Human-wildlife interactions in the Western Terai of Nepal. An analysis of factors influencing conflicts between sympatric tigers (Panthera tigris tigris) and leopards (Panthera pardus fusca) and local communities around Bardia National Park, Nepal

Upadhyaya, S.K.

4

Spatiotemporal patterns of human-wildlife interactions

"Spatiotemporal patterns of human-wildlife interactions in the buffer zone of Bardia National Park, Nepal"

Subodh K. Upadhyaya, C.J.M. Musters, Ashok Bhandari, Babu Ram Lamichhane,
Geert R. de Snoo, Panna Thapa, Maheshwar Dhakal, Hans H. de Iongh.

(Submitted to the Journal of Wildlife Management)

Abstract

The spatiotemporal pattern of conflict incidences in the buffer zone of Bardia National Park over the period 2013-2017 was studied based on compensation paid to the victims. The majority of conflict incidences reported, included (fatal) human injury, crop damage and property damage, as well as livestock predation. Elephants and leopards were responsible for the majority of conflict incidences, followed by tigers and wild boars. The elephant was responsible for killing 14 people during the study period, while wild boar killed one person. Neither tigers nor leopards had been reported to have contributed to human fatalities around Bardia. The conflicts caused by elephants peaked during the autumn season when their favored matured crop. Livestock predation by leopards peaked during the rainy season, whereas predation frequency by tigers was relatively constant throughout the year. There was a significant relationship between livestock predation and moon phase, with most predation incidences taking place during the new moon phase. Moon phase was not significantly related to conflict incidences caused by elephants. When comparing the conflict patterns in different sub-regions of the buffer zone, elephant, leopard and wild boar, but not tiger, showed significant differences between these sub-regions. In terms of monetary loss, most of the losses were attributed to elephants. A total of $ 61,085 was paid to villagers as compensation. Villagers living in the buffer zone mostly preferred electric fencing and improved enclosures in order to minimize human-wildlife conflicts.

Key words

buffer zone, carnivores, compensation, conflict, herbivores, moon-phase.

4.1 Introduction

Farmers in developing and biodiversity rich countries experience economic loss through the loss of their resources by negative interactions with wild predators and herbivores (Thinley et al., 2018). For this phenomenon the term 'human-wildlife conflict' is usually used, but this is misleading as it portrays wildlife as an antagonist with the conscious intent to interfere with people's lives and livelihoods, whereas the real conflict is between conservation and other human interests (Peterson et al., 2010; Redpath et al., 2015; Fisher, 2016). In this study we therefore only use the term 'conflict' to describe negative interactions between people and wildlife.

Besides the previously discussed conflict situations which arise from large predators attacking livestock or even people, other large mammals such as the elephant and rhinoceros may also cause conflicts by destroying agricultural crops or personal properties and by sometimes even fatally injuring people (Sukumar, 1991). Wherever conflicts with wild animals occur, they may cause a certain antipathy and negative attitude among people living in the periphery of natural reserves (Sukumar, 1991). As a result, the conservation of such 'high-risk' species near human settlements often generates a lot of debate as to what extent humans should tolerate the negative impact of these conflict causing species and what could be done to mitigate conflicts and prevent the locals from initiating retaliatory measures (Manral et al., 2016; Carter & Linnell, 2016; Lamichhane et al., 2018). Balancing the needs and aspirations of the often poor farmers living close to protected areas and the need of conserving endangered, large and dangerous animals is a challenging task in developing countries like Nepal (Wegge, et al., 2009).

Human intolerance towards conflict causing mammals is often based on misconceptions about the potential risk these animals pose to property, livestock and humans (Oli et al., 1994; Treves & Karanth, 2003; Pant et al., 2016). A poor understanding of the ecological role they play may also induce a certain resentment against conservation in general (Nyhus, 2016; Thinley et al., 2018). Human-wildlife conflict is one of the most critical threats faced by many wildlife species today, and the topic is receiving increasing attention from conservation biologists (Dickman, 2010). A good understanding of the patterns of human-wildlife conflict and identifying the causes is therefore key to formulating effective conservation strategies (Acharya et al., 2016). One aspect of conflict causing activities of large carnivores and herbivores that needs urgent attention is the spatial and temporal pattern of conflict and how this conflict differs between conservation areas (Wilson et al., 2013; Lamichhane et al., 2018a). For example, moon phase is reported to have an effect on conflict incidence in Africa and Nepal (Tumenta, 2012; Packer et al., 2011; Gunn et al., 2014; Lamichhane et al., 2018a). Crop raiding by African elephants was lower during the full moon phase (Gunn et al., 2014) whereas Lamichhane et al. (2018a) reported more incidents by Asian elephants during the full moon phase. Incidence of attacks on humans and livestock by large carnivores were shown to be lower during the full moon phase in some studies (e.g. Packer et al., 2011; Lamichhane et al., 2018a) while Tumenta (2012) did not report a significant effect of full moon phase on livestock depredation. Traill et al. (2016) reported that the proximity of lions and not the moon phase affects the behavior of prey animals such as zebra and wildebeest. The effect of moon phase on predatory events by large carnivores thus differs between geographical regions and could be influenced by other local factors as well.

