# 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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# Summary

Large carnivores and humans, along with their livestock, have co-existed for thousands of years. However, human population growth and an increase in economic activities are modifying the landscape for large carnivores and their prey. Large cats, which are regarded as keystone species for maintaining a healthy ecosystem through the balance between predator and prey, are now often locally on the verge of extinction. Large predators are sensitive to human activities and have been actively persecuted from all over the world, because of their conflicts with local people. The number of tigers (*Panthera tigris*) has declined rapidly in the past century and now they are confined to 7 % of their historical range. Similarly the range of leopards (*Panthera pardus*) has also declined significantly, although they are more widespread and adaptive than tigers. Since these carnivores require large habitats, degradation and fragmentation of their habitat over past decades are regarded as the major threats for their survival. The other factors responsible for their decline include poaching for illegal trade of body parts, loss of prey species and conflicts with local communities. Local farmers often face negative interactions with wild predators thereby experiencing economic loss by the killing of livestock. These conflicts in combination with a poor understanding of the ecological role which predators play may lead to local resentment against predators and negative attitude towards predator conservation projects.

Nepal is one of the 13 countries to ratify the Global Tiger Recovery Plan at the meeting of world leaders held in St. Petersburg in 2010, aims at doubling the number of wild tigers by 2022. In order to achieve this goal the Government of Nepal has focused on better conservation practices in and around tiger conservation landscape. Tigers are found in five National Parks of the lowland plain (Terai). This area is a part of the greater Terai Arc Landscape which is located in India and Nepal. There has been an increase in the tiger population after the end of civil war in Nepal, as well as a decrease in poaching, due to new government policy which included strict protection measures in national parks and the involvement of youths in anti-poaching campaign. As a result of a significant increase in the population of tigers inside Bardia National Park they are now showing more interaction with leopards. As tigers and leopards are elusive species it is difficult to study their interaction in the field. Therefore, using camera trap data obtained during 2013

and 2016, I studied the interaction between tigers and leopards in Bardia National Park. I found that there is a significant level of spatial avoidance of leopards towards tigers in the core zone of the park whereas in the boundary zone the spatial avoidance is not significant. I found that the temporal activities of leopards in grids of the core zone where tigers and leopards both are present are significantly different compared to grids where tigers are absent. The temporal activities of tiger are not significantly different in grids with leopards present in the core zone. However, the temporal activity of tigers is significantly different in the boundary zone when leopards were present, whereas the activity of leopard does not change. This can probably be explained by the suggestion that leopards approach human settlements more easily, while tigers show strong avoidance of human settlements. This also suggests that habitat partitioning and space use may play an important role in the co-existence of tigers and leopards in Bardia National Park. In general leopards show more avoidance to tigers than the other way round.

I also compared the diet and prey preference of tigers and leopards using their scats. However, due to lower number of leopard scats, I could not process it further and had to limit my study to the diet and prey preference of tigers only. I was able to identify male and female tigers based on DNA analysis of scat. I found that both male and female tigers were relying on medium sized prey (10 kg to 40 kg) namely chital (*Axis axis*) and wild pig (*Sus scrofa*) which was the most abundant prey in Bardia. However the Jacobs index for prey preference of male tiger was for sambar (*Cervus unicolor*) and wild pig whereas for female tiger the preference was for chital and wild pig, however the results were not statistically significant. The diet of tigers showed mostly the presence of wild prey species which suggests that they are generally not involved in the killing of livestock. For the long term conservation of the tiger in Bardia National Park we need to focus on increasing the population of larger prey species in the park, so that the available prey species are energetically beneficial for tigers and there is less competition with leopards.

I also looked into the spatiotemporal pattern of the conflict incidence in Bardia NP for a period of five years, on the basis of compensation paid to the villagers for the damage caused by wildlife. I found that four animals were mainly involved in causing damage to local communities, namely elephant (*Elephas maximus*), leopard, tiger and wild boar. The elephant was responsible for most of the damage. During the five years elephants killed 14 people and wild boar killed one person. Elephants also caused serious damage to the crops, destroyed houses and raided store houses for grains. Leopards and

tigers particularly caused depredation of livestock. Elephants caused more damage during the autumn season when the crops (mainly paddy) had matured. Leopards killed more livestock during the rainy season compared to dry season, while tigers did not showed seasonal pattern of predation. Tigers and leopards were involved in significantly more killing of livestock during the new moon phase compared to the full moon phase. The conflict incidence for elephants, wild boar and leopards was higher in the southern and the western part of the buffer zone, whereas tigers had a similar level of conflict all over the park.

