An assessment of pastoralist attitudes and wildlife conflict in the Rungwa-Ruaha region, Tanzania, with particular reference to large carnivores

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ABSTRACT

Human-wildlife conflict is an issue of pressing conservation concern, particularly when it involves threatened species, and accurately identifying the causes of such conflict is fundamental to developing effective resolution strategies. This study investigated attitudes of Maasai and Barabaig pastoralists towards wildlife in central Tanzania, with particular emphasis on five focal carnivore species. Pastoralists reported significant problems with wild animals, particularly carnivores, and results suggested that low levels of retaliatory killing were predominantly due to circumstantial constraints rather than innate tolerance. Number of stock owned and proportion of losses attributed to predators were the most important determinants of conflict examined, with some inter-tribal variation in tolerance. Successful conflict mitigation will depend upon reducing depredation through improved husbandry and improving the cost-benefit ratio of wildlife presence, thereby increasing pastoralist wealth and providing direct, relevant benefits from conservation. Implementing effective conflict resolution schemes should have significant benefits for both human and wildlife populations.

1. INTRODUCTION

1.1. Conflict between humans and wildlife

Human-wildlife conflict, defined as any action by humans or wildlife that has an adverse impact upon the other (Conover, 2002), is an issue of increasing conservation concern, particularly as burgeoning human populations move ever further into wilderness areas (Foreman, 1992; Gittleman et al., 2001), and, less commonly, as conservation initiatives result in species returning to areas from which they had previously been extirpated (Mech, 1995; Phillips et al., 2004). These changes increase contact between people and wildlife, often generating intense conflict due to wild animals raiding crops (Dey, 1991; Naughton-Treves, 1998), attacking and killing livestock (Mishra, 1997; Marker et al., 2003a; Ogada et al., 2003) competing for game species (Gasaway et al., 1992; Thirgood et al., 2000), attacking humans (Herrero, 1985; Saberwal et al., 1994; Nowell and Jackson, 1996), acting as disease reservoirs (Jenkins et al., 1998; Hudson et al., 2002) and many other factors (Gittleman et al., 2001; Woodroffe et al., 2005).

Such human-wildlife conflict is common worldwide and is experienced by many diverse communities, ranging from ranchers facing wolves (*Canis lupus*; Phillips et al., 2004) and coyotes (*Canis latrans*; Fox and Papouchis, 2005) in North America, to villagers suffering crop damage by nilgai (*Boselaphus tragocamelus*) and wild boar (*Sus scrofa*) in the Far East (Sekhar, 1998). Although a remarkable range of species cause conflict with humans, from rodents such as prairie dogs (*Cynomys ludovicianus*; Reading et al., 2005), to megaherbivores such as African elephants (*Loxodonta africana*; Hoare, 1999), large carnivores are responsible for generating particularly intense conflict. This is due to a

myriad of factors, including their obligate carnivory, which results in competition with humans for both domestic and game species, and their large size and ability to kill humans, which understandably generates powerful antagonism (Sillero-Zubiri and Laurenson, 2001; Baldus, 2004). These factors are often compounded by an innate fear of large predators and deep-seated cultural hostility resulting from past experiences, even if carnivores are not causing present problems (Quammen, 2003). While scientific studies have often revealed that large carnivores are not responsible for as much damage as is commonly thought by local people (Rasmussen, 1999; Marker et al., 2003b), this perception of severe conflict is the important factor, as negative attitudes are strongly linked to removal of the species concerned (Gittleman et al., 2001; Marker et al., 2003a).

1.2 Impact of human-wildlife conflict

Human-wildlife conflict has existed for millennia (Kruuk, 2002), but both the problem and the magnitude of the possible response have increased greatly over recent generations (Gittleman et al., 2001; Treves and Karanth, 2003; Western and Waithaka, 2005). Technological developments have led to a wide range of lethal methods for controlling wildlife, such as shooting, poisoning, trapping, snaring, gassing and even electrocution and the use of explosive devices (Brand and Nel, 1997; Menon et al., 1998; Tuyttens et al., 2000; Treves and Naughton-Treves, 2005). These techniques can have serious impacts on both target (Marker et al., 2003c; Woodroffe and Frank, 2005) and non-target species (Miller et al., 1996), and lethal control has even contributed to species extinctions: for instance, a combination of trapping for fur and poisoning to protect sheep led to the extinction of the Falklands wolf or Malvinas zorro (*Dusicyon australis*) in 1876

(Sillero-Zubiri et al., 2004). Similarly, conflict with humans was identified as a key factor behind the extinction of the Carolina parakeet (*Conuropsis carolinensis*) in 1904 and that of the thylacine or marsupial wolf (*Thylacinus cynocephalus*) in 1930 (IUCN, 2002; Woodroffe et al., 2005).

Even where it does not result in extinction, conflict with humans can have a devastating impact on a species' population size and geographic range, often leading to local extirpation (Mech, 1970; Johnson et al., 2001; Treves and Naughton-Treves, 2005). For example, cheetahs (*Acinonyx jubatus*) once ranged across Africa, Asia and into the Indian subcontinent, with numbers estimated at approximately 100 000 animals in 1900 (Marker, 1998). During the last 50 years, however, cheetahs have disappeared from at least 13 countries with only small, remnant populations left in many other areas, with recent estimates putting their numbers at less than 15 000 animals globally (Marker, 1998). Similarly, African wild dogs (*Lycaon pictus*) have been eradicated from 25 of the 39 countries they once occupied and are now one of the world's most endangered carnivores, numbering fewer than 5000 individuals, with only six populations thought to hold over 100 animals (Fanshawe et al., 1991; Woodroffe et al., 1997). Even a species as well-known and high-profile as the lion (*Panthera leo*) has suffered a substantial population decline and range contraction over recent decades, and has disappeared from much of its historic range (Nowell and Jackson, 1996; Bauer et al., 2003). Such range collapses are not restricted to large carnivores: hen harriers (*Circus cyaneus*), golden eagles (*Aquila chrysaetos*), prairie dogs and many other species have suffered similar fates and are now restricted to a small fraction of their former range (Reading et al., 2005;

Woodroffe et al., 2005). Although these declines are often due to a multiplicity of factors, including habitat loss, degradation and fragmentation, disease risks, conflict with humans is an increasingly important factor driving declines for many species (Nowell and Jackson, 1996; Marker and Dickman, 2004; Reading et al., 2005; Woodroffe et al., 2005).

Paradoxically, those species causing most conflict are also those whose declines are likely to have the most damaging ecological impact. Large carnivores in particular fulfil many important ecological functions, such as regulating prey numbers (many of them crop pests), controlling numbers of mesopredators through competition, and maintaining a functional balance of biodiversity in local communities (Krebs et al., 1995; Terborgh et al., 1999; Logan and Sweanor, 2001). Removing top predators from habitat patches often results in marked changes in biodiversity and community structure, which can have severe ecological effects (McShea et al., 1997; Terborgh et al., 2002).

1.3 The need for conflict resolution outside protected areas

Focusing conservation efforts within protected areas, which cover more than 11% of the Earth's surface (Chape et al., 2003), rather than in human-dominated landscapes, might be seen as the obvious solution to conflict. Even the renowned conservationist Richard Leakey remarked in 2001:

> "It is unacceptable to expect people to live cheek by jowl with animals that so adversely affect their livelihood. We have something like twenty-five thousand square miles of protected land in this country [Kenya], which should be enough to keep the lions' gene pools intact. There's no reason that they should be kept on private land." (Baldus, 2004).

However, the reality is that despite its undoubted importance, we cannot rely entirely upon the reserve network as an exclusive conservation strategy. Many species, especially

large ones likely to cause most conflict, have vast home ranges and there are few protected areas large enough to encompass populations which will be viable in the long-term (Woodroffe and Ginsberg, 1998; Brashares et al., 2001). Furthermore, certain species, such as cheetahs and wild dogs, often fare poorly within reserves due to intraspecific competition (Creel et al., 2001), while many threatened species exist largely outside the boundaries of current protected areas: less than 16% of remaining tiger (*Panthera tigris*) habitat is protected (Miquelle et al., 1999), and this figure drops to less than 10% for leopards (*Panthera pardus*), pumas (*Felis concolor*), jaguars (*Panthera onca*) and snow leopards (*Uncia uncia*; Nowell and Jackson, 1996). Moreover, human-wildlife conflict can affect species even within protected areas, as mortality on and around reserve borders can create significant population sinks, especially for large, wide-ranging species, with serious impacts on long-term population viability (Woodroffe and Ginsberg, 1998).

Conflict resolution is not just a conservation issue, however, but also has very important implications for local people, upon whom even relatively small levels of depredation can have crippling effects. For instance, villagers in Nepal's Annapurna Conservation Area reported losing approximately a third of their annual income to snow leopard depredation (Oli et al., 1994; Nowell and Jackson, 1996), while even relatively low stock losses to lions created acute problems for the Ju/Hoansi pastoralists in Namibia (Stander, 1997). Conflict also has effects that go beyond the immediate economic price-tag of losses: fear of wildlife can inhibit peoples' lifestyles and prevent children from attending school, investing in livestock protection costs time and money, while the costs of human fatalities

are obviously incalculable for the families concerned (Norton-Griffiths and Southey, 1995; Thirgood et al., 2005).

Ultimately, 21st century conservation will have to be conducted in an arena of increasingly fragmented 'wild' places within a matrix of human-dominated land, and developing strategies which enable people and wildlife to coexist in the same landscape will be imperative for long-term success. The issue of conflict resolution is therefore clearly of great concern for conservation biologists today, both for reasons of ecological health and integrity, and to ameliorate the devastating effects conflict can have on wildlife and human communities alike.

1.4 Understanding factors affecting human-wildlife conflict

Devising effective conflict resolution strategies relies upon a detailed understanding of how and why such conflicts arise. In this study, I focus primarily on conflict between people and large carnivores, although many aspects of the work are likely to be applicable to other species. Research has revealed marked local variation in the levels of human-carnivore conflict, with some areas experiencing few or no problems, while people at other, nearby sites report significant conflict (Stahl et al., 2002). Often, problems frequently re-occur at these conflict 'hotspots', even if individual, 'problem' animals are removed (Jackson et al., 1996; Stahl et al., 2001). This suggests that some underlying factors may predispose an area to conflict, and gaining a better understanding of this would be extremely valuable for conservation. Factors identified in previous studies as important determinants of conflict are reviewed below.

1.4.1 Level of stock loss

High levels of stock loss, whether of farmed game or livestock, have been shown to influence conflict, and are exacerbated further if the stock concerned is particularly valuable, represents an important bloodline, or has cultural as well as financial significance (Mech, 1981; Sillero-Zubiri and Laurenson, 2001). In particular, surplus killing, where predators kill multiple animals in one attack, can result in severe financial hardship to the stock-owners concerned (Nowell and Jackson, 1996) and engenders particularly intense hostility towards carnivores (Oli et al., 1994; Jackson, 2000).

Despite clear evidence of some link between stock depredation and human-carnivore conflict (Mishra, 1997; Stander, 1997; Ogada et al., 2003), there is not a simple, consistent relationship between the level of stock loss and the negativity of perceptions towards large carnivores. Research in Brazil indicated that levels of stock depredation did not significantly affect local ranchers' attitudes towards jaguars (Conforti and De Azevedo, 2003), and high numbers of cheetahs were removed from farmland in Namibia even in areas where they were not thought to cause much depredation (Marker et al., 2003b). These counterintuitive results reveal that conflict is not merely driven by stock losses, but is the result of a complex suite of factors. Some of these other contributing elements are dealt with below.

1.4.2 Knowledge

Studies have shown that the more knowledgeable people are about carnivores in their area, the more tolerant they tend to be of their presence (Ericsson and Heberlein, 2003),

and knowledgeable people are also more likely to behave in a way that minimises the chance of conflict (Conover, 2002). Education regarding the value of carnivores in the ecosystem is also important: misinformation and a lack of knowledge about carnivores has been linked to higher human-wolf conflicts in southern Europe (Meriggi and Lovari, 1996) and more intense jaguar-human conflicts in Brazil (Conforti and De Azevedo, 2003). If local people show hostility but little or no knowledge about carnivores in their area, then investing in conservation education could be a valuable strategy for conflict resolution (Kellert et al., 1996; Conforti and De Azevedo, 2003).

1.4.3 Cultural values

Cultural and societal beliefs can also play a key role in perceptions of conflict. For instance, traditional North American communities often revered the grizzly bear (*Ursus arctos*), while European settlers, faced with the same animals, were determined to eliminate them (Kellert et al., 1996). In Maasai societies, spotted hyaenas (*Crocuta crocuta*) are often viewed with hostility disproportionate to their impact on stock, as they have many negative associations with gluttony, stupidity and even witchcraft (Frank, 1998; Maddox, 2002). Conversely, local people may sometimes have an unexpectedly benign attitude, and tolerate carnivores despite depredation and other costs. For instance, in Manang, Nepal, there is a high incidence of livestock depredation by snow leopards, but the local Buddhists are particularly tolerant as they believe the cats are sacred and that killing them is a grave sin (Ale, 1998). In the same region, snow leopards are considered the ‘dog’ of the holy mountain god, and that depredation is a curse from the god in response to forbidden human behaviour, so the leopards themselves are rarely held

accountable for attacks (Ale, 1998). Understanding such variations in attitudes can be an important step towards identifying the reasons behind heterogeneity in reported conflict, and can help guide local conservation strategies.

