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Livestock depredation by tigers and people's perception towards conservation in a biological corridor of Bhutan and its conservation implications

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Abstract

Context. An effective management of human–wildlife conflict is key to successful conservation, especially in areas where large carnivores occur. This is particularly important when new conservation regimes such as biological corridors are to be operationalised, as is the case in Bhutan.

Aims. The aim of the study was to determine livestock depredation by tigers in a biological corridor (BC) in Bhutan and to assess the people's perception towards tiger conservation and BC management.

Methods. A semi-structured questionnaire survey with both open- and closed-ended questions was administered to 91 households from 10 villages. Chi-square tests were used to determine the association between predictor and response variables and multivariate logistic regressions to determine factors affecting the attitude of people towards conservation.

Key results. Livestock losses were common, with 69% of respondents losing one or more livestock to predators between 2016 and 2018. Tigers were responsible for 58.9% of all kills. The people's awareness of the BC was low (16%), but still they had a positive attitude towards tiger conservation (68%) and BC management (65%). Knowledge on the BC was higher in males than in females, in people with than without a formal education, and in inner- than buffer-zone villages. The respondents' attitude towards conservation was significantly more positive in people being aware of the BC, with a formal education, and that had not suffered livestock depredation.

Conclusions. Overall, the results suggest that tigers are active in the BC and that livestock depredation is high. People's knowledge on the BC was low, and a positive attitude towards conservation was driven by cultural values and education level. Implementation of preventive measures, addressing depredation issues and conducting awareness education programs, will further enhance positive attitudes.

Implications. The present study highlighted the need for wildlife damage prevention and mitigating the prevailing conflicts in the BCs. Additionally, communities in and around the BCs need to be informed of conservation programs so that they become conservation partners.

Additional keywords: carnivore conservation, human–wildlife conflict, landscape conservation, protected areas.

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Introduction

The growing human population has increased competition between wildlife and people for resources and space, thus intensifying the human–wildlife interactions causing human–wildlife conflict (Graham *et al.* 2005). Such conflicts mostly involve damage to crops or killing of livestock, and occasionally attacks on people (Graham *et al.* 2005; Inskip and Zimmermann 2009). Human–wildlife conflict may be especially pronounced in the vicinity of protected areas because of rich wildlife and livestock depredation by large carnivores, and concomitant retaliatory or preventive killing is a worldwide conservation concern (Treves and Karanth 2003; Woodroffe *et al.* 2005). Such killings are of particular concern when carnivores cause serious economic damage (Treves and Karanth 2003; Suryawanshi *et al.* 2013) and if involving threatened predators (Mishra 1997; Inskip and Zimmermann 2009; Goodrich 2010). Thus, the conservation of large carnivores may even within protected areas be a challenge for policy-makers and requires multidisciplinary approaches (McShane *et al.* 2011). A solid understanding of the ecological and human dimensions of conflict is imperative for the effective resolution of conflict and for implementing appropriate conservation interventions (Goodrich 2010; Mir *et al.* 2015).

The tiger, *Panthera tigris*, is a large carnivore threatened by habitat loss and fragmentation (Linkie *et al.* 2003), poaching (Sharma *et al.* 2014) and prey depletion (Grey 2009). It is also a prime example of a threatened species that is often involved in conflicts with humans, owing to livestock depredation (Wang and Macdonald 2006; Gurung 2008; Borah *et al.* 2018), and, therefore, faces the risk of persecution (Kissui 2008). Livestock depredation may adversely influence people's attitude towards conservation (Liu *et al.* 2011), causing major challenges. To prevent losses through human–tiger conflict and prioritise conservation interventions, more information regarding livestock depredation by tigers and the people's perception towards tiger conservation is important (Karanth and Gopal 2005; Broekhuis *et al.* 2017).

