International Journal of Pest Management
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/ttpm20

Wildlife damage and control methods around Lake Mburo National Park, Uganda

Mnason Tweheyo [a], David Mwesigye Tumusiime [b c], Nelson Turyahabwe [d], Asaph Asiimwe [a] & Lawrence Orikiriza [a]

[a] Department of Forestry Biodiversity and Tourism, School of Forestry Environment and Geographical Sciences, Makerere University, P.O. Box 5003, NO-1432 Aas, Norway

[b] Department of International Environment and Development studies, Norwegian University of Life Sciences, P.O. Box 5003, NO-1432 Aas, Norway

[c] Department of Environmental Management, School of Forestry, Environment and Geographical Sciences, Makerere University, P.O. Box 7062, Kampala, Uganda

[d] Department of Extension and Innovations, School of Agriculture, Makerere University, P.O. Box 5003, NO-1432 Aas, Norway

Published online: 07 Mar 2012.

To cite this article: Mnason Tweheyo, David Mwesigye Tumusiime, Nelson Turyahabwe, Asaph Asiimwe & Lawrence Orikiriza (2012) Wildlife damage and control methods around Lake Mburo National Park, Uganda, International Journal of Pest Management, 58:1, 25-31, DOI: 10.1080/09670874.2011.641605

To link to this article: http://dx.doi.org/10.1080/09670874.2011.641605

International Journal of Pest Management
Vol. 58, No. 1, January–March 2012, 25–31

Taylor & Francis
Taylor & Francis Group

Wildlife damage and control methods around Lake Mburo National Park, Uganda

Mnason Tweheyo[a], David Mwesigye Tumusiime[b,c]*, Nelson Turyahabwe[d], Asaph Asiimwe[a] and Lawrence Orikiriza[a]

[a]*Department of Forestry Biodiversity and Tourism, School of Forestry Environment and Geographical Sciences, Makerere University, P.O. Box 5003, NO-1432 Aas, Norway;* [b]*Department of International Environment and Development studies, Norwegian University of Life Sciences, P.O. Box 5003, NO-1432 Aas, Norway;* [c]*Department of Environmental Management, School of Forestry, Environment and Geographical Sciences, Makerere University, P.O. Box 7062, Kampala, Uganda;* [d]*Department of Extension and Innovations, School of Agriculture, Makerere University, P.O. Box 5003, NO-1432 Aas, Norway*

(*Received 8 April 2011; final version received 9 November 2011*)

This study documents the different management and control measures developed and implemented by farmers to mitigate vertebrate pest attacks on crops and livestock around Lake Mburo National Park in Uganda. A semi-structured interview administered to 40 randomly selected park neighbours was supplemented with key informant interviews, a review of secondary data, and direct observations of vertebrate pest problems and their management. All participant farmers had experienced some damage from vertebrate pests. Bushpigs ranked as the most destructive to crops, while leopards were most destructive to livestock. Most damage occurred during severe dry seasons. The most common methods for combating pests were guarding, fencing, and poisoning. Physical guarding was perceived as being the most effective method; however, there were reports of pest resurgence, which varied between pest species, seasons, and methods used. Bushpigs showed the greatest resistance against control measures. Control efforts were found to be tedious and time-consuming, and they created the possibility for the transfer of infectious diseases from pests to humans. We recommend conscious efforts to augment local control methods so as to enhance both biodiversity conservation and farm production.

Keywords: crop raiding; human–wildlife conflict; Mburo; pest control; vertebrate pest

1. Introduction

Wildlife damage and the implementation of local control methods have a long history in Africa. Even early European settlers set bounties on vertebrate species that either competed with domestic animals for fodder and water, or damaged crops and livestock. However, some changes were introduced with game legislation, and in 1657 in Southern Africa an early effort culminated in the distinction between protected animals and vermin (Adams 2004). This kind of protection continues, and areas of land have been set aside to protect a number of vertebrate species; yet these same protected species continue to cause damage and losses to farmers settled within their proximity. The International Union for the Conservation of Nature (IUCN) has established six Protected Area (PA) categories with the express aim of protecting the diversity of ecosystems and wildlife (IUCN 2011). However, to the local farmers, the wild vertebrates in these areas constitute a pest problem not only through the direct physical damage they cause to property and crops, but also the threat to human life through direct attacks and the inter-species transfer of zoonoses (e.g. see Tumusiime and Svarstad 2011; Mackenzie and Ahabyona, Forthcoming).

