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# A survey of livestock losses caused by Asiatic wild dogs, leopards and tigers, and of the impact of predation on the livelihood of farmers in Bhutan

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## Abstract

***Context.*** Human–wildlife conflict is a serious impediment to conservation efforts worldwide. This is also true for Bhutan, where dholes or wild dogs (*Cuon alpinus*), leopards and tigers constitute a menace to the livestock of farmers. Livestock losses as a result depredation by wild animals is a major cause of conflict with farmers, threatening their livelihoods, and causing a negative attitude that can lead to retaliatory killing of wildlife.

***Aims.*** To survey farmers and document their livestock losses, as well as estimate the value of livestock losses and the causes of predation.

***Methods.*** We conducted a questionnaire survey of 147 farming households in three zones of the Toebesa subdistrict of Punakha, Bhutan. Respondents provided information on their farming activities and household income, as well as on predation losses of cattle, goats, pigs, chickens, cats and dogs caused by dholes, tigers and leopards between 2006 and 2010. Additional data on livestock populations and losses were obtained from the Renewable Natural Resources Census at the subdistrict.

***Key Results.*** The results showed that dholes kill more livestock than do common leopards and tigers, the two other known livestock predators in the study area. The annual average number of livestock killed by dholes was 0.19 per household, which is ~2% of the total household income and ~11% of income derived from livestock. Annual income from livestock contributes 21% to the total annual revenues of farmers in the study area. The practice of allowing cattle to freely range, unguarded, in the forest was identified as the primary factor causing high livestock losses to dholes.

***Conclusions.*** Dholes are the principal predator in the study area and have a significant negative impact on farmers' livelihoods through loss of income. Our findings that livestock depredation by dholes was significantly less inside the villages and on farmed plots than in the forests showed that the problem can be addressed by improved husbandry practices.

***Implications.*** To reduce livestock depredation by dholes, incentives or strategies should be investigated for encouraging farmers to let their livestock graze inside and around villages, which includes stall feeding and tethering, and to cooperatively shepherd them in the forests during the day.

**Additional keywords:** cattle breeds, dhole conservation, husbandry, livestock depredation.

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## Introduction

Human–wildlife conflicts are a serious impediment to conservation efforts worldwide (Saberwal *et al.* 1994; Holmern *et al.* 2007). Such conflicts are a result of increasing human populations and loss of habitat in some regions, and of growing wildlife populations because of the success of conservation programs in others (Saberwal *et al.* 1994). Conflicts between agricultural interests and wildlife conservation are becoming more and more serious on a global scale (Messmer 2000; Sangay and Vernes 2008; Barua *et al.* 2013; Redpath *et al.* 2013). Human–wildlife conflicts such as livestock depredation by wildlife are particularly serious in areas where livestock holding forms an integral part of the local pastoral and agricultural economy (Wang and MacDonald 2006). Economic losses caused by livestock depredation can lead to retaliatory killing of wildlife, which, in turn, can lead to conflicts between farmers and wildlife managers. Human–wildlife conflicts attract attention when the wildlife species involved are either endangered, or when the conflict poses a serious threat to human welfare (Saberwal *et al.* 1994). Both aspects apply to human–wildlife conflicts in

Bhutan. Therefore, understanding and addressing farmers' economic loss caused by wildlife depredation is imperative both for successful conservation of wildlife species and also for rural development.

In Bhutan, loss of crops and livestock to wild animals affects the livelihoods of subsistence farmers, and poses a major challenge to the country's conservation efforts (Wang *et al*. 2006; Wang and Macdonald 2006; RGOB 2008). Environmental conservation is considered a national priority, and constitutes one of the four pillars of gross national happiness (GNH). The term GNH was coined in the 1970s by the King of Bhutan, to articulate the principle that the growth of the happiness of people is more important than the growth of the gross national product of Bhutan. In fact, the GNH philosophy forms the basis of the developmental strategy of Bhutan, and is classified into nine domains. One of these domains is ecological diversity and resilience, which includes wildlife as an indicator (Pennock and Ura 2011). According to the constitution of Bhutan, one of the primary aims of environmental conservation is to maintain a minimum of 60% of the total land area under forest cover (RGOB 2002) as habitat for wildlife, especially mammals, and to protect forests against population pressure (RGOB 2004; Katel and Schmidt-Vogt 2011). However, 'forests close to villages would attract animals and give them an opportunity to hide in the vicinity of the fields' (Seeland 2000), thereby exposing farmers to dangers emanating from the forests.

Predators not only attack livestock grazing in and at the edge of the forests, but they may also intrude onto farms in search of livestock, thereby posing a risk to humans (Wang and Macdonald 2006). Farmers practicing a combination of cropping and animal husbandry make up 69% of Bhutan's 700 000 population (RGOB 2002; Katel and Schmidt-Vogt 2011). Livestock forms an integral part of the Bhutanese farming system, and provides farmers with a dependable source of food and revenue. Livestock depredation by wild mammalian carnivores has increased in recent years, and now constitutes one of the main constraints of rural development, and is a serious threat to rural livelihoods (RGOB 2004; Wang and Macdonald 2006; Wang *et al*. 2006).

Wildlife species in Bhutan, such as the snow leopard (*Uncia uncia*), the Himalayan black bear (*Ursus thibetanus*), the tiger (*Panthera tigris*), the common leopard (*P. pardus*), the clouded leopard (*Neofelis nebulosa*), Asiatic medium-sized cats (*Felis chaus, F. manul, Pardofelis marmorata, Catopuma temmincki, Prionailurus bengalensis*) and the dhole (*Cuon alpinus*) kill livestock ranging in size from poultry to large bovids (Wang and Macdonald 2006; Sangay and Vernes 2008). In Toebesa Gewog, where research for the present paper was undertaken, dholes are the principal predator of livestock.