Although human–wildlife conflict is an issue relevant to vast areas, there are clearly regional differences in its intensity (Woodroffe *et al.* 2005). Here, Bhutan is distinctive when it comes to the spatial relationship between rural people and wildlife, because some settlements are located within protected areas (NCD 2004; Dorji 2009). This causes a high degree of human–wildlife interactions, especially for people depending on forests for resource collection and livestock grazing (Katel and Schmidt-Vogt 2011; Letro and Wangchuk 2016). Such communities often report crop raiding and livestock depredation by wildlife (Wang *et al.* 2006*a*; Wang and Macdonald 2006; Jamtsho and Wangchuk 2016). Regarding the latter, tiger is a major predator and depredation rates are increasing in Bhutan (Sangay and Vernes 2008; Dhendup and Letro 2016). However, most of these reports come from the protected areas such as National Parks and Wildlife Sanctuaries, whereas information from biological corridors is lacking.

Bhutan has a network of protected areas covering 51.3% of the total area, including five national parks, four wildlife sanctuaries, one strict nature reserve, and eight biological corridors (BCs; Department of Forests and Park Services 2015*a*). BCs were established in 1999, as areas set aside to connect one or more protected areas to facilitate wildlife movement and dispersal (Sherpa and Norbu 1999). They were selected on the basis of vegetation cover derived from Landsat images, land-use maps, and evidence of tiger occurrence. A field validation was not conducted, mainly because of a lack of trained manpower and resources (Thinley 2010). With communities being an integral part of the protected-area systems in Bhutan, communities have the traditional rights for grazing and sustainable collection of forest resources for rural use. However, no commercial extraction and unauthorised entry of people from outside the protected area is allowed inside the protected areas, including BCs (Royal Government of Bhutan 2017). With the implementation of Bhutan's protected-area system more than two decades ago, the government conservation policy has strengthened and many people are now informed about conservation needs (Dorji 2009). However, management of BCs has lagged behind as compared with that of other protected areas, and currently not much is known about the status of wildlife and human–wildlife interactions in BCs (Thinley 2010; Letro and Duba 2019). As BCs form an integral part of Bhutan's strategic conservation plans, gathering more information on human–wildlife conflict within and around these areas as well as the local people's attitude towards conservation is important for effective corridor management.

The present study aims to assess patterns of livestock depredation by tigers and the peoples' attitude towards conservation in BC No. 8 (BC8) of Bhutan. BC8 connects Jigme Singye Wangchuck National Park (JSWNP) in central Bhutan with Wangchuck Centennial National Park (WCNP) in northern Bhutan, as well as some other protected areas. It is expected to serve as an important corridor for tigers, because JSWNP was identified as a tiger-rich area in the 2015 national tiger survey (Department of Forests and Park Services 2015*b*). The data shall assist in framing and implementing policies that help improve the connectivity of the corridor, while reducing human–wildlife conflict.

Materials and methods

Study area

The current study was executed in the part of BC8 that connects JSWNP and WCNP (latitude 27°26′10.05″N to 27°36′12.89″N, longitude 90°10′44.86″E to 90°27′4.18″E), which covers an area of ~240 km^2 (Fig. 1). Altitude ranges between 1850 and 4180 m a.s.l, the climate is warm-temperate, with an average annual temperature of 14°C, and an annual average rainfall of 1956 mm. The landscape is undulating, covered with different types of forest including broadleaved forests, fir forests, blue pine forests, mixed conifer forests, and alpine scrubs. Camera traps recorded the presence of top predators such as tiger, common leopard (*Panthera pardus*), Asiatic black bear (*Ursus thibetanus*) as well as prey species such as sambar (*Rusa unicolor*), wild pig (*Sus scrofa*), Himalayan serow (*Capricornis thar*), barking deer (*Muntiacus muntjak*), Himalayan goral (*Naemorhedus goral*), musk deer (*Moschus chrysogaster*) and takin (*Budorcas taxicolor whitei*; Department of Forests and Park Services 2015*b*). There are various settlements in and around BC8. The inhabitants are either nomadic herders who rear yaks and practice migratory grazing or agro-pastoralists who rear cattle and practice subsistence agriculture. The nomads have most of their winter grazing grounds within BC8 and local people living nearby the BC8 also harvest timber, fuelwood and other non-timber products from within the BC8.

