Human–tiger *Panthera tigris* conflict and its perception in Bardia National Park, Nepal

Babu R. Bhattarai and Klaus Fischer

Abstract Human–wildlife conflict is a significant problem that often results in retaliatory killing of predators. Such conflict is particularly pronounced between humans and tigers *Panthera tigris* because of fatal attacks by tigers on humans. We investigated the incidence and perception of human–tiger conflict in the buffer zone of Bardia National Park, Nepal, by interviewing 273 local householders and 27 key persons (e.g. representatives of local communities, Park officials). Further information was compiled from the Park's archives. The annual loss of livestock attributable to tigers was 0.26 animals per household, amounting to an annual loss of 2% of livestock. Livestock predation rates were particularly high in areas with low abundance of natural prey. During 1994–2007 12 people were killed and a further four injured in tiger attacks. Nevertheless, local people generally had a positive attitude towards tiger conservation and were willing to tolerate some loss of livestock but not human casualties. This positive attitude indicates the potential for implementation of appropriate conservation measures and we propose mitigation strategies such as education, monetary compensation and monitoring of tigers.

Keywords Human casualties, human–wildlife conflict, large carnivore, livestock depredation, Nepal, *Panthera tigris*, retaliation, tiger

Introduction

Human–wildlife conflict arises when humans and animals compete for limited resources (Graham et al., 2005; Wang & Macdonald, 2006). Major causes of conflict include crop raiding, property damage and livestock depredation by wildlife (Gurung et al., 2008; Inskip & Zimmermann, 2009). Conflicts are particularly serious if they involve human casualties or if the local people are so poor that any loss of livestock directly affects their quality of life. Consequently, serious conflict often arises in areas where large carnivores occur (Polisar et al., 2003; Wang & Macdonald, 2006). An increase in the human population has resulted in increased incidence of conflict between people and carnivores (Graham et al., 2005; Woodroffe et al., 2005a). This often results in retaliatory persecution, which is a significant threat to large carnivores (Mishra et al., 2003; Treves & Karanth, 2003; Nyhus & Tilson, 2004). Thus, conservation measures to protect large carnivores can be controversial and may lack support from local communities (Graham et al., 2005).

Large carnivores play a significant role in ecosystem functioning, with their absence inducing changes in predator–prey relationships and inter-specific competition (Treves & Karanth, 2003). Many carnivores serve as important umbrella and flagship species, benefiting other threatened species and attracting funding for wider conservation benefits (Linkie & Christie, 2007). However, large carnivores are generally highly threatened, having been extirpated from many areas as a result of conflict, hunting for skins and use in traditional medicine (Weber & Rabinowitz, 1996), prey depletion (Karanth & Stith, 1999; Mishra et al., 2003) and habitat loss (Weber & Rabinowitz, 1996; Kolowski & Holekamp, 2006).

Previous studies on human–tiger conflict have largely focused on livestock depredation, human casualties and retaliation killings (Nyhus & Tilson, 2004; Muhammed et al., 2007; Gurung et al., 2008). In contrast, we investigated both the incidence of human–tiger conflict and its human dimension because effective conflict mitigation requires knowledge of the underlying human and environmental drivers (Thorn et al., 2012). Our study built on existing data on the level of resource extraction from the Park, predator–prey relationships and competition among predators (Brown, 1997; Allendorf et al., 2007; Wegge et al., 2009; Thapa & Chapman 2010; Thapa & Hubacek, 2011). Earlier studies have shown that killing carnivores is not exclusively motivated by livestock depredation or economic drivers but that factors such as perception, fear and personal, environmental and social motivations may be even more important in driving conflict than the damage incurred (Dickman, 2010; Marchini & Macdonald, 2012; Thorn et al., 2012). The human dimension is often ignored in conflict studies (Dickman, 2010) or considered only in terms of general attitudes towards conservation, which has limited value in designing interventions (Dickman, 2010; St John et al., 2010). We therefore investigated people's attitudes towards a specific target (tiger conservation) in a specific area. We investigated the perception of human–tiger conflict by local people and considered gender differences,