To know more about the attitude and knowledge of local people living in the buffer zone towards conservation, I conducted a questionnaire survey by dividing the park into four different regions. I found that the loss of livestock was significantly related to number of livestock owned, the distance to the park boundary and the ethnicity of the respondent. The attitude of the respondent towards wildlife conservation was dependent on i) knowledge about the species, ii) (higher) educational level, iii) gender (male/female) and iv) level of self-sufficiency of the respondents, with a positive attitude related to more knowledge, male gender, higher education and higher self-sufficiency level of respondents. The sharing of conservation benefits also resulted in a positive attitude among the people living in the buffer zone.

In conclusion, it can be said that, due to the increase in number of tigers inside the park leopards may be pushed out of the park, where they become involved in conflicts while there may also be a spill-over of young tigers moving to the buffer zone. For future conservation of these large cats, additional habitats need to be sought and the community forest of the buffer zone can provide such habitat. Similarly, Banke National Park which has been established to provide a sink for the Bardia source population, which can help in accommodating the dispersed population of Bardia NP. Therefore, for future conservation programs we need to focus on the conservation of tiger and leopard in human dominated landscape. Due to interaction with tigers, the leopards are living in close proximity with people and thereby get more involved in conflicts with local communities. Tigers enjoy a religious and cultural tolerance among the people living in the buffer zone whereas leopards lack such religious and cultural tolerance.

# Samenvatting

Grote carnivoren en mensen, samen met hun vee, leven al duizenden jaren samen in dezelfde gebieden. Bevolkingsgroei en economische ontwikkeling veranderen het landschap van deze gebieden voor carnivoren en hun prooi dieren. Grote katten, die worden beschouwd als sleutel soorten voor gezonde ecosystemen door de wisselwerking predator-prooi, staan nu vaak lokaal op het punt om uit te sterven. Grote carnivoren zijn kwetsbaar voor menselijke activiteiten en worden wereldwijd actief vervolgd, vanwege conflicten met mensen. Het aantal tijgers(*Panthera tigris*) is de afgelopen eeuw sterk afgenomen en tijgers bevinden zich nu slechts in 7% van hun historische leefgebied. Ook het leefgebied van de luipaard (*Panthera pardus*) is sterk afgenomen, alhoewel deze soort meer algemeen en adaptief is dan de tijger. Omdat carnivoren grote leefgebieden nodig hebben, wordt de degradatie van hun habitat over de laatste tientallen jaren gezien als de belangrijkste bedreiging. Andere factoren die van invloed zijn op de afname van carnivoren betreffen stroperij voor de illegale handel in lichaamsdelen van carnivoren, de afname van prooidier populaties en conflicten met lokale gemeenschappen. Lokale boeren ondervinden vaak de negatieve gevolgen van wilde carnivoren, waarbij ze economische schade ondervinden door het doden van vee. Deze conflicten worden verergerd door een beperkt begrip van de ecologische rol van carnivoren en dit kan resulteren in een negatieve houding ten opzichte van carnivoren en gerelateerde projecten voor natuurbescherming.

Nepal is een van de dertien landen die het Global Tiger Recovery Plan hebben getekend op de bijeenkomst van wereldleiders in St Petersburg in 2010, die als doel heeft het aantal wilde tijgers te verdubbelen in 2022. Om dit doel te behalen heeft de regering van Nepal haar aandacht gegeven op verbeterde activiteiten gericht op natuurbescherming in en rond de landschappen waar tijgers voorkomen. Tijgers worden in Nepal nog aangetroffen in vijf nationale parken. In de laagvlakte (Terai). Dit gebied is een onderdeel van het grotere 'Terai Arc' landschap dat zich bevindt in India en Nepal.. De tijger populatie in Nepal is toegenomen sinds het einde van de burgeroorlog, terwijl de stroperij is afgenomen. Dit is een gevolg van het overheidsbeleid, dat strikte natuurbeschermings-activiteiten in nationale parken omvatten e o.m. de deelname van jongeren in anti-stroperij campagnes. Dit heeft geresulteerd in een sterke groei van de tijger populatie in Bardia nationaal park, waar tijgers nu meer interac-

