



**Crop raiding primates:
Searching for alternative, humane ways
to resolve conflict with farmers in Africa**

Claudio Sillero-Zubiri & David Switzer



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About the Authors

Claudio Sillero-Zubiri (DPhil) is the Bill Travers Fellow for Wildlife Conservation at Lady Margaret Hall, Oxford University. He works for the Wildlife Conservation Research Unit, assisting with various conservation programmes worldwide, and leads the People & Wildlife initiative. Claudio coordinated the Ethiopian Wolf Conservation Programme for 12 years, for which he received the 1998 Whitley Award for Animal Conservation from the Royal Geographical Society.

David Switzer (MSc) is a conservation biologist currently based at English Nature. He has several years experience in West and East Africa including conducting biodiversity surveys in the Eastern Arc Mountains of Tanzania, working on the Ethiopian Wolf Conservation Programme, and conducting a number of primate surveys in the forests of Ghana.

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Summary

One of the main challenges facing wildlife conservation in the twenty-first century concerns the increasing interaction between people and wildlife and the resulting conflicts that emerge. In particular, encroachment of wild habitats by subsistence farmers in Africa is increasingly leading to conflict. This quandary is epitomised by baboons, elephants and other herbivores raiding valuable crops, which can cause serious hardship to the already impoverished farmers. Conflict is set to increase as Africa's human population keeps growing at a high rate and encroachment of agriculture into land occupied by wildlife continues.

In their quest to protect their crops against wildlife raiding, farmers utilise strategies that are often cruel and ineffective. Some governments have even resorted to the wholesale capture and trade of primates as a putative control measure. While arbitrary killing or trapping of suspect crop-raiders may provide a short-term solution to the perceived problem, it fails to address the long-term needs of either farmers or wildlife. For example captured animals are frequently taken at random and their removal often has little effect on the level of crop damage. There is a real need for research into the problem of crop raiding leading to the development of alternative humane solutions to the problem.

Conflict resolution is a growing field in conservation biology that seeks to tackle these confrontations between wildlife and human interests with multi-disciplinary approach. Lasting solutions are possible, but require a good understanding of the issues and the participation of all stakeholders in the decision-making process.

Here we review issues of crop raiding and, more specifically, the magnitude of the damage by primates as a perceived problem in parts of Tanzania. The first section briefly re-views the range of wild species and farming practices involved in crop raiding conflicts, and the approaches farmers currently use to prevent the damage. Then a more in-depth look is taken at how Tanzania is affected by crop raiding and why primates pose such a problem to farmers' livelihoods.

On the second section we propose a critical look to investigate alternative management approaches, seeking for longer-term, humane solutions to crop raiding. We draw on recommendations for a study into the issues of crop raiding derived from our review on existing knowledge on past and present use of crop-raiding prevention methods and problem animal control in East Africa. The lessons and solutions identified could be applied worldwide and be transferred to other animal groups.

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Introduction

The conservation of wildlife and their threatened habitats faces many challenges and involves a wide variety of issues, and thus require a fresh look at the ways that these challenges can be met. One of the great dilemmas of our era is the increasing conflict between wildlife and people. As the human population keeps expanding there is an increasing demand for land for agriculture and natural resources for industry, leading to increased opportunities for wildlife and people to come into contact and ensuing conflict. It has become apparent that we can no longer deal separately with the problems facing wildlife and the problems facing people. Rather, we must seek to understand the sociological, economic and cultural aspects of people's involvement with wildlife, paying special attention to the needs of the stakeholders (e.g. wildlife populations under threat, human communities enduring threats / damage from wildlife, agencies responsible to alleviate problem), and apply them to find practical actions to resolve conflicts. There are many different situations where wildlife and people come into conflict. The reasons for these conflicts can be varied and most are not easily solved by a quick fix but require long-lasting solutions.

Wildlife-people conflicts occur worldwide, and are not, as some might first think, confined to the developing world. At first glance it may appear that the nature of these conflicts is as diverse as the numerous variables that contribute to them. But by looking more closely it can be seen that there are several underlying trends that are most often responsible for these conflicts. As the world's human population continues to mushroom there is an ever-spiralling demand for space and resources. Suburbia sprawls, industry escalates, and agriculture keeps expanding, and as a result wildlife is rapidly being squeezed into smaller and more fragmented spaces. Often this expansion is not uniform over all areas but rather occurs in particular areas where the resources that humans cherish most, such as water and fertile soil, are found.

Unfortunately these are often the very same resources that wildlife also value highly, and it is the competition between humans and wildlife for these assets that often leads to conflict. To further compound this situation, the landscape is being fragmented by human expansion. As

the land available to wildlife diminishes and the corridors between pockets of wildlife habitat disappear, a patchwork of habitat fragments is left behind, and the likelihood of humans and wildlife coming into conflict is much higher. This is largely due to what is known as the "edge effect", where a decrease in the area of a fragment of wild habitat causes a disproportionate increase in its boundary, resulting in a larger fringe around the fragment. Obviously if this fragment of land is inhabited by wildlife then there will be a greater interface between that wildlife and surrounding human activities and a strong possibility that conflict will develop.

Although, as stated earlier, the conflicts between humans and wildlife are great in both diversity and number, they can be grouped into a number of categories. The following list sets out some of these conflicts and is illustrated by some examples from around the world.

- *Access to water*

This is a major issue, especially in the more arid regions of the world. Regular access to water is crucial for many wild animals but they may come into conflict with farmers who also need water for their livestock or for irrigating their fields. In Northern Kenya for instance there has been a decrease in the amount of water available to wildlife and livestock due to several irrigation schemes. In response, pastoralists have fenced off some of the water holes traditionally used by their livestock and wildlife, leading to a decline in the populations of some wildlife, notably the endangered Grevy's Zebra (*Equus grevyi*).

- *Livestock predation*

Livestock are often preyed upon by wild carnivores, which often lead to the persecution of the perceived killers. This is often the case where large predators inhabit the same area or live close to areas used by livestock (e.g. the large cats of Africa, wolves *Canis lupus* in Asia, Eastern Europe and North America, and tigers *Panthera tigris* in Asia.)