The dhole, also known as the Asiatic or Indian wild dog, is a social animal living and hunting in packs of up to 30 or more individuals (Murthy 2009), and they cooperatively raise the offspring of single-breeding females (Johnsingh 1982, 1992). They are also capable of killing and feeding on small-to-large wild animals (Johnsingh 1983; Pole *et al*. 2004; Grassman *et al*. 2005). Dholes inhabit a wide variety of vegetation types, including tropical, dry and moist deciduous forests, evergreen and semi-evergreen forests, grasslands, scrubs and alpine steppes >3000 m above sea level (Srivastav and Nigam 2010). Owing to the ability of dholes to occupy a variety of habitats, the species is distributed widely over eastern and central Asia, and can be found in Bhutan, Bangladesh, Cambodia, China, India, Indonesia, Malaysia, Myanmar and Nepal (Fox 1984; Johnsingh 1984; Selvan *et al*. 2013). In Bhutan, dholes have been reported in all Dzongkhags (districts) with the exception of the eastern Dzongkhags of Trashigang, Samdrupjongkhar and Pemagatshel (Wangchuk 2004). According to the IUCN Red List, the dhole is an endangered species because the total number of mature individuals left in the wild is estimated to be less than 2500 (Durbin *et al*. 2008). The species is also placed in Appendix II of CITES. In Bhutan, it is listed in Schedule I of *Bhutan's Forest and Nature Conservation Act* of 1995 (Wang and Macdonald 2006).

In the Toebesa Gewog region of Punakha Dzongkhag, Bhutan, livestock rearing is an important occupation of local farmers. The local inhabitants depend on nearby forested areas for non-timber forest products, wood for energy, and as a place for grazing their livestock at least during part of the year. Conflicts between humans and wildlife in this Gewog region consist of both livestock depredation and crop damage. The population of the wild pig (*Sus scrofa*) in the Gewog is believed to have increased over the years, causing substantial damage to crops not only in the Gewog, but also in most parts of the country. Wild dogs, which were once poisoned and killed, have been re-introduced with the aim to control the wild-pig population.

As per the Renewable Natural Resources (RNR) Census (RGOB 2009), Toebesa Gewog, which is documented annually by the Gewog extension officers, had the highest number of livestock depredation cases by dholes in 2008. However, an assessment of the loss of livelihood of farmers caused by dholes has not yet been undertaken. It is important to gain understanding of the impact of dholes on the livelihood of local people, so as to appraise whether the impact is significant enough to constitute a threat to conservation. The main objective of this paper, therefore, is to assess the losses and to understand the factors associated with predation loss by dholes in Toebesa Gewog, and to document the impact of such depredation on the livelihood of farmers.

## Materials and methods

### Study area

Because of the high incidence of livestock predation mentioned above, Toebesa Gewog of Punakha Dzongkhag, Bhutan, (Fig. 1) was selected as the study area for our research on human–wildlife conflicts. The study area is located between 27°34′50.99″N and 27°27′56.70″N and 89°51′15.18″E and 89°42′18.29″E, covering a total land area of 98 km$^2$, and ranging in elevation from 1400 m above sea level (asl) to 3200 m asl. The topography is rugged. Mean annual rainfall ranges from 572 mm to 882 mm, and mean air temperature from 18°C to 4°C (Wangda and Ohsawa 2006). According to Wangda and Ohsawa (2006), the vegetation in the study area ranges along an altitudinal gradient from a warm, dry subtropical type, to a moist warm-temperate type, to a wet cold-temperate type. Chir pine forest occurs at lower elevations, followed by mixed broadleaf forests and then mixed conifer forests at higher elevations (see land-use map, Fig. 2*a*). Forests cover 92% of the Gewog, with broadleaf forest being the major forest type covering an area of 67.0 km$^2$ (RGOB 2009).