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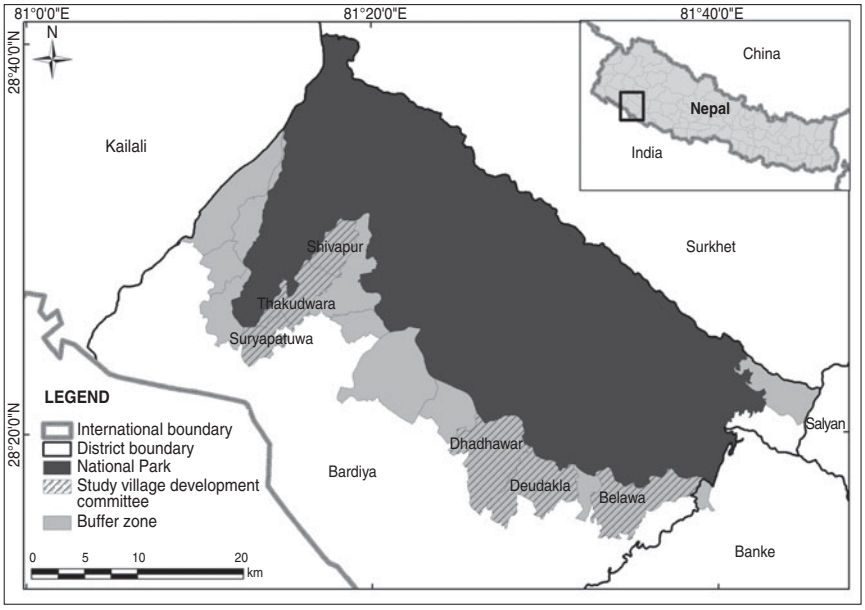

FIG. 1 Location of study communities in the buffer zone of Bardia National Park, Nepal. The rectangle on the inset shows the location of the main map in Nepal.

cultural perspectives and the effect of education on people's attitudes towards tiger conservation.

Study area

The study was carried out in six villages in the buffer zone of Bardia National Park, western Nepal (Fig. 1). The buffer zone includes 17 communities, from which we randomly chose three from an area of high prey density (Thakurbaba, Shivapur Ekikrit, Suryapatuwa) and three from an area of low prey density (Baghkhor, Deudakala, Dhadhawar), which lie under the local government units of Thakurdwara, Shivapur, Suryapatuwa, Bel Dhadhawar, and Deudakala, respectively. The number of communities studied was limited by time and resource constraints. The areas of low and high prey density were defined based on the extensive local knowledge of park rangers, game wardens and game scouts. The area of high prey density is characterized by wide alluvial floodplains and associated dynamic vegetation communities, mostly floodplain grasslands and riverine forests. Stands further away from the floodplains of Karnali River are dominated by sal *Shorea robusta* forests. In contrast, the area of low prey density is characterized by the narrow valley of the river Babai, with early successional plant communities occurring only close to the river, and with the drier slopes dominated by sal forests. The more undulating landscape of the latter area makes it drier, with higher forest coverage, resulting in lower prey density because of a shortage of grassland.

The study area supports a population of c. 18 breeding tigers (GoN, 2009) and is characterized by high human population density (211 km^{-2}; GoN, 2012). Local communities rely on subsistence agriculture but also on forest resources such as timber, firewood and fodder for their daily living (Brown, 1997; Thapa & Chapman, 2010; Thapa & Hubacek, 2011). Subsistence agriculture is sufficient to support lifestyles in only 42% of households; the remaining households rely on additional income. Domestic animals are needed for farming and one pair of ploughing oxen or buffalo costs c. USD 425, which is equivalent to 220 days' earnings for an unskilled man. The study area suffered heavily from political insurgency in the decade prior to the study, which hindered the area's development. As a result, most local people are poor and do not have access to even basic health and adequate sanitation facilities. The agricultural sector contributes nearly one third (32.8%) of Nepal's gross domestic product (IndexMundi, 2012a), which was USD 367 per capita in 2007, when 55.1% of the population had an income of ⩽ USD 1.25 per day. In 2008 25% of Nepalese people were living below the national poverty line (IndexMundi, 2012b).