1.4.4 Livestock husbandry

Levels of loss, and resultant conflict with carnivores, have been related to livestock management strategies in areas as diverse as Nepal (Oli et al., 1994), Namibia (Marker, 2002), Kenya (Ogada et al., 2003) and Brazil (Conforti and De Azevedo, 2003). A wide variety of livestock management practices are employed to prevent depredation, from hi-tech solutions such as toxic collars, conditioned taste aversion and the use of electric fencing, to low-tech traditional solutions such as herding and the use of guard dogs (Landry, 1999; Ogada et al., 2003; Marker et al., in press). In Cameroon, villagers regularly rely upon magic, including specific prayers and the carrying of amulets, in an attempt to prevent cattle depredation by lions (Bauer, 1995).

Extensive management, where stock ranges unattended over wide areas, has been linked to higher losses (Conforti and De Azevedo, 2003), while employing herders, using guarding dogs, and keeping stock in well-made, fenced corrals at night have all proved effective at reducing depredation (Linnell et al., 1996; Ogada et al., 2003; Marker et al., in press). Identifying which husbandry techniques are most effective can help farmers to implement the most efficient ways of protecting their stock, thereby reducing conflict with carnivores.

1.4.5 Income diversification

Where people are solely reliant upon livestock for their livelihood, they have few, if any reasons to tolerate large carnivores on their land. Generating income from other sources, however, especially those linked to wildlife and conservation, has been linked to more positive attitudes towards wildlife (McCarthy and Allen, 1999; Sillero-Zubiri and Laurenson, 2001). Even where the source of income is not wildlife-related, diversification can have a positive impact by improving the financial status of local people and thereby lessening the relative impact of a depredation event, as conflict is particularly intense where people have little cash flow (Stander, 1997).

1.4.6 Other contributing factors

Clearly, determinants of conflict are often site and species-specific, and many factors, apart from those discussed above, have been identified as being potentially important. These include, but are not restricted to, prey availability in the study area (Meriggi and Lovari, 1996; Hemson, 2003), habitat characteristics (Landa et al., 1999; Treves et al., 2004), human density (Newmark et al., 1994), carnivore density (Lugton, 1993) and proximity to a protected area (Sekhar, 1998; Hemson, 2003). Attitudes towards wildlife may also be influenced by a respondent's age (Bandara and Tisdell, 2003), gender (Hill, 1998), and even their perception of environmentalists (Primm, 1996; Sillero-Zubiri and Laurenson, 2001). Due to time limitations, this project focused on establishing base-line attitudinal information, socioeconomic characteristics, and livestock husbandry techniques, but follow-up research is planned in the study area to examine the influence of other environmental and social variables on perceptions of conflict.

1.5 Importance of this study

Many inter-related factors combine to influence human-carnivore conflict, which makes it a particularly difficult issue to address. However, trying to understand the true determinants of conflict is absolutely fundamental to identifying the most appropriate resolution strategies and developing successful initiatives for carnivore conservation in human-dominated landscapes (Røskaft et al., 2003). Resolving human-carnivore conflict will be particularly valuable in Tanzania, which is recognised as globally important for carnivore biodiversity and harbours significant populations of lions, leopards, spotted hyaenas and striped hyaenas (*Hyaena hyaena*), as well as some of the world's largest remaining populations of cheetahs and African wild dogs (Nowell and Jackson, 1996; Woodroffe et al., 1997). Conducting studies such as this one, where human-wildlife conflict involving threatened species outside protected areas is examined, has been highlighted by international experts as a global priority for carnivore research (Nowell and Jackson, 1996; Bartels et al., 2001).

1.6 Aims and objectives

This study aimed to investigate the reported level of conflict between local pastoralists and wildlife, particularly large carnivores, in the Rungwa-Ruaha region of Tanzania, and to examine possible contributing factors. In particular, the aims were as below:

i. To assess attitudes towards wildlife in general and five focal large carnivore species in particular (lion, leopard, cheetah, African wild dog and spotted hyaena) in relation to a variety of characteristics linked in previous studies to conflict,

such as wealth, ethnicity, income diversification, distance from Park boundary, gender and age.

ii. To collect information regarding the importance of depredation as a cause of stock loss, sightings of and attacks by focal carnivores, livestock husbandry techniques, knowledge of local wildlife species, and level of reported carnivore removals by pastoralists.

iii. To use the results of the study to examine which factors appear to be the main determinants of conflict in the area, make recommendations for improved management and conflict resolution, and highlight areas worthy of future research.

2. STUDY AREA

2.1 Regional overview

The study was conducted in the southern part of the Lunda-Mkwambi Game Controlled Area (LMGCA), a 6000km^2 area which adjoins the south-eastern border of the Ruaha National Park (RNP) in central Tanzania (Figure 1). The coordinates of survey locations ranged from 07º 19' S to 07º 36' S and from 35º 05' E to 35º 29' E.

Figure 1. Map of Tanzania showing location of National Parks and main towns (TTB, 2005).

The study area is part of the Rungwa-Ruaha region, which covers over 45 000 km^2 and is an area of outstanding biodiversity and species endemism (WCS, 2005). It is situated within one of the World Wide Fund for Nature's 'Global 200' ecoregions (Olson and

Dinerstein, 1998), and encompasses two Important Bird Areas and two proposed Ramsar sites (WCS, 2005). The area harbours an intact large carnivore fauna, including the continent's third largest population of African wild dogs, and is part of a priority 'hotspot' for African carnivore conservation (Mills et al., 2001; WCS, 2005). The region encompasses the 10 300km^2 Ruaha National Park and four Game Reserves as well as the LMGCA (Figure 2).

Figure 2. Map of the Rungwa-Ruaha region, showing the Ruaha National Park (RNP), surrounding Game Reserves (GR) and the Lunda-Mkwambi Game Controlled Area (LMGCA), where the study was conducted (WCS 2005).

2.2 Biophysical characteristics of the LMGCA

The study area is characterised by a semi-arid to arid climate, with approximately 500mm of rainfall annually, which peaks in December-January and March-April (Walsh, 2000; Arnold, 2001). The area is at the interface of two main vegetation zones, and is a mix of typical East African semi-arid savannah vegetation with the Zambezian *miombo*

woodland of southern Africa, with common species including *Acacia*, *Combretum* and *Commiphora* (Sosovele and Ngwale, 2002).

The LMGCA is a vital part of the Rungwa-Ruaha ecosystem, as it provides dry season habitat for many of RNP's species. The Ruaha River runs along the border of RNP and is a key resource for wildlife in the area, drawing species towards the park boundary with the LMGCA (P. Coppolillo pers comm., Figure 3).

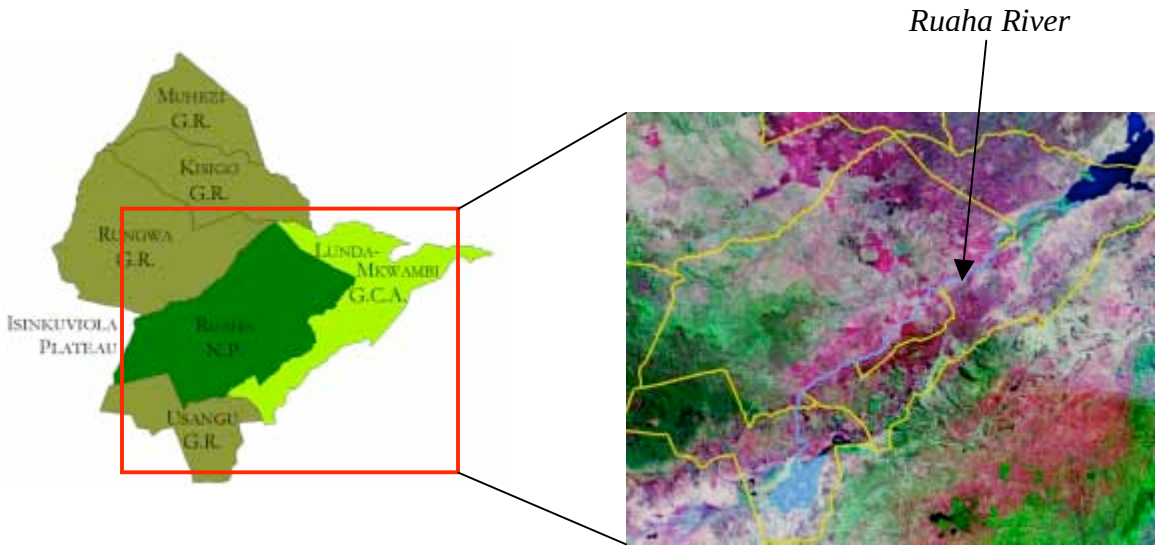

Figure 3. Satellite image of the Rungwa-Ruaha region, showing its demarcation into different land use regimes (outlined in yellow), and the location of the Ruaha River

2.3 Human population and land management in the LMGCA

Hunting, grazing and human settlements are all permitted within the LMGCA, and the people are a diverse combination of small-scale farmers, agro-pastoralists and migrant pastoralists (Sosovele, 2004). Wildlife densities are estimated to have halved in this region between 1990 and 1995 due to uncontrolled hunting and human population

growth, while livestock numbers are thought to have doubled over the same period (Arnold, 2001).

The southern part of the LMGCA, where the study took place, is managed as a Wildlife Management Area (WMA), and is home to the MBOMIPA (*Matumizi Bora ya Malihai Idodi na Pawaga*, or 'Sustainable Use of Wild Resources in Idodi and Pawaga') project. This scheme, covering 4000km^2 and encompassing 40 000 people in 19 villages (Sosovele, 2004), aims to generate revenue through both consumptive and non-consumptive use of wildlife, and uses this revenue to benefit local people, by improving health and education services as well as local infrastructure (Walsh, 2000).

The people in the study area are relatively heterogeneous, with a variety of ethnic groups and lifestyles (Arnold, 2001). These include the Bantu-speaking Hehe, who are traditionally mixed farmers, and a mix of agro-pastoralists and pastoralists, such as the Bantu-speaking Gogo and Sukuma, the Eastern Nilotic Maasai and the Southern Nilotic Barabaig tribes (Arnold, 2001).

3. METHODS

3.1 Survey structure and content

A semi-structured survey design was used (Appendix I), following a similar format to that used by Maddox (2002) to survey Maasai pastoralists in northern Tanzania. The survey was pre-tested on 25 people of varying ages, sexes and backgrounds to ensure clarity before use. It assessed attitudes towards wildlife in general, as well as towards five focal large carnivore species (lion, leopard, cheetah, African wild dog and spotted hyaena), which were chosen due to their tendency to cause intense conflict, as well as their conservation concern. The survey had five main sections, dealing with: (i) socio-economic characteristics of respondents and their livestock holdings, transactions and losses, (ii) attitudes and knowledge regarding wildlife, particularly focal carnivores, (iii) frequency of focal carnivore sightings and attacks, (iv) actions taken to control carnivores and (v) livestock husbandry techniques.

3.2 Subjects

The Maasai were chosen as one of the tribes to examine, in order to compare results from this survey to those obtained by Maddox (2002). Barabaig pastoralists were also interviewed, to enable comparison of attitudes between different ethnic groups living in the same area.

The household or *olmarei* was chosen as the sampling unit, following Maddox (2002), and interviews were restricted to one household per boma. Interviews were conducted in 15 villages or sub-villages in three main clusters: one close ($\leq$ 6km) to the boundary of

Ruaha National Park, one in the middle of the LMGCA (7-12 km from RNP) and one close to the outer edge of the LMGCA (> 12km from RNP; Figure 4) to examine whether distance from the Park affected attitudes.

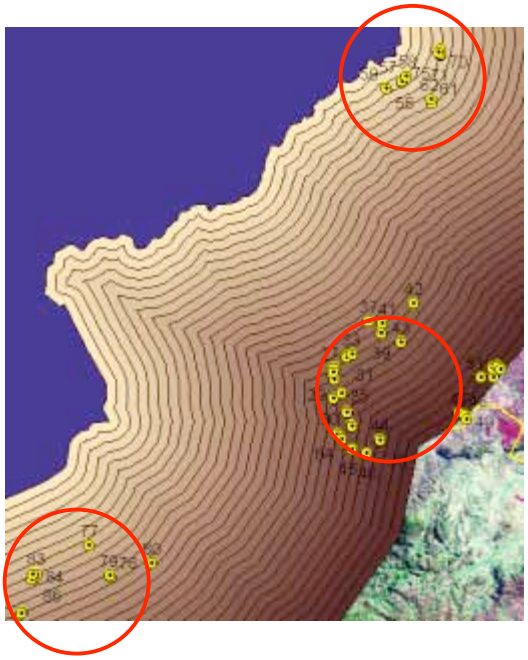

Figure 4. Locations of the surveyed bomas, which were clustered into three main groups, differing in distance from the boundary of Ruaha National Park. Contour lines represent 1-km distances from the Park boundary.

At each village, the chairman and/or headman was approached and the purpose of the research explained. The chairman or headman was asked for locations of Maasai and Barabaig households around that village, and as many as possible of those locations were visited. The most senior member of the household present was asked to participate. Visits to households were often made (n = 14 occasions) without completing a questionnaire, due either to the household having moved on as part of their shifting nomadic lifestyle, or someone of necessary seniority not being present. Women deferred to men in seniority, so interviewees were predominantly male, but interviews were conducted with women where they were happy to do so. No-one of appropriate seniority

that was approached refused to participate in the survey. All interviewees were adults ($\geq$ 18 years old) and self-classified into 'moran' (young adult) or 'mzee' (elder) age sets, as well as providing their actual age.

3.3 Survey administration

The survey was administered in person by the principal investigator (PI) and a Tanzanian research assistant and translator, apart from a subset of interviews (10%, n = 6) which were conducted without the PI present to establish whether the presence of a foreigner affected respondents' answers. The majority of interviews (95%, n = 57) were conducted at the boma, but three interviews had to be conducted in the village for various reasons. Interviews were conducted in KiSwahili and took approximately one hour to complete. At most interviews (n = 49, 81.7%), people apart from the target individual were also present, and the number and status (whether superior, equal or inferior social rank) of onlookers was recorded. All interviews were conducted in July 2005.

