The influence of the Makgadikgadi fence and the re-flowing of the Boteti River on the temporal distribution of human/lion conflict

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Abstract

Incidents of conflict between humans and lions are influenced by a number of factors, some of which are barriers such as fences and rivers. Conflict between carnivores and farmers led the Botswana government to construct a fence along the Boteti River between the years 2004 and 2005 to separate wildlife inside the Makgadikgadi Pans National Park (MPNP) from farmers. Although the fence became porous over time, the reflowing of the Boteti River in 2009 provided a further barrier. The main objective of this study was to assess the influence of the fence and the reflowing of the Boteti River on the temporal distribution of lion predation upon livestock along the Boteti River region. We also determined the level of livestock predation by lions when compared to other carnivores. In order to answer our questions, Problem Animal Control (PAC) reports for the years 2000–2012 from the Department of Wildlife and National Parks (DWNP) were studied. These data were subdivided into three time periods: Before Fence (BF) - when the fence was not yet constructed; After Fence (AF) - when the fence was erected but the river was not flowing; and River Flowing (RF) - when the fence was porous but the river was flowing. We found that lions were responsible for the majority of the reported incidents on livestock predation. There were fewer reported kills during AF period than during the other two periods, and that large livestock was the most affected. The erection of an electrified fence was found to be a more effective method of reducing the numbers of livestock animals killed by lions than the barrier created by the river flowing. We concluded that the continuous maintenance of the fence is necessary to ensure that it forms an effective barrier between livestock and predators.

Key words: Makgadikgadi, Boteti River, human-lion conflict, fence, lion

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Introduction

Carnivore predation on livestock is a challenge for both carnivore conservation (Winterbach et al. 2013; Watson et al. 2014) and pastoralist livelihoods (Macdonald and Sillero-Zubiri 2002; Hemson 2003; Patterson et al. 2004) especially in communities living near a Protected Area (PA) (Van Bommel et al. 2007; Loveridge and Canney 2009; Watson et al. 2014). Conflict between carnivores and farmers intensifies when the carnivores in question are legally protected or when the livestock in question is the main source of pastoralists' livelihood. Fences have been erected to separate livestock from wildlife in several locations in Africa (e.g. Zimbabwe: Sengwa Wildlife Research Area (Butler, 2000); South Africa: Greater Kruger Area (Lagendijk and Gusset, 2008), and Phinda Private Game Reserve (Hunter et al., 2007)). By separating wild from domestic herbivores, fences have the potential to reduce competition for resources between wild and domestic animals (Tambling and Du Toit 2005; Hazelhurst and Kolk 2006). Although fences are considered to be effective at preventing conflict between wildlife and humans, they do not prevent penetration by those animals that can dig underneath them (Kesch, Bauer and Loveridge, 2015).

Some studies show that rivers can act as natural barriers to carnivore movement (Sahil Nijhawan 2008; Cozzi et al., 2013). However, Cozzi et al., (2013)'s study in the Okavango Delta, Botswana, shows that rivers and floodplains are more permeable to lions when the water level is low. The Boteti River has been reported as a significant factor in the distribution of wildlife and livestock, especially during dry seasons (Kgathi and Kalikawe 1993; Omphile and Powell 2002; Hemson, 2003b; Epaphras et al. 2008; Ngaka 2016), and people often settle along rivers (Cassidy 2003; Fritz et al. 2003). Furthermore, lions often hunt near watering points (de Boer et al., 2010; Valeix et al., 2010; Davidson et al., 2013). This creates opportunities for human-wildlife conflict.

Our paper investigates the influence of the newly erected electric predator-proof fences along the boundary of a national park that follows the Boteti River on the incidences of lion predation on livestock in the western part of Makgadikgadi Pans National Park (MPNP), Botswana. This area provides an ecological 'experimental' site because the Boteti River stopped flowing in 1980 (Gieske 1996; Sefe et al. 1996) and the only surface water available for wildlife and communities along the western part of MPNP are pockets of seasonal pools left along the Boteti River (Hemson, 2003a). This significantly increases the chances of contact between livestock and carnivores (Brooks and Maude, 2010). To mitigate this, the Government of Botswana constructed a predator-proof electric fence (hereafter referred to as "fence") along the Boteti River in order to reduce the conflict between carnivores in the MPNP and livestock in the western part of MPNP (Gupta, 2005; Hazelhurst & Kolk, 2006). The study focuses on three time periods in order to understand the influence of the fence and the river-flow on the conflict: 1) before fence (thereafter referred to as BF - between the years 2000-2003 when there was no fence and the Boteti river was not flowing; 2) after the fence (hereafter referred to as AF – between the years 2006–2008 when the fence was operational but the river was not flowing; 3) river flowing (hereafter referred to as RF – between the years 2010-2012 when the Boteti River was flowing and the fence was damaged). The objective of this study is to investigate and compare the incidences of lion predation on livestock during these three periods.

