternatives. Farmers' traditional deterrents may be labour-intensive, inefficient, and ineffective but the only options they can afford or access (Hill et al. 2002). However, traditional deterrents such as basic fences, vigilance, guarding, throwing objects, chasing, and/or culling raiders may be appropriate in many contexts, especially when used systematically (Osborn 2002). These options should be considered first because techniques already familiar to farmers are likely to be locally acceptable and easier to modify when greater efficiencies or efficacy are required. Farmers are also more likely to support and maintain novel deterrents when they build on familiar methods (Osborn and Hill 2005).

Interventions should fit with local social norms, gender- or age-specific roles, and labour availability across agricultural seasons (Hill et al. 2002). Involving farmers actively in planning, implementing, and evaluating deterrents increases their ownership of techniques and commitment to finding solutions, decreasing dependency on 'outsiders' (Osborn and Parker 2002). Ideally, deterrents should be part of a mitigation strategy to not only decrease

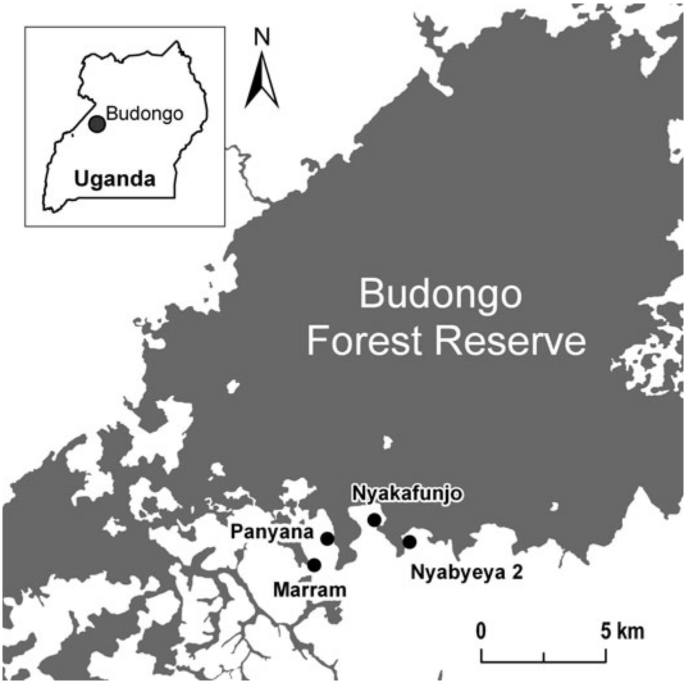

Fig. 1 *Map* showing location of the 4 villages where study farms are located around the southern edge of the Budongo Forest Reserve, Masindi District, Uganda

raid frequency and severity, including requests for compensation, but also increase tolerance of wildlife by reducing the impacts of crop-raiding for farming communities (Naughton-Treves 1998).

Interdisciplinary research often requires a degree of compromise where quantitative and qualitative strategies are combined. Here we use quantitative data collection and analysis techniques typical of behavioural ecology with qualitative, social science techniques to evaluate (i) deterrent effectiveness in changing animal behaviour and (ii) farmer views about deterrent utility and uptake. Our results demonstrate the efficacy of barriers, repellents, early warning systems and active guarding in reducing crop losses to primates, and outline farmers' preliminary assessments of deterrents.

Materials and methods

Study area and sample

A total of 10 deterrents were tested on 13 farms within 4 villages (Marram, Nyabyeya 2, Nyakafunjo, Panyana) around the southern edge of the Budongo Forest Reserve, Masindi District, Uganda (Fig. 1). All farms lay at the forest edge, and all deterrents were positioned at the farm-forest interface (FFI).[1] The realities of working with small-scale farmers

[1] Each FFI comprised a distinct section of farm–forest boundary and included farmland, forest, buffer zones and any regenerating areas perpendicular to the farm–forest boundary.

in isolated communities, combined with the need for an interdisciplinary, two-tiered approach, preclude having a larger sample size.

Data were collected February to September 2006 (Year 1) and February to September 2007 (Year 2), coinciding with the primary crop-growing season each calendar year. Study farms were typical for the area in terms of farm size, crop types grown and crop protection methods already in use (Hill 2005).

Data collection

Observation sites were selected to allow continuous viewing of farmer and wildlife activity and an unobstructed view of the farm-forest edge. A 'hide' was constructed (by the farm owner) at most observation sites to conceal observer presence from wildlife on or near the farm. Data collection schedules were agreed in advance with each farmer to ensure they were aware of when their farm and behaviour were being observed.

Six people, working in pairs, carried out data collection (GW and 5 research assistants). To minimise observer fatigue observation sessions were limited to 5–6 h per day per observer, and observers completed approximately 5 sessions per week. Observation sessions were scheduled to begin between 6.30 and 7.00 (sunrise) or end between 17.30 and 18.30 (sunset). All days of the week, and all hours of daylight, were sampled. However, observations were conducted less frequently during weekends to allow study households days without observers on their farms. Total observation sampling time exceeded 4,080 h across 786 sessions.

Inter-observer reliability trials were conducted regularly in both study seasons to assess and monitor consistency of observational data sampling across and within observers (Martin and Bateson 1986). One-way analysis of variance was used to test for statistical differences between and across observers (Fowler et al. 1998). The criterion for reliability ($p \geq 0.95$) was attained for 19 of 20 trials of behavioural observation datasets (scan data and continuous data), confirming a high level of inter-observer and within-observer consistency. Distance estimates were monitored under field conditions to ensure consistency across and within observers as well as accuracy with measured values. The criterion for reliability ($p \geq 0.9$) was attained in all trials, indicating distance estimation was consistent and sufficiently accurate for analysis.