3.4 Assessing responses

Respondents were asked to independently list ('free-list') all species that they could think of that occurred around their village. These free-lists were used to assess, through a classical multidimensional scaling (MDS) approach based on relative distance between species names in the list, whether or not pastoralists viewed carnivores as a distinct grouping (Maddox, 2002). In addition, free-lists were used to gauge the relative importance of different species: species considered more important are likely to be mentioned more frequently and earlier in free-lists (Bernard, 2002). A saliency index (S),

measured on a scale of 0-1, could be therefore be calculated for each species based on the number of times it was mentioned in lists and its relative position, using the formula provided in Maddox (2002):

$$S = \frac{\Sigma S_i}{N} \qquad \text{where} \qquad S_j = 1 - \frac{r_j - 1}{n - 1}$$

S = saliency index value

N = number of free lists

r_j = position of item j in list

n = number of items in list

The number of species mentioned in free-lists was also used as an indicator of knowledge regarding wildlife, as was whether or not respondents knew the difference between cheetahs and leopards.

To assess levels of conflict, respondents were shown picture cards of 20 species (Appendix II) and were asked to classify them as posing no problem, a small problem or a large problem, and to explain the reasons for any problems. These cards included one picture of a tiger in order to judge respondents' reliability in recognizing local species. A mean 'problem score' was then calculated for each species recognized as occurring in the area, where 'no problem' = 0, 'small problem' = 1 and 'big problem' = 2. This score was used as the main index of conflict. When investigating livestock husbandry, the quality of bomas (traditional stock corrals, here constructed from thornbushes) was subjectively

assessed as ‘good’, ‘medium’ or ‘poor’ based on factors such as height, width and number of weaknesses.

3.4 Data analysis

Data were analysed using the Statistical Package for Social Sciences (SPSS) PC version 12.0 (SPSS Inc., Chicago, USA). The one-sample Kolmogorov-Smirnov test was used to check assumptions of normality: parametric statistics were used where data were normally distributed, but non-parametric alternatives were used where the assumption of normality was violated. Tests used included Mann-Whitney U, Kruskal-Wallis H, chi-squared, the independent-samples *t*-test (using Levene’s test for equality of variances), analysis of variance (ANOVA) and Spearman’s rank correlations. Binary logistic regression was also used to differentiate between respondents who classified all focal species as a big problem from those that did not, with a Hosmer and Lemeshow test used to determine how well the regression model fit the data. All tests were two-tailed and significance was defined as $P < 0.05$, although P values of < 0.1 were considered indicative of trends that may be worthy of future investigation. Figures given after the mean ($\pm$) denote standard deviations.

4. RESULTS

Sixty interviews with pastoralists were conducted, and information about respondents is provided in Table 1.

Table 1. Details of the 60 pastoralists surveyed. Figures in parentheses indicate standard deviation.

	Maasai	Barabaig	Overall
No. male interviewees	27	18	45
No. female interviewees	7	8	15
Total no. interviewees	34	26	60
No. males of young adult set	17	9	26
No. females of young adult age set	2	3	5
Total no. young adult age set	19	12	31
No. males of elder age set	10	9	19
No. females of elder age set	5	5	10
Total no. elder age set	15	14	29
Mean age in years	36.7 (± 9.4)	36.3 (± 12.7)	36.5 (± 10.9)
Mean no. people in boma	12.9 (± 7.0)	12.2 (± 9.3)	12.6 (± 8.0)
Mean no. boma gates	2.9 (± 0.7)	2.7 (± 0.9)	2.8 (± 0.8)

4.1 Respondent characteristics

Respondent ages ranged from 18 to 65 years old with no significant difference between tribes in terms of mean age (t = 0.16, df = 48, P = 0.876) or proportion of different age sets interviewed (χ^2 = 0.56, df = 1, P = 0.455; Table 1). Men accounted for 75% of interviewees, with no significant difference in respondent sex ratio between tribes (χ^2 = 0.81, df = 1, P = 0.367). Bomas had between one and six gates and housed between four and 45 people, with no significant differences between tribes (no. gates: z = -1.35, P = 0.178; no. people: z = -1.06, P = 0.291).

Interviewees owned between four and 465 head of stock, with Barabaig participants owning significantly more cattle (z = -4.43, $P < 0.001$) and donkeys (z = -4.76, $P < 0.001$)

than Maasai ones (Figure 5). Both groups owned similar numbers of smallstock (z = -0.70, P = 0.482), but the Barabaig owned more stock overall (z = -3.04, P = 0.002).

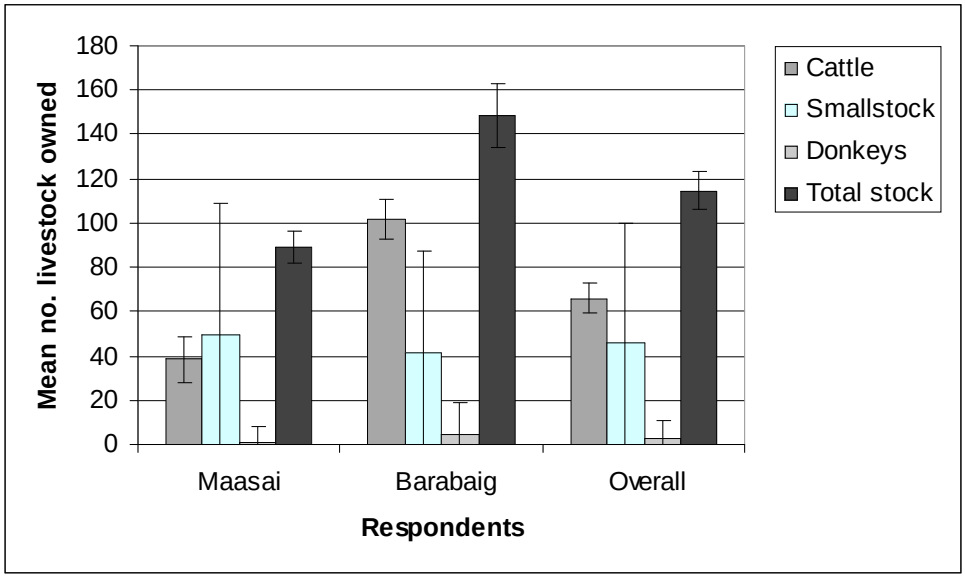

Figure 5. Reported numbers of livestock owned by surveyed pastoralists, both overall and separated by tribe. Error bars indicate standard error.

The majority of respondents (71.7%, n = 43) relied solely upon livestock to provide their income, but 21.7% (n = 13) supplemented this by selling crops. Barabaig pastoralists, who largely lived as shifting nomads, grew crops less frequently than Maasai interviewees (χ^2 = 16.2, df = 1, P < 0.001). Only four interviewees (6.7%; two Maasai and two Barabaig) reported receiving income from tourism.

4.2 Livestock husbandry

High levels of livestock husbandry were reported by all participants, with all respondents claiming to enclose all stock in thornbush bomas at night. However, many bomas seen (42% of Maasai ones and 38% of Barabaig ones) were of poor quality, with less than a

third ranked as good quality for either tribe. Barabaig bomas were taller than Maasai ones (t = -2.18, df = 32, P = 0.037) but construction was similar in all other regards, with no differences in boma quality between tribes for any stock type (cattle: χ^2 = 1.68, df = 2, P = 0.432; calves: χ^2 = 2.13, df = 2, P = 0.344; smallstock: χ^2 = 3.16, df = 2, P = 0.206; donkeys: χ^2 = 1.94, df = 2, P = 0.380).

All but one interviewee reported that they kept guard dogs with all their stock. Number of dogs ranged from zero to 12 and averaged 3.1 ($\pm$ 2.2), with Barabaig bomas containing significantly more dogs than Maasai ones (z = - 2.82, P = 0.005). However, larger Barabaig herd sizes meant that there was no significant difference in the number of dogs per head of stock (z = -1.22, P = 0.221). Almost all the dogs observed were relatively small, were often underfed and/or in poor health, and showed little bonding to livestock (Plate 1).

Plate 1. A typical example of a guard dog observed during the study. Many of the dogs were small, underfed and often showed little bonding with livestock that they accompanied.

All interviewees said all stock were herded in the bush, but small calves and goats were witnessed wandering away from the boma unattended at least three bomas visited. Children were often responsible for herding stock, performing this task alone for 45% of herds studied. Elders and children herded together in 30% of cases, while young adults accompanied the rest.

When asked what they thought were the most effective livestock protection methods, 45 of the 60 respondents mentioned dogs, 25 described lighting fires around the boma, while 19 suggested strengthening bomas with wire or wood (respondents could describe more than one technique). Other strategies suggested included patrolling around bomas with torches (n = 14 respondents), using traditional weapons such as spears to frighten off predators (n = 5), sleeping near the boma (n = 1) and getting someone to control predators in the area (n = 1). Almost all respondents (n = 55) said they used the techniques they described: of those five who did not, cost was cited as the main reason why (n = 3 cases).

4.3 Gains, use and loss of livestock

Reported gains of livestock during the month preceding the survey are shown in Table 2. There was no significant difference between tribes in the level of livestock gain (z = -0.90, P = 0.367).

Table 2. Mean number of livestock reportedly gained by Maasai and Barabaig pastoralists during the one month preceding the survey. Figures in parentheses denote the standard deviation.

			Method of gain			Overall
		n	Born	Bought	Gifts	gains
Maasai (*n* = 34)	Cattle	34	6.8 (± 7.8)	0.9 (± 2.9)	0.2 (± 0.7)	7.9 (± 8.7)
	Smallstock	33	14.3 (± 18.7)	0.6 (± 1.5)	0.3 (± 1.1)	15.2 (± 18.8)
	Donkeys	11	0.5 (± 0.8)	0.2 (± 0.6)	0.0	0.7 (± 1.1)
	All stock	34	20.9 (± 22.6)	1.5 (± 3.4)	0.5 (± 1.8)	22.9 (± 23.4)
Barabaig (*n* = 26)	Cattle	26	17.1 (± 16.5)	0.7 (± 1.7)	0.2 (± 0.5)	18.0 (± 17.0)
	Smallstock	21	11.3 (± 11.7)	0.1 (± 0.5)	0.2 (± 0.6)	11.7 (± 11.8)
	Donkeys	25	0.6 (± 1.0)	0.0	0.0 (± 0.2)	0.7 (± 1.0)
	All stock	26	26.8 (± 25.1)	0.8 (± 1.7)	0.3 (± 0.9)	27.9 (± 25.8)
Overall (*n* = 60)	Cattle	60	11.3 (± 13.3)	0.7 (± 0.6)	0.2 (± 0.6)	12.3 (13.8)
	Smallstock	54	13.1 (± 16.3)	0.4 (± 1.2)	0.3 (± 0.9)	13.8 (± 16.4)
	Donkeys	36	0.6 (± 0.9)	0.1 (± 0.3)	0.0 (± 0.2)	0.7 (± 1.0)
	All stock	60	23.5 (± 23.7)	1.2 (± 2.8)	0.5 (± 1.5)	25.1 (± 24.4)

Reported levels of livestock use and loss during the same one-month period are shown in Table 3. The Maasai reported losing more smallstock (z = -2.35, P = 0.019) and cattle (z = -2.11, P = 0.035) than the Barabaig, but difference in herd sizes meant that only smallstock losses were significantly higher when considered as a percentage of stock owned (z = -2.26, P = 0.024). There was no difference in the number (z = -0.159, P = 0.919) or percentage (z = -0.159, P = 0.919) of donkey losses between tribes. Overall, there was no inter-tribal difference in the reported number of stock lost (z = -0.620, P = 0.135), but larger Barabaig herd sizes meant that Maasai interviewees reported significantly higher losses when considered as a percentage of the number owned (z = -2.06, P = 0.039).

