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ORIGINAL PAPER

Mitigating Human-Wildlife Conflicts Through Wildlife Fencing: A Kenyan Case Study

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Key words
Local community;
Game reserve;
Maasai mara;
National park;
Protected areas

Abstract
A study was conducted between May and August 2007 to compare the intensity of human-wildlife conflicts among local communities neighbouring a fenced wildlife protected area (Lake Nakuru National Park) and an unfenced one (Maasai Mara Game Reserve) in Kenya. A self-administered, drop-and-collect questionnaire was used to collect data from 480 (n = 600, 80% response rate) and 420 (n = 600, 70% response rate) interviewees within communities on the fringes of the National Park and Game Reserve, respectively. Five problematic species were identified around Lake Nakuru National Park and nineteen around Maasai Mara Game Reserve. Major problematic species around Lake Nauru National Park included baboon, warthog and monkey while those around Maasai Mara Game Reserve included elephant, lion, zebra and wildebeest. Major complaints against wildlife included destruction of crops and property, attacking/injuring humans, preying on domestic stock, causing fear among women and children, and being a nuisance. Some wildlife problems were season and location specific. Severity of the human-wildlife conflicts (prominence and intensity of wildlife invasions) was higher within the interface area surrounding the unfenced Game Reserve than around the fenced National Park. Fencing was found to effectively control most, but not all, problematic species. Where feasible, it is recommended to form part of the overall problematic animal management strategy.

Introduction

Wildlife is Kenya's foremost natural resource. It is not only the country's major foreign exchange earner but is also a big source of employment to Kenyans. Kenya's wildlife is a shared resource held in trust by the government through Kenya Wildlife Service (KWS) on behalf of Kenyans. One of the major tasks of KWS is to protect people and their property against wild animals. The organization's failure to attain this goal is the chief cause of indignation that characterizes its relationship with communities neighboring wildlife protected areas. To minimize human-wildlife conflicts and to improve its relations with local communities, KWS has undertaken to fence off a number of wildlife protection areas. Indeed, the organization has been recognized as a world leader in wildlife power fencing by being among the first in the world to use modern high powered electric fencing around the country's wildlife protection areas [1].

Barrier fences have been used to control problematic wildlife species since ancient times. Historical accounts in Africa [2], Australia [3], Europe [4], Asia [5] and America [6] reveal not only the global nature of the practice, but also the changes in

the fencing materials used. Electric fencing, in use since the 1960s [7], represents the latest technological advancement in man's attempts to control problematic wildlife species and its efficacy has been a subject of intense research in recent years [8].
Available literature states that advantages of electric fencing include reduced cost in comparison to the conventional wire fence, reduced labor during building and maintenance and if made from polywires, electric fences can be removed, moved and reused easily [9]. It also offers a nontoxic solution to animal damage problems around highly valuable crops or installations [4]. Disadvantages of electric fencing include regular short out when in contact with snowdrifts or damp vegetation. Also, this method of problematic animal control is based on the animal's capacity to remember the effect of touching the fence, thereby rendering it a psychological rather than a physical barrier. Other disadvantages include reduced efficiency of electric fencing during dry conditions due to poor grounding [4] and if made of steel, fences are relatively permanent and cannot be moved or reused easily [9].
The role of fencing in the management of human-wildlife conflicts, although recognized, has neither been adequately quantified nor clearly documented for Kenya. This study compared the intensity of human-wildlife conflicts between one local community neighboring Lake Nakuru National Park (a fenced wildlife protection area) and another community neighboring Maasai Mara Game Reserve (an unfenced wildlife protection area). The study was based on the working hypothesis that fencing off a wildlife protection area greatly influences the perceptibility and severity of human-wildlife conflicts within the fringe community neighboring the respective protected area.

Methods

Study Areas

The study was carried out among communities living on the fringes of Lake Nakuru National Park and the Maasai Mara Game Reserve. Lake Nakuru National Park was established in 1961 and encompasses an area of 187.9 Km^2. It lies between latitudes 0°17' and 0°30' South and longitudes 36°2' and 36°9' East. In 1976, the whole park was fenced with a chain link and in 1986 a solar electric fence was installed along the inside of the chain link.
Lake Nakuru National park lies between the 760 mm and 1015 mm isohyets. Rains are bimodal, with long lasting rainy periods between March and May and short rainy periods between October and December. Annual mean values for evaporation, radiation and temperature correspond to 1800mm, 490 langleys and 27°C, respectively. The average wind speed is 4 knots at 0600 GMT and 10 knots at 1200 GMT. Most of the soils in Lake Nakuru national park originate from sediments composed of alluvial and ash deposits. The Western and Southern parts consist of volcanic soils. The landscape within the park includes areas of marsh (dominated by *Cyprus laevigatus*) and grasslands (dominated by *Hyparrhenia hirta* and *Chloris gayana*) alternating with rocky cliffs and outcrops, stretches of woodland (dominated by *Acacia xanthophlea*, *Olea hochstetteri* and *Croton dichogamus*), and rocky hillsides covered with bush land (dominated by *Tarconanthes camphoratus*) and forest (dominated by *Euphorbia candelabrum*) [10]. The park is world famous as a haven of the greater flamingoes