Study design and data collection

Ten villages (2720–3380 m a.s.l), being located within (inner zone, $n = 5$) or close to (buffer zone, $n = 5$) BC8, were chosen for conducting a questionnaire survey (cf. Fig. 1, Table 1). Both agro-pastoralists and nomads are prevalent in each village. The survey was conducted in April–May 2018, just before the summer migration of nomadic herders to their summer pastures in subalpine regions. The surveys were mainly conducted in the villages, although some nomads were interviewed in their nomadic huts. In total, 91 people from the 10 villages were interviewed, each representing a household sample unit. Of these, 47 respondents were from the buffer zone, whereas 44 respondents were from the inner zone. With five respondents, Sektang village had the lowest and Lubzur village the highest sample size, with 13 respondents. The respondent was typically the head of the household. The questionnaire included personal information, farming practices, livestock holding, prevalence of livestock depredation and suspected predators, awareness of BC, and perception on

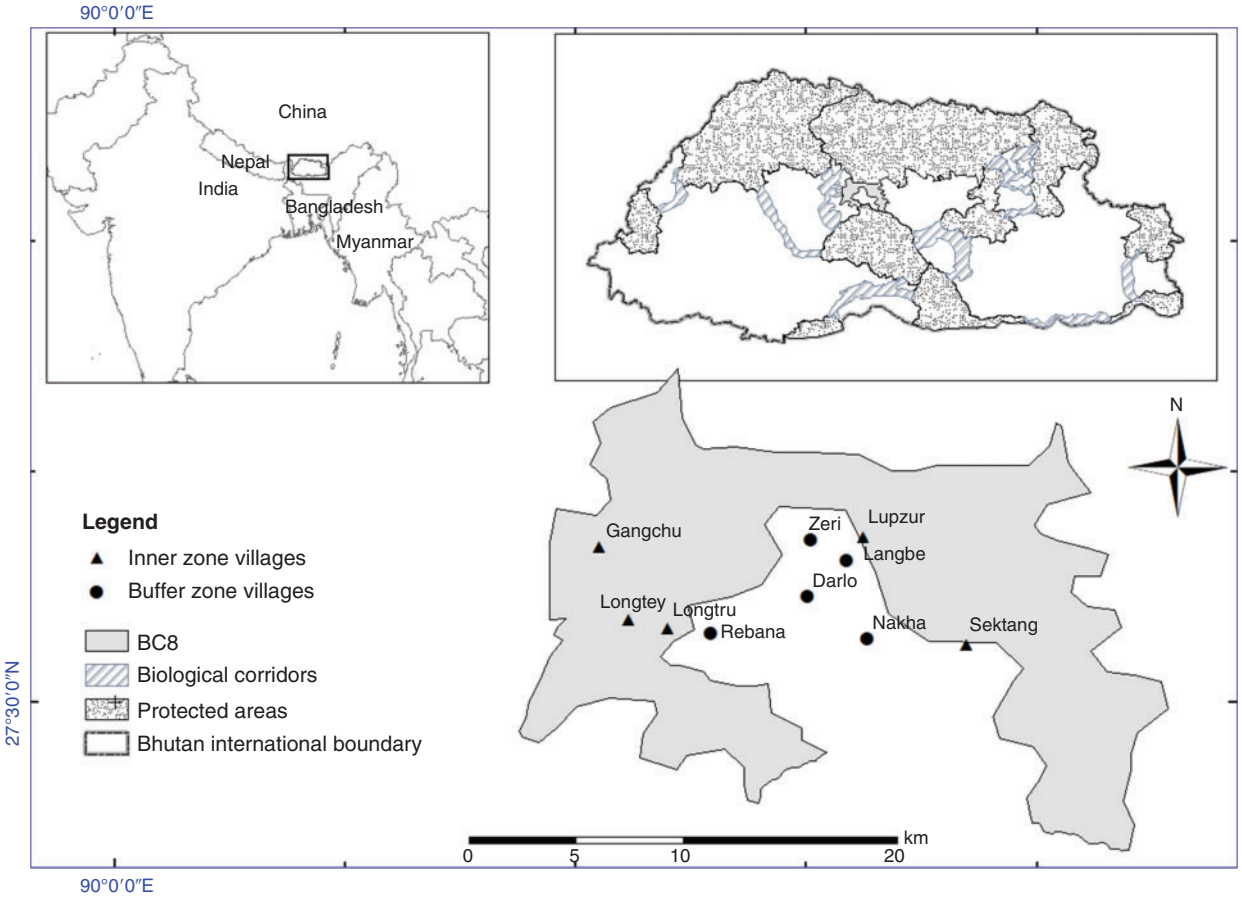

Fig. 1. Location of Bhutan (top left). Bhutan's network of protected areas including biological corridors (top right), and map of the study area (bottom).

Table 1. Questionnaire used in the study

Questions related to personal information
1a. Age and gender of the respondent
1b. Education level: formal education level/non-formal education
1c. Village location: inner zone/buffer zone
Questions related to livestock holding and livestock loss to predators
2a. How many livestock do you own? Livestock type and number
2b. What herding methods do you practice? Nomadic/agro-pastoralist
3a. Have predators killed livestock of yours between 2016 and 2018? Yes/no
3b. If yes, please provide details of the animals killed (predator, livestock killed and numbers)
3c. Do you think that such losses are severe and need to be reduced immediately? Yes/no
3d. If yes, what mitigation measures are necessary?
4a. Did your family suffer human casualty from tiger attacks? Yes/no
4b. If yes, please specify year and place
5. If you know any incidents of retaliatory persecution of tiger, please provide details of approximate date, locality, and number of animals killed