Studies in India (e.g. Panwar 1990; Sukumar 1990) have shown wild vertebrate attacks to cause far greater crop losses than invertebrate attacks or pathological outbreaks. Similarly, studies from Sub-Saharan Africa (e.g. Hill 1998, 2004; Tweheyo et al. 2005) have shown that farmers – who are usually poor – suffer particularly high economic losses and food insecurity in areas with high populations of large mammals such as elephants, buffaloes, hippos and chimpanzees. The extent of economic loss due to vertebrate pest damage tends to vary with the proximity of the farm to the PA (Tweheyo et al. 2005). The extent of damage varies between locations. For example, Mackenzie and Ahabyona (Forthcoming) estimate an average financial loss of US$ 74 for farmers around Uganda's Kibale National park. Reports of farmers losing whole crop fields are also common (Tweheyo et al. 2005).

International debates on pest management and control (e.g. see Dent 2000; Rao et al. 2000) have mainly focused on insect pest problems experienced by farmers. Efforts to control vertebrate pest attacks, particularly by large wild mammals, are limited. Around Lake Mburo National Park (LMNP) where this study was conducted, large wild animals roam into

*Corresponding author. Email: mwesit@umb.no; tumusid@yahoo.com

ISSN 0967-0874 print/ISSN 1366-5863 online

http://dx.doi.org/10.1080/09670874.2011.641605
http://www.tandfonline.com

both crop and livestock farms. The damage to crops and animals is so severe that some farmers have been forced to migrate (Kagoro-Rugunda 2004). Currently, the responsibility for controlling vertebrate pests is left to the local farmers. The country has vermin control units within the local government, but these are non-functional; it is claimed that local governments make no budgetary allocations for their activities. But also, most of the crop raiding vertebrates from PAs are not vermin and are protected by wildlife legislation.

In an effort to minimise the impact of vertebrate pests, farmers have developed a number of control methods. However, their perceived effectiveness is unknown to the scientific community and is undocumented. The aim of this study was therefore to identify and document local methods used in vertebrate pest control and to gauge their perceived effectiveness. This information is relevant to local, national and international, agencies that may build on it to develop appropriate measures to control vertebrate pests while conserving the pest species.

2. Study area

Lake Mburo National Park is located in the drier southwestern part of Uganda known as the cattle corridor, which stretches from northern Tanzania through Uganda to Ethiopia between longitudes 30°20′E, 31°20′E and latitudes 1°30′S, 0°30′N. The park covers an area of approximately 26,000 hectares (Muhweezi 1994). Seventy-two species of mammals have been recorded (Kagoro-Rugunda 2004). These include Uganda's only population of impala (*Aepyt-ceros melampus*) and one of the only two populations of zebra (*Equus burchelli burchelli*). The park has 312 recorded bird species including 19 Afrotropical migrants and 30 Palearctic migrants (Muhweezi 1994). Around the park boundary there are several crop and livestock farms with which the park animals frequently interact.

3. Methods

3.1. Selection of interviewed farmers

The study was carried out between June 2008 and February 2009 in the two parishes of Rwabarata and Akayanja on the northern border of LMNP. The parishes were selected based on their proximity to the park and their ability to represent the dominant farming systems in the area. Rwabarata was selected because it is dominated by crop-farming, while Akayanja is dominated by livestock systems. Within the two parishes, four villages (Rwamuhuka and Kiriibwa in Rwabarata; and Bumaranjara and Rwakobo in Akayanja), constituting 28% of the total villages, were randomly selected. From these four villages, 40 semi-structured interviews were conducted at randomly selected households with the household heads as our interviewees. In the few instances where the head was absent, we selected the most senior and knowledgeable adult of those present. We carried out the interviews in *Runyankore*, the common local language. Before conducting each individual interview, it was made clear that the purpose of the study was purely scientific and academic. It was emphasised that the study had no legal implications whatsoever, and the respondents were also assured of confidentiality and anonymity.

3.2. Data collection

3.2.1. Use of questionnaire for farmer interviews

Pre-testing of the questionnaire was undertaken in one village that was not part of the selected sample. Pre-testing allowed the interviewers to gain familiarity with the questionnaire and provided an opportunity to apply and review the method. The focus was on assessing how respondents understood our questions and identifying any problems encountered in providing answers. Changes were proposed, reviewed, and incorporated into our final questionnaire.

