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**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**

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6

Synthesis



6.1 Context

Around the world, wild large mammals have co-existed with humans and their livestock for over ten thousand years (Pereira et al., 2012). Evidence exists from the Pleistocene era of the interactions between large carnivores and early humans, who not only hunted large carnivores for meat, but may have also scavenged on prey killed by large carnivores (Oliver, 1994, Treves & Naughton-Treves, 1999).

Large carnivores require large habitats, and human-induced degradation and fragmentation of habitats over the past decades is regarded as a major threat to their survival. Their large home ranges, low population densities and slow population growth rates further make them vulnerable to extinction (Dickman, 2010). The world's growing human population and the resulting demand for food, space and natural resources hence poses a great threat to large carnivores and their habitats. Several species of large carnivores worldwide have shown strong population declines in the past decades while at the same time the frequency of conflicts with humans has increased (Inskip & Zimmermann, 2009; Karanth & Chellam, 2009). In Nepal, such conflicts have also increased over the past years, as a result of expanding human settlements near buffer zones of protected areas (Bhattarai & Fischer, 2014; Silwal et al., 2017), but possibly also due to increasing wildlife numbers inside some of the national parks following improved wildlife conservation measures.

The majority of wildlife induced fatalities among people for Nepal had been reported from Chitwan National Park (Gurung et al., 2008; Silwal et al., 2017; Dhungana et al., 2017; Lamichhane et al., 2018), where the conflict problem is severe. During 1979-2006 for example, 88 humans were killed by tigers in Chitwan (Gurung et al., 2008). For Bardia National Park cases in which humans were killed by wildlife had also been reported, although average numbers of fatalities were lower than for Chitwan. During 1994 to 2007 tigers had been responsible for 0.93 fatal attacks per year in Bardia (Bhattarai & Fischer, 2014).

Where tigers and leopards occupy the same habitat, interspecies competition could lead to the displacement of leopards towards park edges (Odden & Wegge, 2005; Harihar et al., 2011; Mondal et al., 2012). In order to promote successful management practices in and around BNP that take into account the current human-wildlife conflict situation, the present research focused on tiger and leopard interactions and prey selection in Bardia National Park,

and how this is related to the conflict incidences occurring in the area. One objective of my study was to assess whether any spatial and temporal patterns of overlap between the activities of tigers and leopards were present. I also studied the spatiotemporal patterns of conflict incidences and identified the major conflict causing wildlife species in the study area. Finally, I examined the perception and attitudes of local communities towards conservation in general and towards the conservation of big wild cats in particular. As the population of tigers is increasing inside the park, I hypothesized that young tigers and leopards may be pushed out of the park. From my results, I formulated recommendations for the conservation of tigers and leopards in the human dominated landscape of Bardia.

6.2 Interactions between tigers and leopards

In chapter 2, I studied the spatiotemporal interaction between two sympatric carnivores. Tigers and leopards are sympatric in most of their distributional range in Asia, and typically inhabit similar habitat. Both species are regarded as umbrella species because of their function at the top of the ecosystem. Due to their elusive nature and low densities, research based on direct observations is difficult. For this study camera traps were therefore used. The park was divided into a core zone and a boundary zone. I found that there was no significant difference in the activity of tigers and leopards between 2013 and 2016. Spatial avoidance between the two species was evident in the core zone but not in the boundary zone, confirming our hypothesis that leopards may have been forced from the core zone into the boundary zone by tigers. In Bardia, habitat and space use partitioning may thus play an important role in the co-existence of tigers and leopards. Leopards were found to be more active during the daytime whereas tigers were mostly active during dawn and dusk. Leopards appeared to temporally avoid tigers in the core zone, while this was not the case near the human dominated area i.e. in the boundary zone. This could be the result of the fact that tigers in the boundary zone may be sub-adult tigers displaced from their home range. Kolipaka et al. (2017) also mentioned the dispersal of young tigers towards the park boundary.