Questions related to local attitudes towards wildlife and conservation
6. Do you know the concept of biological corridors and their prevalence in your region?
7. Is the management of biological corridors important for wildlife conservation in your region? Why?
8. Do you think tigers need to be protected? Why?

tiger conservation and BC (Table 1). For people who were not aware of the BC concept, they were informed about it and subsequent questions were asked. Data on livestock holding were validated by local authorities and data on livestock losses were cross-checked with information gathered by park officials.

Table 2. Average number of livestock per household in 10 villages in the study area in 2018

Village location	Villages	Number of respondents	Cattle	Yak
Buffer	Darilo	12	4.0 ± 0.9	36.9 ± 10.7
Buffer	Langbe	11	5.5 ± 1.4	6.8 ± 6.5
Buffer	Nakha	9	2.0 ± 1.0	6.1 ± 5.8
Buffer	Zeri	8	1.9 ± 1.2	44.4 ± 12.8
Buffer	Rebana	7	0.0	55.7 ± 2.8
Inner	Gangchukha	8	0.0	20.7 ± 7.3
Inner	Longtey	10	0.7 ± 0.7	20.0 ± 9.7
Inner	Longtru	8	4.3 ± 1.3	31.3 ± 6.7
Inner	Lupzur	13	4.5 ± 1.2	16.5 ± 8.4
Inner	Sektang	5	4.6 ± 1.7	14.0 ± 12.5

Data analyses

All statistical tests were performed using R (R Core Team 2018). Chi-square tests were used to determine the association among livestock losses and (1) village location (inner zone and buffer zone), (2) herding practice (nomads and agro-pastoralists) and (3) the relationship between herding practice and depredation in different seasons (summer and winter). Pearson correlations were used to test for relationships between quantitative variables such as livestock holding and livestock loss. Multivariate logistic regressions were used to determine factors affecting (1) the people's knowledge on BC8, (2) their attitude towards BC management, and (3) their attitude towards tiger conservation. Predictor variables included gender, education level, village location, awareness about BCs and livestock loss. Results are reported as estimated coefficient (β), standard error of the coefficient (s.e.), Wald-statistics (χ^2) values, and the level of statistical significance (P), which was considered to be significant if the P-value was <0.05. In descriptive statistics, means ± s.e. are given.