Table 3. Mean number of livestock reportedly used and lost by Maasai and Barabaig pastoralists during the one month preceding the survey. Figures in parentheses denote the standard deviation.

		n	No. stock used			Overall no. stock used	No. stock lost			Overall no. stock lost
			Sold	Slaughtered	Given away		Stolen	Killed by predators	Died	
Maasai (*n* = 34)	Cattle	34	3.8 (± 3.9)	0.4 (± 1.4)	1.3 (± 2.3)	5.5 (± 5.6)	2.8 (± 11.0)	0.6 (± 2.1)	2.4 (± 3.6)	5.8 (± 12.1)
	Smallstock	33	5.3 (± 5.4)	2.8 (± 3.9)	1.3 (± 2.0)	9.4 (± 9.0)	2.6 (± 5.5)	3.2 (± 4.7)	8.1 (± 7.8)	13.9 (± 13.0)
	Donkeys	11	0.0	0.0	0.0	0.0	0.0	0.0	0.3 (+ 0.6)	0.3 (± 0.6)
	All stock	34	8.9 (± 8.5)	3.1 (± 4.3)	2.6 (± 3.8)	14.6 (± 13.4)	5.4 (± 15.1)	3.6 (± 6.2)	10.4 (± 9.1)	19.4 (± 21.1)
Barabaig (*n* = 26)	Cattle	26	7.9 (± 10.5)	0.7 (± 1.4)	1.9 (± 5.2)	10.4 (± 12.7)	2.7 (± 5.7)	1.1 (± 1.8)	6.1 (± 7.9)	9.9 (± 13.7)
	Smallstock	21	5.0 (± 5.8)	2.3 (± 4.6)	0.6 (± 1.5)	7.9 (± 10.1)	2.4 (± 6.6)	1.0 (± 3.0)	4.1 (± 6.7)	7.4 (± 13.3)
	Donkeys	25	0.0	0.0	0.1 (± 0.3)	0.1 (± 0.3)	0.1 (± 0.4)	0.1 (± 0.4)	0.0	0.2 (± 0.6)
	All stock	26	11.9 (+ 14.4)	2.5 (± 4.2)	2.5 (± 5.2)	16.8 (± 17.8)	4.7 (± 10.6)	2.0 (± 3.7)	9.4 (± 11.7)	16.1 (± 22.3)
Overall (*n* = 60)	Cattle	60	5.6 (± 7.7)	0.5 (± 1.4)	1.6 (± 3.8)	7.6 (± 9.6)	2.8 (± 9.0)	0.8 (± 2.0)	4.0 (± 6.1)	7.6 (± 12.8)
	Smallstock	54	5.1 (± 5.5)	2.6 (± 4.2)	1.1 (± 1.9)	8.8 (± 9.4)	2.5 (± 5.9)	2.3 (± 4.2)	6.6 (± 7.6)	11.4 (± 13.4)
	Donkeys	36	0.0	0.0	0.1 (± 0.2)	0.1 (± 0.2)	0.1 (± 0.4)	0.1 (± 0.4)	0.1 (± 0.4)	0.3 (± 0.6)
	All stock	60	10.2 (± 11.4)	2.8 (± 4.2)	2.6 (± 4.4)	15.6 (± 15.4)	5.1 (± 13.2)	2.9 (± 5.3)	10.0 (± 10.3)	18.0 (± 21.5)

Pastoralists lost as much stock to theft, depredations and other deaths as they put to use, *i.e*. sold, slaughtered or gave away (Maasai: z = -0.30, P = 0.764; Barabaig: z = -0.49, P = 0.628). Overall, deaths apart from depredation were responsible for most stock loss, followed by theft and predator attacks (Table 3). Tribes did not differ significantly in the percentage of loss attributed to theft (z = -0.40, P = 0.689), predators (z = -1.30, P = 0.192) or other deaths (z = -0.07, P = 0.941). Although there was some variation between the Maasai (Figure 6) and Barabaig (Figure 7) in causes of livestock loss for different stock types, none of these differences were statistically significant.

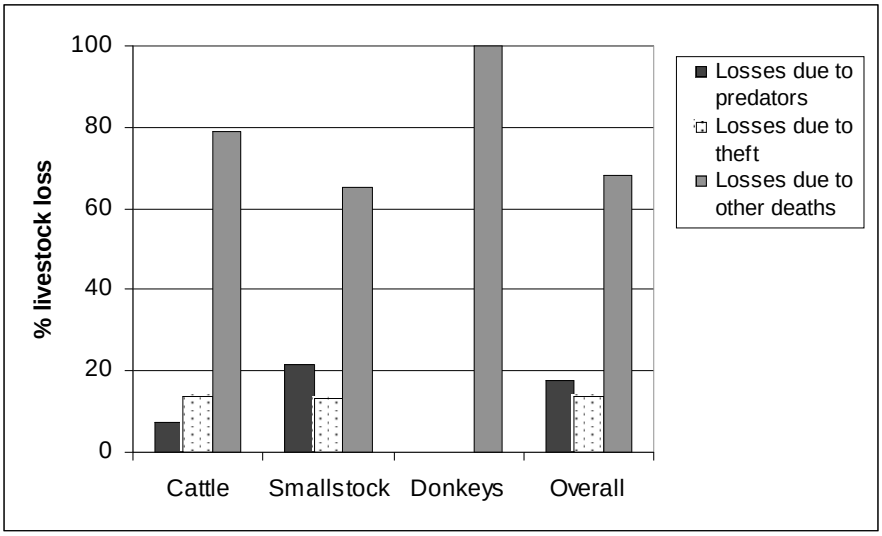

Figure 6. Reported causes of livestock losses for different stock types, suffered by Maasai pastoralists during the one month period preceding the interview.

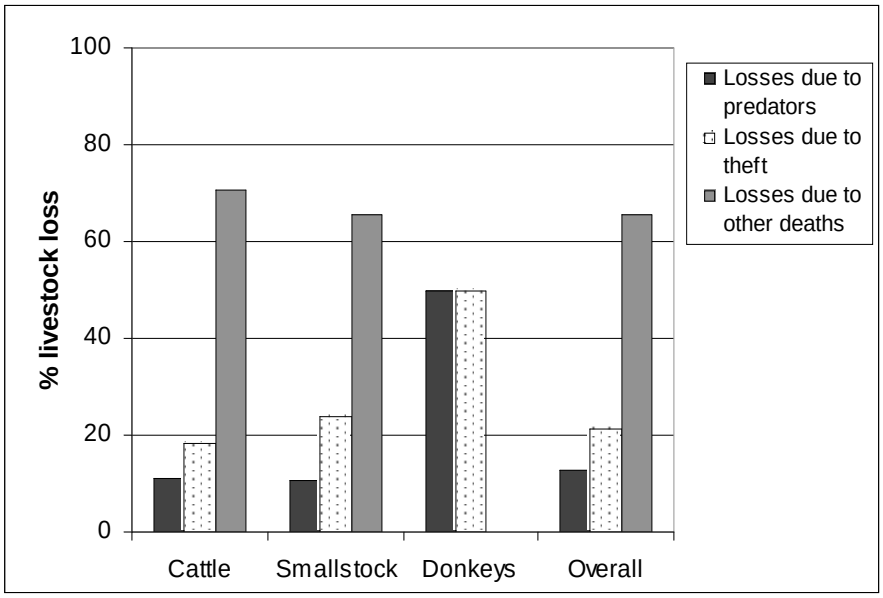

Figure 7. Reported causes of livestock losses for different stock types, suffered by Barabaig pastoralists during the one month period preceding the interview.

There was no relationship for either tribe between the number of guard dogs per head of stock and the number of livestock lost to predators (Barabaig: r_s = -0.22, n = 26, P = 0.283; Maasai: r_s = -0.22, n = 34, P = 0.223). There was also no effect of boma quality on the number of stock lost to predators, for cattle (Barabaig: KW χ^2 = 1.67, df = 2, P = 0.434; Maasai: KW χ^2 = 4.15, df = 2, P = 0.126), smallstock (Barabaig: KW χ^2 = 0.31, df = 2, P = 0.858; Maasai: KW χ^2 = 0.03, df = 2, P = 0.983) or donkeys (Barabaig: KW χ^2 = 1.35, df = 2, P = 0.509; no Maasai had donkey depredations).

On average, respondents reported losing 2.9 stock animals to predators during a one-month period. Assuming the month was representative, this would translate to roughly 36 animals per year, or around a third of average herd size, which would indicate that carnivores had a strong impact on pastoralists' livelihoods. However, when interviewees were later asked to recall the most recent attack by a focal carnivore on their stock,

relatively few people could remember a loss within the last month. Comparison of these detailed recollections with original estimates revealed that on average, initial depredation figures were over-estimated by two-fold for donkeys, four-fold for cattle and five-fold for smallstock. When asked about the discrepancy, all respondents revised their original estimates downwards to match the recalled attacks.

4.4 Knowledge about wildlife species

Respondents often appeared hesitant when asked to free-list species that occurred in the area around their village, and the number of species mentioned ranged from one to 14, with a mean of 5.0 ($\pm$ 2.8). Overall, 24 species were mentioned, including seven carnivores (respondents did not independently differentiate between striped and spotted hyaenas). There was no significant effect of tribe (t = 1.56, df = 58, P = 0.124), gender (t = 1.47, df = 58, P = 0.147) or age set (F = -0.81, df = 1, P = 0.373) on number of species listed. Saliency indices for all species mentioned are shown in Figure 8, and show that dikdik, impala and elephant were the most important herbivores, while lion, hyaena and leopard were the most important carnivores. Wild dogs and cheetahs had lower saliency scores than other large carnivores, although the difference was not statistically significant (t = -3.70, df = 2, P = 0.067).

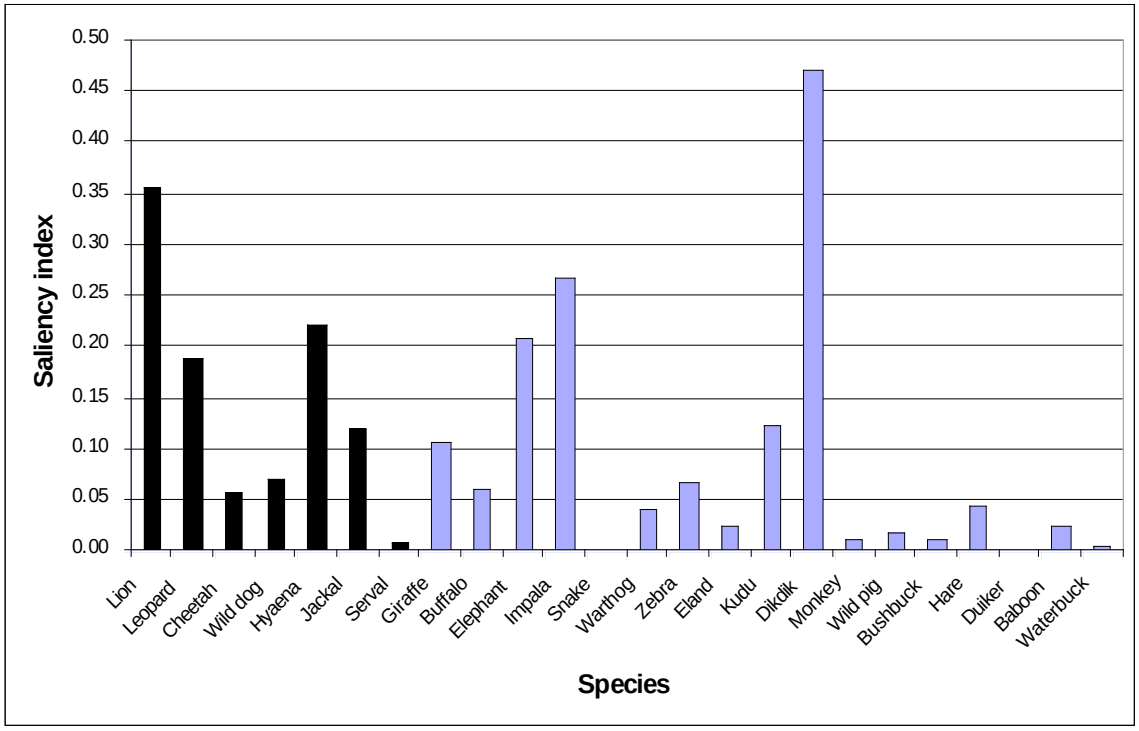

Figure 8. Saliency indices for all species mentioned in respondents' free-lists. Black bars indicate carnivore species, while grey bars indicate other species.

A multidimensional scale plot of commonly cited species (Figure 9) revealed that large carnivores were viewed as a relatively distinct grouping, with closest associations between cheetahs, leopards and wild dogs. Jackals were not grouped closely with larger carnivores, while herbivores showed a loose association with one another.

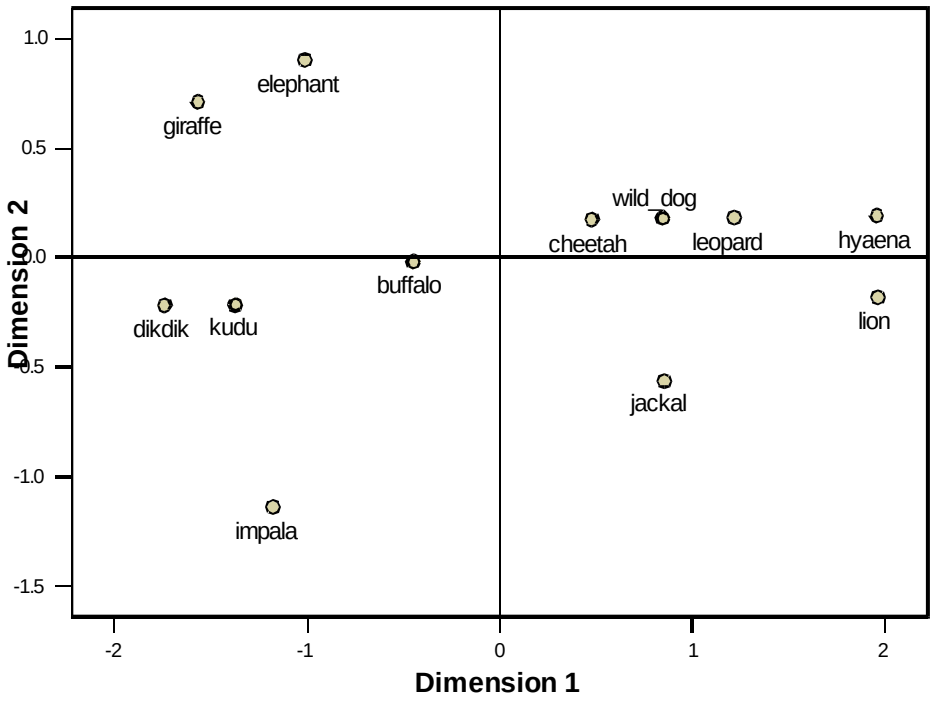

Figure 9. Euclidean distance model, produced by classical multidimensional scaling, of common species ranks in respondents' free-lists. Species that are closer together indicate that they shared similar ranking positions in lists.

Although respondents only independently named an average of five species, there was high recognition of local species when shown picture cards, and all interviewees presented with the tiger picture (n = 46) knew that it did not occur in the study area. Of focal carnivore species, spotted hyaenas were the most well-known, being recognized by all interviewees, followed by wild dogs, who were known by 98.3% (n = 59). Lions and leopards were both recognized by 96.7% (n = 58) of interviewees, while cheetahs had the lowest recognition score at 88.3% (n = 53), mainly due to confusion between the spotted cats. Only 65% (n = 39) of pastoralists were clear about the differences between cheetahs and leopards, with coat colour and pattern, body size, and killing techniques all cited as important differentiating factors.

