RESEARCH ARTICLE

The economic cost of wild mammalian carnivores to farmers in the Himalayan Kingdom of Bhutan

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Livestock casualty from human-wildlife conflict in Bhutan

Abstract

Livestock predation by large carnivores prompted the Bhutanese government to initiate a scheme (the 'Tiger Conservation Fund') to compensate agro-pastoralists losing livestock to attack by tigers (*Panthera tigris*), leopards (*P. pardus*), snow leopards (*P. uncia*) and Himalayan black bears (*Ursus thibetanus*) over a three-year period (2003–2005). In this paper we report on the economic impact of predation to farmers during that period, and how losses were compensated. US$ 138,454 in compensation was paid to 1233 farmers for 1692 livestock kills. On average, compensation covered 35.5% of the market value of predated livestock. Compensated farmers lost on average 1.3 head of livestock in the year they received compensation, a loss equivalent to 39% of annual average household income. Losses were highly skewed; some farmers lost the equivalent of many years of income, and some remote northern regions of the country were heavily impacted. A majority of the compensation (63%) was paid for leopard attacks, so a strategy to reduce livestock losses throughout Bhutan should focus on leopards as the principal livestock predator. Compensation

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schemes are an important mechanism for large carnivore conservation in the Himalayas, and we advocate for a scheme in Bhutan that is long-lasting and sustainable.

Keywords: Bhutan, depredation, compensation scheme, Himalayas, human-wildlife conflict, leopard, tiger, bear, snow leopard

Introduction

In recent decades, many areas throughout the Himalayan region have witnessed an increase in attacks on domestic livestock by large predators (Nature Conservation Division [NCD] 2004; Wang & Macdonald 2006), and these attacks often impose a heavy financial burden on farmers who lose livestock (Oli et al. 1994; Mishra 1997; Maikhuri et al. 2000; Ikeda 2004; Wang & Macdonald 2006; Namgail et al. 2007). Subsequently, tolerance towards the region's carnivores is generally low (Wang et al. 2006; Bagchi & Mishra 2006), and retaliatory attacks on predators have increased (Oli et al. 1994; Mishra et al. 2003; Jackson & Wangchuk 2004; Sangay & Wangchuk 2005).

In Bhutan, four large predators (tiger, *Panthera tigris*; leopard, *Panthera pardus*; snow leopard, *Panthera uncia*; and Himalayan black bear, *Ursus thibetanus*) are responsible for many livestock kills (Wang & Macdonald 2006; Sangay & Vernes 2008). Traditional Buddhist conservation ethics have been embedded in Bhutanese culture (Sangay & Wangchuk 2005) and reflected in modern conservation legislation (Seeland 2000; NCD 2004; Sangay & Wangchuk 2005). Accordingly, all of these carnivores have legal protection in Bhutan, and retaliatory action is prohibited. However, the pastoral practice of grazing free range livestock in Bhutan's forests and alpine rangelands (Sangay & Wangchuk 2005; Wang & Macdonald 2006) and an associated increase in livestock density in recent years (Govil 1999), combined with a rich landscape diversity of large mammalian carnivores, means that many livestock are lost annually (Sangay & Vernes 2008). Substantial economic loss thus befalls agro-pastoralists, many of whom rely heavily on relatively few livestock for their economic wealth (Moktan et al. 2006).

Since 2002, the Government of Bhutan has received complaints of livestock predation by tigers and other large carnivores from across the country (Sangay & Wangchuk 2005). Wang and Macdonald (2006) reported that livestock predation in central Bhutan increased significantly between 1993 and 2001, with about a quarter of households in Jigme Singye Wangchuck National Park losing livestock to predation by mammalian carnivores, equal to as much as 85% of annual household cash income. Wang et al. (2006) further reported that farmers in central Bhutan ranked livestock predation as one of the most serious threats to their livelihood, and many farmers expressed a desire to eradicate problematic wildlife. For many farmers, the cost of livestock losses was becoming too high, as many of Bhutan's poorest farmers live in protected areas (Ministry of Agriculture [MoA] 2013) where predators are expected to be in greatest densities and where carnivore conservation is strongly focused. Some affected farmers were resorting, through economic necessity, to illegally trapping or poisoning wildlife. Therefore, reducing retaliatory killing of large carnivores is integral to improving their conservation prognosis, but doing so may require that economic costs related to predation are compensated, and that wildlife conservation is seen to be either neutral, or to have an overall net benefit to people who coexist with the wildlife (Mishra et al. 2003).