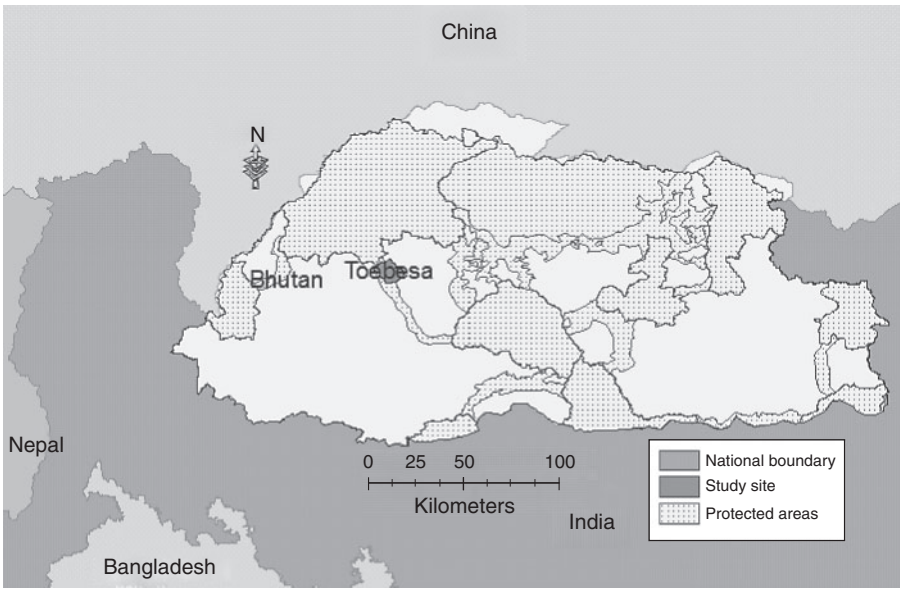


**Fig. 1.** Map of the kingdom of Bhutan, showing location of study site and protected areas.

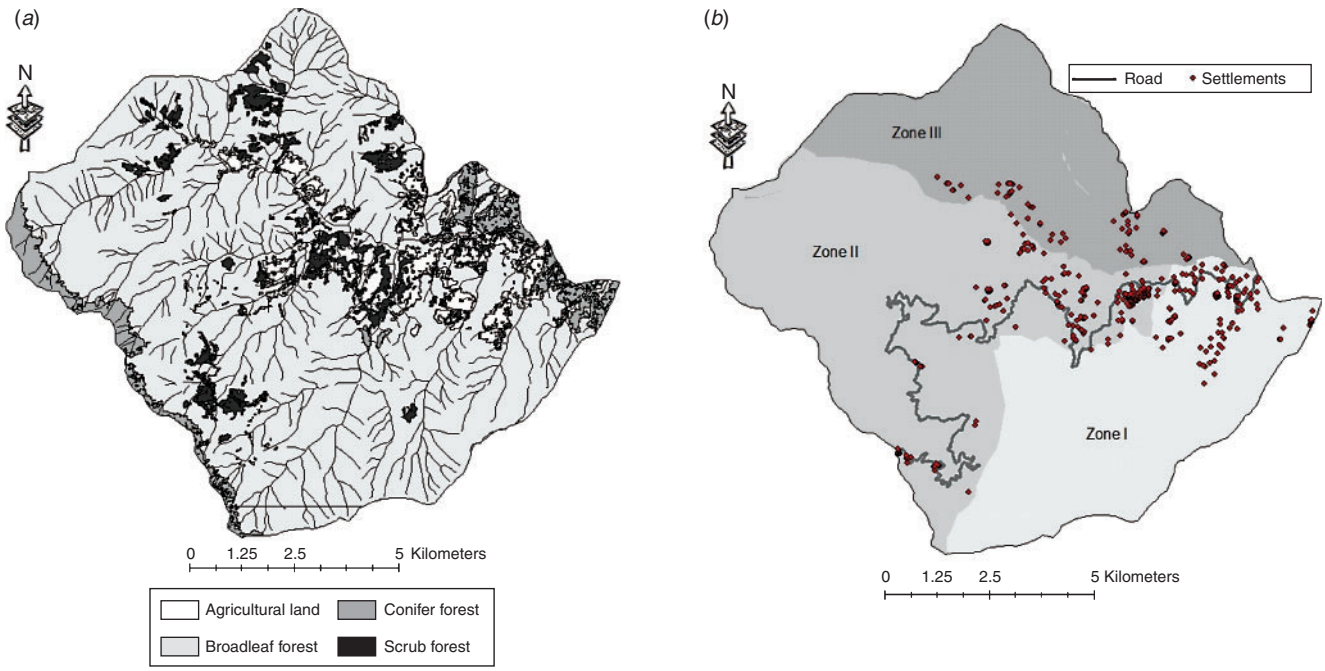


**Fig. 2.** (*a*) Land use and drainage systems. (*b*) Settlements classified in zones.

There are 19 villages in the Gewog, with a total population of more than 3000 individuals. Agriculture is the main occupation, with livestock grazing as an important component of farming systems. The principal crops grown in the Gewog are paddy, wheat, mustard, asparagus, potato, cabbage, cauliflower, eggplant and beans. Irrigated agriculture is the dominant land use. The farmers in the Gewog are mostly subsistence farmers, and many of them depend on livestock for their sustenance. The farmers often rear cattle of the following three breeds: a local breed commonly known as 'siri' cattle (*Bos indica*), mithun (*Bos frontalis*) and jersey (*Bos taurus*), as well as cross breeds between them such as Mithun-cross (a cross-breed between Mithun and Siri) and Jersey-cross (a cross-breed between Jersey and Siri). The pure breeds Mithun and Jersey are difficult to rear so cross-breeds and Siri are preferred by farmers as these cattle can adapt to varying environmental conditions. Pigs and poultry are also important components of their livestock, followed by goats, dogs and cats.

### *Data collection and analysis*

We conducted a questionnaire survey from August to November 2011, that covered all villages in the Gewog. For this purpose, the Gewog was stratified into three zones, namely Zone I, Zone II and Zone III (Fig. 2*b*). The stratification was based on the distance of villages from a local market and from the national highway, following our hypothesis that the number of predators increases with increasing distance from the national highway and from semi-urban areas. This hypothesis is based on the assumption that dholes avoid areas near the national highway, so as to minimise the risk of encountering humans, and that this results in less cattle depredation. Zone III is also connected directly to Jigme Dorji National Park where conservation measures are more favourable to the occurrence of dholes than in the other two zones. We also assumed that villages near the national highway have a better opportunity to earn income by selling vegetables and livestock products such as milk, butter and cheese to people passing by on the highway. Finally, we hypothesised that the income in villages farther away from the national highway and from local markets depends more on livestock products than on vegetables and other crops because these are more perishable than livestock products.