In Year 1 standard systematic behavioural observation techniques (Altmann 1974) were used to collect data regarding (i) primate behaviour on farms and at farm-forest boundaries (species, raid duration and location, responses to human activity) and (ii) farmers' on-farm behaviour (presence, detection of primates, responses to raids). In Year 2 deterrents were implemented at study FFIs, and the same data collected as in Year 1 to evaluate the impact of each intervention. Instantaneous scan-sampling was carried out by one observer at 10-minute intervals throughout each sampling session. Scanning occurred from left to right across the farm and FFI. Scanning frequency was increased to 1-minute intervals for the duration of each crop-raiding event (CRE) to facilitate fine-scale analysis of crop-raiding-related behaviour and interactions with farmers. A CRE was defined as a behaviour sequence when one or more animals entered a farm and interacted with one or more crop items. It commenced when the first animal entered the farm and ended when the last animal left the farm. Each CRE only comprised crop interaction by a single species; simultaneous raiding by more than one species was recorded as separate CREs. Categories of behaviour used for scan sampling are presented in Table 1.

All-occurrences continuous sampling, carried out by the second observer, was used to record details of specific events such as animals or humans entering a farm, farm entry and

Table 1 Categories of behaviour used for scan sampling (Adapted from Wallace 2010, Appendix 5)

Behaviour	Description of behaviour
Animal behaviours	
Carry crop	Carrying crop item away from crop-interaction location
Eating	Consuming or ingesting crop items
Enter	Entering farm
Feeding	Consuming or ingesting non-crop food item
Flee	Escaping quickly from farm or adjacent area in response to action(s) by human(s) and/or dog(s)
Interact crop	Interacting with crop item: handing, manipulating, digging, breaking, processing but excludes eating or carrying crop item
Leave	Exiting farm
Resting	Inactive, stationary, and passive. Excludes social and vigilant
Social	Interactions between or involving 2 or more conspecifics. Includes playing, grooming, touching, mating and agonistic behaviours
Travelling	Travelling-related movement. Includes walking and running
Vigilant	Actively watching or scanning surrounding environment
Human behaviours	
Actively responding	Responding actively to animals on or near farm. Excluding guarding and deterring
Deterring	Action(s) intended, usually used, or likely to deter animals from entering farm and raiding crops
Enter	Entering farm
Guarding	Actively watching, scanning, or overseeing farm, forest edge, crops, and surrounding environment
Leave	Exiting farm
Resting	Inactive, stationary, and passive. Excludes guarding
Travelling	Travelling-related movement. Includes walking and running
Working	Actively working on or adjacent to farm. Includes all farming activities other than actively responding, guarding or deterring

exit points, or human activity within forest buffers and at farm edges. It was also used to record the following for each CRE: time when each animal entered farm; estimated distance of animal to nearest human on entry to farm; behaviour of human; number of animals on farm; number of animals remaining at or near forest edge; number of animals interacting with crop items; location of interaction with crop items; species of crop damaged; where crop item consumed; nature and extent of crop damage; detection of raiding animals by humans; actions by humans; responses by animals; estimated average distance animal/group travelled onto farm; estimated maximum distance any animal travelled onto farm; time last animal exited farm; estimated distance to nearest human when last animal left farm.

Crops planted were determined while mapping farms each study season. Maize and beans were predominant. Amount of crop damage was estimated from counts of crop interaction behaviour, crop items consumed, and carrying of crop items by animals during each CRE. One crop stem was defined as (a) one plant or stalk, including leaves, or (b) one fruit, cob or tuber. When possible, further assessment of crop damage occurred following

CREs or observation sessions. However, this was infrequent because observers were to remain hidden from animals that often stayed near the FFI after a CRE. Average planting densities were calculated for each crop stand on each farm, based on total number of stems counted in randomly selected 5 × 5 m plots.

Three focus groups were conducted prior to Year 2 to explore farmers' ideas and experiences for developing deterrents. All study farmers, 4 village chairpersons and additional members of study farm households participated. Participants were asked to consider ideas for possible deterrents, considerations when constructing and monitoring deterrents, and their prior experiences with crop-protection methods. Semi-structured interviews were conducted in Year 2 to investigate farmers' assessments of deterrents. Questions focussed on a comparison of crop yields in Years 1 and 2, how much guarding farmers engaged in during Year 2 compared with Year 1, any change in farmer on-farm behaviour across the two years, positive and negative aspects of the deterrent measures tested, would they continue to use and maintain any deterrent measures tested, and did they experience problems or concerns with observers on their farm?

All data were collected only after consultation with stakeholders, and with consent and support from village councils and participating farmers. Farmers were assured deterrents would be removed at their request at any time. The university research ethics committee granted ethics clearance, prior to beginning fieldwork. Research permits were granted by the Uganda National Council for Science and Technology.

Deterrents

The aim was to determine which deterrents were effective or not, and why. This was best achieved by matching deterrents to specific FFIs based on observations of CRE frequency and animals' raiding behaviour during Year 1. For example, barrier deterrents designed specifically to deter baboons were trialled at FFIs that experienced frequent baboon CREs during Year 1. Farmers were advised that deterrents differ in operation, require different levels of farmer input, and some farmers might experience better results than others because of the specific deterrents trialled on their farm. Farmers were assured that results and information from testing each deterrent would be shared to benefit all farmers over subsequent seasons.

Three categories of techniques were trialled: barriers, warning systems, and repellents (Table 2). Barriers (e.g. fences) impede or prevent entry to fields. They operate before raids occur and, where effective, restrict or eliminate raiding. Barriers typically require only minor input from farmers, other than construction and maintenance. Warning systems (e.g. bells) alert farmers to animals entering fields. They require farmers to construct and maintain the deterrents, and actively respond when signalled. Repellents (e.g. guarding) operate when animals are already in fields. They require farmers to be vigilant, allocate time to monitoring, and actively respond when raiders are detected; construction or maintenance is only necessary for guard huts. The deterrent categories are not mutually exclusive.