In Bhutan, the creation of a conservation fund received strong support amidst several options explored to satisfy both the goals of conservation and the economic needs of agro-pastoralists. In 2003, with the assistance of the World Wide Fund for Nature (WWF) Bhutan, the Tiger Conservation Fund (TCF) was established with the goal of compensating the financial losses of agro-pastoralists who lose livestock to tiger, leopard, snow leopard and bear, so that viable populations of large predators are maintained. Few studies of human-livestock conflict have reported on the economic cost of predation to farmers (Graham et al. 2005; Inskip & Zimmermann 2009), despite their importance in documenting the extent of economic losses, and identifying

key predators and predation hotspots, all of which are useful for effective management of the problem (Sangay & Vernes 2008; MoA 2013). This paper examines the economic cost to farmers of livestock predation, as revealed by compensation payments made through the TCF over the three-year data collection period (2003–2005). We present an alternative scheme that may be feasible.

Methods

Protocol for the assessment of claims

A major challenge to the TCF was to only pay compensation for genuine cases of livestock predation by the wild carnivores covered under the scheme. In this pursuit, a rigorous verification mechanism was established in order to minimise false claims. The TCF required those making a claim to seek three types of evidence before a claim could be processed: (1) the community leader (*Gup*) had to support the claim; (2) a veterinarian confirmed, by post mortem examination of the carcass, that a predator killed the animal, rather than scavenging it after death; and (3) a local forest or park staff member confirmed the distributional range of the predator claimed to have made the kill, and verified through indirect evidence such as scats, tracks, and other signs in the vicinity of the kill site. Once this documentary evidence was compiled, the claim was forwarded to the Divisional Forest Officer or Park Manager who further evaluated the claim based upon the evidence presented. If at that point the case was considered valid, it was forwarded to the TCF for payment.

Before the scheme was put into effect, regional training sessions for community leaders, foresters and veterinarians were conducted with a focus on understanding different carnivore-specific predatory behaviour, recognising feeding signs and indirect evidence of predators, and collecting necessary data. The compensation scheme was also broadcasted in Bhutan's four major languages on national radio.

Data variables

Data collected for our paper included the date the kill occurred, name of the farmer making the claim, kill site (including village, constituency *[geog],* and district), livestock type (cattle, yak, horse, mule, donkey, sheep), breed (if relevant), sex and age of livestock predated, predator identified as making the kill (tiger, leopard, snow leopard, bear), and amount of compensation paid.

Economic baseline information

The economic analyses were carried out using these baseline figures:

1. At the time of the study, average per capita household income in rural areas of Bhutan was about US$ 23 per month, amounting to about US$ 276 per year (MoA 2000);
2. The rate of exchange used for local currency of the Bhutanese Ngultrum (BTN) to US dollar was the average interbank market rate of US$ 1 = BTN 45.2 for the compensation period 2003–2005;
3. The market prices of livestock types for which compensation was paid (Table 1) were estimated by the Department of Forests, Bhutan.

All successful compensation claims were paid in the local currency, the Bhutanese Ngultrum, but throughout this paper we use the US dollar (US$) as our unit of currency.

We used ANOVAs to compare differences in compensation paid and total value of livestock lost among predator types. Data were log transformed prior to analysis, and tests for normality were performed to ensure data were normally distributed. Post-hoc contrasts were done using pairwise t-tests with Bonferroni adjustment. All analyses were conducted using R version 3.0.2 (R Foundation for Statistical Computing).

TABLE 1 Market value of livestock types commonly raised in Bhutanese subsistence agriculture, and the (per unit) amount of compensation paid by the Tiger Conservation Fund (TCF) for the loss of these livestock to predation. All values are in US dollars.