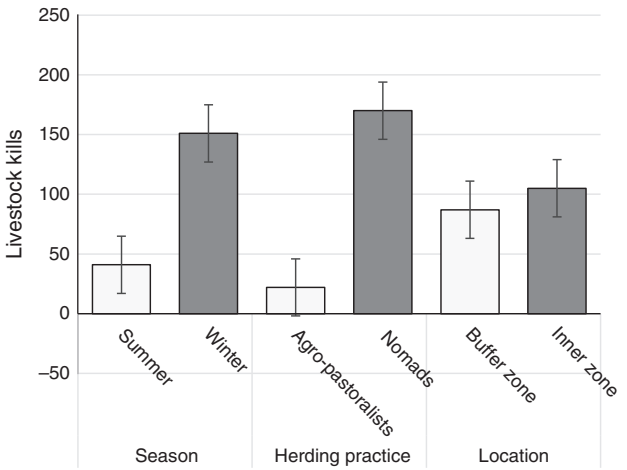

Fig. 2. Livestock losses to tigers in relation to season, herding practice and village location.

Results

Of the 91 respondents, 44 were female and 47 male. The age ranged between 18 and 70 years, with an average of 42.1 ± 1.2.

Livestock holding

Three types of large-sized livestock are reared by the communities, namely cow, yak and horse, totalling 2657 animals (on average 29.2 ± 3.2 per household). Because only seven households kept horses, these data were not taken into account in further analyses. Livestock holding per household ranged from 4 to 95 animals, the average being 7.3 ± 0.34 cattle and 60.38 ± 2.34 yaks (see Table 2 for variation among villages). Twenty-one of the surveyed households reared neither cattle nor yak, five reared both cattle and yak, 31 reared only cattle, and 34 only yak. Thus, 76.9% of the respondents were pastoralists who either reared their cattle in the State Reserve Forest nearby their villages or used pastures within the BC8 in the case of yak herders.

Livestock losses

Of the 91 households, 63 (69.2%) lost one or more livestock to predators between 2016 and 2018 (Fig. 2), equalling 90.0% of all households keeping livestock. In total, 251 livestock were killed by predators. Main predators in the BC as per respondents were tigers (n = 148 kills), followed by wild dogs (n = 45). Respondents saw the predators only rarely, but typically could determine the responsible species by the nature of kill and the signs around the kill site. Snow leopard killed 32 yaks during summer, whereas predators could not be determined in the remaining cases (n = 26). On average, livestock-keeping households lost 1.8 animals per year. In total, 56 households lost livestock to tigers alone. The nomads faced significantly higher livestock losses than did the agro-pastoralist ($\chi^2_{10} = 58.6$, $P < 0.05$), whereas there was no significant difference between inner- and buffer-zone villages ($\chi^2_9 = 10.0$, $P = 0.35$). However, the numbers of livestock and losses to predators were strongly positively correlated ($r = 0.76$, $P < 0.05$, $n = 89$). Losses were significantly higher in winter than in summer (χ^2_2 = 29.5, $P < 0.05$). Most of the respondents who lost livestock to predators (77.7%, $n = 49$) felt that the level of loss was severe and needed to be reduced. Eight of them reported the incidences of livestock depredation to park officials. The majority of the respondents requested that governmental agencies should compensate for the livestock lost to predators (78%, n = 71). However, few felt that livestock owners are equally responsible for guarding their livestock (14.2%, n = 13), whereas seven respondents were indifferent.

Table 3. Summary of answers to fixed-response attitude statements concerning biological-corridor management and tiger conservation (n = sample size)

Perception and attitude statement	Response in % ($n = 91$)	
	Yes	No
A. Do you know the concept of biological corridors and its prevalence in your region?	16.5	83.5
B. Is the management of biological corridors important for wildlife conservation in your region?	64.8	35.2
C. Do you think tigers need to be protected?	68.1	31.9

Table 4. Results of multivariate analyses on the respondents' knowledge and attitude towards biological corridors (BC) and their prevalence near their villages, management of biological corridors for conservation and tiger conservation