Details of the deterrent structures and their distribution across FFIs are summarised in Table 2. Two hedging materials were trialled, jatropha (*Jatropha curcas*) and ocimum (*Ocimum kailimandscharicum*). Jatropha is a drought resistant shrub sometimes used as a living barrier to livestock (Makkar et al. 1997). The seeds are toxic (Henning 2000), enhancing any deterrent impact of the hedge structure. The hedge was expected to obscure primates' view of crop fields from the forest, and their on-farm view of the forest, thereby

Table 2 Description of 10 deterrents trialled on 7 farms, across 8 different FFIs

Category	Deterrent	Location (FFI)	Dimensions and construction notes	Crops present in each year	Is deterrent effective or not?
Barriers	4 strand barbed wire fence	FFI17 Farm 13 Panyana village	128 m long, extending along 60 % of FFI to deter direct entry from forest to 3 of 5 fields	Crop availability was equivalent in both years	Effective. Reduced CRE frequency
	3 strand barbed wire fence	FFI08 Farm 06 Panyana village	107 m long, enclosing field on 3 sides; unenclosed edge was furthest from forest and adjoined farmer's house so considered unlikely wild animals would enter fields at this point	Crop availability was equivalent in both years	No reduction in CRE frequency
	Jatropha hedge	FFI18 Farm 13 Panyana village	2 sections of hedge, perpendicular to each other, enclosing 50 % of FFI. Cuttings planted 60–80 mm apart in September 2006 during rains. Formed dense, bushy hedge of 1.2–1.8 m high by April 2007	Intercropped maize and beans present in Year 1 and Year 2; availability equivalent in both years	Effective. Reduced CRE frequency
	3 row ocimum hedge with and without mesh	FFI16 Farm 12 Nyabyeya 2 village	3 rows of ocimum stems planted 300 mm apart, rows offset, to create dense hedge along entire FFI (57 m) and 23 m along each side boundary. Height ranged from 800 to 1,100 mm, and depth from 900 to 1,200 mm. 18 m length of mesh fence included within ocimum hedge along part of FFI	Crop availability was equivalent in both years	Ocimum hedge alone not effective at reducing CRE frequency, but effective when combined with mesh fence
	1 row ocimum hedge and mesh	FFI06 Farm 04 Marram village	Single row of ocimum stems planted 250–350 mm apart, extended 64 m along FFI and 58 m along farm boundary. Height from 900 to 1,200 mm, depth 350–450 mm. Mesh fence extended the whole length of hedge	Maize present in both years but area under maize was extended in Year 2, i.e. more maize available in Year 2	Effective. Reduced CRE frequency

Table 2 continued

Category	Deterrent	Location (FFI)	Dimensions and construction notes	Crops present in each year	Is deterrent effective or not?
Warning system	Net with bells	FFI02 Farm 01 Nyakafunjo village	110 m net fence (1,400–1,500 mm high) enclosed field on 3 sides. A bell was attached to each section of net, which sounded when a potential raider interacted with the net, alerting the farmer and indicating point of attempted entry[a,b]	Crop availability was different across years with only beans grown in Year 2	Effective warning system. Reduced CRE frequency
	Rope with bells	FFI08 Farm 06 Panyana village	Fence comprised wooden posts and 4 strands of sisal rope, extending 22 m (750–850 mm high). A bell was fixed to the upper rope in each section and ropes were interlinked with twine so it all moved if any sections were disturbed, sounding the bells[c]	Crop availability was equivalent in both years	Limited effectiveness. No reduction in CRE frequency
Repellent	Rope fence and chilli paste	FFI03 Farm 02 Nyakafunjo village	Fence comprised wooden posts and 4 strand of sisal rope, extending 82 m along 3 sides of field. Rope and posts were coated with chilli paste twice weekly[d]	Crop availability was different across years with only beans grown in Year 2	Effective. Reduced CRE frequency
	Full-time guard	FFI04 Farm 03 Nyakafunjo village	Guard present on farm 7 days a week, during hours of daylight	Crop availability was equivalent in both years	Effective. Reduced CRE frequency
	Part-time guard	FFI08 Farm 06 Panyana village	Guard present on farm 50 % of days, assigned randomly to vary each week	Crop availability was equivalent in both years	Effective. Reduced CRE frequency

Where more than 1 deterrent type was trialled at an FFI (e.g. FFI08) they were implemented at a distance from each other to reduce the likelihood of creating a compound effect

[a] Netting was secured to an upper and lower strand of barbed wire to maintain rigidity and deter climbing or digging

[b] The bells were audible to 120 m

[c] The bells were audible to 150 m

[d] Chilli paste was prepared by mixing 3 parts chilli powder, or 5 parts crushed whole chillies, with 1 part water by volume. Design of fence ensured primates had to touch and climb the ropes or posts to enter the field

reducing their information about human on-farm activity and escape routes, increasing perceived risks of raiding.

Ocimum is a perennial, aromatic shrub, forming a dense, interwoven barrier from ground level. Local rhetoric suggests ocimum has repellent properties due to its strong odour and attractiveness to bees (M. Diedonne, pers. comm.). It was anticipated that adding ocimum to a fence would (i) make crops less accessible to primates because the plants form a dense barrier, (ii) render the fence aversive due to odour and presence of bees, and (iii) increase raiding risks by enlarging the barrier to be negotiated and reducing line of sight between the forest and farm.

A 1 m high wire-mesh fence was included within the construction of the 2 ocimum hedges to assess whether deterrent efficacy (if any) depended on, or was augmented by, a fence. In each case the fence was on the farm side of the hedge, ensuring animals approaching from the forest encountered the hedge first. Twelve millimetre mesh made it difficult for primates to secure a foothold on the wire; the lower edge was fixed to the ground to prevent easy passage under it.

From observations made on study farms during Year 1 it was apparent that guarding was sporadic, occurring less frequently than farmers' claimed, and comprising only 15.5 % of their activity budget (Wallace 2010). Farmers were often distracted or preoccupied with other tasks and only intermittently vigilant, usually remaining at one location without patrolling fields or boundaries. Guarding was typically in short bouts of less than two hours. Consequently, 3 guards were hired in Year 2. Each had experience of farming and raiding by wildlife. They were required to guard from sunrise to sunset, be vigilant throughout this period, patrol fields and farm edges frequently although not at regular intervals or in patterns animals might discern, and actively respond to wildlife observed on the farm or at the FFI. Men were selected to avoid any confounding effect of guard age–sex category.

Guards maintained a written record of all animals they observed on-farm, near the FFI, or responded to. Information recorded included species, time, location, number of animals encountered, guarding actions, and animals' responses. Guards could carry weapons, chase animals, and/or throw objects at them but not kill, trap or injure animals.