Breed	Young (< 1 year)	Young (1-3 years)		Adult (>3 years)		Compensation amount set by TCF
		Male	Female	Male	Female	
Cattle - Pure Mithun	$116	$279	$279	$465	$349	$174
Cattle - Mithun-cross	$93	$140	$163	$233	$279	$105
Cattle - Exotic cross-breed	$116	$140	$163	$279	$349	$105
Cattle - Local breeds	$70	$116	$116	$186	$233	$70
Yak	$70	$116	$116	$163	$186	$174
Horse	$70	$116	$116	$279	$186	$81
Mule	$93	$233	$233	$581	$581	$163
Donkey				$465		$163
Sheep	$12	$26	$26	$46	$46	$16

Results

Compensation for livestock losses

Over the three-year period of the TCF (2003–2005), 1233 farmers reported livestock losses (Table 2). Of these, 1183 farmers (95.9%) reported a loss in one year, 48 farmers (3.9%) reported a loss in two years, and two farmers (0.2%) reported a loss in all three years. Compensation was paid for 127 cases reported by 99 farmers in 2003, 694 cases reported by 588 farmers in 2004, and 685 cases reported by 598 farmers in 2005 (Table 2). Over the course of the scheme, tigers, leopards, snow leopards, and bears killed livestock valued at a combined value of US$ 389,879. Compensation of US$ 138,454 was paid for these losses, equivalent to approximately 35.5% of the estimated market price for the livestock.

Of the farmers who reported losses in any one year, each lost on average (± SE) 1.3 ± 0.04 livestock in that year, although a small number lost many more: 14 farmers (1.1% of all farmers making a claim) lost 5–10 head of livestock in a single year, and 6 farmers (0.5%) lost 11–25 head of livestock in a single year. Many of the farmers who reported multiple attacks on their livestock mainly lost sheep in those attacks. Although sheep are valued considerably lower than other livestock types (Table 1), some losses were substantial because so many stock were lost. For example, in one attack, 21 sheep were killed by a leopard, amounting to an income loss equivalent to US$ 966, or 3.5 years of household income. In another attack, 14 sheep were killed by a bear, amounting to a loss equivalent to more than two years of household income (US$ 644). The highest compensation amount for a single event was paid for a tiger attack that resulted in eight yaks being killed, which had an economic impact equivalent to losing 7.4 years of household income (US$ 2048).

At the time of the study, average per capita household income in rural areas of Bhutan was about US$ 276 per year (MoA 2000). We estimate that for households that lost livestock during the 3-year scheme, the average after-compensation annual per capita household loss (in any one year) ranged between $162 and $187, equivalent to 64–72% of annual household income (Table 2). However, when considered over the three-year duration of the scheme, farmers who filed a claim lost the equivalent of 24.6% of their mean annual household income to predation each year because the majority (96%) of farmers only lost livestock in one of the three years of the study (Table 2).

Compensation amount by livestock type and predator

Most of the compensation was paid for losses to cattle (47.5% of total compensation) and horses (24.8%), with the rest spread across remaining livestock types (Fig. 1). Predation events by different predators varied significantly in the compensation that a kill attracted ($F[3,1502]$ = 8.8, $p < 0.001$), with kills by leopards attracting significantly lower compensation payments per kill (mean ± SE = US$ 85 ± 1) than kills by tigers (US$ 100 ± 5; $p = 0.001$), Himalayan black bears (US$ 112 ± 8; $p < 0.001$), and snow leopards (US$ 136 ± 7; $p < 0.001$; Fig. 1). Kills by snow leopards also attracted a significantly greater compensation payment than did kills by tigers ($p = 0.008$).

However, in terms of total amount of compensation paid, the greatest share of compensation went to kills by leopards (63%; US$ 86,705) and tigers (25%; US$ 34,791) (Fig. 2). Comparison of the amount of compensation paid per claim for these two principal predators (leopards and tigers) and the major livestock types they predated (cattle and horses) revealed that tiger predation on cattle attracted significantly higher compensation payments (mean ± SE = US$ 92 ± 2) than did leopard predation on cattle (mean ± SE = US$ 76 ± 2; $F[1,740]$ = 9.7, $p = 0.002$). There was no difference between tigers and leopards for compensation paid per claim for predation on horses ($F[1,424]$ = 1.2, $p = 0.28$).