METHODS

Study site

This study was carried out in communal areas along the western part of MPNP (See Figure 1 below). MPNP falls within a range of 20-21°South and 24-26°East and covers approximately 4,900km^2.

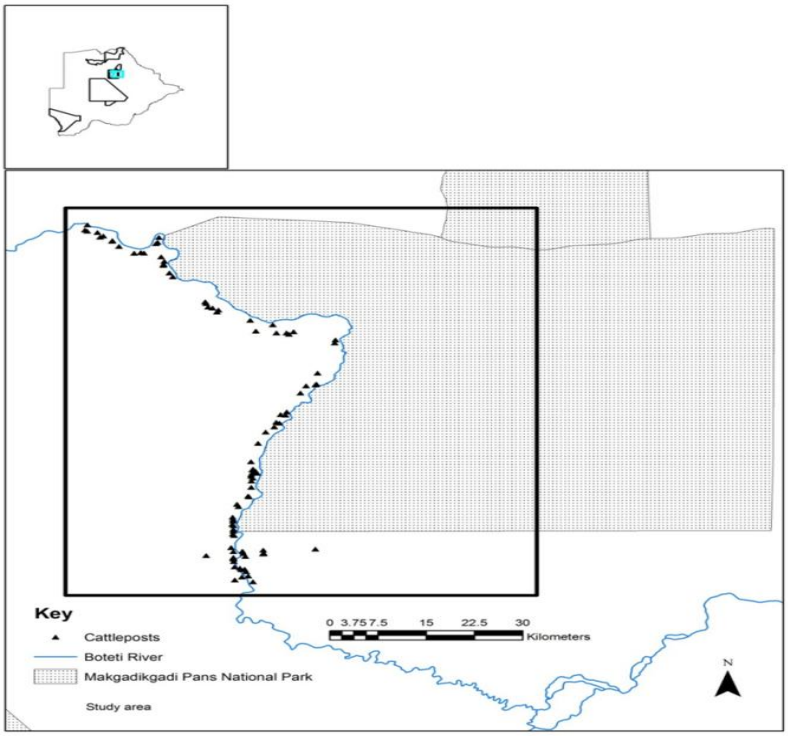


Figure 1: The locations of cattle posts surveyed along the Boteti River. **Source**: ORI GIS Lab

The study area is located close to the Boteti River. The western area of MPNP consists of relatively thick vegetation which includes camel-thorn tree (*Vachellia erioloba),* umbrella-thorn tree (*Vachellia tortillis*), blackthorn tree (*Vachellia mellifera*) and sicklebush (*Dichrostachys cineria*). Wildlife species found within MPNP and the surrounding areas includes elephant (*Loxodonta africana*), impala (*Aepyceros melampus*), greater kudu ((*Tragelaphus strepsiceros*), Zebra (*Equus quagga burchelli),* and steenbok (*Raphicerus campestris*) and migratory species such as zebra (*Equidae equus*) and wildebeest (*Connochaetes taurinus*). These migratory wildlife species are the preferred prey of lions (Hayward and Kerley, 2009). Large carnivores found in the area include lion (*Panthera leo*), brown hyena (*Hyaena brunnea*), spotted hyena (*Crocuta crocuta*), leopard (*Panthera pardus*) and black-backed jackal (*Canis mesomelas*). The people resident in the study area rely predominantly on pastoral farming (Hemson *et al.*, 2009). Local rainfall ranges between 50mm - 1200mm per annum (Thomas and Shaw, 1991) and normally falls between November and April. Due to the unavailability of water in neighbouring areas, farmers in this region are located within 6km to the Boteti River (Figure 1) for easy access to

water for livestock and other domestic uses. Livestock species kept by farmers include cattle, horses, donkeys, goats, sheep, chicken and domestic dog. Cattle are predominant because of their traditional role as symbols of wealth and their cultural role in the payment of bride price and other traditional rites. The majority of the livestock graze in open communal areas and are kraaled during the night.