Two guarding schedules were trialled from June to September 2007. At FFI04 guarding occurred throughout all days of each week. This full-time schedule reflected the maximum effort a farmer could invest in guarding during daylight hours, and represents a continuous and predictable risk for animals raiding crops. Guarding was on a part-time basis at FFI08, occurring throughout 50 % of days, assigned randomly to vary each week. This schedule reflected feasible guarding effort when farmers needed to undertake other tasks regularly and/or could share guarding with family members or neighbours; it provides a sporadic but unpredictable risk for animals raiding crops.

All costs for materials and related expenses were paid from project funds. Although farmers incurred effort costs in trialling deterrents, funding meant they accrued any benefits without monetary investment, allowing them to focus on utility. The deterrents were affordable, easy to use, low maintenance, and used locally-sourced materials purchased in nearby markets. Local people with bicycles were hired to transport deterrent materials. Savings are expressed in Ugandan shillings (UGX) where 1 GBP = 3,300 UGX or 1 USD = 2,100 UGX.

Frequencies of CREs for Year 2 were compared with baseline values for Year 1 to determine effectiveness of each deterrent, i.e. whether there was a substantial reduction in CRE frequency in Year 2 compared with Year 1.

Data analysis

Quantitative data are analysed using non-parametric tests with SPSS 14 for Windows (SPSS Inc., USA). Categorical data (frequency of CREs under different conditions) were analysed using χ^2 or Fisher exact tests and continuous data (number of crop stems damaged; size of raiding group; duration of CRE; distance animals travel onto farm; number of CREs detected/undetected by farmers) were analysed using Mann–Whitney U tests. Tests were two-tailed and $p < 0.05$ was considered significant. Quantitative data are supplemented with qualitative data from interviews with study farmers where appropriate, to explain farmers' viewpoints and, in some cases, actions.

Results

Olive baboons (*Papio anubis*), blue monkeys (*Cercopithecus mitis stuhlmanni*), red-tailed monkeys (*Cercopithecus ascanius schmidti*), vervet monkeys (*Chlorocebus aethiops*), black and white colobus monkeys (*Colobus guereza occidentalis*), and chimpanzees (*Pan troglodytes schweinfurthii*), were recorded crop-raiding each season.

Fences

Barbed-wire fences were trialled at FFI17 (4-strand fence) and FFI08 (3-strand fence). The results are summarised in Table 3. In Year 2 CREs only occurred in unprotected fields and those bordered by the 3-strand fence. Estimated maize damage by primates in Year 2 at FFI17 (82 cobs) was 80 % less than Year 1 (405 cobs). Maize cobs sold for 100 UGX each at local markets (M. Diedonne, pers. comm.); gross savings therefore exceeded 30,000 UGX, representing approximately 12 % of average annual income for rural households (UBOS 2010). The farmer envisaged the 4-strand fence at FFI17 would require only minor maintenance over 3–4 years. Costs to replace the wire were viewed as potential shortcomings, although the farmer added he had "many years to save the shillings" for this, and the fence would "help him to save more money".

The 3-strand fence at FFI08 did not deter primates from raiding (Table 3). There was a 56 % increase in raids during Year 2 despite equivalent availability of maize and beans in adjacent fields. The lower fence height at FFI08 compared to that at FFI17 possibly removed any deterrent effect for primates. In Year 2 primates were observed entering and exiting the enclosed field by jumping over the wire.

Hedges

A jatropha hedge was trialled at FFI18. Primate CRE frequency was similar in both years (Table 4). However, there was an 85 % decrease in raid frequency in fields bordered by the hedge and a significant increase in raids in adjacent fields without the hedge during Year 2 ($\chi^2 = 26.5$, df = 1, $p < 0.001$). Because crop availability and level of raiding activity were similar across the two seasons, we conclude the hedge was an effective deterrent to crop-raiding by primates.

In Year 2 no raiding occurred in the field most enclosed by the jatropha hedge (Field 1) even though 86 % of Year 1 CREs occurred there. The three baboon raids during Year 2 occurred close to the end of the hedge: each raider entered and exited through an unprotected field, avoiding the hedge. Immediately prior to 10 CREs in Year 2 primates were

Table 3 Testing the efficacy of 2 different barbed-wire fences

FFI and type of fence	Fields	Raiding species	Frequency of CREs		Difference in frequency of CREs: Year 2 − Year 1
			Year 1	Year 2	
FFI17 4 strand barbed-wire fence	Fields 1, 2 and 3 (protected by fence)	Baboon	6	0	−6
		Blue monkey	1	0	−1
		Red-tailed monkey	2	0	−2
		All raiding species	9	0	−9
	Fields 4 and 5 (not protected by fence)	Baboon	0	4	+4
		Chimpanzee	0	1	+1
		All raiding species	0	5	+5
FFI08 3 strand barbed-wire fence	Field (protected by fence)	Baboon	1	1	0
		Blue monkey	3	2	−1
		Red-tailed monkey	5	11	+6
		All raiding species	9	14	+5

Frequency of crop-raiding events at FFI17 and FFI08 in Year 1 and Year 2. CRE frequency is summarised for fields protected by fences and those not protected by fences during Year 2

observed travelling along the jatropha hedge and then entering the farm at a point beyond the end of the barrier. Animals were especially vigilant while travelling, appearing to inspect the hedge. Primates were never observed climbing over or through it, using stems as vantage points, or touching it, suggesting jatropha is also a repellent.

Median species-level raiding-group size, raid duration, and on-farm travel distance did not differ significantly across seasons at FFI18. Estimated number of crop stems damaged by primates was not significantly different across seasons. The farmer was observed to guard less frequently in Year 2 (5.2 % of scans) than Year 1 (12.9 % of scans). The farmer thought the barrier would reduce the need to guard, including fields not bordered by the hedge. Because most raiding had been in Fields 1 and 2 in Year 1 the farmer put less effort into guarding Fields 3 and 4, not expecting raiding to shift to unprotected fields as much as it did. However, he did not increase guarding effort in response.