TABLE 2 Economic cost of livestock predation to farmers in Bhutan who reported predation and received compensation, between 2003 and 2005.

Year	Mean (± SE) number of livestock lost per household	Number of households compensated	Mean (± SE) estimated loss per household	Mean (± SE) compensation paid per household (US$)	Lost income (% of mean annual household income)	
					Before compensation	After Compensation
2003	1.88 ± 0.25	99	315 ± 30	153 ± 19	114.0	63.5
2004	1.36 ± 0.06	588	281 ± 8	107 ± 4	101.8	72.3
2005	1.18 ± 0.02	598	288 ± 7	101 ± 3	104.5	70.7
Average over three years	1.32 ± 0.04	1233	100 ± 6	37 ± 3	36.1	24.6

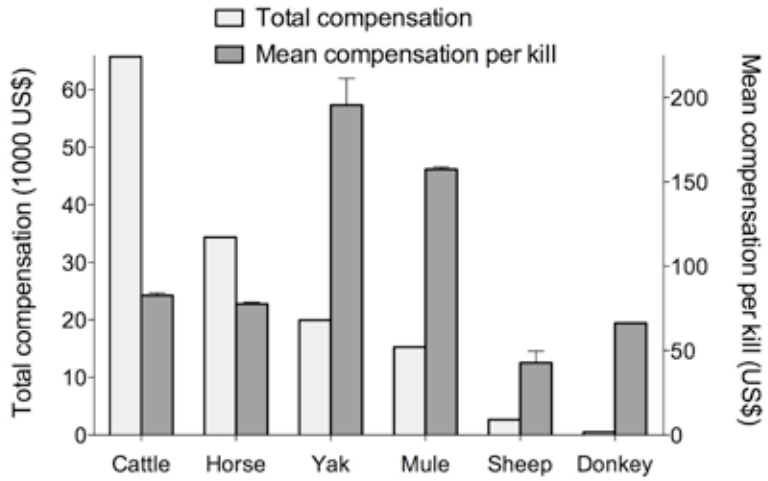

FIGURE 1 Total compensation payments made to famers in Bhutan for livestock losses between 2003 and 2005, and mean compensation per reported livestock kill, for the major livestock types lost to predators.

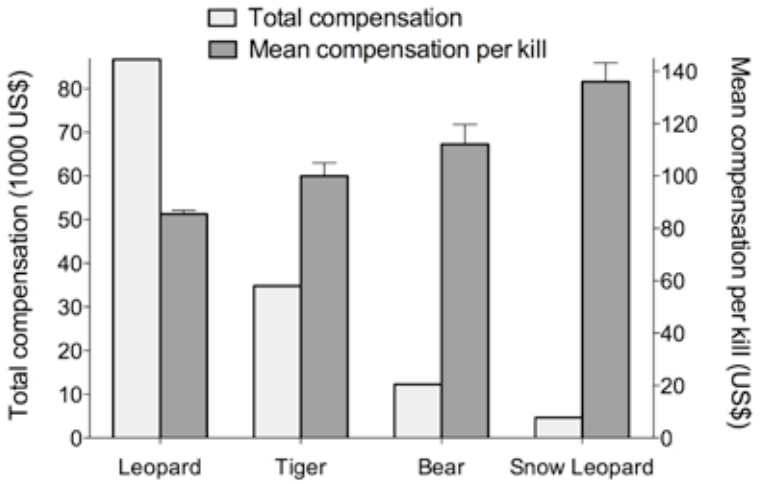

FIGURE 2 Total compensation payments made to famers in Bhutan for livestock losses between 2003 and 2005, and mean compensation per reported livestock kill, for the four predators that killed livestock. 'Leopard' = *Panthera pardus*; 'Tiger' = *Panthera tigris*; 'Bear' = *Ursus thibetanus*; Snow Leopard = *Panthera uncia*.

Geographical differences

Compensation was not evenly distributed across Bhutan (Fig. 3) and we therefore report median values rather than means. Although the median percentage of households that received compensation (in the 99 geogs that reported predation events during the study) across the duration of the TCF was only 1.7%, and less than 1% in any one year of the study (Table 3), compensation claims were greatly skewed. Many claims were filed in northwestern, northeastern and central geogs compared to relatively fewer claims in southern geogs (Fig. 3). High levels of compensation (arbitrarily identified as geogs where percentage of households compensated was more than twice the median) were seen in 34 geogs (Fig. 4; Table 3). In four geogs (Khatey, Khamey, Laya, Khoma), the household claim rate was 10 times greater than the median rate, ranging from 19 to 41% of households (Fig. 4).