(*Phoenicopterus ruber*) and lesser flamingoes (*Phoeniconaias minor*) [1].
Settlement (rural and urban), ranching and agriculture outline the bounds of Lake Nakuru national park. Nakuru town is located to the north of the park while settlement schemes under individual tenure systems are found on the west and southern sides. On the eastern side, there is another settlement scheme together with the Delamere ranch. Dominant human activities around the park include large and small scale crop farming (maize, beans, wheat, pyrethrum, barley) and livestock (cattle, sheep, goats) keeping. The Delamere ranch keeps both wild and domestic animals.
Maasai Mara Game Reserve was established in 1948 and measures 1,510 Km^2. It lies between 34°45' and 35°25' East and 1°13' and 1°45' South. It receives a mean of 1015 mm of rainfall annually in a bimodal pattern with the long rainy period occurring between April and May and the short rainy periods occurring between December and January. Daily maximum temperatures range between 18°C and 30°C while minimum temperatures range between 12°C and 14°C. The game reserve consists of 4 habitat types comprising grassland plains (dominated by *Themeda triandra*, *Setaria sphacelata* and *Acacia drepanolobium*), scrubland (dominated by *Penisetum mezianum*, *Sporobolus pyramidalis*, *Acacia brevispica* and *Indigofera spinosa*), riverine bush (dominated by *Glycine* spp.), and forest habitat (dominated by *Dichrostachys cinerea*, *Croton dichogamus* and *Cordia ovalis*) [11]. It is world famous because of the "big five" of Africa (Elephant, Lion, Leopard, Buffalo, and Rhino) and for the annual wildebeest migration spectacle to and from the Serengeti National Park in Tanzania.
Traditionally, the land surrounding the reserve was communally owned and used for livestock farming under nomadic pastoralism and group ranching. In the recent past however, there has been a subdivision of the communal land and a sizeable part of the former wildlife dispersal area surrounding the reserve is currently under individual tenure with an increasing number of the individual owners turning to crop farming. Whereas livestock (cattle, sheep, goats, donkeys) rearing is still a major activity in the area, an increasing number of residents in the Mara area are turning to crop farming involving wheat, barley, sugar cane, maize, pyrethrum, fruits and vegetables.

Data collection

A self-administered, drop-and-collect questionnaire, prepared according to the Total Design Method [12], was used to randomly obtain data from 480 and 420 adult residents in the fringe communities neighboring Lake Nakuru National Park and Maasai Mara Game Reserve, respectively. At each of the 20 randomly selected primary day schools within each study area, 30 pupils who acknowledged that their parents/guardians were literate were randomly selected and asked to deliver the questionnaire to their parents/guardians between the months of May and August, 2007. Completed questionnaires were returned to the class teachers who delivered them back to the researchers. To ensure equal spatial distribution of respondent, sampling was geographically stratified by selecting schools throughout each study area. Care was taken to ensure that respondent were resident within 3-5 kilometers of the boundary of the respective wildlife protected area.
In addition to identifying the problematic species, the questionnaire sought to determine the perceptibility (percentage of respondent who reported invasion by wild

animals), prominence (total number of cases/invasions) and intensity (average number of cases/invasions per respondent) for each study area within 3 months from the date of questionnaire reception. A specific introductory letter explaining the purpose of the study and the importance of the results accompanied the questionnaire. For credibility purposes meant to enhance response, the introductory letter was on official letterhead and clearly indicated that the investigators are from the department of Biological Sciences at the Masinde Muliro University of Science and Technology.

Results

Questionnaire return rates were 80.00% and 70.00% for Lake Nakuru National Park and Maasai Mara Game Reserve study areas, respectively. Wildlife invasion, prominence and intensity of invasions are given in Table 1. All (100%) respondents within the Maasai Mara Game Reserve interface agreed that wildlife invasions exist in their areas, compared to 30.6% of those from the Lake Nakuru National Park interface. The prominence of wildlife problems was higher within the Maasai Mara Game Reserve interface (1,833 cases) than within the Lake Nakuru National Park interface (186 cases). Overall problem intensity was 0.39 and 4.4 cases per respondent within the interface area surrounding Lake Nakuru National Park and Maasai Mara game Reserve, respectively. Thus, for one (1) invasion encountered by a resident of the Lake Nakuru National Park interface, eleven (11) were encountered in the Maasai Mara Game Reserve interface.