Although large predators have made a come back in some areas, remarkably in the northern hemisphere, it is largely the changes in animal husbandry over recent decades that are to blame for an increase in predation, as they have rendered livestock more vulnerable to

predation. For instance, the reduction of large carnivores through active destruction resulted in flocks and herds increasingly left to pasture unmanned. In many countries in central Europe shepherds has lost the tradition of using guarding dogs to ward off predators from their livestock. Now conservationists plead for the re-adoption of this technique to reduce losses to large predators reclaiming their habitat.

- *Wildlife and disease*

Wildlife may be viewed as a source of diseases that may affect livestock and people. In the UK badgers (*Meles meles*) are carriers of TB and may be able to pass it onto cattle. Therefore many farmers support the culling of badgers to reduce this threat. Foxes across Europe are seen as a threat to people due to rabies. In Africa there is suspicion that primates may be responsible for transferring diseases such as Ebola to humans.

- *Wildlife-livestock separation*

In an effort to reduce disease transmission and competition for fodder, the separation of wildlife from livestock is enforced in some areas by fencing. This practice however can be detrimental to wildlife species that migrate over large distances between feeding areas or water sources, such as the large herbivores of the Africa's plains. In Botswana for example, fences were constructed to prevent the spread of foot and mouth disease to cattle. Unfortunately this resulted in the deaths of many thousand wildebeest (*Connochaetes taurinus*) and other wildlife, prevented from following their traditional migration routes.

- *Dangerous animals*

Animals that are directly dangerous to humans may come into contact with people. For ex-

ample sharks attacking surfers in Australia, crocodiles, "man-eating" large cats, hippos (*Hippopotamus amphibius*) overturning boats on rivers, polar bears (*Ursus maritimus*) encroaching human settlements.

- *Competition between wildlife and fisheries*

Sea mammals feeding on fish farms can result in large financial losses to this industry. This is most acutely seen in Scotland and Scandinavia where common (*Phoca vitulina*) and grey seals (*Halichoerus grypus*) are a real menace to the salmon farming industry, based in the sea lochs and fjords of the North Sea. In general, many fishermen view seals and whales as direct competitors for wild fish stocks. In the past this conflict has lead to culling of these animals in an attempt to preserve populations of certain fish (e.g. wild salmon in the coast of Scotland).

- *Crop raiding*

Crop-raiding animals may cause substantial damage to agricultural crops, and this has always been a major issue of contention throughout the world. Due to the expansion of cultivated land into previous wildlife habitat, crop raiding is becoming one of the most common conflicts antagonising human-wildlife relationships. There are examples of crop raiding involving many species from many areas of the world: e.g. white-tailed deer (*Odocoileus virginianus*) in the USA, African bush (*Loxodonta africana*) and Asian (*Elephas maximus*) elephants, wildboar (*Sus scrofa*) in eastern Europe, and bird species throughout the world.

The rest of this review will examine the specific problems associated to crop raiding, the reasons why crop raiding occurs and why it is on the increase.

Section I. A review of the issues

Crop raiding - The problem

Crop raiding can be simply defined as wild animals moving from their natural habitat onto agricultural land to feed on the produce that humans grow for their own consumption. When people think of damage to crops they probably think chiefly of the damage caused by insects. Some of the more dramatic cases tend to receive wide coverage in the media, such as the swarms of locusts that devastate large swaths of crops in many parts of the world.

However, crop raiding by vertebrates such as birds and mammals is also a major issue, and the scope of this review is limited to the latter.

Crop raiding is not a new phenomenon; it has most likely been occurring since humans first settled down and started practising agriculture. Many different crops are targeted by animals, from cereals, to fruit to vegetables to trees. Today some areas of the world are so intensively

cultivated that crop raiding is not an issue, because there is so little or no natural habitat left that potential crop raiding wildlife occurs in very low numbers, or is absent altogether. Farming to a commercial scale has also mitigated the impact of crop raiding because many farmers are now able to absorb any losses without undue hardship.

In other areas, however, crop raiding is still a frequent event and the cause of a major conflict between wildlife and people. This is especially true of areas adjacent or close to protected areas, like national parks, which can harbour large populations of wildlife. Yet even there, farmers and communities were historically able to cope with crop losses and had some success in reducing it. Therefore, one has to ask the questions: *why has crop raiding become so troublesome in recent times?* and *why is it on increase?*

Perceived or real problem?

Today more and more reports of crop raiding appear in the media, especially in the developing world, where animals has the potential to cause acute hardship. In part this might be caused by a greater access to the media than ever before, which also ensures a greater coverage of local community issues such as crop raiding. It may also be a side effect of a global trend moving away from 'fortress conservation' towards community-based conservation. The latter takes a more active interest in local communities, the difficulties they face and their relationship to natural resources as well as the wildlife conservation concerns. These explanations however can only be partially true. Increasingly real evidence shows that crop raiding is itself on the increase and we therefore need to ask *what are the reasons for this growth?*

Reasons for the perceived rise in crop raiding

There are several reasons why crop raiding may be on the increase globally, namely:

Changes in agricultural methods and techniques

In recent decades there has been a large move towards the intensification of agriculture, and the resulting large monocultures can be very attractive to animals. These extensive areas of cultivation are high quality patches that

herbivores cannot miss nor resist. Some animals are naturally pre-adapted to take advantage of these opportunities, for instance cereal crops are a target for birds that are primarily seed-eaters, and root vegetables are a prime target for species of pigs that are specialist tuber-diggers. Omnivorous species like the baboon will take a whole range and diversity of foods, including many crop species, and often utilise several different parts of these plants, rendering them vulnerable throughout their lifecycles. In addition, monocultures are often unsuitable habitats for predators that would otherwise help reduce the populations of crop raiding species, thereby exacerbating the problem even further.

Increase in wildlife populations

Although there is a general concern over declining wildlife populations, particularly in tropical ecosystems, some species may actually be increasing in numbers. For example, increasing reports of crop raiding by elephants in Africa may reflect the recovery of population numbers since the CITIES' ban on ivory trade and the subsequent decline in poaching. Countries where an improved economy may have led people to cities or young people into classrooms may have also facilitated the recovery of populations of wildlife.

Increase in human populations

More people means more cultivated land, and hence a greater interface between people and wildlife. The world population is predicted to grow by over 50% in the next fifty years, from six billion in 2000 to over nine billion in 2050. Most of this increase is expected to take place in the least developed countries of Africa, Asia and Latin America.