Zone I is located along the national highway, and is closest to the nearby local market at Metshina. Zone II is farther away from the local market, but some households are located along the national highway. Zone III is farthest away from both the local market and the national highway. In Zone I, forest is easily accessible from the national highway through farm roads. Zone II has comparatively less forest but it is still directly accessible from households clustered near the national highway. Zone III has abundant forest resources, but only seasonal access to the national highway (Fig. 2*a*). The number of households sampled in each zone is listed here by village. Zone I comprises the following four villages: Chilikha (11 households), Gyemkha (12), Gyemsa (6) and Lemjakha (11). Zone II comprises the following eight villages: Aachey (5), Lumitsawa (11), Menchuna (7), Phenteykha (7), Siluna (3), Tahogang (3), Thinleygang (16) and Tokha (7); and Zone III the following seven villages: Becheykha (7), Bemsisi (6), Chandana (3), Damchi (6), Eyamoo (12), Lunjam (4) and Renekha (10) (Fig. 2*b*).

The sample households were selected for interview from a total of 293 households registered at the Gewog office. The total number of sample households was determined by using the Yamane formula (Yamane 1967; Israel 1992); households to be interviewed were then selected randomly. Altogether, 147 households (~50% of all households) were interviewed. Respondents (the head of the household or their spouse) were asked questions about household demographics, education and employment, source of income, total household income, number of livestock owned, livestock management, and number of livestock lost to predation. Livestock management was covered by questions similar to the following: 'how do you protect your livestock from dholes and other predators;' 'where do you keep your livestock during night, and where do you take your livestock for grazing;' and 'do you guard them;' To document livestock depredation, farmers were asked to list the number of livestock killed between 2006 and 2010, and to state their perceived reasons for depredation of livestock by dholes. They were also asked questions concerning their perceptions of dhole population dynamics and dhole conservation. To assess the level of tolerance of farmers in the face of livestock depredation, questions were asked, such as the following: 'what would you do if dholes came and killed your livestock in front of your eyes?' If the household head was absent, the oldest family member present was interviewed. The interviews were conducted at respondents' houses or in fields, whichever was more convenient for the respondents. In addition, data were collected through key informant and group discussions.

Interviews were conducted by researchers and members of park staff who have worked with these communities for several years. The data on livestock depredation, livelihoods and demographics were verified by comparing them with official data available at the Renewable Natural Resources (RNR) extension office in Thinleygang Gewog. Data were analysed using the Statistical Package for the Social Sciences (SPSS – Developer(s): IBM Corporation, New York, USA) ver.16 and MS Excel. Levene's statistic was used for homogeneity of variance for testing normality. Normal parametric data such as number of livestock, livestock depredation and economic value of livestock depredation were analysed using ANOVA to compare livestock depredation between the three zones in the Gewog. A *post hoc* test (Bonferroni) was used to identify patterns that were not specified *a priori*. Income data revealed a non-parametric nature; therefore, Kruskal–Wallis and Mann–Whitney *U* tests were used. Correlation was used to compare the relationship between income and livestock loss to dholes and other predators. Our definition of livestock included all domestic animals owned by farmers. Cats and dogs, however, were excluded from the income analysis.

## Results

### *Demographic characteristics of respondents*

Of the 147 respondents interviewed in the Gewog, 63% ($n = 93$) were women, mainly because of the frequent absence of male household heads, and 37% ($n = 54$) were men, with a median age of 48 years. The number of respondents below 48 years of age was 52% ($n = 77$), and older than 48 years of age was 48% ($n = 70$). The oldest respondent was 66 years, and the youngest was 18 years. The average of the total members per household, as registered in the census, was 9.18. However, the average number of members actually living in a household was only 3.37. Most respondents (97%, $n = 143$) were farmers and the rest were students and shopkeepers.

### *Landholding and livestock population*

The median value for land holdings per household was 1.03 ha (ha) (range: 0–10 ha). About 57% ($n = 83$) of the respondents have a land holding of <0.81 ha, whereas 44% ($n = 64$) have a land holding of >0.81 ha. Of the 147 respondents, 90% ($n = 132$) reared cattle (i.e. local cattle mithun-cross and jersey-cross) and only 10% ($n = 15$) did not rear any type of cattle at the time of data collection. The average numbers of livestock holding per household were recorded as local cattle (3.00), mithun-cross (0.39), jersey-cross (1.41), pig (0.12), poultry (4.48), goat (0.01) domestic dog (0.60) and cat (0.98). Poultry ($n = 659$) and local cattle ($n = 462$) populations were the highest among the total livestock population in the study area. Zone III had the

highest population of total cattle (38%, $n = 276$), and Zone II had the highest number of households with jersey-cross (46%, $n = 36$), of the total of all households ($n = 79$) owning jersey-cross.

### *Livestock rearing characteristics and protection measures*

A comparison of villages showed that Eyamoo village in Zone III had the highest number of households ($n = 10$) practicing stall feeding of livestock, whereas Thinleygang in Zone II had the highest number of households that tether their livestock while grazing on-farm ($n = 10$). Of 132 households with cattle, 57% ($n = 75$) never leave or keep their cattle in forests. From the 57 households (43%) that keep their cattle in forests during day and night (for a duration ranging from less than 1 month to more than 6 months), 49% ($n = 28$) guard their cattle while grazing in the forest, whereas 51% ($n = 29$) do not provide guards, and leave their cattle to graze on their own. Young cattle (calves), less than 1 year old, are mostly kept at home, and only a few households (11%) take them into the forest for grazing.

