

Human–carnivore conflict over livestock in the eastern part of the Serengeti ecosystem, with a particular focus on the African wild dog *Lycaon pictus*

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Abstract During 2007–2009 we conducted a survey of attacks by wild carnivores on the livestock of the Maasai and Sonjo tribes in the eastern Serengeti ecosystem of northern Tanzania. Local enumerators systematically recorded incidents of carnivore predation on livestock and their data were quantified by us, with the aid of District Game Officers or trusted local people. The annual rate of attack by African wild dogs *Lycaon pictus* was significantly higher (1.42 animals per 1,000 livestock) in the Sonjo tribal area than in the Maasai tribal area (0.72 animals per 1,000 livestock). In the Maasai tribal area there was a significant amount of predation by leopards *Panthera pardus* and spotted hyaenas *Crocuta crocuta*. In both tribal areas sheep *Ovis aries* and goats *Capra aegagrus hircus* were subject to predation more frequently than cattle. Attacks on livestock by wild dogs occurred most frequently in the afternoon and evening, whereas other carnivores generally attacked livestock at night. Sheep and goats were most frequently attacked by most carnivores during the long rainy season. Cattle *Bos primigenius* were most frequently attacked by wild dogs and leopards during the long dry season and by lions *Panthera leo* during the long rainy season, whereas spotted hyaenas killed cattle most frequently during the short rainy season.

Keywords African wild dog, human–carnivore conflict, large carnivore species, livestock attacks, *Lycaon pictus*, Serengeti, Tanzania

Introduction

Human–carnivore conflict over livestock presents a challenge for both wildlife conservationists and farmers (Diamond, 1997; Chen et al., 2007; Kissui, 2008; Driscoll et al., 2009). It is a global problem (Ciucci & Boitani, 1998; Røskaft et al., 2003, 2007; Treves & Karanth,

2003; Rodney & Rinchen, 2004; Woodroffe et al., 2005) and the decline of many large wild carnivore species is at least partly attributable to revenge killing as a result of predation on livestock (Woodroffe et al., 2005). The African wild dog *Lycaon pictus* is one of the species that has declined because of such conflicts (Woodroffe et al., 2005). It has disappeared from much of its former range (Rasmussen, 1999) and there are only c. 8,000 individuals remaining in the wild (Swarnar, 2004; Masenga & Mentzel, 2005; Woodroffe et al., 2005).

Wild dogs were declared locally extinct in the Serengeti National Park in 1991 (Gascoyne et al., 1993; Creel et al., 1997; Stearns & Stearns, 1999; Carbone et al., 2005). However, c. eight packs of wild dogs were reported in the Park during 2008–2009. These packs, with fewer than 100 adults in total, inhabited the north-eastern part of the ecosystem (Masenga, 2011). Attacks on livestock by wild dogs have been reported in this area since 2000, when packs began to reappear there (Masenga & Mentzel, 2005).

Wild dogs have been reported to prey on livestock near human communities (Rasmussen, 1999; Swarnar, 2004). Experience in East Africa shows that conflict between humans and wild dogs occurs in human-dominated landscapes when the contact between wild dogs and livestock increases (Thomas, 2000; Woodroffe et al., 2005). In southern Africa most conflict with wild dogs occurs outside protected areas; e.g. on communal lands and outside fenced areas (Lindsey et al., 2005). Other large carnivore species also come into conflict with humans as a result of habitat loss caused by human population growth (Kolowski & Holekamp, 2006; Kissui, 2008). The aim of this study was to assess the patterns of attack related to such conflict, and their magnitude, in the eastern part of the Serengeti ecosystem. We focused on the African wild dog and, for comparison, on other large carnivore species in the area (lions *Panthera leo*, leopards *Panthera pardus*, spotted hyaenas *Crocuta crocuta*, striped hyaenas *Hyaena hyaena* and cheetahs *Acinonyx jubatus*).

Study area

The study was conducted in the eastern part of the Serengeti ecosystem, which covers the Loliondo Game Controlled Area and a small portion of the Ngorongoro Conservation Area (Fig. 1). The Maasai and Sonjo tribes inhabit these areas.

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Received 20 June 2012. Revision requested 7 November 2012.