Increase in agriculture and encroachment

The rise in demand for land for cultivation means that in many areas much of the suitable arable land is already cultivated. More marginal land is therefore filled and farming goes right up to the boundary of wilderness and protected areas. Pest species are likely to flourish along the edges of natural habitat and agricultural lands, where they can eat both the food available in undisturbed habitats and the crops growing in the adjoining farmland.

Increase fragmentation and concurrent wildlife/people contact

As wilderness gets converted to agricultural use, protected areas such as national parks, reserves, and hunting blocks, rapidly become "is-

lands" in a sea of farmland. Wildlife populations are thus effectively cut-off from populations in other patches of natural habitat. These fragments inhabited by wildlife differ from the original, undisturbed ranges in two important ways. Firstly, they have a greater amount of edge for the area of fragment, and secondly, the centre of each fragment is closer to an edge. As a consequence, the probability of wildlife-human contacts increases, as it does the likelihood of conflicts such as crop raiding, because potential crop raiders have to travel shorter distances to access crops.

Urbanisation and improved education

The continuing industrialization is having a major influence in shaping the structure of human societies. The wealth generated in urban areas acts as a lure to people from surrounding rural landscapes; it is often the young members of farming communities that first leave in an attempt to achieve a better lifestyle. This leads to a deficit of labour in the community, such thus farmers lack the necessary manpower for vigilance and deterrence of crop-raiders. Together with urbanisation, the availability and quality of education has improved in many developing countries. Children who would have previously been assigned to guard their parents' fields against crop raiders are instead attending school; furthermore, after completing their studies many will not return to their homes but rather will seek employment in neighbouring towns and cities.

Farming practices, farming economics and correlates to crop raiding

Of the above-mentioned factors affecting crop raiding, the latter four are of outmost importance in the developing world at the present time. In many African countries for example agriculture forms the backbone of the economy. In Tanzania agriculture provides 57% of Gross Domestic Product (GDP), and most significantly employs over 90% of the workforce (The United Republic of Tanzania national website, 2001). Although some of this agriculture is concerned with the growing of cash crops such as coffee, tea, and sisal in large estates, the majority of it is subsistence farming.

In Tanzania smallholder farmers grow maize, sorghum, millet, pulses, and bananas in farms that are typically only 0.9-3.0 ha in size. Most often cultivation is by hand, sometimes by ox plough and only rarely by tractors. Average

incomes are extremely low and 50% of the population live below the poverty line. GNP per head in Tanzania is estimated at US\$246 but for many farmers the income fall short of this figure. It is therefore not surprising that in countries like Tanzania crop raiding is viewed as a very serious problem.

Even if the amount of crop damage appears insignificant compared to overall food production, it is not insignificant to those farmers who have to bear the financial burden of it. For example, a study around the Budongo Forest Reserve in Uganda found that the cost of crop raiding and guarding varied from US\$ 96-519 per household per year (Hill, 1997). This is a huge amount if we consider average local salaries in this area are only US\$25-30 per month. In agricultural areas around the Maasai Mara Game Reserve in Kenya, crop raiding costs households US\$ 200-400 per year. In certain cases the impacts of crop raiders can be devastating, as a farmer's whole crop may be destroyed in one night. In general, farmers have little assistance with the mitigation of crop raiding losses. Compensation is rarely available, and where it is present it often implies a lengthy procedure with the claim going through several layers of bureaucracy. Overall, crop raiding can serve to make already insecure livelihoods even more marginal in economic terms.

Human population trends and likelihood of increased crop raiding impact

To make matters even worse, it is highly probable that crop raiding will continue to increase in Africa in the foreseeable future as the human population continues to grow. Africa is predicted to add one billion people to the world population in the next 50 years (Fig. 1). In the year 2000 the population of Sub-Saharan Africa was estimated at 657 million. By 2025 this is expected to have grown to 1,053 million, and by 2050 to 1,556 million.

In Tanzania, annual growth rate is currently 2.3%, and the UNDP predict that in the next 50 years the population will grow from 32 million in 1998 to over 80 million in 2050 (Fig. 2). The rise in human populations will undoubtedly lead to the expansion of agriculture into areas currently unused.

Figure 1: Predicted Population Growth in Sub-Saharan Africa and the World

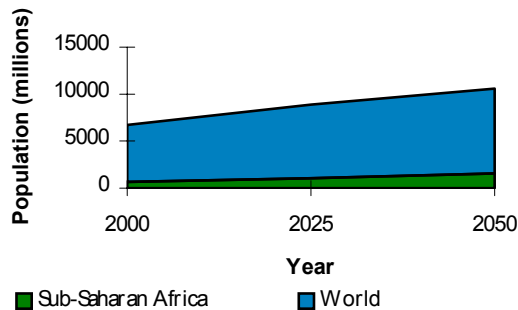
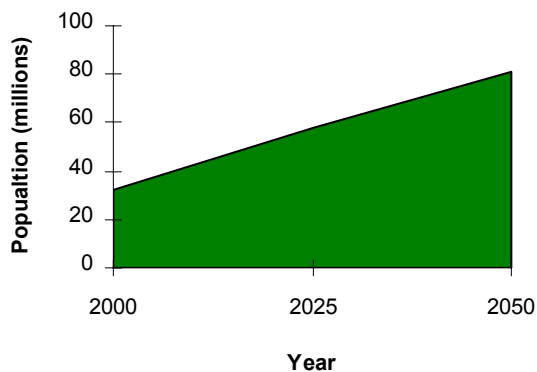


Figure 2: Predicted Population Growth of Tanzania



Tanzania covers approximately 945,000 km² of land, of which 51,000km² (5 million ha) are annually cultivated (roughly 5% of the total land area). Food accounts for 85% of the crops, consisting mainly of maize, sorghum, millet, wheat, pulses, cassava, potatoes, bananas, plantains, and a variety of vegetables and fruit. Ten million ha of arable land are not yet cultivated, and mostly used as pasture for livestock, and another 4 million is contained within national parks, game reserves and forest reserves, which together protect 22% of the land. Although forest and woodland still cover large areas of Tanzania, these have been decreasing at an alarming rate: from 46% 1990 to 40% in 1993, a decrease of 2% per year. In the preceding 35 years, the annual rate of decrease was only 0.3%.