Kills by leopards received more compensation than other predators in 26 (76.5%) of the 34 geogs identified with high predation (Fig. 4). Six (17.6%) geogs (Metsho, Tsamang, Jarey, Nangkor, Yalang, Phangyel) had their compensation payments totally earmarked to kills by leopards. More compensation was paid on kills made by tigers in eight geogs (23.5%; Khorphu, Khazi, Pangkhar, Dangchu, Shengana, Tewang, Kabji, Nubi), while compensation payments for kills made by bears only occurred in 5 geogs (14.7%; Laya, Khoma, Bumdeling, Genekha, Lunana; Fig. 4). Compensation for snow leopard attack was generally limited and only occurred in 4 geogs (11.8%; Lunana, Laya, Khoma, Bumdeling), being especially prominent in the high elevation geogs of Lunana and Laya (Fig. 4).

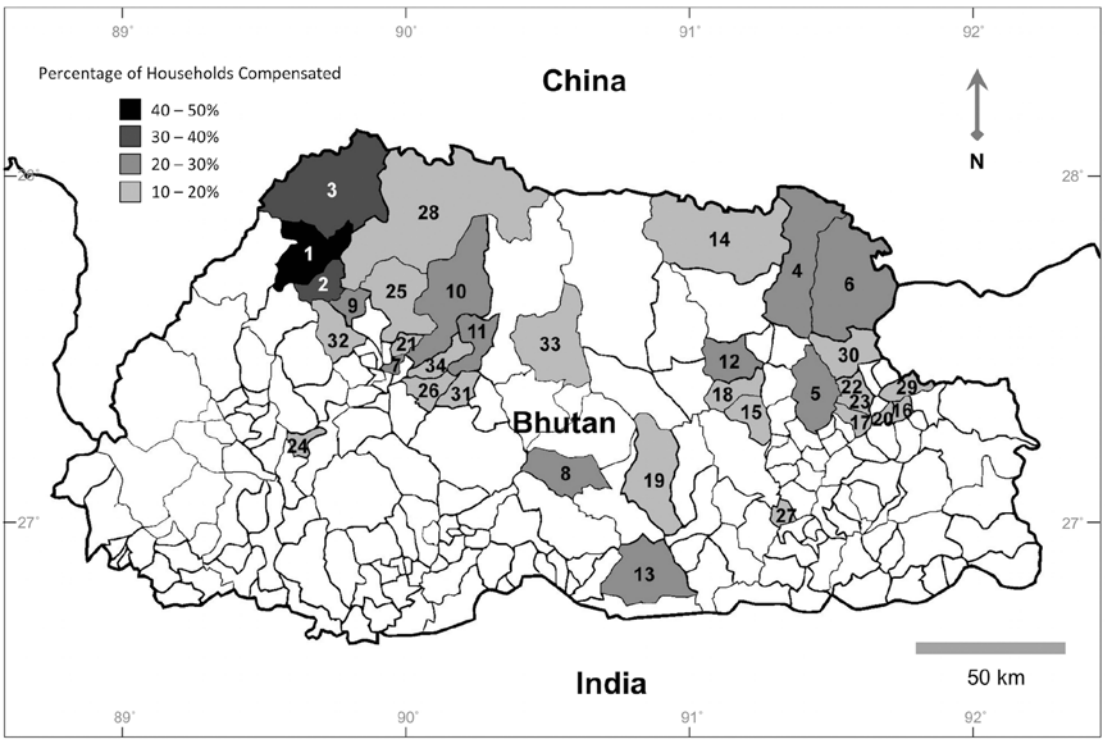

FIGURE 3 The Kingdom of Bhutan, showing the 99 geogs (sub-districts, consisting of a collection of villages), highlighting (with different shades of grey) the 34 geogs for which percentage of households compensated between 2003 and 2005 was more than twice the median value. See Table 3 for a key to the numbered geogs.