Three-row and single-row ocimum hedges, with and without mesh fences, were trialled at FFI16 and FFI06. The results are summarised in Table 4. The 3-row hedge (FFI16) alone had negligible deterrent impact but was effective when combined with the mesh fence (Fisher exact test, two-tailed, $p \leq 0.004$). During Year 2 only one raid occurred within the area bordered by the combined 3-row hedge plus fence (FII16), whereas 12 raids (57 % of all raids) had occurred within this area in Year 1. The raid in Year 2 occurred in June when the hedge was less dense, and involved two red-tailed monkeys entering via the hedge, avoiding the fence, and fleeing when chased by the farmer.

The single-row ocimum hedge plus wire-mesh fence (FFI06) was also an effective deterrent to raiding and shifted raids away from crop fields it bordered (Table 4). Eighty percent of Year 1 CREs were in Fields 1 or 2 and only 9 % occurred there in Year 2. The 3 Year 2 baboon raids in Field 2 were of cassava in April, before maize cobs were present; baboons appeared to 'target' the cassava then restrict raiding to Fields 3 or 4 for the remainder of the season when maize was available in all fields. The 90 % reduction in

Table 4 Testing the efficacy of jatropha and ocimum hedges

Type of hedge	FFI and field status	Raiding species	Frequency of CREs		Difference in frequency of CREs: Year 2 − Year 1
			Year 1	Year 2	
Jatropha hedge	FFI18 Fields 1 and 2 (protected by hedge)	Baboon	13	3	−10
		Red-tailed monkey	6	0	−6
		Vervet monkey	1	0	−1
		All raiding species	20	3	−17
	FFI18 Fields 3 and 4 (not protected by hedge)	Baboon	1	11	+10
		Blue monkey	0	2	+2
		Red-tailed monkey	0	7	+7
		All raiding species	1	20	+19
3 row ocimum hedge	FFI 16 Field edge (protected by hedge only)	Baboon	3	3	0
		Chimpanzee	1	3	+2
		Red-tailed monkey	0	2	+2
		All raiding species	4	8	+4
	FFI16 Field edge (protected by hedge and mesh fence)	Baboon	7	0	−7
		Blue monkey	3	0	−3
		Chimpanzee	2	0	−2
		Red-tailed monkey	0	1	+1
		All raiding species	12	1	−11
	Unprotected fields adjacent to FFI16	Baboon	0	11	+11
		Blue monkey	0	2	+2
		Chimpanzee	2	1	−1
		Red-tailed monkey	0	4	+4
		All raiding species	2	18	+16
1 row ocimum hedge and mesh fence	FFI06 Fields 1 and 2 (protected by hedge and mesh fence)	Baboon	30	3	−27
		Blue monkey	3	0	−3
		Red-tailed monkey	4	0	−4
		All raiding species	37	3	−34
	FFI06 Fields 3 and 4 (not protected by hedge and mesh fence)	Baboon	8	13	+5
		Blue monkey	0	15	+15
		Red-tailed monkey	1	0	−1
		Chimpanzee	0	2	+2
		All raiding species	9	30	+21

Frequency of crop-raiding events at FFI18, FFI16 and FFI06 in Year 2 compared to Year 1. CRE frequency is summarised for fields protected by hedges compared with those not protected by hedges

baboon CREs within fields bordered by the barrier clearly indicates that baboons were avoiding it (χ^2 test, $\chi^2 = 24.926$, df $= 1$, $p < 0.001$).

The single-row ocimum hedge plus wire-mesh fence had greatest impact on baboon raiding but also shifted all blue monkey raids to Fields 3 and 4. Although reasons for the five-fold increase in blue monkey CREs during Year 2 are not known, their presence at FFI06 was consistent across seasons. Baboons and blue monkeys at FFI06 raided in smaller groups closer to the forest edge in Year 2 compared with Year 1 (Mann–Whitney U tests $n_{(\mathrm{YR2})} = 17$ $n_{(\mathrm{YR1})} = 30$: group size $U = 85.5$, $p < 0.001$; average on-farm distance

$U = 146.5$, $p \leq 0.016$; maximum on-farm distance $U = 141.0$, $p \leq 0.011$). Both chimpanzee raids in Year 2 were of papaya close to the farmer's house adjoining Field 4. There was a significant reduction in estimated stem damage by primates from Year 1 (1,047 stems) to Year 2 (382 stems) (χ^2 test, $\chi^2 = 309.465$, df = 1, $p < 0.001$). Median damage per CRE was also significantly lower during Year 2 (11 stems) than Year 1 (15 stems) (Mann–Whitney U test, $n_{(\mathrm{YR2})} = 33$ $n_{(\mathrm{YR1})} = 46$, $U = 493.0$, $p \leq 0.008$). Based on local prices for maize cobs (see above), the barrier generated a crop-loss saving for the farmer of approximately 60,000 UGX.

Primates were never observed or reported climbing the ocimum and mesh fence, using it as a vantage point, or otherwise interacting with it, suggesting ocimum, like jatropha, has repellent qualities. During Year 2 primates were observed to avoid the barrier, travelling up to 70 m through trees before leaving the forest to enter beyond the barrier. Blue monkeys and baboons were at the forest edge opposite Fields 3 or 4 more often in Year 2 (4.7 % of scans) than Year 1 (2.8 % of scans), again indicating avoidance. Similarly, primates often used a longer route to the forest to avoid the barrier when exiting the farm in Year 2, and generally did not raid where the barrier was directly between them and the forest, even when near the farm edge. This suggests the barrier also deterred raiding in fields where it impeded escape.

Guarding was observed infrequently at FFI06 in Year 1 (14.9 % of scans) and even less often during Year 2 (4.6 % of scans), hence CREs were detected significantly less frequently by the farmer during Year 2 than Year 1 (Mann–Whitney U test, $n_{(\mathrm{YR2})} = 18$ $n_{(\mathrm{YR1})} = 33$, $U = 154.5$, $p \leq 0.001$). At the end of Year 2 the farmer stated he had assumed the ocimum hedge plus mesh fence would be an effective deterrent, enabling him to invest less time guarding crops.