4.5 Attitudes towards wildlife and protected areas

Around a fifth of respondents were happy with having all existing species of wild animals around their village (Table 4), for reasons that included 'it is our history to have all these animals around'[1] and a fear that if wild animals were no longer present, then domestic stock would die as well[2]. The majority of respondents, however, would like some change regarding which species occurred around their area (Table 4).

Table 4. Views expressed by pastoralists regarding having wild animals in the area around their village.

Attitude towards wild animals around village	*n* respondents	% respondents
Happy with all wild animals	13	21.7
Only happy with animals causing no problems	15	25.0
Only happy with animals which are not dangerous	2	3.3
Only happy with herbivores	11	18.3
Happy with all except large carnivores	3	5.0
Happy for animals to be in bush but not around village	4	6.7
Not happy with any wild animals	12	20.0

Folklore and superstition played some role in shaping attitudes towards wildlife – for instance, some interviewees[3,4] said that although wildebeest caused no direct problems, they feared them as they believed that seeing a wildebeest alone in the bush meant someone would die. Hyaenas were also linked with death, with one Maasai pastoralist[5] explaining a local belief that witchdoctors used them to bring death to people, and that being followed by a hyaena indicated a person would die soon.

Almost two-thirds of interviewees (63.3%, n = 38) wanted changes made to Ruaha National Park (Table 5). The most common change desired was to allow pastoralists into the Park to graze, followed by taking action to prevent dangerous animals leaving the

[1] Respondent 43, young adult Barabaig man, Kisanga, 19 July 2005
[2] Respondent 33, young adult Barabaig woman, Mtakuja, 16 July 2005
[3] Respondent 51, young adult Maasai woman, Tungamalenga, 20 July 2005

Park. Around 20% of respondents were happy with the Park as it was, however, with several citing the economic importance of tourists visiting the area as well as other benefits from Park revenue such as improved local infrastructure. However, pastoralists commonly complained that the benefits provided by the Park, such as better roads, or the building of schools and hospitals, had little relevance to nomadic pastoralists, and said that they would prefer more direct benefits, such as cash revenue, from the presence of the Park.

Table 5. Reported attitudes of surveyed pastoralists towards Ruaha National Park.

Attitude towards Ruaha National Park	*n* respondents	% respondents
Happy with Park as it is	12	20.0
Want grazing in Park	29	48.3
Want Park fenced/animals contained	8	13.3
Don'*t* know anything about Park	8	13.3
Like Park but scared to graze near it	1	1.7
Want Park to shrink in size	1	1.7

Relatively few interviewees (n = 10, 16.7%) reported having had any contact with Ruaha National Park staff, and even fewer (n = 5, 8.3%) described the contact as positive or educational rather than negative, such as being ordered to graze further from the Park boundary. Positive contact with Park staff had some effect on attitudes towards the Park: respondents who had a positive interaction were more likely to say they were happy with the Park as it was (χ^2 = 3.95, df = 1, P = 0.047), although it had no effect on attitudes towards wild animals (χ^2 = 0.01, df = 1, P = 0.925).

4.6 Sightings of focal carnivores

On average, respondents had seen 3.6 ($\pm$ 1.4) of the five focal species. Virtually all (98.7%, n = 59) had seen at least one of them, while a third (33.3%, n = 20) had seen all five. Cheetahs had been seen by fewest respondents (Table 6), although incorrect species

identification may have had an effect – at least five (19%) of reported leopard sightings were probably cheetahs, judging by behaviour described, such as groups of adults hunting during the day.

On average, respondents had last seen a focal predator around 18 months ago, with time since last sighting ranging from under a month to sixteen years. Species differed significantly in the average length of time since last sighting (KW χ^2 = 19.1, *df* = 4, *P* = 0.001), with hyaenas having been seen most recently and wild dogs seen least recently. There was no difference between the tribes in average time since last sighting (*z* = -0.945, *P* = 0.344).

Table 6. Proportion of surveyed pastoralists that had seen each focal carnivore species, and length of time since last sighting. *s* denotes standard deviation.

	Respondents reporting a sighting		No. years since last sighting	
	n	%	Mean	*s*
Lion	50	83.3	3.3	4.9
Leopard	43	71.7	4.4	5.8
Cheetah	33	55	2.9	5.2
Wild dog	47	78.7	2.6	4.1
Spotted hyaena	43	71.7	2.0	2.9

When asked about population trends, around two-thirds of respondents felt that wild dog and leopard populations had decreased over recent years, with over half thinking that cheetah and hyaena populations had declined (Table 7). Opinion was fairly evenly split for lions, although slightly more people felt that lion populations had increased rather than decreased.

Table 7. Respondents' opinions regarding whether they thought populations of focal carnivore species had increased or decreased since the respondent entered the 'moran' (young adult) age set.

	Increased		Decreased		Don't know	
	n	%	*n*	%	*n*	%
Lion	29	48.3	25	41.7	6	10.0
Leopard	15	25.0	39	65.0	6	10.0
Cheetah	16	26.7	34	56.7	10	16.7
Spotted hyaena	24	40.0	31	51.7	5	8.3
Wild dog	13	21.7	41	68.3	6	10.0

4.7 Attacks by focal carnivores

Fifty-three respondents (88.3%) recalled at least one attack on their livestock by focal carnivores. Almost a quarter of respondents (23.3%, $n = 14$) had suffered attacks by four focal species, while 10% ($n = 6$) had experienced losses by all five.

Over a third of people reporting attacks (35.3%, $n = 19$) had suffered them within the last six months, while a further 28.3% ($n = 15$) had experienced attacks within the last 18 months. Time since the last attack by any focal species ranged from less than a month to 29 years, averaging 1.7 ($\pm$ 2.7) years, with least time having passed since hyaena attacks (Table 8). Smallstock bore the brunt of attacks by all species apart from lions, which mainly killed cattle, and wild dogs killed most animals per attack, with lions killing fewest (Table 8). When describing the last attacks on their stock, only one respondent[6] reported killing the predator thought to be responsible (in this case a spotted hyaena) - in all other cases, respondents said that the carnivore ran away.

[6] Respondent 35, elder Maasai man, Malinzanga, 18 July 2005

Table 8. Details of most recent attacks by focal carnivores reported by pastoralists. Figures in parentheses indicate standard deviation.

	Respondents reporting an attack		No. years since last attack	% attacks on different stock types				No. stock killed	No. stock injured	% attacks with dog present	% attacks with adult present	% attacks at night	% attacks in boma
	n	%		Cattle	Calves	Small-stock	Donkeys						
Lion	31	51.7	5.0 (± 7.0)	74.2	3.2	16.1	6.5	1.7 (± 1.8)	0.4 (± 0.8)	43.3	56.7	61.3	56.7
Leopard	28	46.7	2.8 (± 5.4)	3.6	3.6	92.9	0.0	2.2 (± 1.9)	0.1 (± 0.3)	36.0	55.6	46.4	42.9
Cheetah	25	41.7	3.1 (± 3.5)	0.0	12.5	87.5	0.0	2.8 (± 3.7)	0.2 (± 0.7)	33.3	24.0	0.0	9.5
Wild dog	32	53.3	5.2 (+ 5.9)	3.0	6.1	87.9	3.0	7.2 (± 7.1)	0.2 (± 0.5)	18.8	28.1	0.0	6.3
Spotted hyaena	38	63.3	2.8 (± 3.7)	17.9	2.6	79.5	0.0	2.3 (± 2.1)	0.5 (± 1.9)	69.4	70.3	89.2	75.7

Judging by behavioural descriptions, such as animals attacking stock in bomas at night and then jumping out with the prey, at least 12% (n = 3) of attacks attributed to cheetahs were probably caused by leopards. Similarly, a minimum of 7% (n = 2) of reported leopard attacks were probably misclassified, with one probably a cheetah attack, as it involved two adult males killing a goat in the day, and the other likely to be wild dogs, as it involved 30 animals chasing goats in the bush.

Although almost all pastoralists reported keeping guard dogs with each stock type, dogs were not present when the majority of attacks occurred. Similarly, most attacks happened when there were no adults present, especially for depredations by cheetahs and wild dogs (Table 8). Not all attacks at night took place within bomas (Table 8) indicating that failing to enclose stock in bomas at night was more common than initially reported. These attacks were not due to one or two particularly negligent owners - of 44 pastoralists reporting night attacks, 18% (n = 8) described incidences where animals were not enclosed within a boma at the time.

For all focal species, most respondents felt that attacks on stock had declined over recent years (Table 9). This reported decline was most pronounced for leopards and wild dogs and may have been linked to the reported population declines above. However, despite a perceived population increase for lions, the majority of interviewees still thought that the number of depredations they caused had dropped.

Table 9. Respondents' opinions regarding whether they thought livestock attacks by focal carnivore species had increased or decreased since the respondent entered the 'moran' (young adult) age set.

	Increased		Decreased		Don't know	
	n	%	*n*	%	*n*	%
Lion	10	16.7	44	73.3	6	10.0
Leopard	6	10.0	47	78.3	7	11.7
Cheetah	8	13.3	45	75.0	7	11.7
Spotted hyaena	14	23.3	40	66.7	6	10.0
Wild dog	5	8.3	47	78.3	8	13.3

Four interviewees (*n* = 6.7%) described attacks by focal carnivores on humans in their boma. All four attacks described were by lions, and three of them proved fatal. Two involved children sleeping in or near bomas, while two involved children were herding stock. None of the attacks took place within the last ten years, with an average of 14 years since they occurred, and none of the attacking animals were reported to have been killed.

4.8 Magnitude of reported conflict

4.8.1 Magnitude of reported conflict with all survey species

Overall, respondents rated the majority of wildlife species in their area as a problem, and around half as a big problem (Table 10). Carnivores were ranked as particularly problematic – while they comprised only 55.3% (± 10.0) of species occurring around the study sites, they accounted for 74.6% (± 15.9) of species causing problems and 74.2% (± 21.5) of species causing large problems.

Table 10. Percentage of species ranked by surveyed pastoralists as being a problem, and percentage ranked as being a large problem. Figures in parentheses indicate standard deviation.

	Overall		Maasai		Barabaig	
	% ranked a problem	% ranked a large problem	% ranked a problem	% ranked a large problem	% ranked a problem	% ranked a large problem
All species	63.3 (± 22.4)	50.3 (± 21.9)	73.4 (± 13.2)	61.6 (± 14.7)	50.2 (± 25.2)	35.5 (± 21.0)
All carnivores	84.4 (± 24.2)	69.3 (± 26.7)	91.6 (± 11.2)	80.9 (± 14.1)	74.9 (± 32.4)	54.1 (± 31.5)
Focal carnivores	89.8 (± 21.9)	81.2 (± 29.3)	96.5 (± 8.7)	91.3 (± 15.6)	81.0 (± 29.9)	67.9 (± 37.2)

Problems with wildlife included stock depredation, crop damage, threats to human safety, and disease risk, as wildlife species were sometimes associated with tsetse flies and pastoralists were concerned about disease transmission to livestock (Table 9).

Table 11. Reasons given by respondents for considering survey species problematic. Giraffe, impala, wildebeest and zebra were not included as no respondents said they caused problems. *n* denotes the number of respondents viewing that species as problematic.

Species posing a problem	*n*	% respondents citing main reason for problem								
		Threat to stock				Threat to humans			Threat to crops	Disease risk
		Large stock	Small stock	Chickens	All stock	Humans only	Humans and stock	Humans and crops		
Lion	57	55.8	1.9	0.0	23.1	3.8	15.4	0.0	0.0	0.0
Leopard	52	0.0	90.2	0.0	2.0	0.0	7.8	0.0	0.0	0.0
Cheetah	41	2.4	92.7	0.0	2.4	0.0	2.4	0.0	0.0	0.0
Wild dog	51	0.0	70.6	0.0	27.5	0.0	2.0	0.0	0.0	0.0
Spotted hyaena	53	7.5	58.5	0.0	18.9	0.0	11.3	0.0	0.0	0.0
Striped hyaena	28	17.9	64.3	0.0	14.3	0.0	3.6	0.0	0.0	0.0
Jackal	46	2.2	93.5	4.3	0.0	0.0	0.0	0.0	0.0	0.0
Serval	35	0.0	2.9	97.1	0.0	0.0	0.0	0.0	0.0	0.0
Hippo	53	0.0	0.0	0.0	0.0	14.3	0.0	14.3	71.4	0.0
Buffalo	14	0.0	0.0	0.0	0.0	78.6	0.0	0.0	14.3	7.1
Elephant	20	0.0	0.0	0.0	0.0	35.0	0.0	20.0	40.0	5.0
Snake	38	2.6	73.7	0.0	2.6	0.0	21.1	0.0	0.0	0.0
Warthog	32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Crocodile	18	33.3	0.0	0.0	0.0	22.2	44.4	0.0	0.0	0.0

Hierarchical cluster analysis of species ranking revealed the existence of three main groupings in terms of how problematic species were viewed to be (Figure 10). Those species causing most crop damage formed one cluster (hippo, warthog, buffalo and elephant), while other problematic species were divided into two main groups: the medium to large carnivores posing most threat to stock and humans, and another group comprising of the crocodile and puff adder, both of which posed some threat to humans and stock, and the serval, which mainly threatened chickens.