Data collection and analysis

Confirmed incidents of lion predation on livestock in the study area were obtained from the Problem Animal Control (PAC) unit of the Department of Wildlife and National Parks (DWNP). The PAC records information on incidents of wildlife species causing damage to human property. This information includes the date of the incident, the name of the livestock owner, the type and number of livestock species predated upon, the location of the incident, and the wildlife species which caused the damage. PAC data for the years 2000-2012 was collected from DWNP at the Rakops office. Since the fence was constructed in 2004-05, data gathered during these years were excluded from the analysis. In addition, data for the year 2009 were also excluded because the Boteti River started flowing only in mid-2009. Livestock kills were then grouped according to their body mass range from large - 180-300kg (bull, cow, ox, heifer and horse), to medium - 110-130kg (donkey), to small - 34-80kg (calf, foal, sheep and goats).

Data were analysed using the IBM Statistical Package for Social Sciences (SPSS) Statistics 21 software. Livestock kill incidents were grouped into the three study periods (BF, AF, and RF) and the two seasons (wet and dry) in order to assess the temporal distribution of human/lion conflict in the area. The data met the normality assumptions after being tested with Levine's test. The analysis of variance (ANOVA) test was used to find out whether there was a significant difference in the reports on lion predation during the three study periods and seasons. ANOVA was also used to test for any significant difference in the number of livestock killed and their body mass for the three study periods and seasons. Furthermore, the least significant difference (LSD) test was used in order to find the significant difference between variables.

Jacobs' index (Jacobs 1974) was used to determine lion/livestock prey preference:

$$D = \frac{r - p}{r + p - 2rp}$$

Where D is the lion's livestock prey preference, r is the proportion of lion's total kills for a particular livestock type in a certain site, and p is the proportion of the abundance of that particular livestock species. The outcome of the calculations ranged from +1 (greatly preferred livestock prey), 0 (expected livestock prey) to -1 (greatly avoided livestock prey). The preference range was further sub-divided into 5 levels: >+0.51 to +1.0 (greatly preferred), +0.1 to +0.50 (preferred), +0.1 to -0.1 (according to availability), -0.1 to -0.5 (avoided), and <-0.51 to -1 (greatly avoided).

Results

From 2000-2012, 1796 livestock were killed by carnivores in the study area (Table 1). Lions accounted for 74% of the mortalities, followed by leopards (11%), wild dogs (*Lycaon pictus*)

(7%), cheetah (*Acinonyx jubatus*) (3%) and crocodile (*Crocodylus niloticus*) (2 %). Occasionally hyenas, jackals and caracals (*Caracal caracal*) also killed livestock. Lion predation on livestock was higher in both BF period (25.3 ±2.9 reports/month) and RF period (27.4 ±3.4 reports/month) than in AF period (11.2 ±3.4 reports/month) ($F_2 = 7.01$, $P < 0.05$) (see Figure 2 below).

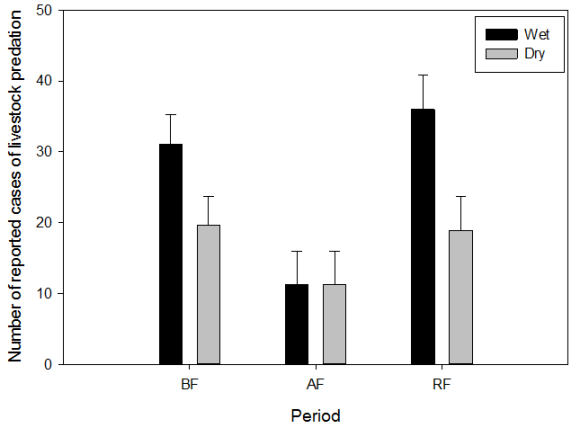
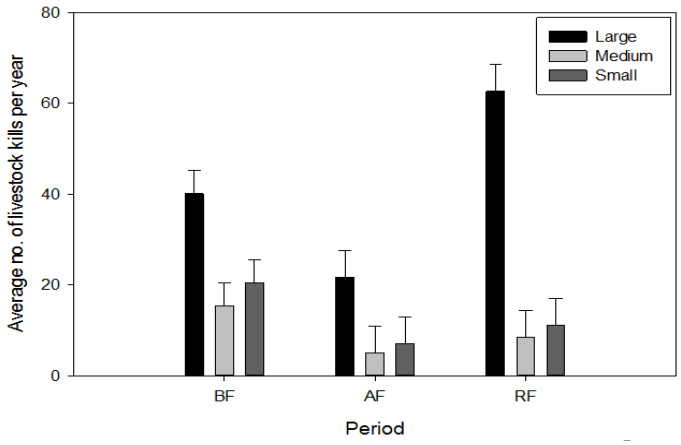


Figure 2: Conflict level before and after fence erection and river flow during wet and dry seasons.