In total, 40 randomly selected respondents were interviewed to ascertain the types of crop grown and livestock kept by the farmers, the seasons of the year when the raids occur, the species of the wild vertebrate pests involved in the raids, the nature, extent and frequency of damage caused to crops and livestock, and the protection measures adopted against the pests.

Respondents rated the severity of damage on a scale of 1 to 3 which denoted: (1) very severe damage; (2) moderate damage; and (3) little or no damage. Respondents ranked all wild vertebrates that caused losses on a scale of 1 to 5 to determine the degree to which farmers considered different animals to be the cause. This was completed for species that (i) cause crop damage, (ii) prey on livestock, (iii) spread diseases to livestock and people, (iv) compete with livestock for pastures, and (v) kill livestock. Within these categories, groups were established in accordance with farmer perception with regards to the extent of loss caused by the animals; classified as (i) greatest loss, (ii) moderate loss, and (iii) least loss.

We sought information on the reactions of wild animals to control methods. Farmers were asked to identify the control methods as: (i) easily resisted; (ii) slightly resisted; and (iii) not resisted. Farmers also categorised methods as either easily detected or not detected by target animals, and specified whether the methods were employed on an individual household or community level, before they were asked to estimate the costs involved. Finally, respondents were asked to rank all the local control methods according to perceived effectiveness and sustainability on a scale of 1 to 4: (1) ineffective; (2) least effective; (3) relatively effective; and (4) very effective.

3.2.2. Direct observations

Following the suggestions of Dearden et al. (1975) and Tweheyo et al. (2010), we used animal marks and signs to identify the type of vertebrate pest species feeding on a particular crop. Local farmers and local assistants were useful in helping to locate signs of pest damage both on crops and livestock. The information from direct observation was recorded and used to supplement information gathered from farmer interviews.

3.2.3. Key informant interviews and secondary data sources

Key informant interviews were held with the Uganda Wildlife Authority (UWA) staff, and officials from Kiruhuura Vermin Control Office and the District Production Office to ascertain: the nature and extent of damage and loss farmers suffer from vertebrate attacks; the measures and methods used to control vertebrate pests; the number and type of cases and conflicts reported; and mechanisms for compensating affected persons. These were supplemented with information from UWA reports. We also reviewed information on wildlife conflict from Makerere University libraries, the Nature Uganda library, and from Internet sources.

3.3. Data analysis

Questionnaire responses were edited, coded and analysed using SPSS version 18.0 for Windows to generate frequencies of vertebrate pest species, crops and livestock raided, feeding signs and extent of damage. Cross tabulations were made between pest feeding and farmer perception of damage caused. Perceived pest feeding and damage were tested by comparing different crops by way of rank index. Given the categorical nature of our data, Chi-squared tests were used to determine the relationships between the incidence of crop raiding and variables such as seasonality and proximity to the park.

4. Results

4.1. Profile of farmers, crops damaged, seasonality and severity of damage

Our respondent sample was male-dominated (70%). The majority of the sample (73%) were agro-pastoralists, 20% grew crops alone, while 7% were pure pastoralists. Unifying features of the group were the possession of some useable land directly bordering the park, and experience of encountering wild vertebrate pests from the park. Approximately 28% of the respondents had experienced only crop damage, 10% only livestock predation, while 62% had experienced both crop damage and livestock predation. Respondents reported that the distance travelled to raid sites varied between species. Some vertebrates were reported to raid crops as far as a kilometre into farmland, and livestock predators travelled even greater distances. While some of the vertebrates exhibited specific preferences, most attacked a variety of crops and livestock (Table 1).

Bushpigs (*Potamochoerus porcus*) were ranked as the most destructive (Figure 1).

The type of crop grown may influence its attraction to crop-raiders. Beans (*Phaseolus vulgaris*) were reported in 83% of all cases, and were raided mainly by bushbucks (*Tragelaphus imberbis*) and bushpigs. Other crops mentioned by the farmers included cassava (*Manihot esculenta*), bananas (*Musa acuminata*), maize (*Zea mays*), millet (*Eleusine coracana*), and sweet potatoes (*Ipomoea batatas*). Cattle were the most affected livestock and leopard was the most common livestock predator, followed by hyena (*Crocuta crocuta*) and African rock python (*Python sebae*). Raided crops and animals tended to be those most commonly grown or kept by farmers. There was no significant association between season and intensity of damage. Most vertebrate species (buffalo, zebra, monkey, baboon and bushpig) raided in large groups of more than ten. Only a few (leopard, hyena, hippopotamus, and bushbuck) were solitary raiders.