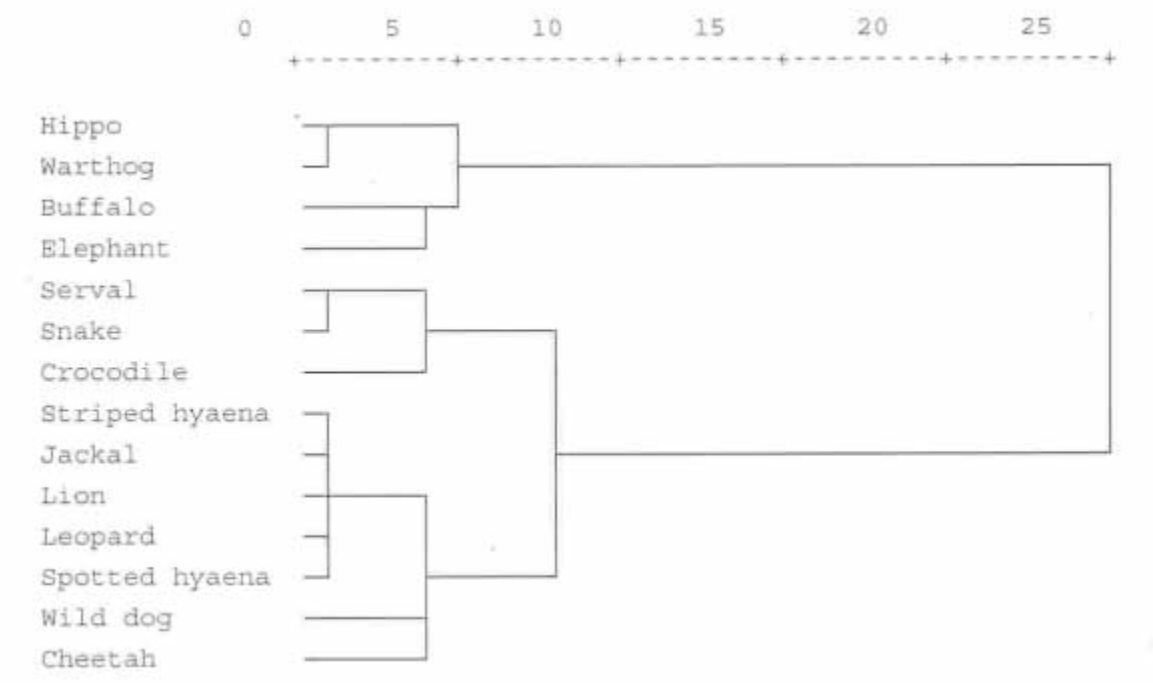

Figure 10. Dendogram revealing hierarchical clusters of survey species in terms of how much of a problem they reportedly posed to respondents. Four species (impala, wildebeest, giraffe and zebra) were not included as they were not considered problematic by any respondents.

Lions were overwhelmingly considered to pose the biggest problem, described by 72% (n = 41) of respondents as the most problematic species, while 18% (n = 10) thought hyaenas were most problematic. Leopards, wild dogs, jackals and baboon were also

mentioned as causing most problems, but none of them were cited in more than 4% of cases.

When respondents' species rankings were used to derive a mean problem score for survey species, it emerged that Maasai pastoralists rated survey species as significantly more problematic than Barabaig ones (z = -4.23, P < 0.001; Figure 11). There was no difference between genders (z = -0.12, P = 0.905) or age sets (z = -0.63, P = 0.529) in average problem scores assigned.

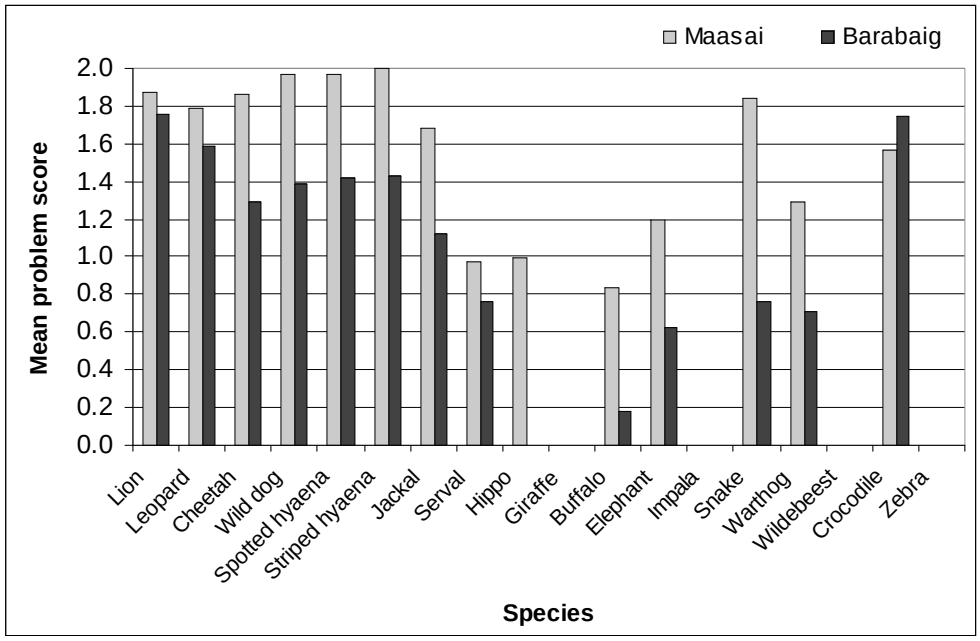

Figure 11. Mean problem scores for all survey species, split by tribe. Scores were calculated from species rankings, where no problem = 0, small problem = 1 and big problem = 2, so higher scores indicate a greater perceived problem.

4.8.2 Magnitude of reported conflict with focal carnivores

Not surprisingly, the focal carnivores were considered particularly problematic and had a significantly higher mean problem score, at 1.7 (± 0.48), than other survey species

(z = -13.3, $P < 0.001$) or other carnivores (z = -6.46, $P < 0.001$). Lions were considered the most problematic focal species, with 91% regarding them as a big problem, while cheetahs were considered the least, with 79% ranking them as a large problem. However, there was no significant difference in mean problem scores between the five species (KW χ^2 = 3.15, df = 4, P = 0.533).

4.9 Factors influencing magnitude of reported conflict with focal carnivores

4.9.1 Respondent characteristics

Owning more stock was correlated with perceiving focal carnivores as less of a problem (r_s = -0.31, n = 60, P = 0.017). Although the same trend was seen with all stock types, only an increase in cattle had a significant effect (r_s = -0.28, n = 60, P = 0.033). Neither respondents' gender (z = -0.96, P = 0.339) nor age set (z = -1.15, P = 0.250) significantly influenced problem scores assigned to focal carnivores, but tribe did: Maasai respondents viewed focal species as significantly more problematic than Barabaig ones (z = -2.72, P = 0.007).

4.9.2 People present at interview

On average, six adult onlookers watched each interview, and overall, who was present did not seem to affect reported levels of conflict (KW χ^2 = 1.61, df = 2, P = 0.447). However, when separated by tribe, the Maasai reported significantly higher levels of conflict when superiors were present (KW χ^2 = 8.22, df = 2, P = 0.016). There was no significant effect on Barabaig interviewees (KW χ^2 = 0.55, df = 2, P = 0.761), and the trend was actually in the opposite direction, with levels of reported conflict lowest when

superiors were present. Whether or not a foreign researcher was present did not appear to significantly affect reported conflict (z = -1.27; P = 0.205).

4.9.3 Number of stock lost to predators

Depredation would seem likely to be an important determinant of pastoralist-carnivore conflict, and indeed the number of stock lost to predators showed a positive relationship with the problem score assigned to focal carnivores (r_s = 0.26, n = 60, P = 0.042). When examined by stock type and tribe, Barabaig respondents rated focal carnivores as significantly more problematic as the number of cattle lost to predators increased (r_s = 0.40, n = 26, P = 0.045), but showed no relationship for other stock types (smallstock: r_s = 0.13, n = 21, P = 0.591; donkeys: r_s = 0.30, n = 25, P = 0.146). However, there was no significant relationship between numbers of any stock type killed by predators and carnivore problem scoring for the Maasai (cattle: r_s = 0.04, n = 34, P = 0.824; smallstock: r_s = 0.10, n = 33, P = 0.569; no donkey losses).

4.9.4 Proportion of stock losses attributed to predators

Overall, the percentage of stock losses attributed to predators was significantly related to pastoralists' perceptions of focal carnivores as problematic (r_s = 0.34, n = 52, P = 0.015). Again, however, there were marked differences when the data were broken down by stock type and tribe: the only stock type that showed a significant relationship for the Barabaig was cattle (r_s = 0.49, n = 22, P = 0.020), while there was no significant relationship for the Maasai for any stock type.

4.9.5 Time since last attack

There was an indication that Barabaig pastoralists rated carnivores as more problematic when they had suffered a depredation event more recently, but the trend was not statistically significant at the $P < 0.05$ level (r_s = -0.42, n = 19, P = 0.071). Length of time since last attack had no evident impact on carnivore problem ranking for the Maasai (r_s = 0.04, n = 34, P = 0.843).

4.9.6 Knowledge about wildlife species

Using the number of species free-listed as an indicator of knowledge, there was no relationship between knowledge and perception of focal carnivores, for either the Barabaig (r_s = 0.21, n = 26, P = 0.297) or the Maasai (r_s = 0.12, n = 34, P = 0.488). Another knowledge index (whether people knew the difference between cheetahs and leopards) also indicated no relationship between knowledge and attitude towards focal carnivores, for either tribe (Barabaig: z = -0.21, P = 0.832; Maasai: z = -1.15, P = 0.241).

4.9.7 Proximity to Ruaha National Park

Whether respondents lived close to the Park boundary, close to the LMGCA outer boundary, or in the middle of the LMGCA, did not significant affect reported levels of conflict with focal carnivores for either tribe (Barabaig: KW χ^2 = 2.89, df = 2, P = 0.236: Maasai: KW χ^2 = 3.56, df = 2, P = 0.166).

4.9.8 Income diversification

Generating additional income apart from livestock did not affect reported conflict with carnivore for either tribe (Barabaig: z = -1.59, P = 0.112; Maasai: z = -0.48, P = 0.634). Similarly, receiving money from tourism had no significant effect (Barabaig: z = -0.15, P = 0.879; Maasai: z = -0.85, P = 0.396), although this analysis was hampered by the very low sample size of pastoralists receiving tourist revenue.

4.10 Analysis of factors leading to particularly intense conflict

Logistic regression analysis was used to build a model, incorporating tribe, age, gender, wealth (using total number of stock owned as an index) and proportion of cattle losses due to predators, which had an 83% success rate in accurately predicted those respondents who classified all focal species as a big problem. Due to the complexity of other factors influencing conflict, the model only explained 41% of the variance in reported conflict levels, but a Homer-Lemeshow χ^2 test indicated that it provided a good fit to the data (χ^2 = 3.96, df = 7, P = 0.785). Wealth and percentage of cattle losses to predators were the most important factors, and both were significant at the $P < 0.1$ level (wealth: P = 0.078; cattle losses: P = 0.073), with greater wealth and less impact of depredation linked to lower conflict. Tribe was not statistically significant (P = 0.105), indicating that the effect of tribe discussed above may have been due to the greater wealth of the Barabaig rather than to inherent cultural differences. A model using just wealth and cattle losses confirmed that wealth was the most significant determinant of intense conflict (wealth: P = 0.014, cattle losses: P = 0.063), and had a 72% success rate in identifying respondents who thought that all focal carnivores were very problematic.

4. 11 Relationship between level of conflict, attitudes and actions towards carnivores

Generally, people were more positive towards focal carnivores than might be expected from the magnitude of problems they caused: although only around 10% of respondents rated focal carnivores as causing no problem, around 20% liked them (Table 12). This difference was most marked for lions and least evident for spotted hyaenas.

Table 12. Attitudes of surveyed pastoralists towards focal carnivores, including how problematic they were viewed as being, whether they liked or disliked the species, and desired population change for each species.

	Problem ranking			Attitude			Desired population change			
	Big problem (%)	Small problem (%)	No problem (%)	Like (%)	Dislike (%)	Don't know (%)	Increase (%)	Decrease (%)	Stay the same (%)	Don't know (%)
Lion	91.2	0.0	8.8	25.0	73.3	1.7	14.0	56.1	28.1	1.8
Leopard	80.7	8.8	10.5	25.0	73.3	1.7	17.0	55.3	21.3	6.4
Cheetah	78.7	8.5	12.8	18.3	71.7	10.0	16.7	55.0	25.0	3.3
Wild dog	82.1	8.9	8.9	20.0	78.3	1.7	13.3	60.0	23.3	3.3
Spotted hyaena	83.1	6.8	10.2	15.0	83.3	1.7	15.0	63.3	18.3	3.3

The degree of problems caused definitely influenced attitudes, as respondents who liked carnivores were usually those who did not consider them very problematic. However, even where carnivores did cause problems, pastoralists recognized other benefits, often considering them important to have around and thinking they should exist in their childrens' futures (Table 13).

Table 13. Reasons given by surveyed pastoralists for liking focal carnivore species. *n* indicates number of respondents claiming to like that species.

Reason	% respondents citing that reason				
	Lion (*n* = 15)	Leopard (*n* = 15)	Cheetah (*n* = 11)	Wild dog (*n* = 12)	Spotted hyaena (*n* = 9)
Important/need them around	20.0	13.3	18.2	41.7	44.4
Should still be around for children	6.7	6.7	9.1	0.0	0.0
Beautiful	6.7	20.0	18.2	0.0	0.0
Causes few/no problems	40.0	40.0	36.4	25.0	33.3
Good for tourism	6.7	6.7	9.1	8.3	11.1
Like seeing it in the bush	0.0	6.7	0.0	0.0	0.0
Like its social structure	0.0	0.0	0.0	16.7	0.0
Combination of reasons above	13.3	6.7	9.1	8.3	11.1
Don't know why	6.7	0.0	0.0	0.0	0.0

The risk of livestock depredation was the main reason for disliking focal carnivores, followed by the threat to humans (Table 14). This was not always due to personal experience – several respondents said that although they had not personally suffered losses, they still disliked carnivores as they posed a potential threat. Pastoralists were particularly antagonistic regarding attacks where carnivores killed more than one animal, as it was seen as 'greedy' behaviour. This was described most commonly for wild dogs and cheetahs, and was cited as a reason for why respondents disliked them.