Accepted 19 November 2012. First published online 30 January 2014.

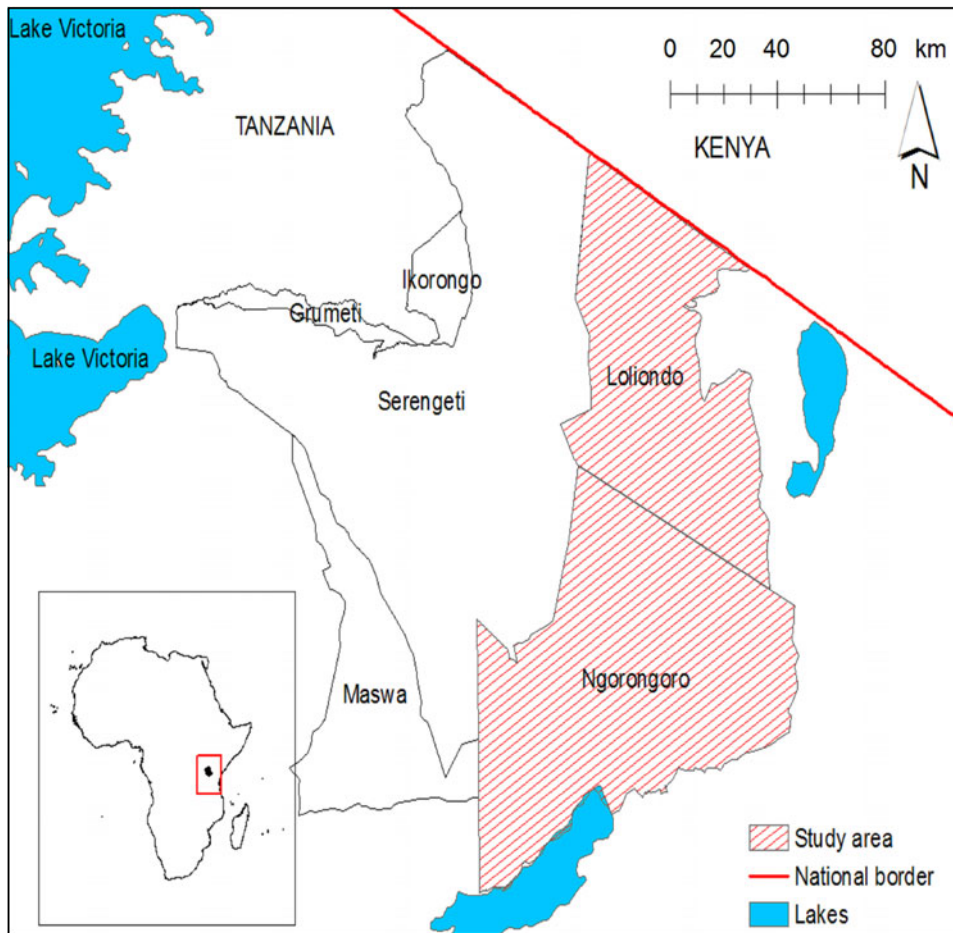


FIG. 1. The location of the two study areas, Loliondo and Ngorongoro, in the north-east of the Serengeti National Park, Tanzania. The rectangle on the inset shows the location of the Serengeti ecosystem in Africa.

The Maasai are nomadic pastoralists and live near the Serengeti National Park. The Sonjo are agro-pastoralists and live in permanent settlements some distance from the Park (Fig. 1; Maddox, 2003; Masenga & Mentzel, 2005).

The Loliondo Game Controlled Area is located in the Maasai ancestral lands in the northern part of Tanzania and covers c. 4,500 km². It is a multiple land-use area and forms the eastern boundary of the Serengeti ecosystem (Fig. 1). The human population increases gradually from south to north, with the highest densities found around Wasso, the town of Loliondo and the area near the Kenyan border. In the south the human population mainly comprises nomadic Maasai, who inhabit the area at a low density. The density of resident wild herbivores in the area is also low, as a result of overgrazing and trophy hunting (Holdo et al., 2010). Rainfall is bimodal, with peaks in December and April and an annual total of 400–1,200 mm (Jaeger, 1982; Maddox, 2003; Masenga & Mentzel, 2005). The area is dominated by open woodland and grassland (Sinclair et al., 2002). Open woodland is mostly found in the northern part of the area on rolling hills, interspersed with rocky outcrops. In the central part there are mountains with steep slopes and densely vegetated gullies. The open areas in the lowlands are either cultivated land or open woodlands

(Sinclair et al., 2002). The southern part of the area includes short grasslands (Masenga & Mentzel, 2005).