TABLE 3 Compensation by geog (sub-district) for those geogs that reported high levels of predation. Ranking is from the highest to lowest percentage of households in that geog that received compensation for the period 2003 – 2005. These 34 geogs accounted for more than 75% of all compensation paid.

Rank	Geog	Dzongkhag (District)	Households compensated (%)				Total # of HH	Total Comp. ($US)
			2003	2004	2005	Total		
1	Khatey	Gasa	0.0	20.8	25.0	41.7	48	$2,088
2	Khamey	Gasa	0.0	18.8	13.7	27.4	197	$5,912
3	Laya	Gasa	0.0	13.1	15.3	20.1	229	$8,989
4	Khoma	Lhuntse	2.6	12.5	9.2	19.2	391	$8,437
5	Shermung	Mongar	0.0	9.7	9.1	15.7	383	$6,160
6	Bumdeling	Tashiyangtse	2.3	16.2	6.7	15.6	390	$11,354
7	Limbu	Punakha	0.0	6.5	14.5	15.3	124	$1,801
8	Korphu	Trongsa	10.5	5.0	0.5	14.1	220	$3,403
9	Goenshari	Punakha	0.0	1.6	14.7	14.0	129	$1,663
10	Kazhi	Wangdue	0.0	8.1	5.7	13.5	297	$3,663
11	Dangchu	Wangdue	0.0	2.6	10.9	11.3	266	$2,365
12	Metsho	Lhuntse	1.2	11.1	0.8	10.3	243	$2,227
13	Pangkhar	Zhemgang	13.2	0.5	1.4	10.0	220	$3,171
14	Kurtoe	Lhuntse	0.0	0.0	9.1	8.1	186	$1,348
15	Tsamang	Mongar	1.8	4.1	2.8	7.8	218	$967
16	Bidung	Tashigang	0.0	3.3	4.6	7.7	391	$2,807
17	Yangneer	Tashigang	0.0	3.7	5.3	7.5	507	$3,906
18	Jarey	Lhuntse	1.4	4.6	2.3	7.4	216	$972
19	Nangkor	Zhemgang	0.2	7.3	2.0	7.3	492	$4,426
20	Bartsham	Tashigang	0.5	3.8	2.8	7.1	424	$3,901
21	Shengana	Punakha	0.0	4.2	3.9	7.0	284	$2,055
22	Tongshang	Tashiyangtse	0.0	4.9	2.6	6.9	349	$2,204
23	Jamkhar	Tashiyangtse	0.0	2.9	3.2	6.1	313	$1,530
24	Genekha	Thimphu	0.0	6.0	1.1	6.0	184	$1,254
25	Tewang	Punakha	0.0	4.2	1.8	6.0	285	$1,343
26	Bjena	Wangdue	0.0	2.7	4.0	5.8	521	$2,287
27	Jurmey	Mongar	0.0	1.1	5.3	5.6	285	$1,204
28	Lunana	Gasa	0.0	0.0	5.9	5.3	169	$1,658
29	Yalang	Tashiyangtse	0.0	2.7	3.2	5.2	402	$2,431
30	Yangtse	Tashiyangtse	0.6	2.8	1.9	5.0	323	$1,525
31	Gangtey	Wangdue	0.0	1.4	4.5	4.5	355	$1,726
32	Kabji	Punakha	0.0	1.8	4.3	4.5	447	$2,641
33	Nubi	Trongsa	0.0	1.5	2.9	3.5	481	$1,591
34	Phangyel	Wangdue	0.0	0.8	3.0	3.4	236	$414
Median (Top 34 Geogs)			0.0	4.0	4.1	7.5	285	$2204
Median (All 99 Geogs)			0.0	0.7	0.9	1.7	361	$607