6.3 Diet and prey preference of tigers and leopards

In chapter 3, I studied the diet composition and prey preferences of tigers in BNP. Knowledge on diet composition and prey preferences could support conservation action plans for both the predator and the prey species. The polymerase chain reaction (PCR) technique was used for the identification of species and sex from scat samples. Prey remains were identified to species level through microscopic hair morphology analysis. Of the 101 scats collected, extraction of DNA and PCR analysis was successful for 84 samples, of which 75 originated from tigers and nine from leopards. From the tiger scat samples 34 were determined to belong to males and 41 to females. The amplified PCR product size was 162 bp for tiger and 130 bp for leopard. The amplified PCR product of nuclear DNA of males had two bands measuring 194 bp and 214 bp, whereas females had one band of 214 bp. Due to the small sample size of leopard scats collected, only tigers were included in the analyses. We found seven and six prey species in the diet of male tigers and female tigers, respectively. The diet of male and female tigers did not differ significantly, with chital as the most abundant prey species for both sexes. Leopards were found to positively select wild boar, hog deer and sheep and goats (Lovari et al., 2015). The Jacobs index did not show any significant prey preference, although male tigers tended to select for sambar deer and wild boar, whereas female tigers more often selected wild boar and chital. The most important difference in diet composition between tigers and leopards was a much higher presence of small mammals and birds in leopard scats as opposed to tiger scats, a larger proportion of domestic animals in leopard scats as opposed to, and more hog deer in tiger scats as opposed to leopard scats (Odden, 2007). Our study demonstrates that tigers mostly preyed on wild species, supporting the relatively low level of tiger-livestock interactions we found for Bardia based on the questionnaire survey. Hence, this park seems to be a prospective area for tiger conservation in the long run. The higher abundance of tiger scats found in the core area of the park versus a higher abundance of leopard scats collected near the edge of the park further supports the assumption that leopards are being displaced by tigers, at least to some extent.

6.4 Spatial and temporal conflict patterns

In chapter 4, I studied the spatial and temporal patterns of conflict in BNP over a period of five years. The study was based on compensation paid to villagers who had been identified as victims of conflict by park officials. The main types of conflict incidences that have been reported were attacks on humans, crop damage, property damage and livestock predation, which is similar to those reported by Peterson et al. (2010). Four wildlife species were responsible for the majority of conflict incidences: elephant, leopard, tiger and wild boar. Elephants were the major conflict causing species responsible for killing 14 humans over a period of five years. Other types of conflict caused by elephants included crop damage and damage to housing along with raiding stored grains. Among the predators, leopards were responsible for most livestock kills. This may have been due to the often poorly constructed sheds and corals in which livestock was kept, offering easy access to leopards (Acharya et al., 2016). Tigers were mainly responsible for killing larger livestock, such as cattle. Other wildlife species that had contributed to at least a certain level of conflict included rhinoceros, chital, sloth bear, nilgai, python, crocodile and porcupine.

In terms of temporal patterns of conflict incidences, most of the predation events took place during dark nights or new moon phase and livestock predation was higher during the monsoon season. The crop damage caused by elephants was higher in the autumn season when the major crop paddy is reaching maturity. Spatial patterns of conflict were reflected in the higher frequency of conflicts which was found for the southern and the western sub-region of the buffer zone, compared to the other zones. This may be due to the presence of a high density of elephants in that zone. The local residents most frequently used electric fencing and improved enclosures in order to prevent conflict incidences. A total of \$ 61,085 was paid to villagers as compensation for conflicts over the study period.

6.5 Defining the risk of attacks by predators

In chapter 5, I focused on defining the probability of predatory attacks on livestock in different regions of the buffer zone of BNP. Large carnivores often cover great distances, thereby sometimes leaving protected areas and roaming into communal lands (Woodroffe et al., 2005). Based on data acquired from a questionnaire survey, I built logistic models to examine the

overall probability of livestock losses, economic damage and the attitude of local residents towards wildlife. I found that the Northern sector of the buffer zone, which was recently included in the buffer zone, experienced a larger loss of livestock than any other sector of the buffer zone. The model on livestock loss predicted the number of livestock owned by the respondents and the distance to the national park as important variables contributing to livestock loss. The model on economic damage marked study sector, number of livestock owned, ethnic group of respondents, and distance to the national park as significant variables contributing to economic loss. In the model on the attitude towards wildlife, the variables that resulted in a positive attitude were higher educational status, greater self-sufficiency and male gender. The higher level of religious tolerance towards tigers and the common conservation benefits that people living in the buffer zone share, positively affected their attitude towards conservation (Bhattarai & Fischer, 2014). Although people’s attitudes towards wildlife can be influenced by predatory attacks and other wildlife-related financial losses (Røskaft et al., 2007), 85% of all our respondents had a positive attitude towards conservation, even when a leopard or tiger, respectively, had killed their livestock.