Methods

Data collection

Between July 2007 and June 2009 information on carnivore attacks on livestock was gathered by eight enumerators trained to collect data for wildlife research. Prior to training the enumerators we informed them, and all local people, that there was no compensation scheme for livestock losses to predators in mainland Tanzania. This information was supplied to ensure that the livestock keepers provided valid responses to the management authority. The enumerators were educated at least to primary level and were chosen randomly from local communities, and based on interviews to evaluate their knowledge and research skills. Before beginning the fieldwork the enumerators received training from us, including instruction on the use of a global positioning system unit and on the completion of the standard form developed to record incidences of carnivore conflict. The form was divided into three sections: herder

TABLE 1 Number of attacks by carnivores on livestock on the Maasai and Sonjo tribal lands (Fig. 1) in the eastern Serengeti ecosystem during 2007–2009.

Carnivore species	Maasai tribal land	Sonjo tribal land
	No. of attacks (%)	No. of attacks (%)
Wild dog <i>Lycaon pictus</i>	229 (47.8)	111 (99.1)
Lion <i>Panthera leo</i>	28 (5.8)	0
Leopard <i>Panthera pardus</i>	99 (20.7)	0
Spotted hyaena <i>Crocuta crocuta</i>	95 (19.8)	1 (0.9)
Other carnivores (5 cheetahs <i>Acinonyx jubatus</i> , 23 striped hyaenas <i>Hyaena hyaena</i>)	28 (5.8)	0
<i>Total</i>	479	112

information, carnivore species involved in the attack, and information on the livestock attacked (goats, sheep, cattle or donkeys *Equus africanus asinus*). The enumerators were also trained to ensure that information was collected as soon as possible and not more than 24 hours after an attack. We normally visited villages on a monthly basis. With the aid of village officers or other trusted members of the community we revisited all bomas where incidences of conflict had been reported by enumerators. We used a checklist of carnivore species to cross-check the information reported by the enumerators. Data that were considered incorrect were rejected. We also followed ground tracks of wild dogs attacking livestock and recorded all sightings of wild dogs. The enumerators used photographic ID to identify the packs responsible for attacks in the region, identifying eight packs in total, six in the Maasai tribal area and two in the Sonjo tribal area. In total 591 incidences of human–carnivore conflict were recorded and confirmed. In addition, secondary data were obtained from the employees of the wildlife department, community representatives and people with experience of conflicts with carnivores. These data included the total number of livestock and the number of households in the area, based on census data from 2008–2009. The livestock population included 246,786 sheep and goats and 149,614 cattle. The Maasai tribe owned 318,209 animals and the Sonjo tribe owned 78,191 animals, giving a total livestock population of 396,400.

Data analyses

The data on carnivore predation on livestock were summarized and analysed using SPSS v.17 (SPSS, Chicago, USA). We performed nonparametric tests for all analyses. The carnivore species responsible for livestock loss were wild dogs, lions, spotted hyaenas, striped hyaenas, leopards and cheetahs (Table 1). Hereafter, we refer to two groups of prey: sheep and goats, and cattle. Few donkeys were attacked, and therefore we excluded them from our analysis. All statistical tests were two-tailed and the significance level was set at $P \leq 0.05$.