Table 1. Perceptibility, prominence and intensity of wildlife invasions within the human-wildlife interface areas surrounding Lake Nakuru National Park and Maasai Mara Game Reserve

Wildlife problems	Lake Nakuru National Park	Maasai Mara Game Reserve
Perceptibility (%)	30.6	100.0
Prominence	186	1833
Intensity	0.39	4.4
Ratio	1:	11

The Lake Nakuru National Park interface reported 5 problematic species (Table 2) while the Maasai Mara Game Reserve interface reported 19 species (Table 3). Primates were the dominant problematic species (60% of all species, n = 3) around Lake Nakuru National Park, followed by herbivores (40% of all species, n = 2). On the other hand, herbivores were the dominant problematic species around Maasai Mara Game Reserve (58% of all species, n = 11) followed by carnivores (26% of all species, n = 5), birds (11% of all species, n = 2) and primates (5% of all species, n = 1).

Table 2. Problem species within the human-wildlife interface surrounding Lake Nakuru National Park

Species	Number of problem cases or invasions	Contribution (%)
Baboon (*Papio anubis*)	74	39.8
Monkey (*Cercopithecus* spp)	45	24.2
Warthog (*Phacochoerus aethiopicus*)	44	23.7
Impala (*Aepyceros melampus*)	17	9.1
Buffalo (Syncerus *caffer*)	6	3.2

Table 3. Problem species within the human-wildlife interface surrounding Maasai Mara Game Reserve

Species	Number of problem cases or invasions	Contribution (%)
Elephant (*Loxodonta africana*)	240	13.1
Wildebeest (*Connochaetes taurinus*)	225	12.3
Zebra (*Equus brucheli*)	215	11.7
Lion (*Panthera leo*)	210	11.5
Leopard (*Panthera pardus*)	165	9.0
Quelea birds (*Quelea quelea*)	110	6.0
Hyena (*Crocuta crocuta*)	95	5.1
Buffalo (*Syncerus caffer*)	90	4.9
Cheetah (*Acinonyx jubatus*	85	4.6
Impala *(Aepyceros melampus*)	80	4.4
Thomson's gazelle (*Gazella thomsonii*)	74	4.0
Hippopotamus (*Hippopotamus amphibius*)	65	3.6
Mongoose (*Herpestes auropunctatus*)	46	2.5
Waterbuck (*Kobus defassa*)	37	2.0
Baboon (*Papio anubis*)	30	1.7
Guinea fowl (*Numida meleagris*)	30	1.7
Warthog (Phacochoerus *aethiopicus*)	19	1.0
Eland *(Taurotragus oryx*)	9	0.5
Black rhino (*Diceros bicornis*)	8	0.4

Table 4 presents the problems caused by individual species. Within the Lake Nakuru National Park study area, 50% of problem cases were associated with 40% of the reported problematic species (n = 2) whereas within the Maasai Mara Game Reserve study area, 50% of problem cases were associated with 21% of reported problematic species (n = 4). Generally, human-wildlife conflicts commonly manifest themselves in several ways including disturbance, human injury, loss of livestock (mainly sheep and goats), destruction of fences, food stores, crops (potatoes, maize, oranges, vegetables, beans, carrots, wheat, fodder, peas), structures and buildings. Cases of wildlife transmitting diseases to humans and livestock were also reported.

Results indicate that some wildlife problems were endemic to certain localities while some were season specific. The majority, however, would occur all year round within the study areas. Endemic problems were particularly associated with baboons, monkeys and warthogs which were notorious around certain sites within the study areas. Seasonal problems included crop raiding and destruction of food stores and water structures which were reported to be rampant during dry seasons.

Discussion

Study results expose the enduring concerns of communities living within the human-wildlife interface surrounding wildlife protected areas in Kenya. The economic and emotional costs of human-wildlife interactions within these areas can be quite enormous, both at the national and household levels. Wildlife related damage in areas adjacent to protected areas in Kenya is often devastating with serious impacts on household income, food security and potential investments especially in agriculture.

Table 4. Problems caused by individual wildlife species.