People living around the buffer zone of Bardia are using both traditional and modern means to guard their crops against wild animals (Thapa, 2010). Conflict mitigation measures include providing monetary compensation to the victims, construction of electric fences and trenches along the forest edges and construction of predator proof corrals to minimize damage to livestock (Acharya et al., 2016). In order to prevent damage caused by elephants, electric fencing and beehives are used as means of protection (King et al., 2009; Sapkota et al., 2014). In other areas, cultivation of unpalatable cash crops such as capsicum is effective in reducing human elephant conflict (Parker & Osborn, 2006). Chili smokes and spotlights are also sometimes used for reducing crop raiding by elephants (Davies et al., 2011).

The main aim of this chapter is to provide an overview of spatiotemporal factors affecting human-wildlife conflicts around Bardia National Park. The research questions which were addressed include:

1. What are the main conflict causing wildlife species?
2. Are there any spatiotemporal patterns found in conflict incidences?
3. How much money is spent on compensation schemes?
4. What is the perception of local communities on how to manage conflicts?

4.2 Study area

Bardia National Park (henceforth BNP) (28°15‘ to 28°35.5‘ N and 80°10‘ to 81°45‘ E, 968 km^2, altitudinal range 152-1440m) was established in 1969 and is situated in the Bardia and Banke districts of Nepal, south west of Kathmandu. The park is designated under IUCN category II (DNPWC, 2018). It is part of the western Terai Arc Landscape (TAL), providing important habitat for large carnivores, including tigers and leopards. BNP is one of the largest protected areas in the Terai lowland. BNP has undergone a series of shifts in terms of property rights and changes in conservation status. The area was first declared as a Royal Hunting Reserve in 1969, but since established rules and regulations were not strictly enforced, access to resources inside the reserve was basically free to the local community. In 1976, an area of 368 km^2 was officially declared as the Royal Karnali Wildlife Reserve and in 1982 renamed as the Bardia Wildlife Reserve. After discovery of the Babai valley with its higher wildlife densities, suitable plains for habitats and the main river course flowing to the far west, the size of the reserve was extended in 1984. Finally, in 1988 the reserve was upgraded to the National Park status (Brown, 1998).

The buffer zone of BNP was established in 1996, when an area of 327 km^2 was added to the park. In 2010 an additional 180 km^2 of the Surkhet district was added to expand the buffer zone to arrive at a final surface area of 507 km^2. The area of the buffer zone is designated as IUCN category-VI (DNPWC, 2018). Buffer zones have been instated in most of the national parks and wildlife reserves throughout Nepal and also in Bardia by government to create areas around national parks which are both of natural value, e.g. including forest patches, river and water bodies, and of cultural or economic importance, e.g. agricultural lands, human settlements, cultural heritages, open meeting spaces and other forms of land use (Budhathoki, 2004). A buffer zone serves the dual purpose of providing an opportunity for local people to collect and use forest products from the community forest on a regular basis, and as extended natural habitat serving as wildlife refuges and corridors (Budhathoki, 2004). Buffer zones are managed by both the park authorities and the local communities through jointly organized community development and natural resource management initiatives (DNPWC, 2018). For this purpose 19 Buffer Zone User Committees (BZUC) have been created in BNP (Figure 4.1).

For BNP, approximately 30 to 50% of the revenue generated by the protected area is invested in local communities residing in the buffer zone. These investments are intended to support conservation and alternative livelihood activities, and are based on the priorities that have been established through an approved management plan (Heinen & Mehta, 2000; Baral & Heinen, 2007). The communities living in the BNP buffer zone are a heterogeneous society comprising indigenous Tharu people and migrants from the hills (Bhattarai et al., 2016).

The park has a sub-tropical monsoonal climate with three distinct seasons: winter (October to February), summer (February to June) and monsoon (June to October) with an annual rainfall of 1500 mm. During summer temperatures could rise to 45°C. About 70% of the forest consists of Sal (*Shorea robusta*) with a mixture of grassland and riverine forest (DNPWC, 2018).