Significant *P*-values are in bold

Variable	Coefficient (β)	s.e.	Wald χ^2	*P*-value	Odds ratio	95% CI
Biological corridors and their prevalence near their villages						
Gender	2.66	1.09	5.89	**0.0150**	14.34	2.4–276.9
Education level	0.79	0.32	6.01	**0.0140**	2.19	1.2–4.4
Village location	1.58	0.76	4.29	**0.0380**	4.85	1.2–25.4
Management of biological corridors for conservation						
Education level	0.82	0.33	6.10	**0.0130**	2.27	0.2–1.5
Aware of BC	1.64	1.05	2.43	0.1200	5.16	−0.2–4.1
Livestock loss	−0.34	0.09	13.16	**0.0002**	0.71	−0.5 to −0.2
Tiger conservation						
Livestock loss	−0.26	0.08	10.07	**0.0020**	0.77	−0.4–0.1
Education level	0.79	0.31	6.49	**0.0110**	2.21	0.2–1.5

People's perception on tiger conservation and BC management

Despite the villages being situated within or close to BC8, the awareness about the BC was low (Table 3). Nevertheless, after informing villagers about the concept of BC to them, the majority of people thought that the management of BCs is important for wildlife conservation and that tigers should be protected, mainly because of their cultural value 38.5% ($n = 35$) and their endangered status 29.6% ($n = 27$). Those who felt tiger conservation is not important (31.8%, $n = 29$) reported losing livestock to predators as the main reason. Of the 69% households that lost livestock to tigers, only 42.85% ($n = 30$) felt that tigers need to be conserved. Knowledge on BCs was significantly higher in males than in females, in people with than without a formal education, and in inner- than buffer-zone villages (Table 4). The respondents' attitudes towards management of BCs was significantly more positive in people who were aware of BC8, with a formal education, and who had not suffered livestock depredation (Table 4). Finally, the attitude towards tiger conservation was significantly more positive in people with a formal education and in those that had not suffered livestock depredation (Table 4).

Discussion

The present study showed that people living in and around BC8 are well aware of the presence of tigers near their localities because of the high degree of interaction between people and nature. However, people had little knowledge on the concept of BCs and its demarcation in their locality. Being based inside the BC, formal education, and male sex positively influenced knowledge on the BC. This may be because respondents in the inner zone have more interactions with forestry officials and educated persons are better informed. Such observations were reported for the national parks of Bhutan in the past as well (Wang *et al.* 2006*b*; Dorji 2009). That female respondents have less knowledge than men could be due to the fact that females are mainly busy with household work, whereas males spend more time to interact socially (Katel and Schmidt-vogt 2011). Whereas people are better informed about national parks and wildlife sanctuaries in Bhutan through various awareness programs and conservation incentives (Katel and Schmidt-vogt 2011; Dorji *et al.* 2011), the lack of knowledge about BCs could be caused by a lack of operationalisation of the BCs after their establishment. This lack of knowledge may hinder the sound management of BC8, especially because people associate protected areas with increased levels of predation (Saberwal *et al.* 1994; Studsrod and Wegge 1995; Maikhuri *et al.* 2001; Wang and Macdonald 2006).

Our survey showed that livestock depredation by carnivores is common in the study area. The communities lost ~1.8 heads per household, equalling 4.4% of their stocks per year, which is higher than the loss rates recorded in the early 2000s in JSWNP, where the mean loss was 1.3 heads per year (2.3% of the stock; Wang and Macdonald 2006). Although the high values found here are alarming, they are comparable to those in protected areas in Nepal and India (e.g. Studsrod and Wegge 1995; Maikhuri *et al.* 2001). Moreover, not all lost livestock was killed inside the BC, but some individuals were killed during the summer on alpine pastures by snow leopards. As 58.9% ($n = 148$) of the total kills could be attributed to tigers, BC8 is used by tigers either as a migratory corridor or as a home range,

indicating that framing a management plan is crucial to curb livestock loss and prevent threats to tiger.