Methods

We used a structured questionnaire survey to obtain data on perceived human–tiger conflict (Table 1). In total 273 households (Thakurdwara, 69; Shivapur Ekikrit, 63; Suryapatuwa, 38; Belawa, 40; Deudakala, 33; Dhadhawar, 30) were included. All questions were closed-ended for ease of quantitative analyses. Interviews were conducted primarily with the head of the household, although other family members often participated to formulate a collective response. Interviews were conducted in participants' homes during March–May 2009 and each interview lasted 45–60 minutes. We validated the interview data on livestock depredation and human casualties by cross-checking with neighbours, National Park archives and key persons, to minimize exaggeration. Key persons were official

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TABLE 1 Summary of the structured questionnaire used to gather data on human–tiger *Panthera tigris* conflict in the buffer zone of Bardia National Park, Nepal (Fig. 1). For items 2, 4 and 8–13 only one answer was allowed.

1. Name, age, sex & address of interviewee
2. Education (illiterate, pre-primary, primary, secondary, higher secondary, university)
3. Sources of livelihood (crops, livestock, employment, other; %)
4. Period for which interviewee can be sustained by own crops & livestock (<3, 3–6, 6–9, 9–12 months)
5. Livestock holding (no. of cows/oxen, buffalo, goats/sheep, poultry)
6. Number of livestock (cows/oxen, buffalo, goats/sheep, poultry) lost in tiger attacks within the last 3 years
7. Attacks by tigers on family members within the last 20 years (place, date & time, sex & age of victim, injury or death)
8. Attitude towards tigers (conserve, eradicate)
9. Reason for conserving (beautiful appearance, Endangered species, indicator of intact ecosystem, religious significance, revenue from tourism) or eradicating (human casualties, livestock depredation) tigers
10. Support for tiger conservation even if a family member was killed by a tiger (agree, disagree, neutral)
11. Support for tiger conservation even if a family member was attacked & injured by a tiger (agree, disagree, neutral)
12. Support for tiger conservation even if livestock was killed by a tiger (agree, disagree, neutral)
13. Best strategy to minimize human–tiger conflict (education, monitoring & alarming, compensation for loss)

representatives of local communities (n = 8), local nature guides (n = 10) and National Park officials (n = 9). Data were adjusted if necessary, although the results from different sources were generally similar. Respondents saw the predators in only a few cases but they identified the animal responsible by the pugmarks in the vicinity of the carcass. The correct identification of sighted predators was ensured by showing photographs of different predators to the interviewees. Two assistants from the local community, who were educated to at least high-school level, helped administer the questionnaire. They received training and conducted interviews under the supervision of BRB before being permitted to work independently.

Data on human casualties and loss of tigers as a result of human–tiger conflict were retrieved from National Park archives and interviews with key persons. All such data were validated by independently cross-checking with Park officials and other key persons. Key person interviews were carried out exclusively by BRB, using a semi-structured mix of closed- and open-ended questions. The study data cover the entire National Park and its buffer zone.