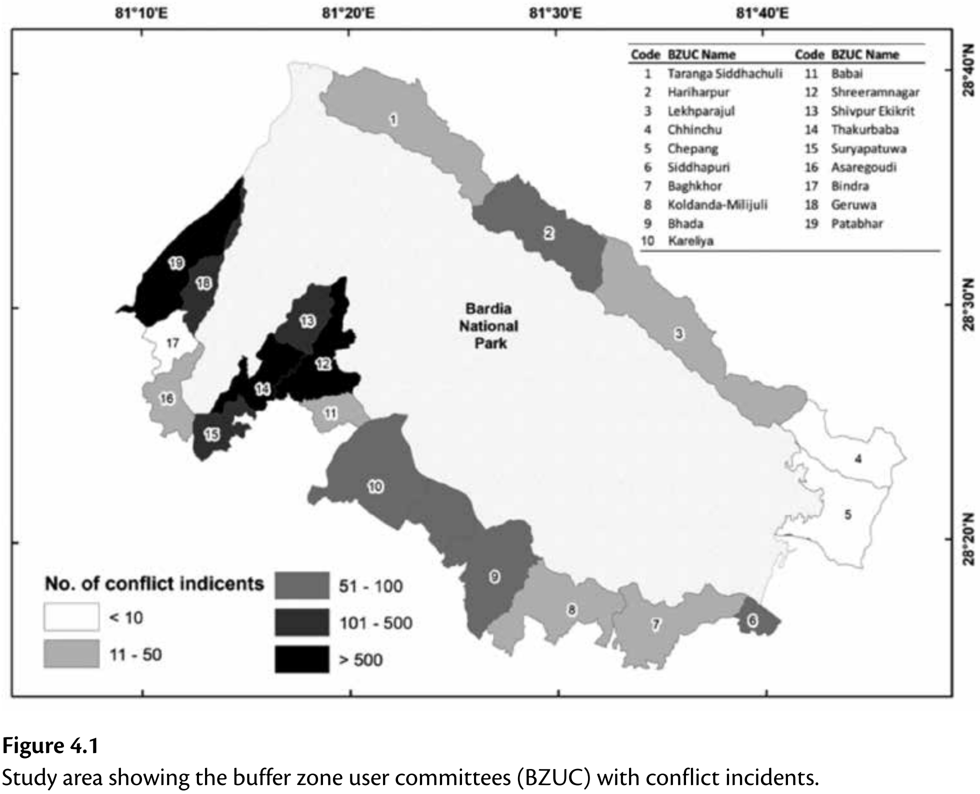


Figure 4.1
Study area showing the buffer zone user committees (BZUC) with conflict incidents.

4.3 Methods

Yearly data on human-wildlife conflict cases were collected from existing park records, based on compensations paid to the victims as per the recommendations of the BZUC for the loss or damage of property between 2013 and 2017. We used the data to identify the main conflict causing wildlife species and the major spatial and temporal factors affecting conflict incidences. We performed chi-square to know about the predation event of tigers and leopards. We divided the BZUC into East, West, North and South sub-regions according to their location. We performed a single factor ANOVA to test the spatial pattern of conflict over different sub-regions of the buffer zone. The response variable was number of conflicts per year per sub-region, and the single factor tested was sub-region.

Seasons were defined as follows: Winter: December to February, Spring: March to May, Summer: June to August and Autumn: September to November.

Lunar days were assigned using the Gregorian-Lunar calendar conversion table of the Hong Kong Observatory (www.hko.gov.hk/gts/time/conversion.html). Day 1 was assigned New moon day and Day 15 Full moon day. Days 28, 29, 1, 2, 3 or 29, 30, 1, 2, 3 were assigned as New moon phase (dark phase) and days 13, 14, 15, 16, 17 as Full moon phase (light phase) (following Traill et al., 2016). A waxing moon is defined as the period after the new moon and before the full moon, whereas a waning moon is defined as the period after the full moon and before the new moon. We performed a two tailed, paired t- test to compare the conflicts during new moon and full moon and during the waxing and waning moon phase over a period of five years.

In order to calculate spent compensations (compensations spent on real price), annual fluctuations in inflation rate were taken into account. We calculated the real price that has been adjusted with an inflation rate over the five years of our study period. We used the real price of 2017 as the amount of compensation paid. Inflation rate figures for Nepal were taken from www.statista.com/statistics/422594/inflation-rate-in-nepal.

Data on perceptions of local inhabitants on conflict-prone wildlife was collected during a questionnaire survey among 290 households in the buffer zone (Supplementary material 4.1). The selection of villages and household heads took place according to Upadhyaya et al. (2018) (accepted). The household heads were asked to rate several aspects of human-wildlife conflicts by giving a preference score from 1 to 6 (where 6 is most preferred and 1 least preferred). All statistical analyses were done in Microsoft Excel 2010 (Microsoft Redmond, USA).

4.4 Results

A total of 3,283 conflict incidences were reported over a period of five years. Eleven species were found to cause conflicts during the study period: Elephant (*Elephas maximus*) (60%), Leopard (*Panthera pardus*) (24%), Wild boar (*Sus scrofa*) (6%), Tiger (*Panthera tigris*) (6%), Rhinoceros (*Rhinoceros unicornis*) (0.6%), Sloth bear (*Melursus ursinus*) (0.06%), Chital (*Axis axis*) (0.5%), Nilgai (*Boselaphus tragocamelus*) (2%), Crocodile (*Crocodylus palustris*) (0.3%), Python (*Python bivitattus*) (0.06%) and Porcupine (*Hystrix indica*)(0.03%). Elephant, leopard, wild boar and tiger were responsible for conflicts during each of the five years of the study period whereas the other seven species caused conflicts in some years only.

Elephants were responsible for most conflicts, resulting from damage to crops, stored grains, houses as well as injuries inflicted to human beings which were even fatal on 14 occasions (Figure 4.2). Although no human beings had been killed by tigers or leopards, wild boar was reported to have caused one fatality among local residents. Tigers and leopards were mainly involved in killing livestock such as goats, pigs, sheep and cattle (Figure 4.4).