At night, livestock are protected in villages by keeping them inside an enclosure or shed. The most common protection measures employed by farmers in Toebesa Gewog were grazing cattle in the forest by day and escorting them back home at night, grazing on the farm and near settlements, tethering them while grazing, and guarding cattle by a cattle herder. According to farmers, calves and milking cows are usually kept in a shed or enclosure, whereas bulls and oxen are most often kept outside. The majority of respondents owning cattle (91%, $n = 120$) kept cattle inside a shed at night and 9% ($n = 12$) kept them in the ground floors of their houses. In all, 29% ($n = 38$) of respondents used both tethering and keeping cattle indoors.

### *Farmers income*

All interviewed households practice agriculture for both home consumption and cash income (both livestock products and vegetables). They also earn cash income from forest products and from non-farm activities, such as business or contract work, salaries, property rent, wages and remittances from relatives living outside the Gewog area. For farmers in the Gewog, non-farm activity (44%) was found to be the most important source of cash income, followed by agricultural products (31%) such as vegetables, livestock products (21%) such as cheese and butter, and forest products (4%) such as wild vegetables and fruits. About half of the farmers interviewed (87 households; 59%) depend on livestock for cash income (Table 1). The average cash income per household per year from livestock, agriculture, forest products and non-farm activities amounted to approximately US$900. The average annual cash income earned from livestock per year per household was about US$192. According to the respondents, remittances from family members living outside the Gewog have been increasing since the Year 2001, which may indicate that the number of people moving out of the Gewog area is also increasing. Our results showed a significant relationship between total cash income and non-farm income of farmers ($r_s = 0.70$, $P < 0.001$); however, income from non-farm activities was not significantly different between the three zones ($H(2) = 4.75$, $P > 0.05$). Whereas income of farmers from agriculture and total annual cash income showed a significant correlation ($r_s = 0.63$, $P < 0.01$), income from agriculture was significantly different among the three zones ($H(2) = 31.53$, $P < 0.01$). Nonetheless, land holdings of farmers did not show a significant relationship with their cash income ($r_s = 0.17$, $P > 0.05$). The total income from agriculture was greater in Zone I than in Zone II and Zone III (see villages in Fig. 2). Zone III had more income from the sale of forest products than did the other two zones.

There was no difference in average cash income from livestock between the three zones ($H(2) = 3.40$, $P > 0.05$). Additionally, there was no significant association between income from livestock and the total number of cattle owned ($r_s = 0.21$, $P > 0.05$), although there was a difference in cattle holdings between the zones. However, the relationship between income from livestock and total number of farm animals became significant when dogs and cats were excluded ($r_s = 0.27$, $P < 0.05$). Forest products also contributed significantly to the livelihood of farmers. Although cash income of farmers from the sale of forest products was significantly different among the three zones ($H(2) = 7.69$, $P < 0.05$), the relationship between cash income from sale of forest products and total cash income did not show a significant relationship ($r_s = 0.12$, $P > 0.05$).

### *Livestock depredation*

During the past 5 years (2006–2010), 173 livestock in total, including cattle and domestic dogs, were killed by wild predators, including dholes. This includes 158 cattle lost to all predators, with an average annual loss of 0.21 head of cattle per household. However, there were no reports on losses of goats, pigs and poultry to large predators in the Gewog. It is not clear whether there were no actual losses or whether losses were simply not reported. Table 2 shows that farmers in Zone I and Zone III lost more cattle during 2010, wherea those in Zone II lost more in 2009. However, total livestock depredation by wild predators was not significantly different among the three zones during the past five years ($F(2, 57) = 0.05$, $P > 0.05$). Moreover, livestock depredation showed an increasing trend from 2006 to 2010. In this research, wild predators are defined as the common leopard, the tiger and the dhole. From 2006 to 2010, common leopards killed 28 livestock, affecting ~14% ($n = 20$) of all households

**Table 1. Sources of cash income for farmers**

| Source of income | Households dependent (%) |
|---|---|
| Livestock | 87 (59.2) |
| Agriculture | 115 (78.2) |
| Forest | 48 (32.7) |
| Non-farm | 101 (68.7) |

**Table 2. Yearly losses of livestock to wildlife (% in parentheses)**

| Year | Zone I | Zone II | Zone III | Total |
|---|---|---|---|---|
| 2006 | 4 (33.3) | 5 (41.7) | 3 (25.0) | 12 (100.0) |
| 2007 | 3 (27.2) | 4 (36.4) | 4 (36.4) | 11 (100.0) |
| 2008 | 13 (31.7) | 13 (31.7) | 15 (36.6) | 41 (100.0) |
| 2009 | 14 (29.2) | 22 (45.8) | 12 (25.0) | 48 (100.0) |
| 2010 | 23 (37.7) | 14 (23.0) | 24 (39.3) | 61 (100.0) |
| Total | 57 (33.0) | 58 (33.5) | 58 (33.5) | 173 (100.0) |

surveyed, whereas depredation by tigers affected just over 1% ($n = 2$) of households, with a total of four livestock being killed, all of them cattle, and all killed in forests. Livestock depredation by leopards comprised 46% ($n = 13$) cattle and 54% ($n = 15$) domestic dogs, with most livestock depredation by leopards having occurred on farms (70%, $n = 20$). The average value of livestock lost as a result of depredation by all three wild predators was about US$25, that being 2.7% of the annual cash income per household.

### *Livestock depredation by dholes*

About one-third of all the households interviewed (35%, $n = 51$) reported loss of livestock to dholes within the recorded period of 5 years from 2006 to 2010. The number of livestock lost to wildlife depredation ranged from one in some households, to up to six in others. The recorded data indicated that of the total number of livestock killed by predators (173), 82% were killed by dholes (Table 3). The loss caused by dholes alone was about US$22 (i.e. 2% of the total cash income and 11% of cash income from livestock). The mean livestock depredation by dholes per year and per household was 0.19 head of livestock. The average monetary value of one livestock was estimated to be US$100. The monetary values of livestock were estimated on the basis of the existing market price during the time of data collection. Taking all 147 households together, the dhole caused a total loss of US$3234 annually. The mean value of the livestock lost to predation by dhole was US$2922, with monetary value ranging from a minimum of US$20 to a maximum of US$320.