ties hebben met luipaarden dan vroeger. Omdat tijgers en luipaarden schuwe dieren zijn is het moeilijk hun interactie in het veld te onderzoeken. Camera val surveys zijn een goede methode om de aanwezigheid en afwezigheid van tijgers en luipaarden te onderzoeken. Daarom heb ik met behulp van camera val data uit 2013 en 2016 de interacties tussen tijgers en luipaarden bestudeerd in Bardia nationaal park

Ik vond daarbij een significante ruimtelijke ontwijking van luipaarden t.o.v. tijgers in de centrale zone van het park, terwijl in de bufferzone en geen significant patroon van ontwijking was. Ik vond ook dat de activiteiten in de tijd van luipaarden in grids in de centrale zone, waar zowel tijgers als luipaarden aanwezig waren, significant verschilden met grids waar tijgers niet aanwezig waren, maar luipaarden wel. De activiteiten in de tijd van tijgers in grids waar luipaarden ook aanwezig waren in de centrale zone verschillen niet van grids zonder luipaarden. Ik vond echter in de bufferzone een significant verschil wat betreft de activiteiten van tijgers in de tijd in grids met luipaarden vergeleken met grids zonder luipaarden, terwijl de activiteiten van luipaarden in de tijd niet verschilden in grids met en zonder tijgers. Dit kan waarschijnlijk worden verklaard door de suggestie dat luipaarden dichter bij menselijke nederzettingen komen, terwijl tijgers menselijke nederzettingen vermijden Dit geeft ook aan dat het gemeenschappelijk gebruik van habitat en ruimte een belangrijke rol speelt in het samenleven van tijgers en luipaarden in Bardia nationaal park In het algemeen ontwijken luipaarden meer de tijgers dan andersom. Ik heb ook de dieten en prooidier voorkeuren van tijgers en luipaarden willen vergelijken.op basis van uitwerpselen. Echter, vanwege een onvoldoende grote monster-grootte van luipaard uitwerpselen, kon ik deze niet verder gebruiken en heb ik mij beperkt tot het analyseren van de uitwerpselen en prooidier voorkeuren van tijgers. Gebaseerd op het DNA in de uitwerpselen kon ik een onderscheid maken tussen vrouwelijke en mannelijke tijgers. Ik vond dat zowel mannelijke als vrouwelijke tijgers vooral prooidieren eten van medium gewicht (10 tot 40 kg)., namelijk Chital (*Axis axis*)en wild zwijn (*Sus Scrofa*), die de meest algemene prooidieren zijn in Bardia nationaal park. Echter de Jacobs index voor prooidier preferentie van mannelijke tijgers gaf een voorkeur aan voor Sambar hert ( *Cervus unicolor*) en wild zwijn, terwijl de Jacobs index voor vrouwelijke tijgers een voorkeur aangaf voor Chital en wild zwijn.

Deze resultaten waren echter statistisch gezien niet significant. Het dieet van tijgers bestond voornamelijk uit wilde prooidier soorten, hetgeen suggereert dat tijgers over het algemeen geen vee consumeren. Voor de lange termijn bescherming van de tijger in Bardia nationaal park moet meer aandacht gegeven

worden aan de groei van prooidier populaties in het park, zodat de beschikbare prooidier populaties energetische voordelen bieden voor tijgers en er minder competitie is met luipaarden. Ik heb ook gekeken naar het verloop van conflicten in Bardia nationaal park in ruimte en tijd, over een periode van vijf jaar, op basis van de statistieken van compensatie die is betaald aan dorpelingen voor de schade veroorzaakt door wilde dieren.