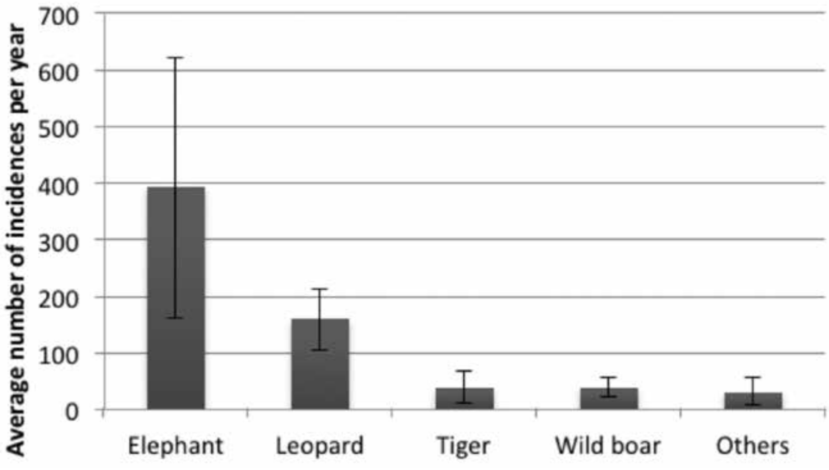


Figure 4.2
Average number of conflict incidences from 2013 to 2017 caused by different wildlife species. The error bars indicate standard deviations.

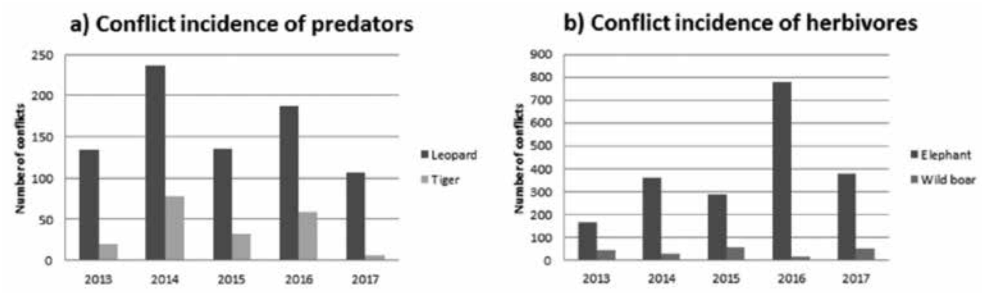


Figure 4.3 (a-b)
The conflict incidence frequency caused by predators and herbivores over five years.

Over the entire study period, livestock predation rates were higher for leopards than for tigers (χ^2= 27.391, df= 4, p< 0.001) (Figure 4.3a). Leopards mainly killed goats and pigs (731 and 234 respectively), whereas tigers also killed cattle (100), in addition to goats and pigs (147 and 23 respectively) (Figure 4.4). The overall livestock predation rate was higher in 2014 and 2016 compared to the other years. The damage caused by elephants was highest during 2016 (Figure 4.3b).

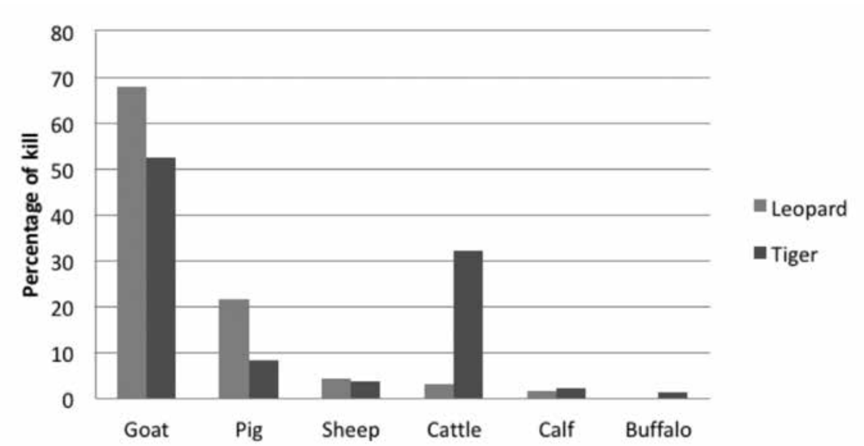


Figure 4.4
Percentage of livestock killed by tigers and leopards during the study period.

Property damage caused by wildlife mainly comprised damage to housing and raiding of stored grain, followed by damage to kitchen facilities and wall structures (Figure 4.5a). Paddy was the major crop damaged by elephant, followed by wheat and maize (Figure 4.5b). Maize was the major crop damaged by wild boar, followed by paddy and wheat (Figure 4.5c).