Results

Of the 273 interviewees 64 (23.4%) were female, the oldest interviewee was 75 years old, and the mean age was 40.4 ± SD 13.0 years (n = 260). Mean livestock ownership was 6.7 animals per household: 1.9 ± SD 2.6 cows/oxen, 1.1 ± SD 1.4 buffalos, 3.1 ± SD 3.8 goats/sheep, and 0.6 ± SD 1.5 pigs. The numbers of cows/oxen and goats/sheep were higher in the area of low prey density than in the area of high prey density (cows/oxen: 2.5 ± SD 3.3 vs 1.5 ± SD 1.9, $Z = 2.3$, $P = 0.022$; goats/sheep: 3.8 ± SD 4.4 vs 2.7 ± SD 3.4, $Z = 2.3$, $P = 0.021$). No significant differences were found in the numbers of buffalos (1.3 ± SD 1.5 vs 1.0 ± SD 1.3; $Z = 1.7$, $P = 0.087$) and pigs (0.6 ± SD 1.6 vs 0.6 ± SD 1.3; $Z = 0.3$, $P = 0.778$) between the two areas. Human–tiger conflict was evident as 77 of 273 (28.2%) households reported loss of livestock as a result of tiger predation in the previous 3 years, amounting to a mean loss of 0.75 livestock per household surveyed. Specifically, 41 (15%) households reported a loss of a total of 78 cows/oxen, five households (2%) reported a loss of a total of five buffalos, 46 (17%) reported a loss of a total of 112 goats/sheep, and five (2%) reported a loss of a total of six pigs. Predation rates in the previous 3 years were highest for cows/oxen (15% of all cows/oxen were killed by tigers), followed by goats/sheep (13%), pigs (4%), and buffalos (2%). Significantly more cows/oxen ($Z = 2.3$, $P = 0.024$) and goats/sheep ($Z = 3.8$, $P < 0.001$) were killed by tigers in the area of low prey density than in the area of high prey density. This was not the case for buffalos ($Z = 0.2$, $P = 0.847$) or pigs ($Z = 0.2$, $P = 0.849$; Fig. 2).

Key persons (n = 27) suggested the following reasons for livestock depredation by tigers, in order of priority: grazing of livestock in tiger habitat (n = 10), physical impairment of tigers, forcing them to shift from wild prey to domestic animals (n = 7), prey depletion by excessive hunting and habitat degradation (n = 6), and reduced habitat size, forcing tigers to hunt close to humans (n = 4).

During 1994–2007 seven people were killed and four injured in tiger attacks in Bardia National Park. Five others were killed by tigers in adjacent areas, three in 1994 in the Rammapur area and two in 1999 in the Suryapatuwa area. Key persons (n = 27) cited the following reasons for casualties: humans collecting resources (e.g. grass, herbs, firewood) and grazing livestock in tiger habitat (n = 9), physical impairment of tigers (n = 7), reduction of natural prey (n = 6), and individual tigers developing a taste for human flesh (n = 5).

At least 26 tigers were lost from the study area during 1989–2009, of which 17 died for natural reasons (nine in intra-specific fights, five as a result of infanticide and one each as a result of old age, flood and disease). Six tigers were lost as a result of human–tiger conflict, including three

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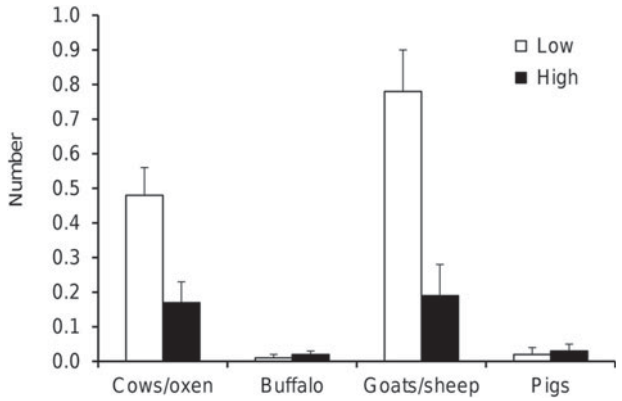

FIG. 2 Mean number of livestock (+1 SE) killed by tigers in areas of low and high prey density in the buffer zone of Bardia National Park, Nepal (Fig. 1).

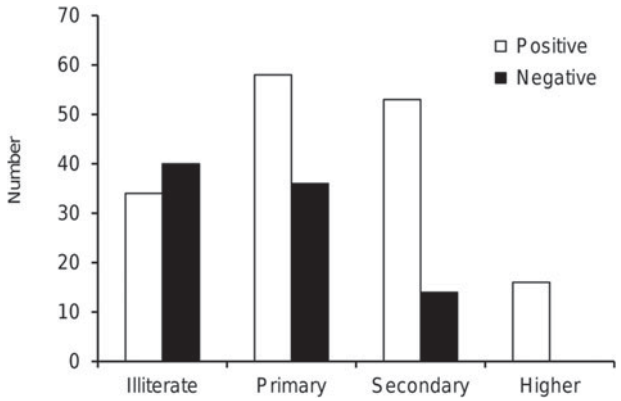

FIG. 3 Local attitudes towards tiger conservation in the buffer zone of Bardia National Park, Nepal (Fig. 1), depending on respondents' level of education.

illegal revenge killings, one killed by authorities, one caught and transferred to a zoo by authorities, and one that was poached for the illegal trade of tiger body parts. The cause of death of the remaining three tigers is unknown.