Clearly in Tanzania, and many other developing countries, agriculture will expand rapidly into new areas, into and around protected areas, increasing the interface between wildlife habitats and agriculture. Crop raiding by wild animals is bound to be an ever-increasing problem.

The crop raiders

Crop damage has traditionally been viewed as largely the fault of a wide range of invertebrates, from caterpillars to locust, or to the countless species of birds that feed on crops. However many mammals are also pests that cause significant losses. Mammals from a variety of taxa are potential crop raiders; some are listed below with examples from around the world. The list is not an indicator of their overall importance, as the contribution each taxonomic group makes to the total damage differs dramatically within regions, and from country to country.

Elephants

African bush and Asian elephants are the most high profile crop raiders. Throughout their range in sub-Saharan Africa, the Indian sub-

continent and South-East Asia, elephants have a long tradition of crop raiding. Records in India have existed for thousands of years, but crop raiding has increased in recent years in spite of the sharp reduction in elephant populations over the last few decades. As their range shrunk with the increasing demand for land, elephant populations became isolated and traditional migration routes severed by human encroachment. This has caused conflict because elephants keep raiding agricultural areas that occupy much of their former range. Elephants are especially troublesome because they can inflict severe damage during a single night-raid and also because they are potentially lethal to farmers who try to prevent the incursions. Human/ elephant conflict has de-

veloped from being perceived as a mere nuisance to a major conservation concern.

Deer/Antelope

Many deer and antelope species become involved in crop raiding, and are listed as pest species throughout the world, both in temperate and tropical habitats. They can cause extensive damage to both food crops and also to tree plantations where they eat young buds and strip bark off trees. In a survey of the USA, white-tailed deer were consistently reported as the most frequent and most damaging crop-raiding animal, and in several states elk and moose were also reported as problematic species. In India, nilgai (*Boselaphus tragocamelus*) and blackbuck (*Antilope cervicapra*) are frequent crop raiders around protected areas, and in the UK some species of deer can also cause extensive damage to tree plantations.

Wild Pigs

By digging up roots and tubers several pig species cause serious crop damages. In Africa, bushpigs (*Potamochoerus larvatus*) are among the species most frequently cited by farmers as notorious crop raiders, capable of causing heavy crop damage; warthogs (*Phacochoerus africanus*) are also involved. In mainland Europe and Asia wild boars often visit and damage farms.

Rodents

Hundreds of species of rodents live in or near human dominated landscapes and, given the opportunity, many will feed on crops in the fields or in the storage areas where they are kept after harvesting. Problematic rodents vary from small mice and rats to larger rodents like the cane-rats (*Thryonomys* sp.), and porcupines (Hystercidae) in sub-Saharan Africa. Rodents can be the primary crop raiding species in landscapes so heavily cultivated that larger mammals no longer exist. In addition rodents are particularly difficult to control because their high intrinsic rates of growth makes population highly resilient to disturbance. Rodents are undoubtedly a major pest and over time can cause significant damage, but they are unlikely to cause the level of extensive damage to a particular farm that larger crop raiders can in-

flict in a single raiding event. Farmers also see crop damage by rodents as inevitably and realize that conservation agencies are not to blame for their damage.

Domestic livestock

Throughout the world livestock can and do cause extensive damage to crops. Cattle, sheep, horses, and especially goats, often wander into fields and cause considerable damage. For example in the areas surrounding several national parks in Tanzania, domestic livestock were reported as the second most frequent and damaging crop raider (Newmark et al. 1994). In such cases, however, the economic loss to a farmer is often mitigated. In many communities there are laws that force the owner of the livestock to compensate the affected farmer for any crops that have been damaged.

Primates

Across the globe primates are the most frequently identified crop-raiding animals. From Africa to the Arabian Peninsula to South-East Asia to Japan, primates come into conflict with humans due to the renowned crop raiding behaviour of many species. The impact of primates as crop raiders and the search for solutions to mitigate its consequences is central to this work and is dealt with in detail below.

Previous research on crop raiding

Given the wide variety of mammalian species involved in crop raiding, and the impact they can on local economies, it is surprising that only a handful of studies have been conducted on this topic. On the large these have been concerned with crop raiding elephants. Due to their high conservation value, and the many wildlife managers and conservation biologists involved, a relatively large volume of recent work has focused on elephants. In contrast, little attention has been paid to other groups such as rodents, pigs and primates. Because these species are not often perceived as having a high conservation value by government agencies and the public, they are simply treated as pests and their lethal removal prescribed.

Crop raiding in Tanzania

With 945,000 km² Tanzania is the largest country in East Africa. Tanzania has large tracts of open woodland and savannah, and a great diversity of large mammals. Almost 22% of its land is allocated to protected areas and wildlife conservation, including 12 national parks, 13 game reserves, 38 game controlled areas, and the Ngorongoro Crater Conservation Area. These are spread throughout the country, though the majority of the national parks are situated in the north. Many of these areas hold large mammalian populations.



Which areas of Tanzania are most affected by crop raiding?

Crop damage by wildlife occurs throughout Tanzania but the most seriously affected areas appear to be those adjacent to protected areas. This is a common pattern in other East African countries and worldwide, largely because protected areas harbour large populations of potential crop raiders. In a 1987-1989 survey of over 1,000 people living adjacent to several national parks and game reserves in Tanzania, over 71% reported to having difficulties with wildlife, of which 86% reported crop raiding as a problem (Newmark et al. 1994).

Which mammalian species damage crops in Tanzania?

In the same survey respondents mentioned primates (51.7% of all responses), bushpigs (13.3% of all responses) and rodents (10.6% of all responses) as the most problematic species. Many primate species were involved, including olive baboon (*Papio anubis*), yellow baboon (*Papio cynocephalus*), vervet monkey (*Cercopithecus aethiops*), black and white colobus (*Colobus guereza*), patas monkey (*Cercopithecus patas*), and chimpanzee (*Pan troglodytes*).