Table 1. Wild vertebrate pests that cause the most damage to crops and livestock as reported by farmers and recorded from our own observations around Lake Mburo National Park, Western Uganda.

English name	Scientific name	Local name	Major crops or livestock preyed on
Bushpig	*Potamochoerus porcus*	Empunu y'omwishwa	Cassava, sweet potatoes, maize
Baboon	*Papio anubis*	Enkobe	Maize, bananas, pumpkins
Vervet monkey	*Cercopithecus aethiops*	Enkyende	Maize, bananas
Waterbuck	*Kobus ellipsiprymnus*	Enshama	Sweet potatoes, millet, beans, cassava
Roan antelope	*Hippotragus equines*	Enkorongo	Millet and maize
Leopard	*Panthera pardus*	Engwe	Cattle, goats, sheep
Spotted hyena	*Crocuta crocuta*	Empitsi	Goats and sheep
Impala	*Aepytceros melampus*	Empala	Maize, millet
African buffalo	*Syncerus caffer*	Embogo	Bananas, millet, maize
Zebra	*Equus burchelli burchelli*	Enturegye	Bananas, millet, beans
Hippopotamus	*Hippopotamus amphibious*	Enjubu	Bananas, millet, maize
African rock python	*Python sebae*	Oruziramire	Cattle, goats, sheep
Bushbuck	*Tragelaphus imberbis*	Engabi	Beans, maize, cassava

Overall, the majority of interviewees (93%) explicitly stated the extent of damage from vertebrate pests to be very severe. Perception of severity of damage significantly increased with the size of the invading group ($P \leq 0.05$) and proximity to the park boundary ($P \leq 0.05$).

4.2. Local vertebrate pest control methods and pest response to the deterrent

Respondents employed a number of control measures against raiding vertebrate pests but the most commonly used methods were guarding, fencing, poisoning, trenching and chasing (Figure 2). At farm level, control methods were applied by men (41%), women (23%), children (21%), and in some cases, hired labour (15%).

The most frequently reported cost of pest control was loss of time (Figure 3). Other costs included the monetary cost of hiring labour or buying poison, the possibility of contracting disease from the animal, and the increasingly strained relationships with park management either due to the latter's disapproval of the methods used or the local farmers' complaints about the damage caused by the wildlife.

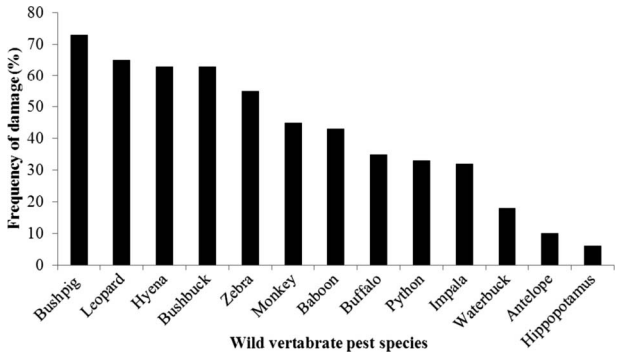

Figure 1. Percentage frequency of the most common vertebrate pests reported by farmers around Lake Mburo National Park, Uganda.

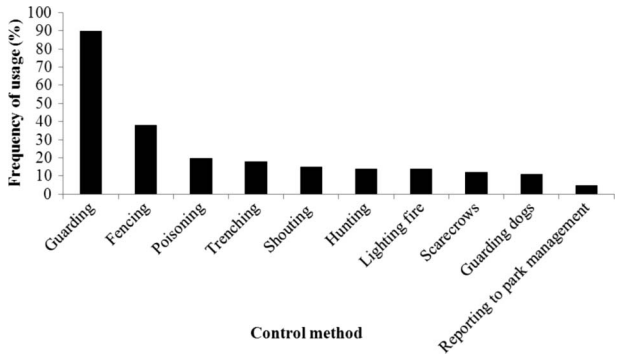

Figure 2. Common local wildlife control methods reported by farmers around Lake Mburo National Park, Uganda.