Of the 141 cattle lost to dholes, 68% ($n = 96$) were of the local cattle breed. The maximum losses to predation occurred in 2010, when 51 cattle belonging to 24 households were killed. The 5 years of data of livestock killed showed an increasing trend of cattle killed by dholes, compared with other predators such as leopards and tigers (Fig. 3). Of the cattle killed by dholes, only 4% ($n = 5$) were killed inside farms or in villages, whereas 97% ($n = 136$) were killed in forests. From the cattle killed by dholes, 91% ($n = 128$) were adult (>1-year old) and only 9% ($n = 13$) were young (<1-year old). All the cattle killed by dholes in the forests were older than 1 year.

The majority of cattle were killed by dholes during the wet season, from June to September (Fig. 4), when livestock graze freely in the forests. Of the 19 villages surveyed, respondents from four villages (Siluna and Tahogang in Zone II and Chandana and Lunjam in Zone III) reported no loss of cattle to dholes because these respondents did not let their cattle roam in the forest. In 2010, most cattle ($n = 51$) depredation by dholes occurred in Zone I. All of those losses took place in the forest and ~77% ($n = 39$) happened during the day. Similarly, in Zone II, all losses took place in the forest ($n = 41$) and ~56% ($n = 23$) of the losses happened during the day. In Zone III, ~90% ($n = 44$) of cattle were lost in the forest, and the remaining losses occurred inside farms. About 63% ($n = 31$) of losses happened during the day. However, no significant difference in loss of cattle to dholes was observed between the three Zones. Also, the depredation of local cattle ($F(2, 40) = 0.11$, $P > 0.05$) and jersey-cross ($F(2, 18) = 1.54$, $P > 0.05$) by dholes did not show a significant difference among the three zones during the past 5 years. Zone I showed the largest variation in estimated income lost (Table 4), but no significant difference in loss of income as a result of cattle depredation by dholes.

Dholes were clearly responsible for the majority of the livestock depredations in the Gewog over the 5-year period from 2006 to 2010. According to 42% ($n = 62$) of the respondents, depredation of cattle by dholes was mainly due to cattle left to graze freely in the forest without a herder attending

**Table 3. Number of cattle lost to wild predators during 2006–2010 (% in parentheses)**

| Predator | Cattle killed | Household affected |
|---|---|---|
| Wild dogs | 141 (89.2) | 51 (34.7) |
| Common leopard | 13 (8.2) | 20 (13.6) |
| Tiger | 4 (2.6) | 3 (2.0) |

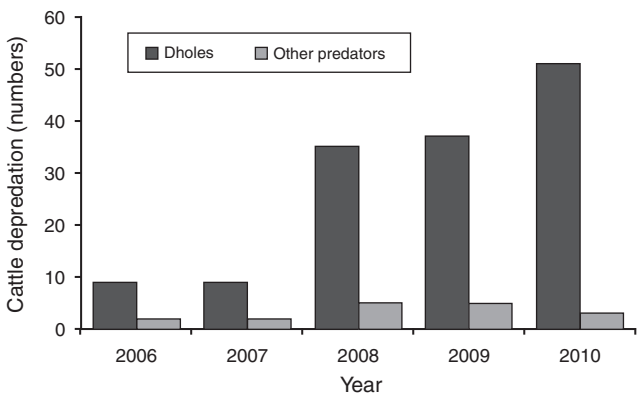


**Fig. 3.** Comparison of cattle depredation by dholes and other predators.

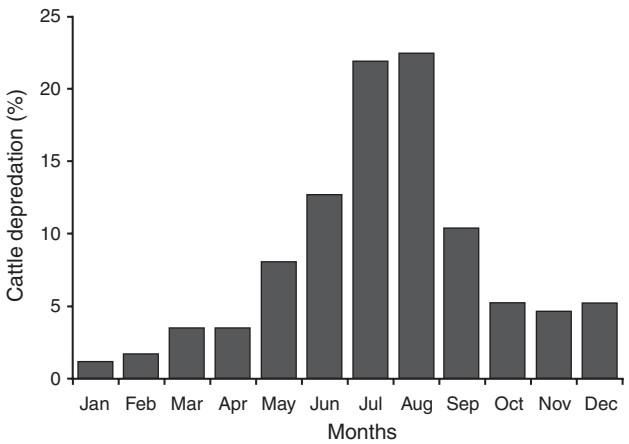


**Fig. 4.** Month-wise depredation of livestock by dholes.

**Table 4. Estimated livestock value lost to dholes in US$ in 2010**

| Zone | *N* | Mean | s.d. | Min | Max |
|---|---|---|---|---|---|
| I | 17 | 285.8 | 183.4 | 33.3 | 683.3 |
| II | 14 | 304.2 | 136.7 | 66.7 | 483.3 |
| III | 20 | 208.3 | 150.6 | 16.7 | 516.7 |
| Total | 51 | 260.5 | 161.5 | 16.7 | 683.3 |

them, whereas only 4% stated that it was due to an increase in the number of dholes. Some (10%) respondents believe that cattle are easy prey to dholes, whereas a few others (2%) believe that high levels of livestock predation are due to a scarcity of wild prey species in the forest. The majority of respondents (43%) mentioned multiple reasons and were not sure about the specific reasons. It is, however, difficult to come to a conclusion on this without a better understanding of dhole ecology, behaviour, and that of the other predator and prey species in the study area.