Similarly a wide variety of rodents feed on crops, including several mouse and rat species

(Muridae), cane-rats, and porcupines. Elephants are also responsible for large amounts of crop damage. In other parts of East Africa, notably Uganda, other studies noted a similar trend. Several other mammals also raid crops but perhaps not as frequently or as damaging, including bushbuck (*Tragelaphus scriptus*), duikers (*Cephalophus* spp.), striped ground squirrel (*Xerus erythropus*) and African civet (*Viverra civetta*). As many as 23 species of vertebrates were reported to raid crops around the Budongo Forest Reserve in Western Uganda (Hill, 1997).

Which types of farms and crops are most affected?

Most food crops grown in Tanzania are susceptible to crop raiding. Although there have been few studies on crop raiding in Tanzania parallels can be drawn from studies in Uganda. In the Budongo area maize, cassava, finger millet, and sweet potato are, in that order, the four most commonly grown carbohydrate sources. Of these, cassava, maize and sweet potato are at most risk of being raid by wildlife. The Budongo survey found average crop losses of 25% for cassava (range 4.5-61%) and 19% for maize (range 7.7-53%). Crop raiding may be greatest during harvest season, but it does occur throughout the year. In particular maize seems to be targeted and damaged throughout its growing cycle, from the newly sown seed to the time when the cobs are mature. Damage sustained at any stage can cause severe crop losses, but these are most serious when crops are mature.

The location of a farm is also an important factor determining how much damage the crop is likely to suffer. In Budongo, and around Kibale National Park (also in Uganda), crop raiding by larger mammals was found to generally be limited to within a few hundred metres of the forest edge, with fields further away receiving little or no damage (Hill, 1997; Naughton-Treves, 1998).

Also regions dominated by agriculture are more susceptible than those where there is a mixture of agriculture and pastoralism.

How much damage is being done?

It is difficult to quantify the amount of damage due to crop raiding, both in actual yield and economic terms, and there are few such studies in Tanzania. At an individual farmer's level, a severe or prolonged attack by crop raiders can be extremely damaging. The farmer may lose his entire crop for the year, or a substantial part of it. Given that the vast majority are subsistence farmers, such a loss is potentially devastating and may bring about severe hardship. Studies in Uganda and elsewhere in Africa estimated that in areas of intense crop raiding activity, raiding can on average cost farmers the equivalent of several hundred dollars per year, which is an enormous sum in comparison to their low income levels.

A reduction in farmers' incomes will often have a knock on effect on the whole community. If a village suffers a high degree of crop raiding, all the farmers in that village will collectively have a lower yield of crops, which will generate

a proportional fall in their incomes. Lower incomes mean less disposable cash to spend in the markets and shops, and can eventually bring about a wholesale decline in the strength and stability of the local economy.

At the country level crop raiding may not have a huge negative effect on total agricultural production or economic performance, but it will still affect the economy in indirect ways. Many governments have schemes to supposedly compensate farmers for the damage caused by wildlife. In many cases obtaining appropriate compensation is an extremely arduous task for a small claimant, but considerable sums are still paid out and significant human resources are tied up in administering these schemes that could be better used elsewhere. On the other hand, lack of action by governments is likely to cause resentment among those who suffer from crop losses. In such cases crop raiding reinforces the attitude amongst farmers that conservation programmes and protected areas contribute to their subsistence problems rather than benefiting them. This can prompt hostility towards natural habitats and wildlife, and in particular the wildlife management authorities that are responsible for their conservation.

Primates as crop raiders

A wide-ranging number of mammal species are pests in the tropics. Of these primates are perhaps the most troublesome, due to their intelligence, adaptability and opportunistic tendencies. Primates have the potential to be involved in conflict through a variety of situations: by raiding crops, houses, gardens and chicken coups; by killing young or small livestock; and by raiding of guest rooms and halls in tourist lodges. The following section identifies which species are the chief perpetrators and examines the reasons why primates can be such problematic animals.

Which primate species damage crops?

A large number of primate species raid crops, but it appears that terrestrial species are more likely to damage crops than arboreal species, and non-folivores are greater crop raiders than folivores. Amongst the Old World monkeys, the most common, and better able to coexist with man, species are from the genera *Macaca*, *Papio*, and *Cer-*

copithecus, in particular the several species of baboon (*Papio* spp.), the rhesus monkey (*Macaca mullatta*), and the vervet monkey. They share the traits that enable them to be successful at exploiting the agricultural landscape around them, namely: they have complex social organisations, are highly omnivorous, and are primarily terrestrial while retaining the ability to utilise arboreal habitats. Baboons in particular are important crop raiders across much of their range in Africa and also Arabia; in Tanzania they are the most troublesome crop-raiding animal of all. Vervets are pests throughout their sub-Saharan range, where they not only raid farmers' crops but also many tourist resorts where they boldly steal food from the hotel residents. In India rhesus monkeys are considered sacred and are often permitted to live alongside people; as a consequence they can very easily raid crops in their surroundings. Macaques (*Macaca fuscata*) are reported as being serious crop raiders across their range in South-East Asia and in Japan.

Why are primates so successful at crop raiding?

That primates are one of the most successful groups of crop raiders is unsurprising; the same characteristics that allow them to overcome many different situations, make them elusive for humans attempting to prevent or at least control their crop raiding activities.

Intelligence

Primates are recognized as being highly intelligent animals. Their intelligence help them to overcome deterrents such as fences, scare-crows, etc., constructed by framers to stop them from raiding crops, or to break into food storage containers or huts that are out of reach from most other wild animals. Their ability to quickly learn new behaviours heighten the success of their crop raiding activities; primates learn for example that after been chased away from crops they can wait until the person who chased them leaves the field, and then return to the fields to feed unhindered.

Adaptability

Primates can quickly adapt to new circumstances and environments. In areas under serious ecological change and habitat modifications, many herbivores are unable to adapt and would eventually disappear. Primates instead are amongst the most adaptable of all animals and a few species, for example baboons, appear to be unfazed by the close proximity of humans and thus take readily to living alongside humans in an agricultural matrix.

Wide dietary range

Primates can employ a broad range of feeding strategies and can correspondingly eat a wide range of foods. Still some species are highly specialised, for instance black and white colobus feed mainly on the mature leaves of trees. Others are highly omnivorous and can eat a range of plants, invertebrates and even other vertebrates such as birds, reptiles and small to medium sized mammals. These have the capacity to survive in many different habitats and would potentially raid a wide variety of crops. In addition, their ability to eat swiftly and to carry surplus food away further increases the amount of crop

damage they can inflict during any single raid and in a relatively short bout of time.