Table 14. Reasons given by surveyed pastoralists for disliking focal carnivore species. *n* indicates number of respondents stating they disliked that species.

Reason	% respondents citing that reason				
	Lion (*n* = 44)	Leopard (*n* = 44)	Cheetah (*n* = 43)	Wild dog (*n* = 47)	Spotted hyaena (*n* = 50)
Threat to stock	81.9	93.2	83.7	74.5	76
Threat to humans	18.2	6.8	4.7	6.4	10
Surplus/multiple killing	0	0	9.3	10.6	2
Ugly/bad	0	0	0	0	4
Calls are disturbing at night	0	0	0	0	2
Don't see any benefit from having around	0	0	0	0	2
Combination of reasons above	0	0	2.3	0	4

There was not a clear-cut relationship between attitudes towards carnivores and desired population trends. For all focal species, most respondents wanted numbers to decline, but in all cases the percentage wanting a decline was smaller than the percentage that disliked that species (Table 12). Although interviewees would generally like populations to decline, they rarely said they wanted the species to disappear entirely from the area. A desire for total elimination was expressed most commonly with regard to hyaenas, (by 10% of respondents, $n = 6$) but was mentioned by $\leq 5\%$ of respondents when discussing other focal species.

The overwhelming reason for wanting populations to decline or stay the same, cited in 98% of cases, was to minimize conflict, and even where respondents said that they liked the carnivore concerned, they rarely wanted populations to increase incase conflict intensified. As one respondent[7] succinctly put it, "If it is already hot outside, then you don't want it to get any hotter."

Despite the high levels of conflict reported, few respondents (10%, $n = 6$) admitted that they or anyone in their boma had ever killed a predator, and only two said they had participated in traditional lion hunts. Five reported having killed carnivores themselves (four spotted hyaenas and one leopard) while one said that someone else in his boma had killed a spotted hyaena. Only two respondents admitted to using poisons or traps in an attempt to control predators, but this was apparently more because they didn't know how to acquire or use these methods rather than a lack of desire to do so (Table 15). Barabaig respondents explained more often than the Maasai that they felt it was wrong to kill

[7] Respondent 23, young adult Maasai man, Malinzanga, 15 July 2005

carnivores, although the difference was not statistically significant (χ^2 = 3.27, *df* = 1, *P* = 0.070).

Table 15. Reasons given by surveyed pastoralists for not using poison or traps to control carnivores.

Reason for not using poison or traps	n respondents	% respondents
Don't have them/know where to get them	17	31.5
Don't know how to use them	13	24.1
Think that it is wrong	9	16.7
Use other methods for control	6	11.1
Threat to stock/domestic animals	4	7.4
Wild animals not enough of a problem	2	3.7
Too busy	1	1.9
Too expensive	1	1.9
Combination of above	1	1.9

Despite the low level reported, lethal control of carnivores undoubtedly did occur, as before our surveys began we were shown the skins of two lions (a female and a cub) that had been snared and shot the week before (Plate 2).

Plate 2. Local villagers demonstrating how they had set up gin traps which caught this lion cub. The mother refused to leave the cub and both animals were shot.

5. DISCUSSION

5.1 Tolerance of traditional pastoralists towards wildlife

Traditional pastoralists are often held up as examples of people successfully living alongside large carnivores and other potentially dangerous wild animals (Maddox, 2002), with the implication that other societies could copy their strategies and achieve a more harmonious coexistence with problematic wildlife. However, this study showed that although pastoralists undoubtedly exhibited some tolerance, with people often stating a desire to conserve wildlife for future generations and rarely saying they wanted problematic species to disappear entirely, they also revealed high levels of conflict, especially with large carnivores. The low numbers of respondents who reported killing or attempting to kill predators could be taken to indicate remarkable tolerance, especially as it is at odds with peoples' usual response to conflict (Jackson et al., 1996; Breitenmoser, 1998; Marker et al., 2003c). It is more likely, however, that respondents were uncomfortable about openly admitting to killing or attempting to kill predators, especially to an outsider. Lethal control undoubtedly did occur, and a group of villagers were happy to show us the skins of two recently snared lions, but people were more reticent about admitting to personally killing carnivores. Gaining sufficient trust from interviewees in order to be told potentially sensitive information is a process that takes considerable time (Scholte et al., 1999; Bauer and Hari, 2001), so these low levels of reported removals should not be taken at immediate face value.

Even if removals are indeed low, this is likely to reflect a lack of opportunity rather than innate tolerance. Respondents viewed many species as highly problematic and often said

they would control them more pro-actively if they had the chance. Increased modernization and access to new technologies is likely to give more people just that chance in the future, which makes it imperative to devise more effective strategies to resolve human-wildlife conflicts urgently, especially as carnivore populations are already reported to be declining in the study area. This is crucial in order to prevent a scenario where instead of developed-world societies copying traditional societies' conflict resolution techniques, traditional societies copy the developed world's techniques instead and manage to extirpate dangerous species from large areas, with devastating implications for conservation.

5.2 Factors affecting reported conflict and attitudes

5.2.1 Wealth

One of the main factors influencing the degree of human-carnivore conflict was level of stock ownership: pastoralists who owned more stock reported less conflict. Numbers of animals owned can be used as an index of wealth for pastoralists (Maddox, 2002) and this relationship between affluence and positive attitudes towards wildlife has been noted previously (Infield, 1988). Here, the relationship is presumably due to the fact that a single depredation event is particularly devastating for someone who owns very few animals, as has been seen in previous studies (Oli et al., 1994; Mishra, 1997). The number of cattle owned was particularly important, which is unsurprising given the very high importance that cattle hold for both the Barabaig and the Maasai (Klima, 1970; Sankan, 1971). These pastoralists exhibit what has been termed a 'cattle-complex', where cattle provide both a cultural and existential focus for the society, providing people with a

means of survival, security, personal recognition and social prestige, whereas smallstock and donkeys are far less valued (Klima, 1970). It is not solely the number of cattle owned that is important, however – certain cattle, due to their colouration or physical traits, have particularly high cultural value. For instance, animals with a black head, a black tail and a white body are prized by the Barabaig, while a bull with one horn pointing forwards and one pointing backwards is a highly cherished animal (Klima, 1970). This marked variation in value between different animals is likely to exacerbate the impact of losses, especially for people with small herds: such people are likely to have few valuable animals, so the loss of one would be especially damaging and create more intense antagonism regarding large carnivores. The huge cultural significance of cattle is probably one of the key reasons why lions were viewed as being so problematic: despite killing fewest animals on average per attack, they predominantly killed cattle, unlike the other predators, which mainly attacked smallstock.

5.2.2 Age, gender and tribe

This study found no significant effect of age or gender on reported levels of conflict, although both have been identified as important determinants of attitudes towards wildlife elsewhere (Hill, 1998; Bandara and Tisdell, 2003; Naughton-Treves et al., 2003). There was a tribal influence, however, with Barabaig pastoralists seemingly more tolerant than their Maasai counterparts, which may be driven in part by their larger stock holdings. Attitudinal variation between different groups of people living in close proximity to one another has been demonstrated previously (Baumgartner, 1998), and highlights the importance of not assuming homogeneity of attitudes between people

living in the same area. There was some evidence that people were influenced by social pressure while being interviewed, with the Maasai ranking focal carnivores as more problematic if someone of higher social rank was listening. This effect was not found for the Barabaig, but researchers should be aware of the possible bias that different onlookers can create.

5.2.3 Depredation levels

Previous studies have shown that higher levels of livestock depredation are linked to greater hostility towards carnivores (Oli et al., 1994; Ogada et al., 2003). Overall, the same trend was evident here, but there were marked discrepancies when the relationship was examined by tribe and stock type. As would be expected from their cultural importance discussed above, loss of cattle was particularly influential in shaping the attitude of Barabaig pastoralists, but the Maasai showed no relationship between levels of loss and attitude towards focal carnivores for any stock type. There is no clear reason for this intertribal difference, but it highlights the fact that attitudes towards carnivores are not formed in a simple cause-and-effect manner, but are shaped and driven by a complex suite of economic, cultural and social factors.

Relationships between reported losses and attitudes should be viewed with caution, however, as reported figures can be unreliable indicators of true depredation rates (Rasmussen, 1999; Marker et al., 2003b). This was exemplified here, as initial calculations of depredation rates turned out to be over-estimates when compared to in-depth recollections of predator attacks, and highlights the need for researchers to avoid

taking estimates of initial stock losses at face value without investigating them further. However, this *perception* of severe conflict remains the important factor, due to the strong linkage that has been demonstrated between attitudes and retaliatory action (Marker et al., 2003a).

5.2.4 Knowledge about wildlife and conservation

Contrary to the results of some previous studies (Harcourt et al., 1986; Sillero-Zubiri and Laurenson, 2001), no obvious relationship was detected here between wildlife knowledge and attitudes towards wildlife. However, it is possible that some link between these factors would be detected using other indicators of knowledge, so this should still be investigated in follow-up studies.

There was a need for more education regarding predators, as there was evidence of carnivore misidentification regarding both sightings and attacks. In Namibia, the Cheetah Conservation Fund organizes workshops where local herders and farmers are taught how to differentiate between predators, how to identify the species responsible for depredation events, and are informed about carnivore ecology, behaviour and conservation status (Schumann, 2003), and it could be worthwhile replicating such workshops in this area. There was a tendency for pastoralists to group predators together, as shown by the saliency index, and cheetahs and leopards in particular were often confused. Better differentiation would be important for local people, as correct identification of species responsible for losses is critical to developing the most effective preventative strategies.

Increased education and outreach regarding Ruaha National Park would be also be beneficial. Positive contact with Park personnel was associated with improved attitudes towards the reserve, showing that such contact can have clear benefits. However, few pastoralists reported experiencing positive contact with Park staff, and several knew nothing of the Park at all, despite living within 35km of its boundary. A conservation education programme has been established for schoolchildren in the LMGCA, incorporating visits into the Park (Arnold, 2001), but this has little relevance for nomadic pastoralists. It would be valuable to develop similar schemes with adult pastoralists, and to use these programmes to highlight the importance of wildlife, with the aim of improving attitudes not only towards the Park, but also towards the species it supports.

5.3 Addressing causes of conflict

Relative poverty and a high proportion of losses attributed to depredation, especially for cattle, emerged as the main determinants of conflict examined here, so these are important issues to address. Reducing the number of stock killed by predators would tackle both issues: this could be achieved by various means, such as controlling predators (Stahl et al., 2001), excluding them from the area (Sillero-Zubiri and Laurenson, 2001) or by adapting livestock management (Breitenmoser et al., 2005). However, previous studies have shown that removing carnivores rarely produces a long-term decline in losses (Landa et al., 1999; Stahl et al., 2001), while predator exclusion would be impractical for mobile pastoralists. Therefore, improving livestock protection is likely to be most viable method of conflict resolution in this area. A combined strategy aimed at both improving livestock husbandry and increasing pastoralist wealth could

simultaneously reduce losses and increase tolerance, which has been highlighted as the optimal solution to human-wildlife conflict (Sillero-Zubiri and Laurenson, 2001; Hemson, 2003).

5.3.1 Improving livestock husbandry

Although reported standards of livestock husbandry were high, there are still substantive changes that could be made in order to improve the current situation. For example, almost all respondents had dogs with their stock, and the effectiveness of this method was highlighted by the fact that most attacks occurred when dogs were not present. However, the dogs used were often small, underfed and inattentive to the stock, which is likely to considerably hamper their usefulness. Effective guarding dogs should ideally be large, intimidating and should be well-bonded to the stock they are placed with (Sims and Dawydiak, 1990; Marker et al., in press). Anatolian Shepherd livestock-guarding dogs, which show these characteristics, were placed on Namibian farms as a conservation initiative, and the strategy was linked to significant declines in livestock depredation and increased tolerance of large carnivores by the farmers concerned (Marker et al., 2005). A similar initiative could be worth pursuing in Tanzania, although it would require significant investments of time and money by a conservation organization, as well as commitment and dedication from people receiving dogs. Donkeys, which many pastoralists already own, can also be used as guardian animals (Smith et al., 2000; Schumann, 2002) and it would require only a small change in behaviour to enclose them in the same boma as the most vulnerable cattle, e.g. young, calving and dehorned ones. Guarding animals are not a fix-all solution, however: dogs require considerable attention

and training, as well as veterinary care and a specific diet (Marker et al., in press), while donkeys may themselves be potential prey (Breitenmoser et al., 2005). Nevertheless, while they are unlikely to prevent all attacks, especially those due to the largest predators, effective guarding animals are likely to diminish livestock depredation, with considerable advantages for the pastoralists concerned.

All households visited had at least one thornbush boma in which to enclose stock at night. However, boma quality was often poor, and improvements could help reduce livestock depredation, as good boma construction has been associated with reduced losses to large carnivores (Ogada et al., 2003). In particular, building more internal walls within bomas may be beneficial: this lessens the chances of cattle stampeding out when a predator approaches (Ogada et al., 2003). Such stampedes can lead to multiple kills outside the boma, and as multiple kills caused particular hostility towards carnivores in this study, reducing the likelihood of this happening would be particularly advantageous. Many respondents interviewed here felt that strengthening bomas with wire would reduce losses, but research in Kenya revealed that bomas strengthened in this way actually suffered increased hyaena depredation, so it may not be an effective conflict resolution technique (Ogada et al., 2003). Attacks on cattle, which created most conflict, mainly occurred in bomas at night, so fortifying bomas and increasing night-time protection could be particularly significant for reducing conflict, as has been suggested in other African countries (Butler, 2000).