Reports for BF period were not significantly different from RF period (post hoc test, $P > 0.05$) (Figure 2). However, reports for AF period were significantly different from those in BF and RF periods (post hoc test $P < 0.05$). Wet season monthly reports (26.1 ± 2.6) were significantly higher than those for dry seasons (16.6 ± 2.6) ($F_1 = 6.51$, $P < 0.05$) (Figure 2). Reports for the wet seasons during BF and AF periods were significantly higher than those for dry seasons ($P < 0.05$ for all comparisons, Figure 2) while reports between seasons were not significantly different for the AF period ($F_1 = 6.51$, $P > 0.05$) (Figure 2).

The number of large livestock kills by lions were significantly higher than that of medium and small stock kills (Large: 41.5 ±3.2 reports; Medium: 9.6 ±3.2 reports; Small: 12.9 ±3.2 reports) for all periods ($F_2 = 29.3$, $P < 0.05$) (Figure 3) and seasons (F_1, $P < 0.05$) (Figure 3).



Figur in the Boteti River area.

The grouping of the livestock kills was done according to the prey animals' body-mass for the reported lion kills cases attended to by DWNP. We observed a significant decline in the number of large livestock predated upon by lions between BF and AF periods, and a significant increase in those during AF and RF periods (Figure 3). The average number of large livestock predated upon by lions per month was 40.1 ± 5.1, 21.7 ± 5.9 and 62.7 ± 5.9 for BF, AF and RF periods, respectively. There were no significant changes in the number of medium and small livestock predated upon by lions during the three periods (Figure 3). Although lion preyed more often on large livestock and less often on small and medium livestock (figure 4), all livestock types were preferred during BF period (D > 0.1, Figure 4).

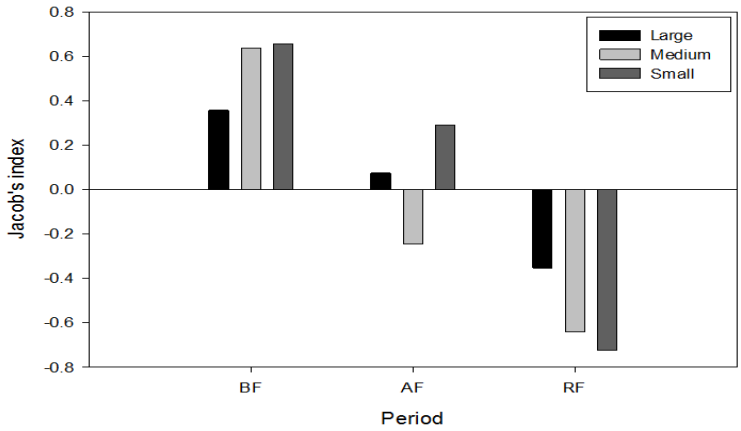


Figure 4: Lion prey (livestock) preference at different periods calculated from Jacob's index of preference.

The results of the analysis show that only medium sized livestock were avoided during AF period. During RF period all the livestock groups were avoided; medium and small stock were greatly avoided while large livestock were avoided.

In the table below the results show the cumulative number of domestic animals killed by predators from the period 2000-2012; the years 2004, 2005 and 2009 were excluded for the reasons discussed above.

Table 1: Cumulative number of livestock killed by different carnivores in the study area.

Carnivore species	Reported livestock kills	Percentage (%)
Caracal (*Caracal caracal*)	1	0.06
Cheetah (*Acinonyx jubatus*)	44	2.45
Crocodile (*Crocodylus niloticus*)	38	2.12
Hyena (*Crocuta crocuta*)	16	0.89
Jackal (*Canis mesomelas*)	9	0.50
Lion (*Panthera leo*)	**1334**	**74.28**
Leopard (*Panthera pardus*)	206	11.47
Wild-dog (*Lycaon pictus*)	148	8.24
TOTAL	**1796**	

Discussion

Conflict between lions and farmers is high during the BF and RF periods. Lack of barriers between the park and the farmers is likely to have contributed to this. A previous study for this period (Hemson, 2003a) found that cattle moved into the park and were frequently left outside their kraals at night. Lion predation on livestock for the RF period was the highest during that period, suggesting that that river was permeable to lions (Cozzi *et al.*, 2013). The AF period has a smaller number of PAC reports (Figure 2) because the conflict-fence was electrified and succeeded in keeping lions and livestock separate. As a result, a smaller number of lion predation on livestock cases was reported during AF period as the fence had reduced the chances of contact between livestock and predators. Although lion predation on livestock was reduced during this period, a few incidents were still recorded. This can be explained by other possible factors such

as lions digging underneath the fence. Also, some lions could have remained outside the park when the fence was constructed.