Complex social organization

Primates often live in large groups with an extensive repertoire of co-operative behaviour. This gives them an advantage when crop raiding as they can work together to maximise their gain. They may attack fields in separate groups, enabling one group to feed as another is occupying the attention of any humans guarding the crops.

Aggression

Several of the larger primate species are hefty animals, with baboons and chimpanzee males weighing up to 50 kg, and are noted for their strength, and sometime aggressive behaviour. Males in particular can be extremely aggressive, especially when they are protecting the females and young of their troop from an outside threat. This will include interference or disturbance by humans that the males might interpret as a threat to the troop. Some primates, particularly baboons are known to attack humans on occasion. With their speed, strength and powerful jaws baboons can inflict serious injuries and consequently humans are at real risk of being badly injured or even killed. This has an obvious implication in the crop raiding conflict, as people may be reluctant to chase baboons from their fields or they may even find themselves being chased by baboons, especially as women and children, who baboons appear to be less intimidated by, often are responsible to undertake field-guarding duties. This will lead to an overall reduction in the effectiveness of crop guarding strategies.

Protected by wildlife laws

In many areas primates are protected by wildlife laws, which prevent humans from capturing, injuring or killing primates. Traditionally farmers would have set snares and cage traps to capture crop-raiding primates, and would also have hunted in their fields, further reducing the population of crop raiding primates. With wildlife laws and hunting prohibitions protecting many primate species these control methods are no longer available to farmers, reducing the options that a farmer has available to try to prevent crop raiding.

Preventing crop raiding

A colossal sum of money has been a put into agricultural research over recent years with the

aim of increasing yields and reducing losses. Scientific research advanced rapidly on such di-

verse subjects as genetically modified foods, crop variety development, and crop protection against invertebrate pests and plant diseases. It is therefore somewhat surprising that so few studies on the issue of crop raiding by vertebrates has been conducted, and fewer still into methods used in the prevention of crop raiding, or the development of new methods to reduce the overall impact. Similarly, little information is available on the scale or magnitude of crop raiding.

This information is of great importance in the development of pest management strategies. Without accurate data on crop raiding it is difficult to formulate strategies that will take into account not only invertebrate but also vertebrate pests. Even when such information does exist, there is often a gulf between scientists who collect it and wildlife managers which are meant to implement policy. Failure to communicate the research findings in a useful format is often the cause. By looking at the methods traditionally used to resist crop raiding, evaluating their success, and attempting to find ways to improve upon them, it may be possible to set down a framework to help mitigate crop losses.

What methods are traditionally used to prevent crop raiding?

Crop raiding is not a new phenomenon. Farmers have evolved resourceful strategies to fight back against the animals responsible for damaging their crops. The methods that are employed by an individual farmer are deeply influenced by the resources at his disposal. In developed countries farmers have considerable levels of capital and expertise to summon to combat crop raiding. In developing countries such as Tanzania farmers have small incomes and little access to technology. A range of methods has evolved in such countries, relying on simple, manpower based techniques to tackle crop raiders.

Chasing crop raiders

The most straightforward and common method to prevent crop raiding is to simply chase the animals away from the crops. Once animals are spotted in a farm, people will run at them, yelling, banging drums and throwing objects to chasing them away. This can be effective at times, but often the animals return to the crop as soon as the people disappear. With animals such as elephants this can be hazardous method, as the culprit instead of fleeing, may attack and even kill the chaser.

Guarding

An extension of the chasing method is to permanently guard the fields. Guarding is undertaken throughout the year, but often increases in the harvest season when the risk from crop raiding is perceived to be at its greatest. Children and women are often given the task of guarding their family's fields. A study on Budoongo Forest reserve in Uganda showed that children and women were responsible for 30% and 34% of the guarding respectively. In some areas farmers employ guards to protect their fields, whilst others use dogs to frighten away and chase crop raiders. Co-operation between farmers often means that a guard will also help protect neighbouring farmers' crops. Guarding can be costly both directly, and also indirectly, through time that could be spent elsewhere, (e.g. women doing housework, children attending school) and as it is almost impossible for farmers to guard their fields all the time, it is inevitable that some crop raiding will still occur.

Scarecrows, plastic flags, fireworks

Several methods are used to try and prevent crop raiding by scaring animals away through the use of brightly coloured objects, and loud noises.

Use of scents

Strange or unusual smells are sometimes used in the belief that they will ward off wild animals. For instance, some farmers believe that burning sheep dung around the edge of fields will help keep elephants away, whilst others place scented soap around their fields to mimic the smell of humans and therefore scare animals away. There is some evidence that these techniques can be effective against the more timid animals, but bolder crop raiders appear not to be off put.

Fences

Fencing is used in an effort to keep animals away from farmers' fields and thus prevent crop raiding. Most fencing is constructed from local materials and is of a simple design. As a result fences are not very effective in many cases, many animals can get through it or over it (e.g. primates) whilst others will simply destroy it (e.g. elephants). In addition to fences constructed by individual farmers there are also large-scale fences funded and constructed by governments. These are often electrified and have been used in attempts to prevent crop raiding by elephants. The downside is that fencing can also cause huge ecological problems, by cutting off the traditional migration routes used by

many species and by preventing widely scattered species from finding reproductive mates.

Hunting

Farmers have traditionally mitigated some of the loss from crop damage by hunting wildlife in their fields, thus reducing the population of potential crop raiders while providing a source of much needed protein to the local communities. Hunting is carried out either with guns or more basic weapons, like a bow and arrow, and the off take of animals is relatively low. However this method of control is no longer an option to many farmers, especially those inhabiting land which fringes protected areas, as often wildlife protection laws prohibit local people from hunting wild animals. These laws have been put in place to tackle poaching and are enforced by local and wildlife authorities, with offenders often facing stiff penalties.

Trapping

Farmers may place traps or snares in their fields to catch animals that crop raid. Alternatively, they may be paced inside wildlife habitat in an attempt to reduce general wildlife numbers. Traditionally these captured animals would have been killed and often used for food. In recent years some species, especially primates, have been kept alive to be sold either as pets or for experimental use in the medical and pharmacological research.