The farmer (FFI16 and FFI06) claimed he could not afford to erect a mesh fence without saving for at least five years, even though he expected it to require little maintenance and reduce losses for many years. However, confidence in the barrier as a deterrent had allowed him and his family more time to weed crops to improve yields and engage in (illegal) pit-sawing. The farmer noted the mesh fence would "stay strong for many years" but identified two shortcomings of ocimum. Firstly, he would need to set aside land to cultivate seedlings because the plant's lifespan is only 3–4 years. Secondly, over time the hedge would occupy almost 3 m of land along the farm edge, reducing the area available for primary crops. In contrast, the single row of ocimum at FFI06 occupied very little land; the farmer considered this a key benefit, particularly as it retained repellent properties. The farmer suggested the barrier's efficacy was tied to ocimum's odour and the presence of bees, in addition to probably being difficult for primates to climb.

Repellent

Chilli paste applied to a rope fence was trialled as a repellent device at FFI03. Crop availability differed across seasons, with only beans grown in Year 2. A total of 23 CREs occurred during the 6 weeks before deterrent introduction but only one CRE was observed during the 6 weeks when chilli was used. The ratio of raids one month before versus one month after deterrent introduction was 18:1. Farmer vigilance and guarding behaviour did not change with use of the chilli paste, confirming the decrease in raiding activity was due to the barrier.

The farmer observed blue monkeys and red-tailed monkeys occasionally at the fence. On each occasion monkeys were rubbing both hands vigorously; none entered the field and the farmer chased them into the forest. The farmer noted that chilli paste was "easy to mix" and "powerful", and key to the fence's effectiveness. He added that only one hour was required every 3–4 days to apply the paste, and this was a small time investment relative to the fence's benefits. The farmer planned to replace the ropes as needed and grow chilli for paste, but noted that heavy rain could remove the chilli and weaken the ropes, and if chilli paste had to be prepared and applied more than twice per week it would no longer be cost-effective. However, he acknowledged that persistent rain usually only occurred early in the season before crops are raided regularly.

Systematic guarding

Two guarding strategies were trialled: full-time (FF104) and part-time (FFI08).

CRE frequency decreased from Year 1 to Year 2 under both guarding regimes (Table 5), confirming guarding can mitigate raiding. The decrease was evident for each raiding species, except baboons at FFI08, and was aligned with guarding effort (one-sample χ^2 test, $\chi^2 = 16.277$, df $= 1$, $p < 0.001$). The only raids at FFI04 occurred in June (when guarding commenced), where baboons entered from another farm, raided far from the guard's hut, and were detected and chased when the guard patrolled. Observations and neighbouring farmers' reports indicated raids increased by 30–50 % at adjoining farms in June and July. Most (79 %) raids at FFI08 during the trial were on days when the guard was absent; the owner guarded infrequently when the hired guard was off duty. Only 4 raids occurred while the guard was working. Results confirm that to be effective guarding should be an active behaviour, and is more than simply on-farm human presence.

Warning systems

A net fence with bells attached was trialled as a warning system at FFI02. Crop availability and farmer presence were equivalent across seasons. Results are summarised in Table 6. There was a significant reduction in raids after introducing the net with bells (one-sample χ^2 test, $\chi^2 = 13.762$, df $= 1$, $p < 0.001$) (Table 6). Only 2 raids occurred after deterrent implementation. On one occasion baboons entered the field via a neighbouring farm, bypassing the fence and bells. On the second occasion the farmer responded when a bell

Table 5 Testing the efficacy of different guarding strategies

Species	Frequency of CREs		Difference in frequency of CREs: Year 2 − Year 1
	Year 1	Year 2	
FFI04: full-time guarding			
Baboon	11	3	−8
Vervet monkey	14	0	−14
Sum of all species	25	3	−22
FFI08: part-time guarding			
Baboon	10	10	0
Blue monkey	4	1	−3
Chimpanzee	9	1	−8
Red-tailed monkey	10	7	−3
Sum of all species	33	19	−14

Frequency of crop-raiding events at FFI04 and FFI08 in Year 2 compared to Year 1. Refers to CREs from June to September each season

Table 6 Frequency of crop-raiding events within the field protected by the net fence with bells at FFI02

Period	Frequency of CREs				
	Baboon	Blue monkey	Red-tailed monkey	Vervet monkey	Sum
Year 1	5	0	0	9	14
Year 2 prior to fence	3	2	4	10	19
Year 2 after fence	1	0	0	1	2
Difference in CRE frequency after fence installed	−2	−2	−4	−9	−17

sounded, chasing vervet monkeys from the field. The farmer repelled primates attempting to enter the farm on 4 further occasions during Year 2.

The net fence was a novel structure that primates appeared to avoid during the first week after construction; on 6 occasions primates were observed travelling along and visually 'inspecting' the netting without interacting with it. CREs within adjacent fields were monitored for control purposes. In Year 1 there were 28 raids in neighbouring fields while in Year 2 there were 13 prior to fence construction and 34 after fence construction. This increase in CRE frequency in adjacent fields occurred despite relatively high levels of guarding each season compared to other study farms.

A modified version, using a rope fence with bells attached, was trialled at FFI08. In 4 instances baboons or chimpanzees triggered a bell on entering the field via the fence, alerting the farm guard. However, primates avoided the fence to raid on 5 occasions and primate activity near the fence only reduced slightly after installation. The system had some deterrent value but did not reduce CRE frequency, probably because it was of insufficient length to be unavoidable, demonstrating an alarm system is only a useful adjunct to guarding if covering a sufficient portion of the boundary to force potential raiders to interact with it.

Discussion

A range of tools and techniques to deter crop-raiding were trialled, including fences and other barriers, chilli infusions, nets and bells, and systematic guarding. The deterrents addressed crop-raiding by primates but may be effective against other species (Table 2). Deterrents were rated favourably by farmers, who considered them easy to use and locally appropriate. Barbed wire fences were designed primarily to deter crop raiding by wild pigs. Consequently farmer comments about effectiveness of barbed-wire fences were only reported where they relate directly to effectiveness against primate raiding species. Therefore we had no specific feedback about the 3-strand fence's efficacy against primate raiding activity from the household trialling this fence.