Results

Livestock attacks by carnivores

African wild dogs were the most common livestock predator in both tribal areas, responsible for 47.8% of attacks on livestock in the Maasai tribal area and 99.1% of attacks in the Sonjo tribal area (Table 1). Approximately 20% of the attacks in the Maasai tribal area were carried out by leopards and spotted hyaenas, compared to 0.9% (hyaenas) in the Sonjo tribal area. Lions were responsible for 5.8% of attacks in the Maasai tribal area, where cheetahs and striped hyaenas were together responsible for a further 5.8% of attacks (Table 1). There was a significant difference in the frequency of attacks by the different carnivores between the two areas ($\chi^2 = 97.8$, $df = 8$, $P < 0.001$; Table 1). The annual rate of attack per 1,000 livestock differed between the two tribes. The Maasai tribe lost 0.72 animals per 1,000 per year, whereas the Sonjo lost 1.42 animals per 1,000 per year. This difference was highly significant ($\chi^2 = 100.5$, $df = 1$, $P < 0.001$). Although the absolute number of attacks by wild dogs was higher in the Maasai tribal area, the rate of attack was significantly higher in the Sonjo tribal area. The rate of attack by other carnivores (combined) was significantly higher in the Maasai tribal area (0.81 per 1,000 livestock per year) than in the Sonjo tribal area (0.01 per 1,000 livestock per year; $\chi^2 = 97.8$, $df = 1$, $P < 0.001$).

Most attacks on cattle, sheep and goats were by African wild dogs, although they killed more sheep and goats than cattle. Leopards and spotted hyaenas were also reported to kill more sheep and goats than cattle (18.3% and 16.7%, respectively; Table 2), whereas lions were the only carnivore species that killed more cattle than sheep and goats (Table 2). The rates of predation on sheep and goats and on cattle differed significantly between the different carnivore species ($\chi^2 = 155.9$, $P < 0.0001$; Table 2). Striped hyaenas and cheetahs killed only sheep and goats (Table 2).

The rates of attack on sheep and goats differed significantly between the two tribal areas ($\chi^2 = 93.9$, $df = 8$, $P < 0.001$; Table 2). African wild dogs were responsible for all of the attacks on sheep and goats in the

TABLE 2 Total number of attacks by carnivores on cattle *Bos primigenius* and on sheep *Ovis aries* and goats *Capra aegagrus hircus* in the two study areas (Fig. 1) during 2007–2009.

Carnivore species	No. of attacks on cattle (%)		No. of attacks on sheep & goats (%)		Total no. of attacks (%)
	Maasai	Sonjo	Maasai	Sonjo	
Wild dog	36 (43.4)	4 (80.0)	193 (38.0)	107 (100)	340 (56.7)
Lion	26 (31.3)	0	2 (0.004)	0	29* (4.8)
Leopard	6 (7.2)	0	93 (18.3)	0	100* (16.6)
Spotted hyaena	10 (12.1)	1 (20.0)	85 (16.7)	0	101* (16.6)
Other carnivores	0	0	28 (5.5)	0	28 (0.7)

*The total numbers are higher than the sum of cattle, sheep and goats because they include donkeys.

TABLE 3 Total number of attacks by carnivores on cattle and on sheep and goats in the two study areas (Fig. 1) in different seasons during 2007–2009.

Carnivore species	No. of attacks on cattle (%)				No. of attacks on sheep & goats (%)			
	Short dry season (Jan.–Feb.)	Long rainy season (Mar.–May)	Long dry season (June–Oct.)	Short rainy season (Nov.–Dec.)	Short dry season (Jan.–Feb.)	Long rainy season (Mar.–May)	Long dry season (June–Oct.)	Short rainy season (Nov.–Dec.)
Wild dog	15	25	55	5	9	55.3	19.3	16.3
Lion	19.2	50	26.9	3.8	0	100	0	0
Leopard	0	33.3	66.7	0	2.1	46.2	26.9	24.7
Spotted hyaena	9.1	27.3	18.2	45.5	21.4	32.1	28.6	17.9
Other carnivores	0	0	0	0	0	10.7	0	89.3

Sonjo tribal area but only 38% of the killings in the Maasai tribal area (Table 2). Lions were responsible for 31.3% of the attacks on cattle in the Maasai tribal area but did not kill any cattle in the Sonjo tribal area (Table 2).

A similar (but not statistically significant) difference between the two tribal areas was found for the rates of attacks on cattle, with lions responsible for 31.3% of the attacks on cattle in the Maasai area (Wilcoxon W, $z = -1.101$, $df = 2$, $P = 0.271$; Table 2; leopards, hyaenas and other carnivores were pooled).