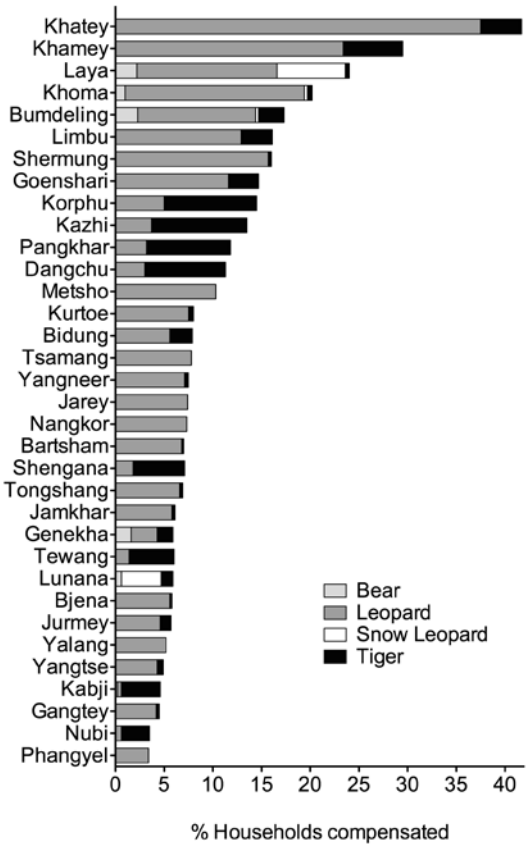

FIGURE 4 The 34 geogs for which percentage of households compensated between 2003 and 2005 was more than twice the median value, showing the contribution each predator made to the total percentage of households compensated.

Discussion

At the time of this study, nearly 70% of Bhutan's population was rural-based and made a living from subsistence agriculture (National Statistics Bureau 2007). Of the approximately 87,000 rural households in Bhutan, most owned just a few head of livestock; about 60% of households that owned cattle and more than 90% of households that owned horses had fewer than five cattle and horses respectively (Department of Livestock [DoL] 2007). Only the relatively few households (14%) that owned yak maintained large herds (DoL 2007). However, the relatively few livestock owned by each household drove the local economy, with an estimated 80–90% of cash income derived from cattle and horses (Moktan et al. 2006).

Our analysis of the TCF data was an attempt to project the conflict in terms of economic burden to the livestock farmers, and to give a nationwide scenario of livestock predation (using compensation claims as a surrogate measure) and the intensity of conflict by different predatory species, for the period of study. Results showed that the loss of a single animal could constitute a major economic setback for a farmer. For instance, at the time of the TCF, the market value of an adult female mithun cow was US$ 279, equivalent to the average annual income (Table 1). Losing just a

single sheep (valued at US$ 46) was equivalent to losing two months of income (Table 1).

Compensation claims were filed by less than 1% of households in Bhutan. For most farmers, livestock losses were tolerable and probably not a serious concern. However, because rate of compentation claims were highly skewed among geogs, some regions may have experienced intense economic pressure from predation, with more than 20% of households claiming compensation in some high predation areas. For these districts, livestock predation may have been placing strong downward pressure on the local economy and the livelihood of the affected farming families (MoA 2013).

The type of livestock predated and the predator involved, had a strong influence on the cost of predation. On average, leopard kills attracted the smallest compensation payments, because leopards usually targeted the smaller 'local' cattle, which are less costly to replace compared to improved breeds (Sangay & Vernes 2008). Leopards also killed many horses and sheep, both of which attracted relatively low compensation payments. Tigers on the other hand killed larger cattle, typically the expensive pure and crossbreed cattle that attracted greater compensation payments. Bear and snow leopard attacks also drew large compensation payments, because both of these predators had a tendency to kill yak, which had high replacement costs. Bears also killed many sheep, and although individual sheep did not attract a high compensation amount, bears occasionally killed many sheep in a single attack, making those attacks costly.

Leopards were the most widespread and common predator of livestock among the 34 geogs with high rates of compensation claims; 33 (94%) of the 34 geogs requested compensation for leopard predation and for 25 geogs (74%), more households were compensated for attacks by leopards, than for attacks by any other predator. Therefore, although leopard kills attracted on average the smallest average compensation claim, their high rate of livestock attack relative to other predators (see also Wang & MacDonald 2006; Sangay & Vernes 2008) and their widespread geographical distribution translated into a total compensation sum that was more than double that paid for attacks by tigers, and numerically, much higher than the amount paid for attacks by bears and snow leopards. In Bhutan, leopards should therefore be considered the principal livestock predator, and the predator of greatest concern in terms of economic impact. Any national strategy aimed at reducing livestock kills should, therefore, focus principally on leopards. However, because a few districts filed more claims for other predators (such as the high number of claims made for snow leopard attacks on yaks in the high altitude regions of Laya and Lunana; see Fig. 3), local strategies tailored to specific geogs will also need to be developed.