High depredation rates, as reported by the herders, are complex issues that are difficult to settle. With BC8 serving as winter pasture for yaks, our result supported the finding that abundance of food, in this case livestock, leads to increased predation by tigers (Wang and Macdonald 2006; Inskip and Zimmermann 2009; Rostro-García *et al.* 2016). Whereas reduced escape abilities of livestock as compared with wild ungulates make them more vulnerable (Nowell and Jackson 1996; Bhattarai and Fischer 2014), high livestock densities may also reduce native ungulate numbers, thereby increasing predation on livestock (Mishra 2001; Bagchi and Mishra 2006). It is, therefore, vital to monitor the abundance and presence of wild prey species to understand the tiger–prey dynamics (Karanth *et al.* 2004) in the BC8.

Herding practices contributed to increased depredation rates in Bhutan, with free-ranging and unattended livestock being found to be more vulnerable to predation (Sangay and Vernes 2008; Tshering and Thinley 2017). Similar observations were made in our study area. Nomads with high numbers of yaks often leave most of their yaks unattended in the forests. Likewise, in summer, agro-pastoralists are mostly engaged in agriculture, also leaving their cattle unattended. However, the availability of alternative income sources for farmers is reducing the interest in rearing yaks (Wangchuk and Wangdi 2015), which results in leaving the yaks unattended for certain months during the winter, leading to higher livestock losses during winter. Thus, one way to reduce depredation rates is a proper herd management (see Wang and Macdonald 2006) and reducing the time livestock spends free ranging (Mir *et al.* 2015). In contrast, the high number of kills is unlikely to be due to a high density of tigers, because the entire study area is expected to hold only one or two individuals considering an average tiger density of 0.42 tigers per 100 km^2 in Bhutan (Tempa 2017).

The survey showed that more than 30% of the respondents had a negative attitude towards tiger conservation. Such adverse attitudes were mainly driven by livestock depredation, which also caused negative attitudes towards BC management. Similar results were obtained by Bagchi and Mishra (2006) in the Indian Himalaya. Although no incidents of retaliation are known by now in the study area, fear of losing livestock to predators may translate into negative attitudes towards conservation (Gurung 2008; Goodrich 2010; Bhattarai and Fischer 2014) and possibly retaliation in the future (Sangay and Vernes 2008). Still, more than 65% of the respondents showed a positive attitude towards tiger conservation and BC management, documenting the high potential for the long-term conservation. Because knowledge on the threatened status of tiger and socio-cultural values promoted a positive attitude, implementing education programs for the communities in BC8 are expected to have a positive impact. Thus, awareness education programs by conservation practitioners and education through Buddhist religious discourses on conservation by spiritual leaders (Bhatia *et al.* 2017) are recommended. Besides, as sought by the respondents, it is important that compensatory measures and *ex gratia* options for the people in case of livestock predation are important for management planning. Conservation incentives such as pasture management, livestock intensification and alternatives to natural resources should be identified by the government after due consultation with the communities so that negative attitudes towards wildlife are reduced (Gurung 2008; Bhattarai and Fischer 2014; Mir *et al.* 2015). Several studies have demonstrated links between developmental programs and positive attitudes towards conservation (Studsrod and Wegge 1995; Maikhuri *et al.* 2001; Dorji 2009). An improved understanding of tiger ecology and the aims of corridor management, based on empirical knowledge and local experiences (Treves and Karanth 2003; Graham *et al.* 2005; Goodrich 2010), may further enhance the co-existence of humans and tigers in the study area.

In conclusion, BC8 seems to effectively connect JSWNP in central Bhutan with WCNP in northern Bhutan. High incidences of livestock depredation by tigers show that they are actively using BC8. However, the fact that there are human settlements in and around BC8, resulting in high livestock depredation rates, stresses the need for an appropriate BC management to benefit both wildlife and communities. Therefore, we strongly recommend framing a holistic conservation management plan for BC8 that identifies mitigation measures such as pasture improvement and livestock-intensification programs. Compensatory or *ex gratia* options should be explored and other conservation incentives relevant to local communities need to be planned through community engagement. Predator–prey dynamics need to be studied, and there is an urgent need for a better education of the people regarding the concept of BCs and conservation needs. Finally, we recommend to replicate such studies in other BCs and, ultimately, to develop conservation management plans for all BCs in Bhutan, which may support the co-existence between wildlife and communities in the long run.

Conflicts of interest

The authors declare no conflicts of interest.

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