Primates raided crops less frequently where a deterrent was used confirming deterrents impeded or excluded raiders. Four-strand barbed wire fences, vegetation hedges (jatropha and ocimum), and net fencing with bells shifted raiding to unprotected areas of the same or neighbouring farms, including farm entry and exit points, as has been reported for other species (Geisser and Reyer 2004; Sitati and Walpole 2006).

Extensive crop availability and sporadic crop protection close to most study farms made it relatively easy for deterrents to shift raiding location. This does not imply the deterrents were ineffective; however, it may be informative to assess raider behaviour when there are fewer alternative crop-foraging options. This would provide a rigorous evaluation of deterrent effectiveness because raiders may be more persistent in attempts to circumvent the deterrent. It might also be useful to identify the threshold criteria that determine whether or not raiders shift their effort to alternative locations; these features could then be accentuated over time to maintain deterrent effect.

The results for shifting raid location demonstrate the importance of considering impacts for neighbouring farmers. If crop-loss savings for some are offset by increased losses for others there will be no change in community food security and tolerance of wildlife (Rollins and Briggs 1996), compromising any conflict mitigation that deterrents were intended to achieve. Similarly, extending a barrier to protect greater proportions of a farm will probably shift raiding to adjacent fields without deterrents. This is likely for jatropha or ocimum hedges, which are readily and inexpensively extended. Raiding patterns in response to the ocimum and mesh fence at FFI06 were very similar to those for the jatropha hedge at FFI18; CRE frequency decreased markedly in fields most enclosed by the barrier but increased considerably in unprotected or only partly protected fields. We recommend this be taken into account when developing deterrent strategies by (i) including all vulnerable farms in close proximity and (ii) installing deterrents simultaneously rather than sequentially across farms to ensure that any delay in implementation does not render individual farmers more vulnerable to crop losses as a consequence of raiding activities being focussed on their farms.

It is possible that deterrents were partly effective because they were novel at farms. The presence of construction activity, unusual structures, alarms, or guards that had previously been absent might encourage raiders to be especially cautious and avoid fields, at least initially. Deterrent effectiveness was also often greater when crop-protection techniques were combined. Similarly, deterrent categories were not mutually exclusive. For example, systematic guarding regularly warned of potential crop-raiding while the nets and bells alarm system also acted as a barrier to impede farm entry.

Each farmer considered the deterrent(s) trialled at their farm useful, effective, and beneficial. On project completion farmers requested structural deterrents remain in situ, and stated they would continue to use them. Similarly, farmers claimed systematic guarding would be used to the extent that resources allowed. All study farmers were enthusiastic and actively involved in assessing deterrents, and often exchanged progress reports about their utility. Farmers confirmed they would share information about the deterrents within their village; other farmers were encouraged to visit study farms to observe deterrents in use. This participatory and cooperative approach was central to positive perceptions of deterrents, enhancing prospects for conflict mitigation. While demonstrating the efficacy of deterrents does not ensure uptake (Sitati and Walpole 2006; Graham and Ochieng 2008), positive perceptions increase the probability that farmers will maintain and adapt deterrents, and continue to view them as beneficial. A follow-up survey in 2008 confirms farmers were continuing to use many of the tools developed. Additionally, some farmers not included in the original study have installed modified versions of the original deterrents on their own farms (Hsiao 2008).

Farmers also identified indirect benefits from some deterrents. Farmers at FFI06 and FFI16 considered ocimum potentially valuable as a cash crop, providing there were an organisation or large group of farmers promoting it. The farmer at FFI02 stated the nets and bells alarm system allowed him to work and rest further than usual from the farm edge (because he would be alerted if animals attempted to enter the farm) and to guard less frequently. There was an unintended shift in farmer behaviour at FFI06 during Year 2, where the farmer spent more time organising pit-sawing teams and travelling to sawing sites compared with Year 1. Consequently, increasing farmers' time to engage in other economic activities can be important for households but have unexpected conservation implications.

Participatory projects build stakeholder relationships, improve communication, promote understanding of alternative perspectives, and inherently reduce conflict and misconceptions (Newmark et al. 1993; Hulme and Murphree 2001; Madden 2004). Deterrent development should be participatory but not viewed as a complete solution to conflict issues. In many cases deterrents might address the symptoms of conflict rather than causes (Barnes 2002). However, the more intervention and mitigation strategies are based on accurate comprehensive accounts of crop-raiding, incorporate an understanding of raider and farmer behaviour, involve farmers, and acknowledge farmers' interests and perceptions, the greater the probability that strategies will be effective.

Conclusions

Many crop-protection techniques are viewed as ineffective with primates (Warren 2003; Webber 2006; Hockings 2007). However, we demonstrate that primate crop-raiding activity can be reduced using relatively unsophisticated and inexpensive techniques, including barriers. While most primate deterrents will require modification over time to offset habituation, it is clear that primates can be deterred by a broader range of techniques than usually proposed. The keys to efficacy are (a) understanding local primate raiding behaviour, (b) selecting, fine-tuning, and varying deterrents to address this behaviour and prevent animals habituating to them (Osborn and Hill 2005) and (c) working with farmers as partners throughout the process (Wallace 2010).

Acknowledgments We thank the following for permission to conduct the research: Uganda National Council for Science and Technology, Uganda Wildlife Authority, and National Forestry Authority, Uganda. Financial support was provided by The Leverhulme Trust, Rufford Small Grants, North of England Zoological Society, The Parkes Foundation, The American Society of Primatologists, and The Primate Society of Great Britain. Field assistance was provided by M. Diedonne, A. Fani, A. Geoffrey, J. Ayebale, A. Wallace, R. Bacon, and T. Pearson. Figure 1 is adapted from a vegetation map courtesy of N. Laporte of the Woods Hole Research Centre's Africa Program (Protected Area Watch Program). We especially thank the people of Nyabyeya Parish for their enthusiasm, hospitality and support throughout the project, and M. McLennan, F. V. Osborne, N. Priston and 2 anonymous reviewers for comments on earlier drafts.