Compensating farmers for predated livestock may help to ensure the livelihood of affected farmers, thereby promoting a tolerance to large carnivores in the landscape and reducing the likelihood of farmers resorting to illegal, retaliatory action (MoA 2013). Although not often appreciated, maintaining predators in the landscape also has indirect benefits to farmers, because large predators control crop-raiding animals such as wild pigs (*Sus scrofa*) that cause considerable economic losses in Bhutan (Wangchuk 2004). We believe, therefore, that compensation schemes, in one form or another, are an integral mechanism for managing the human-wildlife conflict in Bhutan.

However, compensation schemes are fraught with problems, not least of which is their long-term financial sustainability. Like most compensation schemes in developing countries, the TCF relied on the support of external donors. Such schemes, while generously supported and well intentioned, typically have short lifespans, as was the case with the TCF. By 2006, the TCF was experiencing difficulty in making payments to claimants, which led to discontinuation in filing claims; however, the TCF still receives a few claims annually, which are paid as and when funds permit. Thus, while the scheme was very successful in generating invaluable data on

the geographical extent of livestock losses (for which claims were made) and the economic costs of predation, it gave only short-term financial relief to farmers. More sustainable solutions need to be developed, including a viable long-term compensation scheme.

A potential solution lies in a community-managed livestock insurance scheme that is being piloted in ten geogs across Bhutan under the auspice of the Geog Conservation Committee (GCC). The Royal Government of Bhutan has funded the GCC with seed money of Nu. 300,000 (approx. US$ 4800) for investment; interest generated will then be used to pay compensation. Every member of the scheme also pays a one-time membership fee of Nu. 200 (approximately US$ 3), and an additional premium of Nu. 100–150 (approximately US$ 1.60–2.40) per animal. Additional revenue will be generated from community-based income generating programs such as eco-tourism and sale of non-wood forest products from community-managed forests.

The benefit of such a scheme, if well run, would circumvent many of the complaints made about livestock compensation schemes such as long time-lags between reporting and payment, excessive bureaucracy, and the great distances herders must travel to report livestock attacks. We advocate, as others have (see Wang & MacDonald 2006; MoA 2013), that preventative livestock husbandry practices should also be integrated into such a scheme, whereby good livestock housing and adequate livestock guarding would need to be demonstrated in order for a claim to be successful. Ultimately, this scheme, or any other future scheme, needs to be financially self-sustaining for long-term success. Our results on livestock losses and compensation at the geog level presented here should assist the development of financially viable models in each geog if the scheme is implemented countrywide.

Our data report a snapshot in time (2003–2005) with respect to compensation payments for predated livestock, but livestock predation is still a valid and relevant national issue in 2014, with conflicts reported from across the country. Although there has been a recent decline in livestock holdings in some regions of Bhutan, particularly among yak herders (Namgay et al. 2013), livestock is still the mainstay of the Bhutanese rural economy, contributing 7% of GDP and accounting for 22% of rural income (MoA 2009). Understanding the economic cost of conflict to local farmers, spatial patterns and the relative intensity of conflicts by different predatory species is necessary for planning effective mitigation measures for the human-wildlife conflict in Bhutan. The results from this study may serve as a useful baseline for future human-wildlife conflict mitigation planning, which should include additional research to confirm the relevance of results to current socio-economic conditions.

Conclusion

Human-wildlife conflicts involving large mammalian predators are complex, but management of the problem is central to good conservation outcomes (Inskip & Zimmermann 2009). Data collected by the TCF enabled us to document the economic cost of large predators, and how impacts vary according to geography, predator type, and livestock type. The future task for conservation agencies and wildlife managers in Bhutan is to use our results as an initial baseline, pending further research, to develop potential long-term solutions to the problem. Doing so would enhance the likelihood that viable populations of large mammalian predators can persist in the Himalayan landscape into the foreseeable future.

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