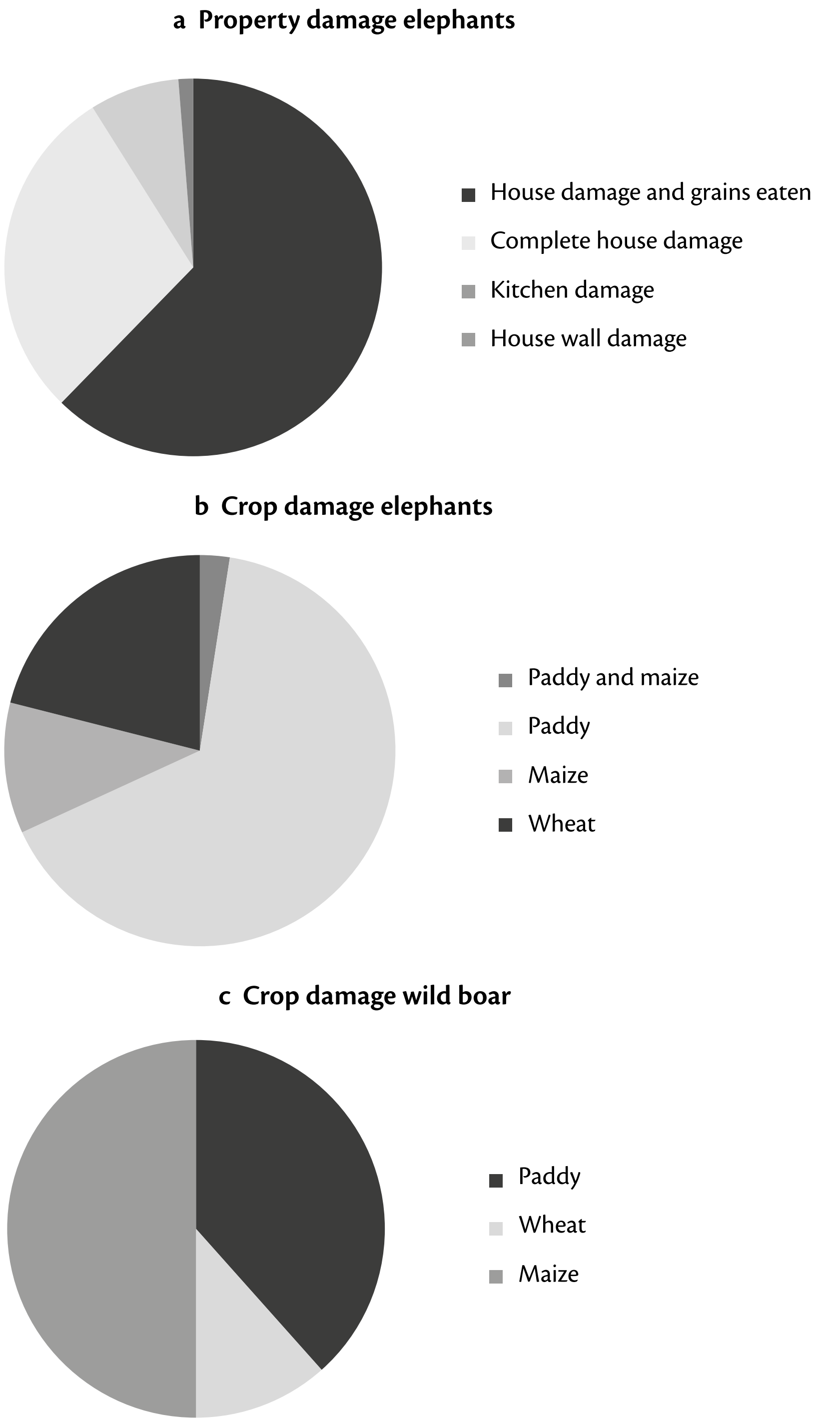


Figure 4.5 (a-c)
Crop and property damage caused by elephants and wild boar.

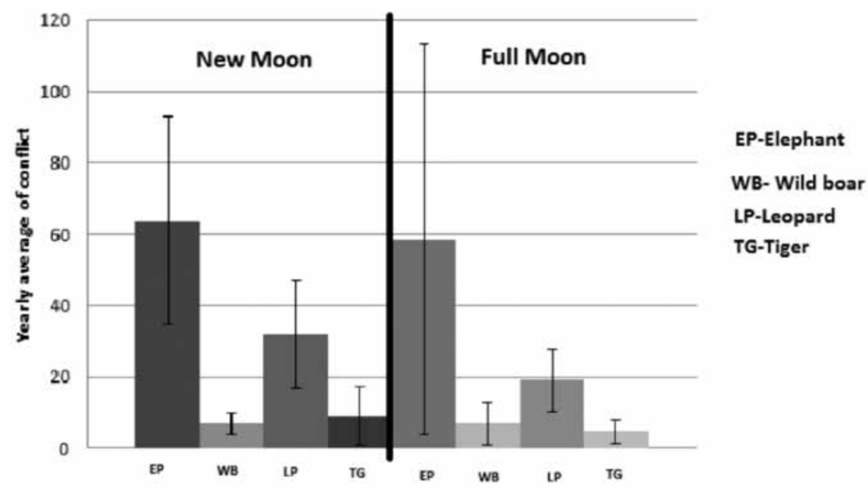
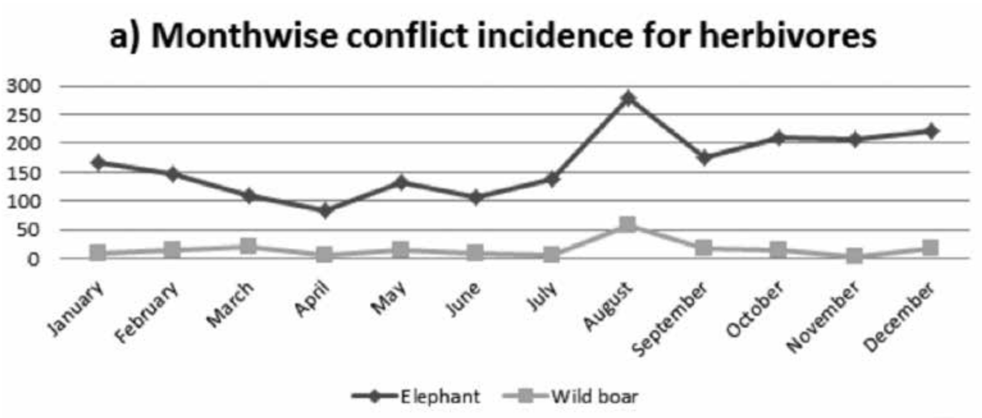