Despite livestock depredation and the occurrence of human casualties, the local people's attitude towards tiger conservation was generally positive, with 63% (n = 271) in favour. The reasons included expected benefits from ecotourism (38.4%, n = 172), the ecological value of tigers as an indicator of intact ecosystems (26.2%), their endangerment and population decline (21.5%), their beautiful appearance (11.6%) and their religious importance in Hindu culture (2.3%). Those with a negative attitude towards tiger conservation were concerned about human casualties (53%, n = 99) and livestock depredation (47%). Education had a significant influence on attitudes (Fig. 3), with the people supporting tiger conservation generally having a higher level of education than those with a negative attitude ($\chi^2_{df=3} = 36.4$, $P < 0.001$). Males (69.4%) had a more positive attitude towards tiger conservation than females (45.3%; $\chi^2_{df=1} = 12.3$, $P < 0.001$).

Discussion

The mean annual loss of livestock found in our study (0.26 animals per household) is within the range of predation rates reported elsewhere (Madhusudan, 2003; Nyhus & Tilson, 2004; Bagchi & Mishra, 2006; Wang & Macdonald, 2006; Tamang & Baral, 2008). Opportunistic killing of livestock by tigers is common as domestic animals are easy prey. Livestock depredation in our study area is facilitated by the failure of local people to use corrals or stalls at night and by grazing of livestock in the National Park and its buffer zone (authors, pers. obs.). Furthermore, reduction of natural prey may force predators to prey upon livestock (Kolowski & Holekamp 2006; Gusset et al., 2009). In Bardia National Park numbers of spotted deer *Axis axis*, the main natural prey of tigers (Støen & Wegge, 1996; Wegge et al., 2009), have declined by 80% since 1993 (Sharma, 2006). Our data indicate that the availability of natural prey is a key factor in determining the level of livestock predation by tigers; predation rates were higher in areas with low prey density. However, there are alternative explanations, including differences in tiger density and an increased availability of livestock in the area of low prey density. We cannot entirely rule out that leopards were responsible for some of the depredation of livestock. Key persons considered grazing of livestock in tiger habitat, depletion of natural prey, habitat loss and physical impairment to have a significant effect on livestock depredation by tigers. Although low in absolute terms, predation rates amount to an annual loss of 2% of livestock. Given that most households are poor and are dependent on subsistence agriculture the economic effect of predation may be high and prompt retaliation killings (Bagchi & Mishra, 2006). The loss of a ploughing ox or buffalo can be disastrous for a subsistence farmer.

The number of humans killed by tigers in our study area (0.93 per year, 1994–2007) was relatively low compared to other areas (Nyhus & Tilson, 2004; Gurung et al., 2008; Barlow et al., 2010), probably because tigers are mainly restricted to the National Park, where most (82%) lethal attacks occurred. Even if infrequent, such events may have severe and long-lasting implications for tiger conservation, undermining support from local people. Muhammed et al. (2007) attributed the occurrence of man-eating tigers to old age, injury or dental problems, impairing the tigers' ability to hunt natural prey, depletion of natural prey, and habitat loss and fragmentation, forcing tigers to hunt outside forests. This is largely consistent with the perceptions of the key persons in our study area. Physical impairment may be particularly significant. In Chitwan National Park, for example, 10 of 18 human-killing tigers had physical impairments such as missing teeth or injuries (Gurung et al., 2008).