References

Altmann J (1974) Observational study of behavior: sampling methods. Behaviour 49:227–267

Barnes RFW (2002) Treating crop-raiding elephants with aspirin. Pachyderm 33:96–99

CARE, ITFC, CDC, WCS (2003) Reducing the costs of conservation to frontline communities in southwest Uganda. Knowledge Base Review Report. CARE International in Uganda, Institute of Tropical Forest Conservation, Conservation Development Centre, and Wildlife Conservation Society

Conover M (2002) Resolving human–wildlife conflicts: the science of wildlife damage management. Lewis Publishers, Boca Raton

Fowler J, Cohen L, Jarvis P (1998) Practical statistics for field biology, 2nd edn. Wiley, Chichester

Geisser H, Reyer H-U (2004) Efficacy of hunting, feeding, and fencing to reduce crop damage by wild boars. J Wildl Manag 68:939–946

Gillingham S, Lee PC (1999) The impact of wildlife-related benefits on the conservation attitudes of local people around the Selous Game Reserve, Tanzania. Environ Conserv 26:218–228

Graham MD, Ochieng T (2008) Uptake and performance of farm-based measures for reducing crop raiding by elephants *Loxodonta africana* among smallholder farms in Laikipia District, Kenya. Oryx 42:76–82

Henning RK (2000) The jatropha booklet. GTZ-ASSP Project Zambia, Choma

Hill CM (2000) Conflict of interest between people and baboons: crop raiding in Uganda. Int J Primatol 21:299–315

Hill CM (2005) People, crops, and primates: a conflict of interests. In: Paterson JD, Wallis J (eds) Commensalism and conflict: the human–primate interface. American Society of Primatologists, Norman, pp 40–59

Hill CM, Osborn FV, Plumptre AJ (2002) Human–wildlife conflict: identifying the problem and possible solutions. Albertine Rift Technical Report Series No. 1. Wildlife Conservation Society, Kampala

Hockings KJ (2007) Human–chimpanzee coexistence at Bossou, the Republic of Guinea: a chimpanzee perspective. PhD Dissertation, University of Stirling

Hockings K, Humle T (2009) Best practice guidelines for the prevention and mitigation of conflict between humans and great apes. IUCN/SSC Primate Specialist Group, Gland

Hsiao SS (2008) Evaluation and monitoring of crop raiding mitigation strategies in villages around Budongo Forest Reserve, Uganda. MRes Dissertation, Roehampton University

Hulme D, Murphree MW (2001) Community conservation in Africa. An introduction. In: Hulme D, Murphree MW (eds) African wildlife and livelihoods: the promise and performance of community conservation. James Curry, Oxford

Lee PC, Priston NEC (2005) Human attitudes to primates: perceptions of pests, conflict and consequences for primate conservation. In: Paterson JD, Wallis J (eds) Commensalism and conflict: the human–primate interface. American Society of Primatologists, Norman, pp 1–23

Madden F (2004) Creating coexistence between humans and wildlife: global perspectives on local efforts to address human–wildlife conflict. Hum Dimens Wildl 9:247–257

Makkar HPS, Becker K, Sporer F, Wink M (1997) Studies on nutritive potential and toxic constituents of different provenances of *Jatropha curcas*. J Agric Food Chem 45:3152–3157

Martin PR, Bateson P (1986) Measuring behaviour: an introductory guide. Cambridge University Press, Cambridge

Naughton-Treves L (1998) Predicting patterns of crop damage by wildlife around Kibale National Park, Uganda. Conserv Biol 12:156–168

Newmark WD, Leonard NL, Sariko HI, Gamassa D-GM (1993) Conservation attitudes of local people living adjacent to five protected areas in Tanzania. Biol Conserv 63:177–183

Osborn FV (2002) Capsicum oleoresin as an elephant repellent: field trials in the communal lands of Zimbabwe. J Wildl Manag 66:674–677

Osborn FV, Hill CM (2005) Techniques to reduce crop loss: human and technical dimensions in Africa. In: Woodroffe R, Thirgood S, Rabinowitz A (eds) People and wildlife: conflict or coexistence?. Cambridge University Press, Cambridge, pp 72–85

Osborn FV, Parker GE (2002) Living with elephants II: a manual for implementing an integrated programme to reduce crop loss to elephants and to improve livelihood security of small-scale farmers. Mid Zambezi Elephant Project

Osborn FV, Parker GE (2003) Towards an integrated approach for reducing the conflict between elephants and people: a review of current research. Oryx 37:80–84

Reynolds V (2005) The chimpanzees of the Budongo Forest: ecology, behaviour, and conservation. Oxford University Press, Oxford

Rollins K, Briggs HC (1996) Moral hazard, externalities, and compensation for crop damages from wildlife. J Environ Econ Manag 31:368–386

Sekhar NU (1998) Crop and livestock depredation caused by wild animals in protected areas: the case of Sariska Tiger Reserve, Rajasthan, India. Environ Conserv 25:160–171

Sitati NW, Walpole MJ (2006) Assessing farm-based measures for mitigating human–elephant conflict in Transmara District, Kenya. Oryx 40:279–286

Sitati NW, Walpole MJ, Leader-Williams N (2005) Factors affecting susceptibility of farms to crop raiding by African elephants: using a predictive model to mitigate conflict. J Appl Ecol 42:1175–1182

Strum SC (1986) Activist conservation: the human factor in primate conservation in source countries. In: Else JG, Lee PC (eds) Primate ecology and conservation. Cambridge University Press, Cambridge, pp 367–382

UBOS (2010) Uganda National Household Surveys Report 2009/2010. Uganda Bureau of Statistics, Kampala

Wallace GE (2010) Monkeys in maize: primate crop-raiding behaviour and developing on-farm techniques to mitigate human–wildlife conflict. PhD Dissertation, Oxford Brookes University

Warren Y (2003) Olive baboons (*Papio cynocephalus anubis*): behaviour, ecology and human conflict in Gashaka Gumti National Park, Nigeria. PhD Dissertation, University of Roehampton

Webber AD (2006) Primate crop raiding in Uganda: actual and perceived risks around Budongo Forest Reserve. PhD Dissertation, Oxford Brookes University

Webber AD, Hill CM, Reynolds V (2007) Assessing the failure of a community-based human–wildlife conflict mitigation project in Budongo Forest Reserve, Uganda. Oryx 41:177–184