Season

Attacks occurred during all seasons of the year. Attacks on sheep and goats by most predators were significantly more frequent during the long rainy season ($\chi^2 = 112.1$, $df = 8$, $P < 0.001$), whereas most cattle were killed by wild dogs during the long rainy season and by lions and leopards during the dry season ($\chi^2 = 26.95$, $df = 6$, $P < 0.001$; Table 3). Striped hyaenas killed sheep and goats during the short rainy season (November–December), whereas cheetahs killed sheep and goats during the long rainy season (March–May; Table 3). Spotted hyaenas killed cattle most frequently during the short rainy season (Table 3).

Time of day

Carnivore attacks were reported to occur at any time during the day or night. The patterns of attacks differed

significantly between species, depending on the time of day (sheep, goats and cattle pooled; $\chi^2 = 249.1$, $P < 0.001$; Table 4). Attacks by wild dogs were reported to occur primarily in the evening (87.2% for cattle and 41.8% for sheep and goats; Table 4). However, most other carnivores attacked sheep and goats most frequently during the late evening and night (Table 4). Cattle were only killed by spotted hyaenas during the night but were killed by all carnivores during the day (Table 4). Very few attacks by other carnivores occurred during the early morning.

Discussion

Incidences of attack by wild dogs and other carnivores

African wild dogs are probably the most serious predator in both the Maasai and Sonjo tribal areas following their reappearance in the eastern part of the Serengeti National Park (Marsden et al., 2012). As a result of their large home range and their social lifestyle African wild dogs can consume large amounts of food relative to other carnivores (Rasmussen, 1999; Creel & Creel, 2002). Woodroffe et al. (2005) pointed out that wild dogs attack more sheep and goats in northern Kenya and our findings are consistent with this.

Wildlife population densities tend to be lower outside the Serengeti National Park than inside the Park and to decrease with increasing distance from the Park (Setsaas et al., 2007),

TABLE 4 The percentage of attacks that occurred at different times of the day, by wild dogs, lions, leopards, hyaenas and other carnivores on sheep and goats and on cattle in the north-eastern Serengeti ecosystem (Fig. 1) during 2007–2009.

Time	No. of attacks (%)				
	Wild dog	Lion	Leopard	Spotted hyaena	Other carnivores
Sheep & goats					
Early morning (06.00–08.00)	6.1	0	5.4	2.4	0
Morning (08.01–12.00)	20.5	0	7.5	15.7	17.9
Afternoon (12.01–16.00)	31.6	50	20.4	6.0	0
Evening (16.01–19.00)	41.8	0	29.0	43.4	0
Night (19.01–05.59)	0	50	37.6	32.5	82.1
<i>Total</i>	297	2	93	83	28
Cattle					
Early morning (06.00–08.00)	0	11.5	16.7	9.1	0
Morning (08.01–12.00)	2.5	19.2	0	9.1	0
Afternoon (12.01–16.00)	10.3	57.7	83.3	18.2	0
Evening (16.01–19.00)	87.2	11.5	0	27.3	0
Night (19.01–05.59)	0	0	0	36.4	0
<i>Total</i>	39	26	6	11	0

because of legal and illegal hunting, human encroachment and human activities in general (Holmern et al., 2007; Nyahongo & Røskaft, 2011). Normally, the densities and behaviour of wild dogs are negatively affected by the presence of other carnivore species in the Serengeti National Park (Estes & Goddard, 1967). Lions may directly cause pup mortality in wild dogs (Creel & Creel, 1996), and spotted hyaenas follow wild dogs hunting and steal their kills (Estes & Goddard, 1967; Creel & Creel, 1996; Carbone et al., 1997, 2005). For these reasons wild dogs are normally found in areas with low densities of other carnivores (Creel & Creel, 1996; Vucetich & Creel, 1999). The relative absence of other carnivore species is probably the main reason that wild dogs are the most common predator of livestock in this area.

Wild dogs and most of the other carnivores, except lions, preyed more frequently on sheep and goats than on cattle. This is because wild dogs, as well as leopards and both species of hyaenas, prefer medium-sized prey, within a bimodal body mass range of 16–32 kg to 120–140 kg (Estes & Goddard, 1967; Hayward et al., 2006; Woodroffe et al., 2007). They also prefer abundant prey species that have a relatively low probability of injuring the attacking predator (Hayward et al., 2006). However, lions prefer larger prey, including cattle (Kissui, 2008).