Figure 4.6
Average conflict frequencies in relation to moon phase over a period of 5 years.

Livestock predation occurred more often during the new moon phase compared to the full moon phase (Figure 4.6) by leopards (p=0.006) and tigers (p=0.046), whereas no significant relation was found between conflict incidence and new moon/full moon phase for any of the herbivore species. No effect of waxing/waning moon phase was found for any of the four studied species.



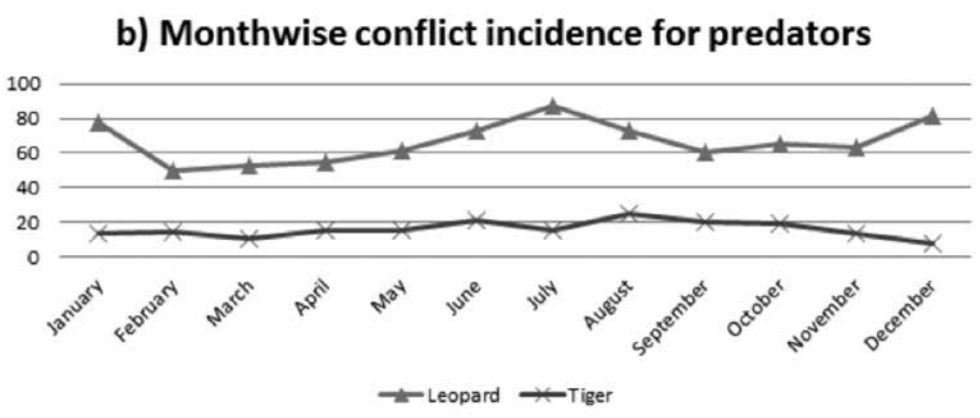


Figure 4.7 (a-b)
Monthly variations in conflict incidence by wildlife group.

The month-wise conflict incidence showed that elephants and wild boars were damaging more crops during the monsoon season (Figure 4.7a). Among the predators, leopards showed a peak in predation incidences during July, whereas predation incidences by tigers remained relatively constant throughout the year (Figure 4.7b).

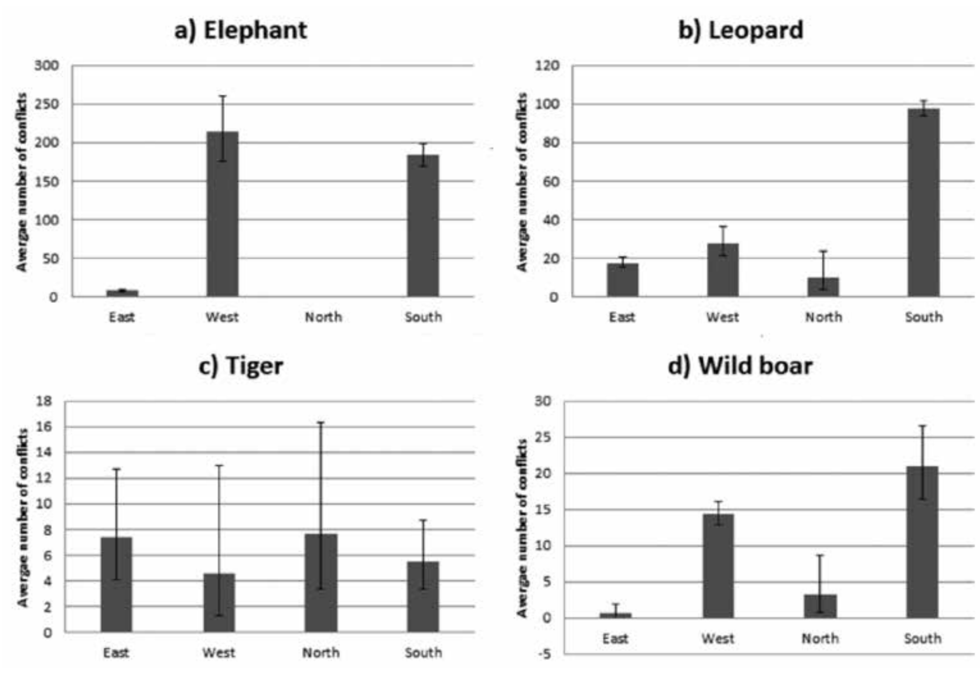


Figure 4.8 (a-d)
Average number of conflict incidences in different sub-regions of the buffer zone for elephants, tigers, leopards and wild boars.