Poisoning

To kill crop-raiding wildlife poisoned baits are placed in and around fields, a method that may work in the short-term. Many animals however show neophobia, e.g. rejection of new food stuffs, others learn not to eat poisoned food and some, including primates, may not eat any food that has an unusual taste. There is also the added risk that livestock and non-target wildlife will eat the baits intended for crop-raiders, so a farmer has to be very careful and selective in where to deploy the poison baits.

How effective are traditional methods at preventing crop raiding?

It should not be assumed that just because a technique has been used over a long time-span it is successful. It rather may be used because there are few alternatives available. There is not much quantitative data on the effectiveness of traditional methods and the little there is suggests that the success in the control of wildlife by local people is mixed. Only half of the respon-

dents in the 1987-1989 survey of areas adjacent to several Tanzania national parks stated that they were successful in controlling wildlife.

Several studies have indicated that passive forms of prevention are fairly ineffectual and even methods such as trapping, shooting, and poisoning are only marginally successful. In Barbados 10,000 vervet monkeys were trapped over a fourteen-year period with the majority being sent to medical research laboratories, but this did not have the desired effect of reducing crop raiding, as the population of monkeys remained stable due to the species' high breeding rate (Boulton et al, 1996). But not all wildlife will have the ability to withstand high harvest rates. Obviously this creates a dilemma for wildlife managers who want to conserve wildlife but also have an obligation to try and reduce the damage inflicted by these animals.

What existing programmes are there to combat crop raiding?

There have been relatively few projects or programmes that aim to combat crop raiding or to develop new methods to help prevent it. What work there has been has tended to concentrate on African and Asian elephants. This is largely due to the high profile and conservation status of elephants.

Elephant crop raiding has increased in the last ten years since the 1989 CITIES ban on ivory trade and the associated drop in poaching. This is because in some areas elephant populations are recovering, but more significantly because of continued range restriction and human population growth. Because of the huge interest and concern for elephants from both conservationists and the general public, large amounts of money have been invested in finding solutions to control elephant crop raiding. Efforts has largely focused on the development of elephant-proof electric fences, with only limited success, as well as other methods like protective ditches, creation of habitat corridors to ease elephant pressure, and the translocation of problem elephants to other areas. These programmes are having some success, but they are often prohibitively expensive to the average individual or community, and even where money is available, it has proven difficult to transfer the maintenance and control of the programme to local community groups.

In contrast to the situation with elephants, little work has been done on developing programmes to deal with crop raiding by primates. Studies on the use of taste aversion conditioning have been carried out in Kenya, and in Japan. The technique involves conditioning the animals to associate eating a certain food source with being sick, which is achieved by baiting food with an emetic such as lithium chloride. Studies have not yet proved the method to be very effective, but none of them have been long-term. Recently experiments have been conducted in Japan with electric shock treatments to prevent crop raiding by macaques. This seems to be a very extreme, as well as an impractical, measure to apply, inflicting unnecessary suffering to animals. A common feature of many of these techniques is that they are expensive and often technologically sophisticated. It must be remembered that, although widely applicable and affordable in the more industrial countries, these techniques are less suitable for use in the developing world. There, what little funds are for wildlife conservation and management are already over-stretched.

What can be done in the future to help prevent crop raiding?

It is evident that although traditional methods have some success at preventing crop raiding,

this success is limited and large areas of crops are still susceptible to damage. Given that the scope for crop raiding is likely to increase in the near future, this issue desperately needs to be addressed by conservationists and wildlife managers. Traditional techniques require scrutiny in order to identify where they could be improved upon, and to be developed and evaluated new, novel, alternative approaches to preventing crop raiding.

By evaluating patterns of land use and how they affect the incidence of crop raiding, a better indication can be achieved of where in the agricultural matrix crop raiding is most likely to take place. A number of case studies across different ecological, social, and economic environments can help to elucidate these patterns and evaluate the success of various methods. Certain methods of preventing crop raiding from one species may be transferred to another species. Finally, by combining all of these approaches it may be possible to conceive integrated crop protection strategies to control the level of crop raiding. No single management strategy can prevent all crop raiding and the goal of management should not only be to reduce the levels of crop raiding, but also to raise the tolerance level of crop raiding by lessening its impact to farmers.

Section II. Guidelines for alternative crop-raiding control

Crop raiding primates in Tanzania

Crop raiding is a large issue of contention in Tanzania, as it would be expected from its large populations of wildlife and the low living standards the vast majority endure. Primates are to blame for much of the crop raiding and in particular one species, the baboon, is repeatedly cited as the worst culprit. A brief description of the baboon species in Tanzania is given in Box 1.

Farmers get little assistance from governmental agencies to deal with crop raiding. Therefore farmers are forced to take the law into their own hands. Many of the methods they presently employ are in-humane, such as chasing, poisoning, shooting, and trapping with snares, cage or leg-hold traps. These methods cause a lot of unnecessary suffering to animals and are responsible for the wasteful killing of thousands of animals every year. A lucrative trade of primates for

use in laboratories has flourished as a flawed response to the crop-raiding problem. The number of export permits has increased in recent years; 5,500 export permits were granted by the Tanzanian government in 2000.

There is therefore a need to find and develop more humane methods to reduce, if not prevent, crop raiding by primates in Tanzania. A review of existing knowledge and literature on both the incidence of crop raiding and the methods employed to prevent it, will certainly help in finding practical, humane solutions to primate crop raiding in Tanzania.

A file of case studies from around the world, with details on the different approaches to the issue, will generate a range of possible solutions and recommendations for the relevant Governmental departments. Ideally a number of these

methods should subsequently be tested in field based pilot studies across the country.

The identification of successful methods would be a major boost to wildlife conflict resolution and to wildlife conservation in general. The methods could be applied throughout East Africa in places where crop raiding is major conflict, and potentially be exported to other African regions and worldwide, helping alleviate one of the largest conservation conundrums of the 21st Century.

Box 1: Baboons - The Facts

Two species in Tanzania

- Olive baboon (*Papio anubis*)
- Yellow baboon (*Papio cynocephalus*)

Habitat

Sahelian woodland, forest mosaic, thickets, Miombo woodland, bushland.

Food

Grass, fruit, seeds, shoots, lichens, fungi, worms, insects, other invertebrates.