Ik vond dat voornamelijk vier soorten dieren betrokken waren bij schade gevallen gemeld door de lokale bevolking; olifant, luipaard, tijger en wild zwijn. Gedurende die vijf jaar werden 14 personen gedood door olifanten en één persoon door een wild zwijn. Olifanten veroorzaakten ook ernstige schade aan gewassen, vernielden huizen en vielen opslag schuren voor graan aan. Luipaarden en tijgers veroorzaakten vooral schade aan vee. Olifanten veroorzaakten meer schade gedurende de herfst wanneer gewassen (vooral rijst) aan het rijpen waren. Luipaarden veroorzaakten meer schade aan vee gedurende het regenseizoen in vergelijking met het droge seizoen, terwijl de schade toegebracht door tijgers geen verschillende vertoonde tussen de seizoenen.. Tijgers en luipaarden veroorzaakten meer schade aan vee gedurende de donkere maan periode vergeleken met de volle maan periode. De frequentie van conflicten met luipaarden was hoger in het zuidelijke en westelijke deel van de bufferzone voor olifanten en wilde zwijnen, terwijl de frequentie van conflicten met tijgers gelijk was over het hele gebied. Om meer te weten te komen over de attitudes en kennis van lokale bewoners die in de bufferzone leven, van belang voor natuurbescherming, heb ik interviews gehouden. Dit heb ik gedaan door het park te verdelen in vier verschillende regio's. Ik vond dat de schade aan vee een significante relatie had met i) de aantallen vee in bezit van bewoners, ii) de afstand tot de park grens en ii) de etnische afkomst van de respondent. De attitude van de respondenten ten opzichte van de bescherming van wilde dieren was gerelateerd aan de volgende factoren; i) kennis over de soort ii) opleidings nivo respondent iii) gender van de respondent (man/vrouw) en iv) nivo van onafhankelijkheid van de respondent. Een positieve attitude was gerelateerd aan meer kennis over de soort, een hoog opleidings nivo, en een hoog nivo van onafhankelijkheid. Het delen van voordelen en inkomsten uit natuurbescherming resulteert ook in een positieve attitude onder de bevolking in de bufferzone. Concluderend kan gezegd worden dat als gevolg van een toename van het aantal tijgers in het park luipaarden waarschijnlijk uitwijken naar de bufferzone, waar ze in conflict komen met bewoners, terwijl ook jonge tijgers het park verlaten. Voor de toekomstige bescherming van deze grote katten is het van belang dat nieuwe habitats worden gezocht en de gemeenschapsbossen in de bufferzone zouden hier aan bij kunnen dragen. Ook kan het nabijgelegen

Banke nationaal park een *sink* vormen voor de bron-populatie in Bardia nationaal park. Dit kan de verdere verspreiding van de tijger populatie in Bardia faciliteren. Voor toekomstige natuurbeschermings programma's is het van belang zich te concentreren op de bescherming van tijger en luipaard in een door mensen gedomineerd landschap. Vanwege de interactie met tijgers leven luipaarden dichter bij mensen en komen ze zo ook vaker in conflict met lokale bewoners. Tijgers genieten een culturele en religieuze tolerantie onder de bevolking die leeft in de bufferzone terwijl luipaarden deze tolerantie niet genieten.

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# Curriculum Vitae

Subodh Kumar Upadhyaya was born on the 8th of October 1965 in Khanchikot, Arghakhanchi district of Nepal. He followed his primary and secondary school from 1972 to 1984 in Kendriya Vidyalaya, Shillong, India and attended there the St. Edmund's College affiliated to North Eastern hill University in Shillong, India, where he obtained a Bachelor's degree with Zoology Honours in 1987. He obtained his first Masters degree in Zoology from Tribhuvan University, Kathmandu, Nepal in 1989. and a second Masters degree in Biotechnology from Birla Institute of Technology and Science, Pilani, India in 2004. Since 1998 he is working as a staff member in the Department of Biotechnology, School of Science, Kathmandu University, Nepal.

Subodh started his PhD at the Institute of Environmental Sciences Leiden (CML) in 2014, when he received a fellowship of the Netherlands Organization for International Cooperation in Higher Education, the Netherlands fellowship program (Nuffic-NFP). His PhD research was on the interaction between tigers and leopards in relation to human-wildlife conflict in Bardia National Park, Nepal. This PhD is part of a collaborative agreement between Leiden University, the Netherlands and Kathmandu University, Nepal and between Leiden University and the National Trust for Nature Conservation Nepal (NTNC).


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