Elephants were responsible for the majority of conflict incidences in the west followed by the southern sub-region of the park (Figure 4.8a). Conflicts caused by leopards and wild boars were also higher in the southern and western part of the buffer zone (Figure 4.8b, d). Conflict incidences caused by tigers were spread relatively evenly over the park (Figure 4.8c).

The results of a single factor ANOVA only showed significantly different conflict incidence rates between different sub-regions for elephants ($p<0.001$), leopards ($p=0.006$) and wild boars ($p=0.003$).

A total of NRs (Nepali Rupees) 6,719,420 ($ 61,085; 1$=NRs 110) were paid to villagers as compensation for conflicts over the five year study period. Although compensation fees for each of the species did not change over the years (Table 4.1), there was a marked increase in the average amount paid to each household in 2017 compared to other years.

Table 4.1
Compensation paid (in Nepali Rupees) for damages caused by four major species, adjusted as per the real price of 2017.

Year	Animal				Average amount per household	Inflation %*	CPI (-)
	Elephant	Tiger	Leopard	Wild boar			
2013	312,172	78,862	255,242	36,252	1,773	9.87	0.74
2014	683,035	260,432	580,955	25,859	1,995	9.04	0.81
2015	414,856	82,696	274,848	67,190	1,527	7.21	0.87
2016	1,472,437	154,630	378,218	9,090	1,879	9.93	0.96
2017	1,273,920	74,000	439,000	264,400	3,743	4.48	1.00

*Inflation rate is calculated based on price change over previous year.
CPI= Commodity price index.

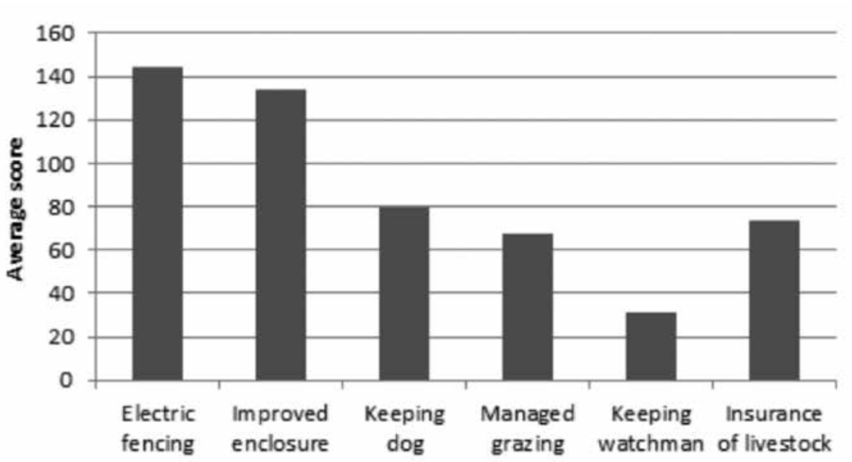


Figure 4.9
Effectiveness scores for six wildlife damage prevention methods according to the questionnaire survey of respondents. The Y-axis shows average preference scores, with the highest score (6 points) for the most preferred measure and the lowest score (1 point) for the least preferred method.

Improved enclosures which are mainly used to prevent livestock depredation and electric fencing, mainly used to keep elephants away from human settlements and crop fields were rated as the most preferred damage prevention methods among the respondents (Figure 4.9).

4.5 Discussion

This study examined the conflict incidences around Bardia on the basis of compensation paid to the villagers for the loss of crops or livestock attributed by different wildlife. The use of human dominated zones by elephants was highest during the autumn season when crops like paddy and maize mature (Pant et al., 2016; Lamichhane et al., 2017). Crop raiding incidences were higher during the cool autumn season which may be due to the low quality of the forage available in the forest during the late part of the autumn season (Pradhan & Wegge, 2007). A high level of crop raiding was also reported for Assam in India (Wilson et al., 2015) during the cooler months between August and December. Similar to our findings, Dublin & Hoare (2004) reported that agricultural loss due to African elephants is mainly due to loss of food crops, cash crops and even crops stored inside houses.

Our results on tiger and leopard conflict incidences in relation to moon phase are comparable to those presented by Packer et al. (2011) on lions in Tanzania, Africa and Lamichhane et al. (2018a) and on tigers and leopards in Nepal, with significantly more attacks on livestock taking place during the new moon phase. The reason for this may be as tigers and leopards are nocturnal predators and dark nights of the new moon make them easy for predation because they are not detected. However, since our data lacks the time period of the incidence a detailed study in future with time of the incident would be helpful to understand the effect of moon phase.