6.6 Conclusions

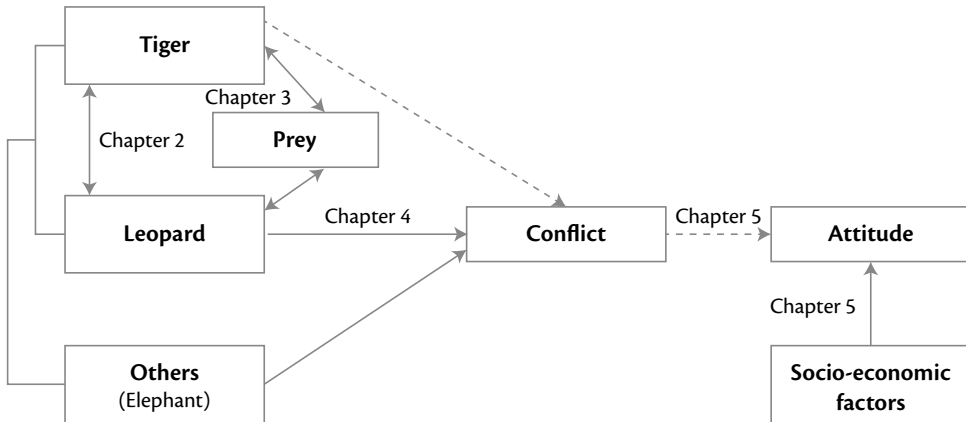


Figure 6.1
Present situation regarding conflicts in Bardia National Park.

As summarized in Figure 6.1, the main conflict causing animals in Bardia are leopards and elephants. With the increased number of tigers in recent years, it is likely that leopards as well as sub-adult tigers in search for their own home range, will roam into human inhabited areas outside the Bardia National Park. In order to protect these large carnivores, additional habitat should ideally be included into the conservation program. Protection measures could for instance focus on the adjoining community forest or the Government forest. The Banke National Park, which was established in 2010 in continuation with the eastern border of the Bardia National Park, could thereby act as a sink for the Bardia tiger population. In Summary, the following findings have been presented in this thesis:

- 1 Leopards appeared to avoid tigers in and around Bardia National Park, both in time and space. This avoidance behavior is more prominent in the core area of the park than towards the fringe of the park. Leopards were found to be more active during daytime whereas tigers were more active during dawn and dusk.
- 2 The diet of tigers predominantly consisted of wild prey species, with only a single scat sample containing domestic prey. This suggests that tigers around Bardia are generally not involved in direct conflicts with humans. Whereas tigers in Bardia mostly preferred medium-sized prey such as chital and wild boar, other studies suggested that such prey may be energetically suboptimal for tigers as they usually kill larger bodied prey in order to meet their energy demand. Since larger ungulates occur at relatively low densities in Bardia, tigers here are probably trying to compensate this by catching more medium-sized prey. As the prey preference index indeed showed a preference towards large sized prey, future park management efforts should ideally focus on increasing the density of large prey species.
- 3 Elephants were responsible for most of the human fatalities around Bardia whereas tigers and leopards were not involved in any fatal encounters with local people in recent years. Leopards were responsible for more killing of livestock compared to tigers. Livestock predation incidences mostly occurred during the new moon phase. Crop damage mostly occurred during the autumn season when paddy is cultivated.
- 4 Self-sufficiency and education had a positive impact on the attitude of villagers towards conservation and wildlife. Survey respondents with a

negative attitude towards conservation were mostly female, probably due to their involvement in wood collection, requiring women to enter dangerous tiger and leopard habitat more frequently than men. The Northern sector of the buffer zone experienced more conflict incidences, which could be a result of poor animal husbandry techniques. Since the Northern sector has been included in the buffer zone of the National Park only recently, the villagers living in the area have not yet had the opportunity to profit from conservation benefits, such as ecotourism in comparison to other sections of the buffer zone.