Social Structure

Often form large troops, 30-80 individuals.

Threats

Agriculture, persecution, hunting.

Status

Vermin (African Convention).
Lower Risk/Near Threatened (IUCN Red Book); CITES Appendix II

Proposed study objectives and outputs

Objective 1: Information review

To collect, evaluate and summarise existing information on the occurrence, damage, and prevention of crop raiding by primates in Tanzania, East Africa and worldwide.

Outputs

- A historical review
- Case studies: presented in a standard format to facilitate easy comparison (wildlife species involved; area affected; farming practice; crops grown, field size, whether fields fenced, etc.; type of landscape: adjacent to protected areas, distance to forest, fragmented landscape vs. homogenous, open vs. woodland, etc.; estimated crop losses; control measures used; evaluation of success of control methods (have losses declined?); source of information
- Discussion of any general trend in case studies.

Objective 2: Evaluate existing projects

To identify, review, and evaluate existing projects that are currently involved with crop-raiding issues in East Africa and worldwide. This will focus on control, prevention and compensation schemes.

Outputs

- Information presented as a number of case studies with a standard format, allowing easy

comparison and evaluation, including sources of funding and cost of programme

- Evaluation of success of the control methods used, difficulties the programme is facing, attitude of local communities towards the programme.
- Ease of transfer and expansion of programme to other area/species?

Objective 3: Model crop raiding

To identify the range of variables affecting crop raiding, evaluate their impact on the level of crop raiding, and create GIS and spatial models to predict the incidence if crop raiding and better suited methods to prevent it.

Outputs

- A list of variables that affect the level, frequency and pattern of crop raiding.
- A list of variables that influence the effectiveness of crop raiding prevention techniques.
- Spatial (GIS) models showing current and predicted future distribution of humans, primates, and land uses, and how the interaction between these factors influences the crop raiding levels.
- Mathematical models to assess how variables affect crop raiding and its prevention.
- Combined models to predict crop raiding "hotspots", future trends in crop raiding, and the effectiveness of various prevention techniques. The models' outputs could assist agencies and wildlife managers to on their man-

agement decisions and targeting control efforts.

Objective 4: Review the role of conservation

To evaluate the impact that conservation education might have on peoples' perception of crop raiding; and evaluate the usefulness of educational tools such as brochures, training manuals, and videos.

Outputs

- A summary of how effective conservation education is in areas of crop raiding at reducing peoples' negative attitudes towards wildlife.
- An evaluation of the usefulness and effectiveness of the different methods that are utilized in conservation education.
- This information can then be used to help in the design of anti-crop raiding schemes, adding an education element alongside actual preventive methods to reduce levels of conflict between farmers and crop raiders.

Objective 5: Compile literature and personnel directories

Compile an annotated reference list of all relevant information on crop raiding, by primates and other mammals, in East Africa and worldwide. Identify and compile a directory of key personnel, organisations, agencies, and projects working on wildlife conflict, particularly on crop raiding.

Outputs

- A list and description of literature relevant to crop raiding by wildlife.
- A list and description of web sites relevant to crop raiding and/or primate conservation.
- A list and a brief synopsis of key people, organisations, agencies, and projects involved in crop raiding issues and primate conservation.
- These lists will be extremely useful for those studying or tackling the problem of crop raiding in the future.

Objective 6: Design a pilot study

Design a pilot study to collect qualitative and quantitative data on crop raiding and evaluate the effectiveness of traditional and new prevention methods in rural Tanzania.

Outputs

- An outline of aims, objectives, experimental design and methodology for a pilot study on crop raiding.
- A selection of suitable areas where such a study could be conducted.
- A list of individuals, organisations, agencies businesses, etc that could be responsible for conducting or fund such study.
- The pilot study would provide valuable and much needed data on crop raiding and the effectiveness of methods to reduce it.

Objective 7: Overall evaluation and recommendations

Evaluate all the information collected and compare advantages and limitations of the different approaches taken in tackling the issue. On this basis, develop a number of recommendations to present to governments or NGOs on how they can better combat the crop-raiding problem.

Outputs

- A series of recommendations to help reduce the problem of crop raiding by primates.
- Recommendations should focus on: how to plan land use to help reduce crop raiding; how farmers and communities can plan their agriculture to help reduce crop raiding; which methods are viable options for controlling and preventing crop raiding; which areas deserve highest priority in dealing with the crop raiding issues; how conservation education schemes could be designed and implemented.
- A list of pilot studies that could be undertaken to help to further understand and find solutions to the problem.

Project beneficiaries

The proposed study has potentially far-reaching implications. Resolving the conflict between farmers and primates will be beneficial not only to the parties directly involved but also to the

deter/control crop raiders are identified and implemented, and should instigate a correspond-

wider community and even countrywide level. These benefactors include:

- **The primates that are involved in crop raiding** will benefit if humane solutions to ing reduction in the use of non-humane methods such as trapping, shooting, poisoning.

- **The individual farmers that are suffering from crop raiding.** By providing solutions to crop raiding they will benefit economically in terms of the higher yields crops produced, income generated, and also a decrease in time wastage through ineffectual control methods.
- **The communities that these farmers live in** should see an overall improvement in their standards of living, as an increase in income and time by farmers will permeate through local communities and benefit them through a rise in spending.
- **Wildlife agencies and wildlife managers** will benefit if solutions to crop raiding are developed. If local farmers can implement these solutions themselves, there will be less need for wildlife managers to intervene, freeing up vital human and financial resources that can be used elsewhere. It would help to reduce ill feeling towards wildlife managers, thus boosting their relationship with the local communities and en-

abling them to carry out their work more effectively.

- **Wildlife and habitat conservation in general may benefit.** A reduction in crop raiding is likely to generate a decrease in any ill feelings towards local wildlife and conservation areas, as wildlife is no longer seen as such a destructive force. If local communities see positive steps being taken to address the crop raiding issue they may be more prepared to cooperate with wildlife authorities in tackling other issues, such as poaching, and habitat destruction.
- **Local and national governments can benefit** as decreasing crop raiding increases farmers income, thereby reducing their dependence on the state. A fall in crop raiding also reduces the amount of compensation that some governments have to pay out to farmers, and may also reduce complaints and ill feeling towards the government.

Suggested reading

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