Season

Attacks on sheep and goats by most carnivores are more frequent during the long rainy season, although lions attack cattle more frequently during the long rainy season. The increased frequency of attacks on sheep and goats during the long rainy season is probably because wildebeest *Connochaetes taurinus* have migrated to the plains in the Ngorongoro area, south of the normal range of the wild

dogs, in search of high-nutrient pastures (Fig. 1; McNaughton, 1985; Wilmshurst et al., 1999; Maddox, 2003; Musiega & Kazadi, 2004). The livestock remain and are available as prey to the carnivores that continue to hunt in the area.

Wild prey species are abundant on the plains during the long rainy season. Nevertheless, more predation on livestock occurred in our study area during this season. The increase in attacks on livestock is probably associated with the annual calving of the wildebeest, which generally occurs during February and March (Ndibalema, 2009). During this period the wildebeest transmit malignant catarrhal fever, which causes many livestock fatalities (Bourn & Blench, 1999; Fyumagwa, 2010). To avoid exposure to this disease the Maasai usually move their animals from areas with favourable pastures on the plains to the highlands and hills but this increases the contact between livestock and wild dogs, which den in these areas (Masenga, unpubl. data). The rate of predation on livestock increases because wild dogs and the other carnivores are forced to prey on livestock if there are few or no wild prey species available (Woodroffe et al., 2005).

Attacks on cattle by wild dogs and leopards were most frequent during the dry season, when livestock herders move into forested mountain regions in search of pasture and water. These new pastures are especially important for cattle, which require more food than sheep and goats. The movement of both predators and livestock to these areas during the dry season increases the probability of contact between livestock and wild dogs.

Time of day

Wild dogs attack livestock at different times of the day compared to other carnivores. These differences are related

to the activity patterns of the wild carnivores in the area. For example, lions, spotted hyaenas and leopards are more active during the night, whereas wild dogs are only active during the day (Frank et al., 2005).

As a result of these activity patterns wild dogs attacked more livestock during the late afternoon and evening than at any other time of the day. Sheep and goats were attacked more than cattle during this time. The same pattern has been observed by other surveys (Creel & Creel, 2002; Frank et al., 2005; Woodroffe et al., 2005, 2007; Fuller & Kat, 2008). There are reports that wild dogs are usually active from 05.00 onwards (Estes & Goddard, 1967; Woodroffe et al., 2005) but we recorded few attacks on livestock during the early morning. This is because the Maasai and Sonjo tribes do not start to herd their livestock until later in the day, and wild dogs have rarely been found to prey on livestock inside or near bomas (Frank et al., 2005; Woodroffe et al., 2005). We found that wild dogs began to prey on livestock from 09.00 onwards, when most herders began to take their livestock out to graze. Before 09.00 wild dogs tend to attack wild prey rather than livestock (Woodroffe et al., 2005). After 09.00 they switch to livestock if they have been unsuccessful in hunting wild animals. Such prey switching has been found to increase in the study area and elsewhere from 10.00 onwards, reaching a peak at c. 16.00 (Woodroffe et al., 2005).

Conclusions

We conclude that losses of livestock to wild dogs and other carnivores are not critical in the study area. The approximate annual rate of loss is one animal per 1,000 livestock. However, every animal has a cultural and sentimental value to the Maasai and Sonjo tribes. For this reason any occurrence of predation causes a great outcry. We therefore recommend that the intensity of herding should be increased at all times, especially during the afternoon and evening as well as during seasonally sensitive periods.

Acknowledgements

We acknowledge the Tanzania Wildlife Research Institute and Frankfurt Zoological Society, both of which provided financial support and helped with field equipment. We are indebted to the staff of the Serengeti Wildlife Research Centre for their help during data collection, and we thank all those who participated in making this project possible. This work is part of a larger Serengeti Wild Dog Conservation Project financially supported by Frankfurt Zoological Society, Vodacom Tanzania Ltd and Ngorongoro District Council in the Serengeti Ecosystem.

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