Farmers indicated varying views regarding the degree of effectiveness of pest control methods. Rank scores ranged from very effective to ineffective (Table 3). Farmers perceived effective methods to be those which (i) provided sufficient deterrence to the pest with relatively less effort in application in terms of time and cost, and (ii) either deterred all of the pest species or killed the target animals. Most farmers (85%) viewed their methods to offer only partial control of the target animals but the remainder (15%) reported complete control. The respondents in all these categories acknowledged that different methods had different effects on the animals; ranging from live capture, through non-lethal injury, to death (of targeted and non-targeted animals).

All farmers perceived physical guarding to be the most effective method especially against bushpigs, baboons, vervet monkeys and bushbuck (Table 2). Poisoning with acaricides was also reported as very effective since it resulted in death of the animal.

4.3. Pest resurgence and resistance after the application of control methods

Most farmers (52%) reported pest resurgence to vary between vertebrate pest species, ranging from less than a day to approximately fourteen days before the animal returned to raid. The time lapse depended on the behavioural and physical effects of the deterrent on the animal. It reportedly took at least 14 days before a vertebrate species returned for raiding whenever individuals of the same species had been subjected to some bodily injury. Injuries were more common in buffalo, bushbuck, leopard and waterbuck. Animals that were treated gently or chased away returned for raiding in less than an hour. This was common with bushpig, monkey, baboon, zebra, bushbuck and impala. Large-sized vertebrates and livestock predators took longer to return. More than 80% of farmers indicated that animals developed resistance to the deterrent methods. Animals were reported to easily

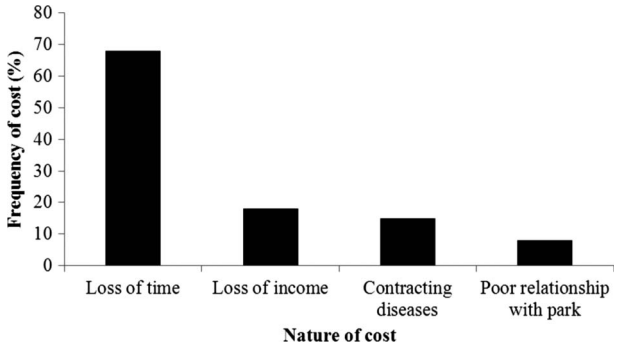

Figure 3. Costs incurred by farmers in controlling wild vertebrate pests around Lake Mburo National Park, Uganda.

Table 2. Frequencies of farmers using a particular method for a vertebrate pest.

Local control method	Animal species controlled (responses in numbers)[a]												
	BP	BA	MO	BB	ZE	WB	AN	BU	HI	LE	HY	PY	IM
Guarding	29	25	25	26	22	22	22	24	22	23	23	24	22
Shouting and chasing	1	1	1	1	–	–	–	–	–	–	–	–	–
Scare crows	1	1	–	–	–	–	–	–	–	–	–	–	–
Poisoning	3	3	2	1	–	–	–	–	–	4	4	–	–
Hunting and Killing	3	–	–	–	1	–	–	–	–	–	–	–	1
Fencing	3	3	3	8	12	3	3	9	4	3	3	–	4
Trenches	5	–	–	–	–	–	–	–	–	–	–	–	–
Fires	1	1	1	1	3	1	2	3	3	3	3	–	1
Spot hunting	–	–	–	–	1	–	–	–	1	–	–	–	–
Reporting to the park authorities	1	1	1	1	1	1	1	3	1	1	1	1	1
Shelters	–	1	1	–	–	–	–	–	–	2	1	1	–
Guarding dogs	3	–	–	1	–	–	–	–	–	–	–	–	–

[a]Key: BP = bushpig, BA = baboon, MO = monkeys, BB = bushbuck, ZE = zebra, WB = waterbuck, AN = antelopes, BU = buffalo, HI = hippopotamus, LE = leopard, HY = hyena, PY = python, IM = impala. "-" Signifies methods are not applicable.

Table 3. Perceived effectiveness of different local wildlife control methods as ranked by farmers around Lake Mburo National Park, Uganda.