Lions are responsible for more livestock predation than other carnivores as shown on Table 1. This may be due to the fact that lions are larger than other carnivores such as leopards and they live in medium to large prides, and therefore their energy requirement tends to be higher, so they hunt more frequently. One of our predictions was that lion predation on livestock would decrease when the fence was intact and the river was flowing because the two factors were expected to be effective barriers to lions' contact with livestock. This hypothesis is not supported by the data. Lion predation on livestock was as high during BF as during RF period (Figure 2). It is likely that lack of a barrier during the BF period led to this high conflict level between lions and farmers. Secondly, the water-pools which occurred along the river may have resulted in congregations of livestock and lions in smaller areas, leading to more direct contact between lions and livestock for the BF.

Further analysis shows that cumulatively, the BF and RF periods have greater lion predation on livestock incidents than the AF period (Figure 2). Since there was no barrier during the BF period lions and livestock could interact. During the RF period the greater conflict level may have been caused by weaknesses in the fence, as suggested by Kesch (2015), and because the expected barrier (river) was partially permeable. This permeability of the river and possible weak areas in the fence may have led to lions killing livestock inside and outside the park. The conflict level was also higher during the wet season than during the dry season for the BF and RF periods, whereas it was not significantly different for the AF period. This is because the migratory wild prey - zebra and wildebeest – move away from the Boteti region to the eastern side of the park in large numbers after it has rained, therefore leaving livestock as the only available prey (Hemson, 2003). During the AF period, when the fence was mainly intact, even though the migrating animals left the Boteti, the lions killed fewer livestock than during other periods. The conflict levels are significantly higher for wet and dry seasons during BF and RF period since the potential barrier of the Boteti River may have failed to separate lions from livestock, leaving them to continue interacting directly. Water-bodies are considered to be more permeable to lions than fences (Cozzi et al., 2013), which could contribute to more reported incidents during RF period. In addition, water in the Boteti River contributed to the higher conflict level as both lions and livestock could easily meet at this watering point which encourages their interaction and subsequent conflict. Bauer et al. (2010) also indicated that HWC is normally intense in rangelands with permanent water supply shared by wildlife and livestock.

Hemson (2003) found that some lions remained at the Boteti River region when migratory wild-prey (zebra and wildebeest) had moved to the east of the MPNP, changing their diet to livestock during wet seasons which lead to higher conflict levels. Furthermore, some livestock strayed and failed to return for kraaling since farmers and herders passively waited for them to come back for the night (Hemson, 2003). Hemson (2003) argued that failure to kraal livestock during the night led to most of the livestock being killed outside the kraals. However, it is possible that farmers reported livestock kills as being caused by lions rather than by other carnivores in order to claim compensation since lion kills are the only ones for which farmers receive compensation. False claims increased because, according to the farmers, the reaction from DWNP to verify which carnivore made a kill was very slow. In addition, lions are able to steal kills from other smaller carnivores such as wild dogs, which could increase the chances of mistaken identity of the carnivore that actually made the kill.

There was a decrease in the number of kills of large stock from BF to AF period since there was an effective barrier that separated lions from livestock. The large livestock group was highly predated upon by lions during the BF and RF periods (Figure 3). Additionally cattle, which form the majority of the large livestock, are capable of moving longer distance from the cattle post compared to other livestock species (Hemson, 2003). This increases their chances of coming into contact with lions, especially when they move towards the park boundary. An increase in grazing distance increases vulnerability to predation. Compared to other livestock, cattle depend on water-point and forage quality, but these are not easily found within a short distance of each other so that after drinking cattle may have to travel long distances to find pasture. Some farmers do not kraal their cattle and donkeys during drought periods so that they can eat grass in the early mornings while it is still moist from morning dew. This forces cattle to move longer distances to find pasture and risk being killed by predators. However, this study does not investigate the reasons why cattle appear to be the preferred prey for lions.

Medium and small sized livestock kills did not change significantly between the three study periods, whereas a greater number of the large sized group was killed during the RF period (Figure 3). Even though the small group appears to be affected less frequently, it might be killed at higher numbers per incident compared to the other groups. This is because small sized kills are known to be under-represented in many studies of large carnivore diets as they are consumed whole or entirely removed by scavengers (Radloff & Du Toit, 2004).

In conclusion, the results of this study show that lion predation was high during the period when the fence was intact. This suggests that if well maintained, fences can mitigate the predation on livestock by carnivores. In addition, the availability of water led to avoidance of all livestock prey species by lions, because their wild preferred prey (zebra and wildebeest) densities were higher (Brooks & Maude 2010; Valeix et al. 2012; Ngaka 2016).

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