Attentive herding of stock has also been linked to lower depredation rates (Creel and Creel, 2002; Ogada et al., 2003), and every respondent here said they herded all stock animals. However, many of the herders were quite small children, which could reduce their effectiveness, as it seems to be the presence of adults that acts as the most significant deterrent to carnivore attacks. Most interviewees used a combination of husbandry methods, such as lighting fires and patrolling around bomas with torches, which is particularly effective at deterring hyaena attacks (Bauer and Hari, 2001). However, all husbandry techniques clearly rely on them being used effectively. Despite high reported levels of boma use, attentive herding and use of guard dogs, many of the described attacks occurred either outside a boma at night, when stock was unattended or when a dog was not present. Ensuring that existing livestock husbandry techniques are implemented as well as possible could therefore have significant benefits in terms of reducing depredation without requiring large changes in pastoralist behaviour or significant additional investment.

5.3.2 Increasing wealth and providing benefits from conservation

Wealth, in terms of stock holdings, was the most significant factor linked to higher tolerance of carnivores, so investing in strategies to increase or at least stabilize herd sizes could be an important facet of conflict resolution. Reported stock turnover rates showed that pastoralists here lost as much stock as they put to use, mainly due to 'other' deaths (i.e. not caused by depredation) and theft, so reducing the magnitude of such losses would be very beneficial. Placing livestock guarding dogs on farms has been shown to reduce stock theft as well as depredation (Marker et al., in press), so this

strategy could have far-reaching benefits for pastoralists. Disease has been shown to have a greater impact than depredation in previous studies, and the role of disease in causing these 'other' deaths should be investigated further, to help pastoralists develop the most effective strategies for reducing losses.

However, even though the livestock protection techniques mentioned above are likely to reduce losses, they can be costly to implement, in terms of both time and money, which means that carnivores are still imposing significant costs on pastoralists. The key to successfully resolving conflict will depend on wildlife being seen as a substantial asset to local people, rather than as a slightly mitigated cost. There is evidence from previous studies that increased monetary income, particularly from wildlife and conservation-related benefits, such as tourism, can significantly improve attitudes towards wildlife (Parry and Campbell, 1992; Murphree, 1993). Tanzania is a popular tourist destination, with 576 000 visitors in 2003, contributing US $ 731 million to the country's economy (Sosovele, 2004). The Rungwa-Ruaha landscape has high tourism potential, both for non-consumptive activities such as photographic safaris and for consumptive activities such as hunting (Sosovele and Ngwale, 2002), so tourism could play an important role in reducing local human-wildlife conflict. There was some suggestion of a trend here that pastoralists who received some tourist revenue were less negative towards focal carnivores, but the effect was insignificant, possibly due to the very small sample size of pastoralists who received any direct benefits. This shows that despite their potential, methods of generating income from wildlife are currently failing to impact many of the most relevant stakeholders.

One of the reasons for this seems to be that present conservation-related benefits are perceived as irrelevant to many people facing conflict with wildlife. Revenue from the MBOMIPA project in the study area, generated from the sale of wildlife hunting permits, has been significant and has undoubtedly benefited some local communities through village development and improved infrastructure (Walsh, 2000; Arnold, 2001), but such changes have little beneficial impact on traditional nomadic pastoralists. This reflects the findings of other studies, where there is a mismatch between those who reap most benefit from wildlife presence, and those who bear most of the costs (Emerton, 1998; Hemson, 2003). Pastoralists surveyed here were keen for more direct benefits, such as cash payments from conservation, which they felt would provide more relevant and tangible rewards. Although such schemes can be problematic (Nyhus et al., 2005), they have been used elsewhere with some success, and should be examined as a possible strategy for increasing pastoralist revenue and tolerance.

One possibility would be implementing direct payments for conservation (Ferraro and Kiss, 2002), given to local people based on the abundance of wildlife in their area. Payments for conservation have been implemented in Scotland, where farmers are rewarded financially if they manage land in a way that is likely to conserve threatened goose populations (Cope et al., 2005), and a direct-incentive scheme has also been established in Sweden, where reindeer herders receive money for having successful wolverine (*Gulo gulo*) dens on their land (Nyhus et al., 2005). Unlike compensation schemes, where people may receive money but still kill the animals concerned (Naughton-Treves et al., 2003), these initiatives provide an obvious incentive for

tolerating potentially problematic species. They are not problem-free, however: there are issues regarding how to decide appropriate levels of financial reward, how to monitor populations, and how to divide revenue between local people: for instance, a carnivore denning on someone's land may cause significant damage on adjoining properties, where people have not received any financial incentive to tolerate it (Nyhus et al., 2005). Revenue division would be particularly difficult for transhumant pastoralists such as those in the study, as they do not live in one clearly delineated area. However, money could be allocated to each village depending on the status of target wildlife populations around it, which would probably be more feasible than rewards at an individual level, and could have additional benefits by encouraging tolerance across an entire community.

Other possibilities include mimicking schemes such as the Snow Leopard Enterprises™ programme, which, in return for various conservation commitments, pays herders in remote areas of snow leopard habitat a premium for local products, thereby increasing household income (Mishra et al., 2003). If any poaching of prohibited species occurs, all participants lose their bonus, so the scheme provides a powerful community-level incentive for conservation. Such schemes will often have flaws, particularly in terms of equitable revenue-sharing, but it is worth investigating their potential viability in this area so that pastoralists see a direct benefit from their tolerance.

5.4 Conclusions and management recommendations

This study highlights the complexity of human-wildlife conflict and reveals just some of issues that must be addressed for successful conflict resolution. Although this complexity

means that all the factors influencing conflict will probably never be fully understood or resolved, certain key determinants can be identified and addressed. Results here suggest that pastoralists in the Rungwa-Ruaha region experience high levels of conflict with wildlife, but that improving their economic standing, predominantly by reducing livestock depredation, could considerably mitigate the problem. Strategies that should be implemented in an attempt to lower depredation rates include the use of effective guarding animals, improving boma structure, and ensuring that all stock are attentively herded and are enclosed in a boma at night. Improving education about predators would also be advantageous by helping people correctly identify species causing losses and decide upon the most effective techniques for preventing depredation. Reducing losses is unlikely to be enough alone, however – there is a need to develop schemes where local people perceive tangible economic benefits from tolerating wildlife on their land. A joint strategy of improving livestock husbandry to reduce losses, and implementing relevant incentive schemes for conservation, should have significant benefits in this area, by reducing conflict and therefore easing pressures on both human and wildlife populations.

5.5 Limitations of this project and suggestions for future study

Constraints on this research, mainly due to the limited time-frame, meant that only a small subset of factors likely to influence human-wildlife conflict could be examined. In particular, it was not possible to measure temporal variation in levels of conflict, which have been highlighted as important elsewhere (Hemson, 2003). The lifestyle and culture of nomadic pastoralists imposed additional constraints on the study: locating them was frequently problematic and time-consuming, which limited sample size, while it was hard

to collect information on sensitive topics as an outsider. Conducting future studies over a longer timescale should address several of these issues, as it would allow more in-depth examination of social and ecological factors likely to affect conflict, and more trust could be built with pastoralist communities. Incorporating both socio-economic and ecological variables into a spatial model would be a valuable component of future studies, as this could be an effective way of identifying conflict 'hotspots' and determining their main characteristics. This approach has been used previously in human-carnivore research (Treves et al., 2004), and could be valuable tool for guiding the most appropriate conservation strategies in this unique and important area.

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Appendix I: Survey administered to pastoralists

Date	Questionnaire no.	Interviewer(s)	Other people present? (describe)

GPS location	Nearest village
S: _ _ . _ _ _ _ _ E: _ _ . _ _ _ _ _	

Name	Age	Age set	No. men/women /children in boma	Boma name	No. boma gates	No. dogs in boma

Stock owned at present	Cattle	Smallstock	Donkeys	Do you grow any crops?

1. During the last year, have you received any income from:

	Yes	No
Selling/exchanging livestock		
Selling crops/vegetables/grain		
Trophy hunting		
Photographic tourism		
Other (specify)		

2. How many cattle/smallstock/donkeys have you gained over the past month?

	Born	Bought	Gifts	Other (specify)
Cattle				
Smallstock				
Donkeys				

3. How many cattle/smallstock/donkeys have you lost over the past month?

	Sold	Died	Slaughtered	Given away	Stolen	Predators	Other (specify)
Cattle							
Smallstock							
Donkeys							

Attitudes and knowledge

4. Please tell me all of the wild animals that live in this area that you can think of:

1.	2.	3.	4.	5.
6.	7.	8.	9.	10.
11.	12.	13.	14.	15.

5. Can you sort these pictures into animals that are a big problem, small problem or no problem to your village, and explain why? *(show picture cards):*

	A big problem	A small problem	No problem	Don't know animal/does not occur here
Why?				

6. Which animal (even if it has not been mentioned so far) causes the biggest problems in the area around your village? Why?

_____

_____

_____

7. Overall, what do you think about wild animals living in the area around your village?

_____
_____
_____

8. Have you ever had someone from Ruaha National Park come and talk to you about the park (describe encounter)?

_____
_____
_____

9. What do you think about Ruaha National Park?

_____
_____
_____

10. Can you tell me the difference between…..? *(show pictures of cheetah and leopard)*

_____
_____
_____

11. What do you think of the following animals?

	Like them	Dislike them	Don't know	Why?
Lion				
Cheetah				
Leopard				
Spotted hyaena				
African wild dog				

12. What would you like to see happen to the numbers of the following animals in the area around your village?

	Increase	Decrease	Stay the same	Don't know	Why?
Lion					
Cheetah					
Leopard					
Spotted hyaena					
African wild dog					

<u>Frequency of sightings and attacks</u>

	Lion	Cheetah	Leopard	Spotted hyaena	African wild dog
13. When did you last see…..? Season Where Time of day How many No/sex/age of predators What were you doing What happened to the predator					
14. Have numbers of…. increased or decreased since you became a *moran*?					

15. When was the last attack on your livestock by……?	Lion	Cheetah	Leopard	Spotted hyaena	African wild dog
Season? Where? Time of day? Livestock type? No. injured/no. killed? Who was with the livestock? Was there a dog with the stock? Adults present? Did they see the attack? No/sex/age of predators What happened to the predator					
16. Have attacks by…. increased or decreased since you became a *moran*?					
17. Has anyone in your boma been attacked by……?					
Name					
Age when attacked					
Where?					
When?					
Season					
What was person doing?					
Injury/killed?					
What happened to the predator?					
18. Have attacks by…..on people increased or decreased since you became a *moran*?					

Actions

	Yes	If yes, how often?	No	If no, why not?
19. Do people in this boma ever need to use poison or traps to control predators?				
20. How many lion hunts have you been on?				
21. How many lions did your age set kill?				

	Yes/No	If yes, what kinds?	How many?
22. Have you ever killed a predator yourself?			
23. Has anyone else in the boma ever killed a predator?			

Livestock husbandry

24. Who usually looks after your stock?

Cattle _____
Smallstock _____
Donkeys_____

25. How are your stock tended to at night?

	Roam in veld	In stone boma	In thornbush boma	Bedded down in veld	Other (specify)
Cattle					
Smallstock					
Donkeys					

26. Boma characteristics

	Boma height	Boma width	Proportion stems out	No. weaknesses	Overall quality
Cattle					
Smallstock					
Calves					
Donkeys					

27. Do you have a guard dog with your:
Cattle? Yes/No/NA **Smallstock?** Yes/No/NA **Donkeys?** Yes/No/NA

28. What do you think are the most effective ways of protecting livestock from predators?

_____
_____
_____

29. Do you use these methods? If not, why not?

_____
_____
_____

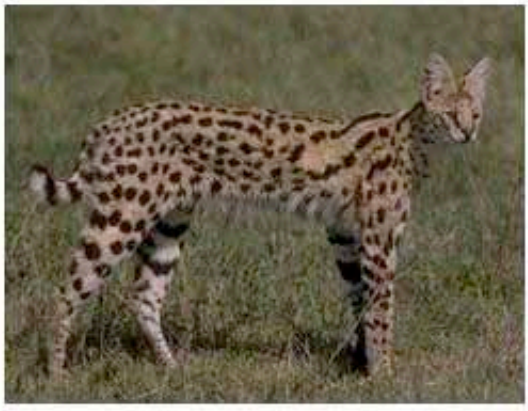
Thank you for your participation!

Appendix II: Photographs used to identify survey species

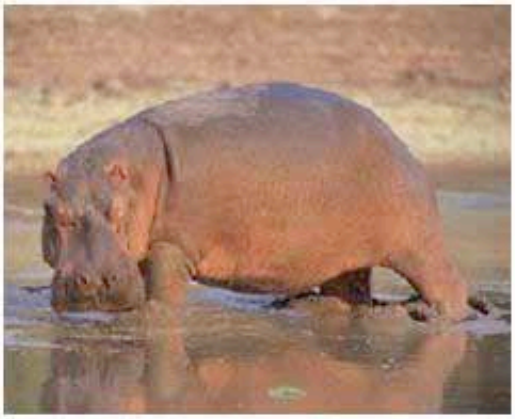
Buffalo

Spotted hyaena

Crocodile



Serval



Hippopotamus

Zebra

Striped hyaena

Warthog

Wildebeest

Lion

Puff adder

Elephant

Leopard

Jackal

Black rhino

Tiger

African wild dog

Giraffe

Impala

Cheetah