Local pest control method	Perceived level of effectiveness	% of farmers	Rank score
Human guarding	Very effective	17	68
	Relatively effective	5	15
	Least effective	1	2
	Ineffective	1	1
Poisoning	Very effective	4	16
	Relatively effective	6	18
	Least effective	3	6
Hunting and killing	Very effective	3	12
	Relatively effective	5	15
Fencing	Very effective	6	24
	Relatively effective	7	21
	Least effective	3	6
	Ineffective	1	1
Spot hunting	Very effective	1	4
Buffer management	Very effective	9	36
	Relatively effective	2	6
Trenches	Relatively effective	3	9
	Least effective	3	6
Fires	Relatively effective	2	6
Traps	Relatively effective	2	6
	Least effective	2	4
Shouting and chasing	Ineffective	1	1
Scarecrows	Ineffective	1	1

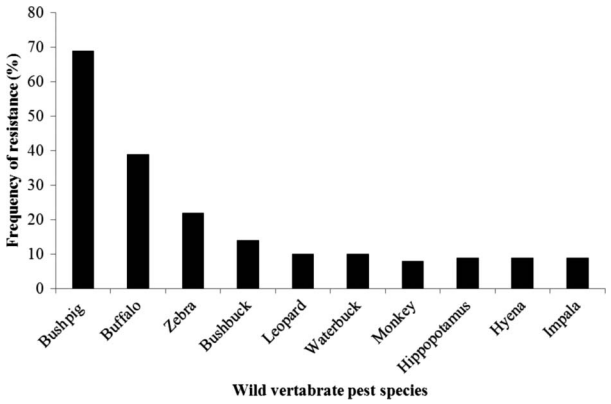

Figure 4. Wild animals that show resistance against control methods as reported by farmers around Lake Mburo National Park, Uganda.

adapt to methods that spared them of bodily harm. Bushpigs were reported to show the greatest resistance against control measures (Figure 4).

Farmers perceived the vertebrate pest's resistance to the deterrent as being: the ability of the animal to detect the presence of a deterrent and continue the raid; or the animal becoming familiar with the deterrent and becoming habituated to it, for instance in the use of hot pepper spray against baboons. Baboons were reported to find sprayed pepper to be painful but not fatal and so braved the sprayed area to raid crops. There was no significant relationship between the types of control method applied by farmers and animal resistance to the deterrent; the timing of implementing the control methods and the animal developing resistance, nor between the frequency of vertebrate pest occurrences on the farm and the ease with which pests resisted the deterrents. However, there was a significant ($P \leq 0.05$) relationship between the size of the group of invading animals and the ease with which the animals adapted to the deterrent.

4.4. *Cost of crop raiding and control methods*

Over 70% of farmers reported an incident in which they lost an entire field, especially when the pest attack occurred at harvesting stage, necessitating the application of control methods. However, all farmers perceived the application of local control methods to be tedious and time-consuming. This was noted in regard to the practice of guarding in particular, which usually involved all-night and all-day vigils; especially towards harvest time. These vigils were reported to constrain adults from using labour on alternative means of livelihood, and to reduce children's school attendance. Another significant problem with local control

methods was the likelihood of acquiring zoonoses from the pest. Around 39% of farmers mentioned fear of diseases such as anthrax, rabies, and Marburg virus, which can result from the hunting of vertebrate pests. These fears were heightened when the claimed incidents were discussed on a local FM radio station. In another example, there were reports of a Marbug virus outbreak in 2010 that killed more than 20 people around nearby Kibale National Park. The incident was linked to farmers eating meat from monkeys that were reported to have fed on fruit contaminated with bat saliva. The fear of infection among farmers is further hastened by reports of deaths in 2004, 2008 and 2010 due to anthrax after the consumption of elephant and hippo meat in the nearby Queen Elizabeth National Park. Also, in the process of guarding and hunting crop-raiding animals, farmers face risks such as contracting rabies from foxes. Three farmers had contracted the disease from fox bites while guarding against crop-raiding.

Furthermore, farmers considered the application of pest control methods to be expensive, reporting costs ranging between US$ 10 and 50 per season, depending on the method employed. The high financial costs were reported by both crop and livestock farmers across all crop and livestock species.

Overall, the local people asserted that the act of crop-raiding leads directly to food and thus livelihood insecurity, and that each of the above-mentioned costs implies a less secure livelihood.

5. Discussion

5.1. Vertebrate pests and farms invasions

Our results from LMNP are in accordance with those obtained in other studies. For example, Newmark et al. (1994) reported that 86% of farmers around six protected areas in Tanzania faced a problem of vertebrate pests. Similar reports have been made by Naughton-Treves (1997), Hill (2004), and Mackenzie and Ahabyona (unpublished) in other parts of Uganda. Examples from outside Uganda include Sillero-Zubiri and Switzer (2001) in Cameroon and Studsrød and Wegge (1995) in Nepal. Crop-raiding thus constitutes a severe problem for farmers and is often a key element of local narratives about PAs (Tumusiime and Svarstad 2011). The problem of vertebrate pests thus needs to be considered as part of an integrated pest management strategy given that international debates on pest management and control (e.g. see Dent 2000; Rao et al. 2000) have focused mainly on entomological problems and overlooked the problem of vertebrate pests.