The respondents were nearly evenly split on the question whether the dhole population has increased or remained the same. Slightly more respondents stated that it has remained the same (43%), whereas 42% stated that it has increased. There was, however, more consensus on the perception that the wild pig population has increased (70% of respondents) over the past 5 years (2006–2010; Fig. 5).

In response to the question on how they would react if a pack of dholes killed their livestock right in front of them, the majority of the respondents (68%, $n = 100$) stated they would chase the dholes and not kill them, whereas 23% ($n = 34$) said they would kill the wild dogs on the spot. The remaining 9% gave unspecific answers such as that they would not be able to do anything, or that they would call their friends and families for help. Some farmers invoked the Buddhist ban on killing as a reason for developing tolerance of dholes, and requested the support of authorities to help them reduce livestock loss.

## Discussion

Farming and animal husbandry are important components of the Bhutanese economy, providing employment and livelihoods to ~69% of the Bhutanese population, and contributing substantially (33%) to the Gross Domestic Product (Sangay and Vernes 2008). Almost all households in rural areas rear livestock, and almost all livestock graze in nearby forests or in pastures for at least part of the year. One of the most important concerns of livestock keepers in Bhutan is the depredation of livestock by wildlife species. Farmers in the study area are of the opinion that human–wildlife conflicts are putting their livelihoods in jeopardy. Human–wildlife conflicts in Bhutan have increased recently (Wang and Macdonald 2006), and even in the study area livestock depredation by wild predators has increased, although the increase is not yet statistically significant.

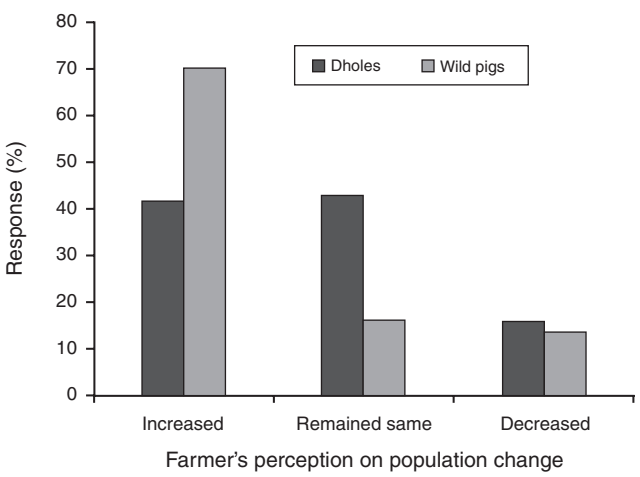


**Fig. 5.** Farmer's perception on population trend of dholes and wild pigs.

Income of farmers from livestock was similar in all three zones, and possession of more cattle did not result in more income. This can be due to the greater number of unproductive local cattle than jersey-cross and mithun-cross. However, greater variety of farm animals correlated with increased income, possibly because of the contribution from poultry. Poultry farming, which in Bhutan is relatively more profitable (Nidup *et al*. 2005), could be an alternative to cattle rearing. Whereas the population of local cattle showed a decline, the number of jersey-cross and poultry showed an increase over the 5-year period from 2006 to 2010.

The increasing population trend for jersey-cross and poultry could be explained by the growing demand for dairy products and eggs in local markets over the 5-year period. Zone II had more jersey-cross than did the other zones, possibly because of its proximity to a veterinary centre for artificial insemination, and for other related care. Cross-breeds such as jersey-cross produce a greater quantity of milk with a value that is estimated to be 10 times higher than that of local cattle (Udo *et al*. 2011). Therefore, raising cross-breed cattle such as jersey-cross can be expected to contribute more to the livelihood of farmers, as well as reduce grazing in the forest. Cross-bred cows are stall fed and are milked everyday, whereas local cattle are grazed in the forest. However, farmers in all zones own more local cattle even though this breed yields less milk, probably because local cattle demand less care than do other breeds of cattle, so that they can be reared relatively easily, even by small households or households with labour scarcity.

Farmers in the Toebesa Gewog earn cash income by selling crops and livestock products. The national highway passing through the Gewog provides an easy roadside market for farmers to sell their agricultural products to travellers. However, farmers with more land holdings did not necessarily earn more income, possibly owing to a shortage of labourers to work in the fields. Farmers in Zone I earned more income from agriculture than did farmers in the other zones, probably because of at least two reasons. First, Zone I is located at a lower elevation than Zone II and Zone III, which enables farmers to cultivate a greater variety of crops. Key informants also mentioned that Zone I has more fertile land and suffers less from water scarcity than do the other two zones. Second, Zone I has more family members per household, which means more labour is available to work in the fields. Income from the sale of forest products was higher in Zone III than in the other zones because households in Zone III have easy access to abundant forests, although they are located far away from the national highway. This finding refutes our first hypothesis that farmers away from the highway earn less income not only from forest products, but also from other farm products.

The main cause for the loss of farmer income as a result of livestock depredation was found to be dholes, which are the primary predators in the Gewog, causing more damage than tigers and leopards. Moreover, depredation by dholes affected only cattle. The greater variation of cattle depredation seen in Zone I is caused by higher numbers of calves ($n = 6$) depredated by

dholes. The higher incidence of cattle depredation by dholes in forests rather than on farms is consistent with the findings of Johnsingh *et al*. (2007), that all the cases of depredation by dholes during 1999–2003 in Toebesa Gewog occurred in the forest. This also indicates that cattle depredation could be reduced if cattle were grazed on the farms rather than in the forests.