6.7 Recommendations

Based on the findings presented in this thesis, I formulated several recommendations for wildlife managers, local communities and for future research:

6.7.1 For wildlife managers

- 1 Habitat management should focus on providing suitable habitat, especially for larger ungulates, as especially tigers could benefit from this and therefore it is expected to positively affect the long term viability of the tiger population in Bardia. The habitat management should focus on providing optimal diversity for the sustenance of a large range of prey species.
- 2 Poaching of tiger/leopard and their prey species needs to be minimized as it is one of the crucial issues in the conservation of tiger/leopard.
- 3 Additional habitat, outside the currently protected areas, should ideally be allocated in order to facilitate the dispersal of sub-adult tigers and leopards. Corridors passing through the adjoining community or government forests could be created for this purpose.

6.7.2 For local communities

- 1 Local communities should continue to be involved in conservation action planning. Local action groups could for instance encourage youth to join anti-poaching campaigns. Local initiatives could also include education programs, e.g. by introducing study material on wildlife ecology and behavior at primary and secondary school level curricula.

- 2 Initiatives targeted at benefit sharing of park revenues by the local communities could continue to provide incentives to reduce retaliatory actions following conflicts with wildlife. However, current initiatives need to become more practical to execute and compensations after livestock has been lost should be paid with minimum delays. Modernizing and improving existing livestock husbandry techniques and promoting insurance of livestock by livestock owners could reduce the financial burden that may result from the depredation of livestock.

- 3 The reliance of local communities on forest and agricultural resources could be minimized by providing alternative livelihoods. Local initiatives could promote commercial activities in ecotourism, such as involvement in safari tours, home stay and cottage industries. Cultivation schemes targeted at alternative cash crops, such as mentha and chamomile could be implemented in order to reduce the loss of crops by raiding elephants.

6.7.3 Future research

Based on the present thesis, several focal points have been identified for future research on large carnivore interactions and conflicts with local communities (see Figure 6.2):

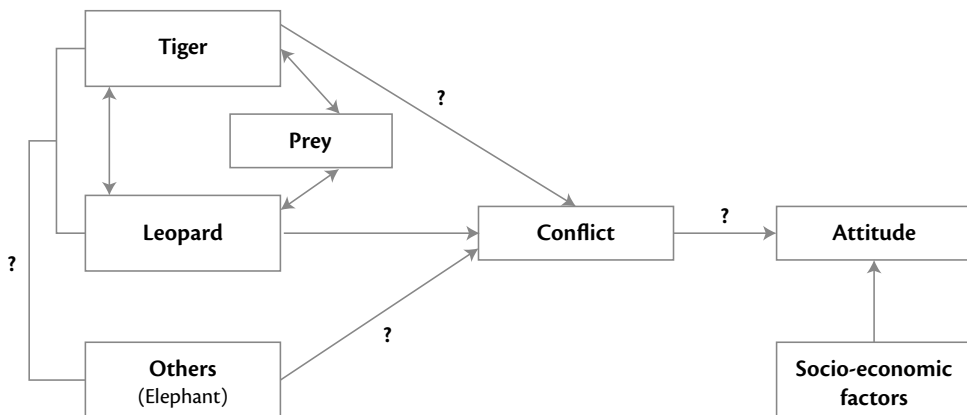


Figure 6.2

Diagram showing major interaction flows between research focal points, with suggestions for future research questions (indicated by a question mark).

- 1 Continuation of a monitoring program in Bardia National Park, using camera trapping, scat collection and molecular analysis techniques would greatly contribute to detecting long-term trends in population dynamics of leopards and tigers. Especially trends caused by increasing herbivore populations should be further investigated.
- 2 Since our study showed that elephants are responsible for the majority of conflict incidences in which property damage, crop damage or human fatalities occurred, future studies should ideally address possible techniques and measures that could effectively reduce human-elephant conflicts.
- 3 Although the people in Bardia were generally in favor of conservation efforts targeted at both big cat species, their positive attitude is likely to change when conflict incidences are to occur more frequently, possibly as a result of increasing wildlife numbers, in the future. A study on the socio-economic status of villagers could provide valuable insights for this purpose. Indigenous knowledge of local people should be taken into account when defining objectives for this kind of research.