5.2. Seasonality of the pest problem and implementation of control methods

Contrary to findings from other areas (e.g. Tweheyo et al. 2005), the vertebrate pest incidences in our study showed no seasonal patterns, that is, season-specific vertebrate pests that feed on specific crop parts or crops at a certain stage of development (e.g. Newmark et al. 1994; Hill 1998). This finding was possibly due to the presence of large herds of livestock in farms adjacent to the park and the presence of perennial crops such as cassava and bananas, which meant prey or food was available throughout the year (as opposed to the situation in a crop farming system where food availability tends to be seasonal). Thus farmers are potentially at risk of having to combat crop-raiding all year round.

Our results show that although household members are expected to help guard their farms against vertebrate pests, only men would dare to deal with large vertebrates. However, as has been observed in other areas (Hill 2004), women and children have helped in the case of primates because they are less dangerous. The crop farms of relatively wealthy households that could afford to hire expert guards were always offered better protection, with guards being used most frequently against livestock predators that often attack at night. The poor and female-headed households are thus more vulnerable to crop damage, because of their lack of labour and limited funds to hire expert guards.

We found that although the use of scarecrows, shouting, fires, guard dogs and chasing techniques were effective in repelling raiding animals in the short term, the vertebrate pests returned for raiding, tempting farmers to prefer techniques that inflicted bodily harm or killed the pest. Chemical poisoning using acaricides and dimethoides was particularly appealing because farmers had knowledge of these chemicals in controlling invertebrate pests in both agricultural crops and livestock.

5.3. Pest detection and resistance to the control methods

Reports by farmers of vertebrate pests being able to detect control methods are supported by literature that documents the behavioural responses of wildlife. Examples include elephants withdrawing from areas where conspecifics have been killed (Whyte 1993), and the ability of lions to avoid dangerous areas (Frank et al. 2005). From a conservation point of view, the ability of pests to avoid areas where control methods exist may result in congestion in relatively peaceful areas, which together with the negative effects of congestion implies that the developing situation may not be sustainable in the long term. Also, the ability to detect and resist control methods varies between species. In our study, pigs and primates were reported to be most able to detect and resist control methods. Those less able to detect or resist control methods may be in danger, especially when lethal methods such as poisoning are used. Scientific literature is replete with

cases of the extinction of species due to local control methods (e.g. see Woodroffe et al. 2005). It is thus important that active management of the problem is sought. The ability of wildlife to detect and resist control methods may frustrate farmers, but may not sufficiently ensure survival of the target species. Appropriate methods will vary between cases but it seems essential that the burden of controlling wildlife damage should not reside with the local farmers alone.

6. Conclusion

Vertebrate pests constitute a severe problem for the farmers adjacent to LMNP. The preference of farmers for more effective techniques, such as poisoning, is understandable since methods that cause no bodily harm to pests are less effective. However, such techniques may pose a conservation concern especially when practised adjacent to a protected area as in the case of LMNP. Lions and elephants are already locally extinct in our study area and this is partly due to farmers' pest control methods (Emerton 1999; Kamugisha et al. 1997). In particular, lions were poisoned by cattle keepers and elephants died in trenches dug around the farms. Trenches have been used in other areas of Uganda and other countries to control crop raiding; this is a method that frequently injures or kills its victims (e.g. see Fernando et al. 2008). It is thus imperative that the burden of vertebrate pest control is not left to poor farmers who, quite understandably, have to safeguard their own livelihoods first.

Acknowledgements

We would like to thank the local communities around LMNP, and the staff of Uganda Wildlife Authority and the Local Governments of Kiruhuura and Isingiro Districts for their cooperation during data collection. We also acknowledge the valuable comments from this journal's editor and anonymous reviewers.

References

Adams WM. 2004. Against extinction: The story of conservation. London: Earthscan.

Dearden BL, Pegau RE, Hansen RM. 1975. Precision of microhistological estimates of ruminant food habits. J Wildl Manage. 39(2):402–407.

Dent D. 2000. Insect pest management. Wallingford (UK): CABI international.