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Conservation implications and mitigation strategies

The support of local people and their participation in the conservation of carnivores depend largely on the value they place on these animals (Gusset et al., 2009). In our study the majority of local people had a positive attitude towards tigers and their conservation (Gurung et al., 2008; Karanth & Nepal, 2012), in contrast with studies in other areas (Bagchi & Mishra, 2006; Lucherini & Merino, 2008). The prevalence of positive attitudes in our study area may be attributed to expected monetary benefits from ecotourism. Revenues earned by the National Park are partly allocated to development projects in the buffer zone (c. USD 256,410 until 2007; GoN, 2009). Local people also value the National Park and its buffer zone as a source of thatching grass and other natural resources (Allendorf et al., 2007; Thapa & Chapman, 2010; Thapa & Hubacek, 2011). Some people were concerned about an increase in prey populations and consequent crop raiding in the absence of tigers, which reflects the notion that tigers indicate an intact ecosystem. Twenty-two percent of local people were in favour of tiger conservation because of the species' Endangered status and 12% because of its beauty. Therefore not all people support tiger conservation exclusively for their own benefit. The religious value of tigers may also contribute to the overall positive attitude in this region, where people are predominantly Hindu and believe that tigers are the vehicle of the goddess of might. Negative attitudes were related to human casualties and livestock depredation. The less positive attitude towards tiger conservation among women compared to men is probably because women more commonly collect resources in the forests and may therefore be more afraid of attacks by tigers.

The prevalence of positive attitudes towards tiger conservation holds potential for the long-term conservation of this species. Unlike in other areas (Dickman, 2010; Thorn et al., 2012) conflict seems to be driven by the occurrence of human casualties and, less so, by economic losses. Mitigating these areas of conflict may result in broad support for conservation measures (Karanth & Nepal, 2012). Our study thus illustrates how taking local people's perceptions into account may help to identify principal drivers of conflict, which is necessary to launch and prioritize specific conservation actions (Dickman, 2010; Thorn et al., 2012). Based on our results and analysis we make the following recommendations:

Reducing the number of human casualties The abundance and distribution of tigers and the occurrence of conflict tigers should be monitored and local communities informed immediately of the occurrence of human-eating tigers. Human-eating tigers (having killed at least one person) should be removed from the area as soon as possible by the National Park authorities. We recommend that a relief fund is established for the families of victims. Encounters between humans and tigers should be reduced by enforcing the existing regulations banning grazing and the collection of forest products in the National Park.

Compensation for livestock depredation Local people should receive quick and fair compensation for livestock lost in tiger attacks. A subsidized livestock insurance system could be implemented. However, compensation and insurance schemes are often difficult to implement for various reasons, including lack of sustainable funding, difficulties in verifying tiger attacks and determining fair payment, long delays, excessive corruption, bureaucracy and cultural unfamiliarity (Madhusudan, 2003; Nyhus et al., 2003; Woodroffe et al., 2005b; Nyhus & Tilson, 2010).

Strengthening support for tiger conservation A development and education programme about tiger ecology should be implemented, along with training in farming skills. Advice should be provided on using alternative energy sources, growing food for livestock, stall feeding and alternative livestock breeds, to reduce dependence on forest products, and encounter and depredation rates. Local people should be directly involved in development, education and conservation programmes and decisions, which may improve their perception of conservation (Mehta & Heinen, 2001; Thapa & Hubacek, 2011).

We passed our recommendations to the authorities of Bardia National Park. In 2010 a project to mitigate human–tiger conflict was launched, which included an education programme to raise conservation awareness and promote the construction of predator-proof corrals for livestock, and it was well received by the communities in the Park buffer zone. In the meantime the Nepalese government has formulated compensation guidelines for human casualties of tiger attacks.

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Biographical sketches

Babu R. Bhattarai has worked in a number of protected areas in Nepal. He is interested in the management of protected areas, human–wildlife conflict mitigation and prey–predator interactions of large felids and canids. Klaus Fischer's main research interests are life-history evolution, adaptation to environmental stress and the conservation biology of threatened species. He is working on sexual selection, factors affecting the occurrence of animal species, and the effects of climate change on biodiversity, using butterflies as his principal model organisms.

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