	Humans									Stock and crops			
	Death	Attack, Injury	Causing fear	Home invasion	Food store destruction	Vehicle accidents	School program disruption	Disease transmission	Nuisance Disturbance	Death	Attack, injury	Crop/property destruction	Disease Transmission
Baboon		+	+	+	+	+	+		+			+	
Black rhino		+	+										
Buffalo	+	+	+					+				+	+
Cheetah	+	+	+							+			
Eland								+				+	+
Elephant	+	+	+		+							+	
Gazelle												+	
Guinea fowl									+			+	
Hippopotamus	+	+	+								+		
Hyena										+			
Impala												+	
Leopard	+	+								+	+		
Lion	+	+	+							+	+		
Mongoose									+	+	+	+	
Monkey				+	+	+	+	+	+			+	
Porcupine												+	
Quelea birds									+			+	
Warthog									+			+	
Waterbuck												+	
Wildebeest												+	+
Zebra						+						+	

Persistence of human-wildlife conflicts leads to emergence of two major opposing interest groups. Whereas local communities view wildlife as a liability and are opposed to its conservation because it threatens their livelihood, conservationists and hoteliers consider wildlife to be highly value because of its contribution to tourism revenue and strongly support its conservation. Conflicts between wildlife and local communities, in turn, result in further conflicts between local communities and wildlife managers. The need for effective resolution of these human-wildlife conflicts among communities neighboring wildlife protected areas cannot, therefore, be overemphasized.

The numbers of problematic species identified in this study contrast sharply with Kenya Wildlife Service records. Official records [13] indicate more (200%) problematic species for the Lake Nakuru National Park region and fewer (57%) problematic species for the Maasai Mara Game Reserve region than those reported in this study. These discrepancies imply that official records may not accurately depict the scale of the wildlife problem in the two study areas.

The breadth and seriousness of the wildlife menace within the two human-wildlife interface areas involved in this study are pointers to the costs borne by people living in close proximity to wildlife protected areas in Kenya. Previous studies of human-wildlife conflicts in Kenya have often limited wildlife problems to crop or livestock loss and human injury or death [13]. However, as this study reveals, wildlife problems are more extensive. The evaluation of human-wildlife conflicts should therefore be comprehensive enough to reveal the real danger posed by Kenya's wildlife to people bordering protected areas.

Results reveal that fencing effectively ameliorates the wildlife menace situation at the human-wildlife interface surrounding conservation areas. Although animal density is higher in Lake Nakuru National Park than in Maasai Mara Game Reserve [1] and one would therefore expect more invasions within the Lake Nakuru National Park interface, results from this study reveal the converse to be true. It is therefore plausible to associate the reduced wildlife invasions within Lake Nakuru National Park interface with the presence of the fence. Thus, a community that is separated from wildlife by a fence is better protected against wildlife incursions than one without it. These findings corroborate those by other workers in South Africa [14], Malawi [15], Kenya [16], Zimbabwe[17] and Botswana [18] who similarly found that fencing off wildlife provides an important physical barrier that effectively reduces human-wildlife encounters and hence conflicts.

Prominence of the primate and warthog menace around Lake Nakuru National Park interface suggests that fencing is not an effective deterrent against them. Empirical evidence shows that with time, baboons and monkeys identify live wires and then carefully climb across the electric fence, successfully avoiding them. On the other hand, warthogs easily burrow their way out of the park beneath the fence. In this case, the fence fails as an effective control measure against primates and warthogs. Failure of electric fencing to effectively control some problematic species, as established in this study, has similarly been reported elsewhere [9,19,20,21]. This finding implies that in some situations, management of the wildlife menace requires species-specific approaches, as no single control method may be effective against all problematic species.

Although this study demonstrates that the fence is an effective control against most

of the reported problematic species, fencing off wildlife areas in Kenya remains controversial among the country's conservationists and other interest groups. Opposition against fencing is based on the arguments that it denies local communities access to natural resources such as water and pasture in the wildlife protected areas, interferes with wildlife dispersal and breeding patterns [22] and creates ecologically unviable "Islands of Biodiversity" [23,24]. Supporters of fencing [1], however, insist that Kenya's wildlife protection areas are by nature island ecosystems due to their "sudden" boundaries coupled with sharp differences in land use patterns within the immediate surroundings of their boundaries, and not necessarily because of their being fenced in, maintaining that land use practices in areas neighboring protected areas do not accommodate wildlife needs. Fencing thus becomes the surest way to minimize negative human-wildlife interactions within such areas.

This study suggests that, because it perceptibly reduces wildlife invasions of private land bordering protected areas thereby effectively minimizing human-wildlife conflicts, fencing should, where feasible, form part of the overall problem animal management strategy in Kenya.

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