In terms of livestock predation, leopards in our study area were responsible for more conflicts than tigers, which was also the case all over Nepal mainly in the protected areas and community and government forests (Acharya et al., 2016) and in Chitwan NP, Nepal (Lamichhane et al., 2018a). Sangay & Vernes (2008) also documented more killings of livestock by leopards (70%) than by tigers (19%) in Bhutan. The relatively high rate (67.8%) of attacks on goats in our study area is supported by findings from e.g. Chitwan NP where 87.7% of the livestock killed by leopards were goats (Dhungana et al. 2018). Goats are ideal food items for leopards because of their medium size and relatively high availability around the study area. Kabir et al. (2014) also reported significant killing of goats by leopards from in and around the Machiara National Park, Pakistan.

Leopards caused significantly more conflicts and killed more livestock than tigers around Bardia, tiger attacks could potentially lead to greater damages because they more frequently attack larger livestock such as cattle (32% as opposed to 3% for leopards), which per head are considered much more valuable than goats. Tigers generally kill larger prey in order to meet their energy requirement (Hayward et al., 2012; Upadhyaya et al., 2018). Livestock predation by leopards peaked during the monsoon season which was also found for leopards in Bhutan (Sangay & Vernes 2008). One of the causes for this peak could be a more random dispersal pattern of wild prey, away from water sources, which reduces hunting success during this time of the year (Moe & Wegge, 1994). Decreased visibility due to high standing grasses and shrubs inside the park is also considered as an important factor contributing to lower hunting success rates by large predators on wild prey (Dinerstein, 1979). As a consequence, leopards could become more tempted to attack livestock that is often poorly protected against predatory attacks (Acharya et al., 2016).

In order to minimize financial damages, respondents mostly preferred electric fencing and improving enclosures. This was a direct consequence of the damage caused by elephants and leopards, which contributed to most damages suffered. Since electric fencing and improved enclosures have been reported to effectively control damages caused by elephants (e.g. Davies et al., 2011 in Assam, India) and leopards, damages inflicted by these two species are expected to decrease over time (King et al., 2009; Sapkota et al., 2014). Plantation of cash crops like chili *Capsicum sp.* has effectively reduced damages by elephants in Zimbabwe (Parker & Osborn, 2006).

Cases for Nepal in which humans are injured or even killed in wildlife encounters mainly involve four wildlife species: tiger, leopard, elephant and rhinoceros (Acharya et al., 2017). Most of the human fatalities in our study were caused by elephants, which are known for their unpredictable behavior, like males elephants have been found to more frequently cause conflicts with humans than females due to their inherent higher risk-taking behavior (Sukumar, 1991). Combined with their exceptional force, elephants are likely to kill anyone who gets in their way. This is reflected in the figures from all over the elephants' distributional range, where they are responsible for the majority of human fatalities in conflict situations (e.g. in India and Nepal) (Wilson et al., 2015; Acharya et al., 2016). Although wild boars are generally shy and not likely to spontaneously attack humans, when provoked they could attack ferociously with their sharp tusks, leading to serious and occasionally fatal injuries (Manipady et al., 2006). The single fatal casualty caused by wild boar from our study is in line with this, and other reports on wild boar attacks in the region (e.g. India, (Manipady et al., 2006; Chauhan et al., 2009)

4.6 Management Implications

Our study is the first comprehensive study on human-wildlife conflicts conducted around Bardia National Park. The conflict 'hot spot' in the southern and western sub-region of the buffer zone we identified, could serve as a primary focal point for which to develop and implement conflict prevention measures. Such measures should take into account that certain prevention techniques are more effective than others, e.g. the use of alternative cropping patterns and electric fencing could effectively deter elephants. Improved livestock husbandry techniques and predator proof corals could be helpful in protection against predators. Promotion of livestock insurance schemes could also help to reduce the financial burden on the government and thus help in maintaining sustainability.

Acknowledgements

We are grateful to the Department of National Parks and Wildlife Conservation (DNPWC), Kathmandu, Nepal for providing permission to carry out this research. We also thank the officials of Bardia National Park for their support and permission to work in BNP. We are grateful to Mr. Shyam Thapa, Incharge and other members of the Bardia Conservation Program of National Trust for Nature Conservation for their support during the field work. We are also thankful to the Buffer Zone User Committees (BZUC) for their support in data collection.

Supplementary material 4.1

Questionnaire used for survey

Name of interviewer: ____________________

Date: ____________ Time: ____________

Address: Muncipality/VDC: _______ Ward No: ________ Village: ______________

Consumer group: ____________________

GPS location: ____________ N-_____ E-_____ Elevation-_____________

Questionnaire for Interview on assessing best strategy to minimize damage caused by wildlife

1 Name: ____________________

2 Age: ____________ Gender (Male/Female) (Score 1,2): _________

3 Occupation:

4 Family members: Male ______ Female _____ Children (below 15 years age)-______

5 Ethnic group (Score 1, 2, 3, 4, 5):

- a Bahun/Chhetri __________
- b Tharu __________
- c Janjati __________
- d Dalit __________
- e Other(mention) __________

6 Best strategy to minimize damage caused by wildlife- Score 1 (least preferred) to 6 (best preferred)

- a Improved enclosure __________
- b Keeping dog __________
- c Managed grazing __________
- d Electric Fencing __________
- e Keeping watchman __________
- f Insurance of livestock __________