Emerton L. 1999. Balancing the opportunity costs of wildlife conservation for communities around Lake Mburo National Park, Uganda. London: International Institute for Environment and Development (IIED).

Fernando P, Kumar MA, Williams AC, Wikramanayake E, Aziz T, Singh SM. 2008. Review of human–elephant conflict mitigation measures practiced in South Asia. AREAS technical support document submitted to World Bank. WWF – World Wide Fund for Nature.

Frank L, Woodroffe R, Ogada MO. 2005. People and predators in Laikipia district, Kenya. In: Woodroffe R, Thirgood S, Rabinowitz A, editors. People and wildlife: conflict or co-existence, Cambridge: Cambridge University Press. p. 286–304.

Hill CM. 1998. Conflicting attitudes towards elephants around the Budongo Forest Reserve, Uganda. Environ Conserv. 25(3):244–250.

Hill CM. 2004. Farmers' perspectives of conflict at the wildlife–agriculture boundary: Some lessons learned from African subsistence farmers. Hum Dimens Wildl 9(4): 279–286.

IUCN [Internet]. 2011. IUCN Protected Area management categories [cited 5 Nov 2011]. Available from: http://www.iucn.org/about/work/programmes/pa/pa_products/wcpa_categories/.

Kagoro-Rugunda G. 2004. Crop raiding around Lake Mburo National Park, Uganda. Afr J Ecol. 42(1):32–41.

Kamugisha JR, Ogutu Z, Ståhl M. 1997. Parks and people: Conservation and livelihood at crossroads. Four case studies from Kenya and Uganda. Technical Report No. 17. Nairobi: Regional Soil Conservation Unit.

Mackenzie CA, Ahabyona, P. Forthcoming 2012. Elephants in the garden: Financial and social costs of crop raiding. Ecol Econ.

Muhweezi A. 1994. The Lake Mburo National Park Management Plan: 1994–1998. Kampala: Uganda National Parks. Located at: The library of the Uganda Wildlife Authority (UWA).

Naughton-Treves L. 1997. Farming the Forest Edge: Vulnerable places and people around Kibaale National Park, Uganda. Geogr Rev. 87(1):27–46.

Newmark WD, Manyanza DN, Gamassa DGM, Sariko HI. 1994. The conflict between wildlife and local people living adjacent to protected areas in Tanzania: Human density as a predictor. Conserv. Biol. 8(1):249–255.

Panwar H. 1990. Status of management of protected areas in India: problems and prospects. Paper presented at the regional expert consultation on management of Protected Areas in the Asia-Pacific region, FAO regional office for Asia and the Pacific, Bangkok.

Rao M, Singh M, Day R. 2000. Insect pest problems in tropical agroforestry systems: contributory factors and strategies for management. Agrofor Syst. 50(3):243–277.

Sillero-Zubiri C, Switzer D [Internet]. 2001. Crop raiding primates: searching for alternative humane ways to resolve conflict with farmers in Africa [cited 5 Nov 2011]. Available at: http://www.peopleandwildlife.org.uk/crmanuals/CropRaidingPrimatesP&WManual.pdf

Studsrød JE, Wegge P. 1995. Park–people relationships: the case of damage caused by park animals around the Royal Bardia National Park, Nepal. Environ Conserv. 22(2): 133–142.

Sukumar R. 1990. Ecology of the Asian elephant in southern India: Feeding habits and crop raiding patterns. J Trop Ecol. 6(1):33–53.

Tumusiime DM, Svarstad H. 2011. A local counter-narrative on the conservation of mountain gorillas. Forum Dev Stud. 38(3):1–27.

Tweheyo M, Hill CM, Obua J. 2005. Patterns of crop raiding by primates around the Budongo Forest Reserve, Uganda. Wildl Biol. 11(3):237–247.

Tweheyo M, Amanya BK, Turyahabwe N. 2010. Feeding patterns of sitatunga (*Tragelaphus speki*) in the Rushebeya Kanyabaha wetland, south western Uganda. Afr J Ecol. 48(4):1045–1052.

Whyte I. 1993. The movement patterns of elephant in the Kruger National Park in response to culling and environmental stimuli. Pachyderm. 16:72–80.

Woodroffe R, Thirgood S, Rabinowitz A. 2005. The impact of human–wildlife conflict on natural systems. In: Woodroffe R., Thirgood S, Rabinowitz A, editors. People and wildlife: conflict or co-existence? Cambridge: Cambridge University Press. p. 1–12.