The average loss of livestock in the Gewog is relatively lower than that in Jigme Singye Wangchuck National Park (JSWNP), where the mean loss per household was 1.29 head of livestock per year (Wang and Macdonald 2006). JSWNP was established in central Bhutan in 1995, and connects the temperate zone in the north with the subtropical zone in the south via biological corridors. Depredation in JSWNP, according to Wang and Macdonald (2006), is mainly due to leopards (53%) and tigers (26%), and to a far lesser extent caused by dholes (13%) or by bears (8%). The difference between Toebesa Gewog and JSWNP can be explained by differences in livestock herding practices, and also by the availability of prey species. In Toebesa Gewog, free ranging of cattle in forests without a herder is common practice. Moreover, the exposure of cattle to dholes may have been augmented by an increase in the number of dholes, as was suggested by farmers we interviewed. Also, cattle can be killed more easily by predators than similar-sized wild prey because they are lacking in the anti-predator behaviour of their wild ancestors (Linnell *et al*. 1999). However, hardly anything is known concerning the relationship between population size of predator species and the number of cattle killed. Reasons for differences in cattle depredation by dholes between Toebesa Gewog and JSWNP may also be related to differences in habitat, prey density and pack size of dholes. All these aspects demand future research.

Differences between Toebesa Gewog and JSWNP with respect to predation of cattle by dholes, leopards and tigers could also be explained by differences in the hunting behaviour of these species, and by differences in the availability of prey species such as sambar (*Rusa unicolor*), chital (*Axis axis*) and wild pig, which are the main prey species of dholes, as reported by Kamler *et al*. (2012) and Selvan *et al*. (2013). Whereas dholes are a diurnal (day-active) species, leopards and tigers are nocturnal (night-active). Thus, cattle grazing in the forests during the day without herders and kept inside or near settlements at night are more exposed to dholes than to leopards and tigers. The presence of prey species is affected by climatic conditions and topographic factors. JSWNP has a diverse range of habitats from subtropical to temperate, with a corresponding variation in vegetation structure and composition; whereas, in Toebesa Gewog, the climatic conditions are relatively cold and vegetation comprises mainly wet temperate forest, which provides a less suitable habitat for prey species (Wang 2008). Furthermore, domestic animals may compete, through excessive grazing, with prey species for resources. Long-term studies are required to confirm whether the population of prey species is changing over time and space in habitats with and without cattle grazing.

Our findings concerning more depredations of cattle by dholes are consistent with the findings of Johnsingh *et al*. (2007) who reported that the dhole is the major predator responsible for livestock depredation in Toebesa Gewog, followed by leopards, tigers and bears. However, according to Selvan *et al*. (2013), dholes avoid cattle and wild pigs, and prefer other prey species such as chital and sambar, provided they are available in the area. The abundance and distribution of ungulates as the major prey species in the study area warrants further research.

The mean loss of household cash income as a result of depredation by dholes reported in our study was 2% of the total cash income, and 11% of cash income from livestock. In contrast, loss of household cash income as a result of depredation by dholes was 38% in Nepal (Oli *et al*. 1994), 12% in Kibber Wildlife Sanctuary in India (Mishra 1997), 10% in Tibet (Jackson 1999) and 8% in China (Schaller *et al*. 1987). The loss of farmers' income as result of depredation by all predators, including dholes, was significantly higher in JSWNP (84%) than it was in Toebesa (Wang and Macdonald 2006). The difference in the mean annual loss of farmers' income between the JSWNP and Toebesa Gewog can be explained by the fact that the number of livestock killed by other predators in JSWNP was higher, and also by the lower level of dependency on livestock by farmers in Toebesa Gewog than by farmers in JSWNP. Another reason why the value of cattle killed by dholes is lower in Toebesa Gewog is that depredation affected mostly local breeds.

The level of livestock depredation by dholes was similar in all the three zones of the study area, although Zone III contains more forested areas than do the other zones. This is most probably due to the fact that dholes inhabit a variety of ecosystems, and refutes our second hypothesis that depredation by dholes would be less closer to the national highway. However, this result is based on frequency of sightings reported by farmers, and not on actual ecological research on dholes.

The fact that dholes kill more cattle during the summer months (June to September) may be attributed to the fact that cattle are less exposed to dholes during the winter months because they are either kept near the houses to feed on hay and grain, or in the uncultivated fields to browse on the residues of past harvests. In addition, some farmers take their cattle to lower elevations outside the study area during winter because of a lack of forage and cold weather. In the summer months (June to September), which are the peak cropping season when farmers are not free to look after their animals, livestock are more likely to be left to graze and browse in the forest. This shows that there is a link between seasonal variation in cattle depredation by dholes and seasonal variation in herding practices. The findings on seasonality of livestock depredation are consistent with the findings of Thinley *et al*. (2011), Sangay and Vernes (2008) and Wang and Macdonald (2006) in north-western Bhutan, and in JSWNP.

Other possible reasons for variation in livestock depredation, such as the effects of droughts affecting the availability of prey species, cannot be confirmed as climate data show no significant variability for the years surveyed (SNC 2011). According to our study, the higher incidence of adult cattle being killed by dholes indicates that most people keep their calves and yearlings near their homes. Although farmers know that predation in the forest is a serious risk, they are more likely to leave the cattle in the forest because of lack of human resources and lack of space during the cropping season. Therefore, promoting better breeds of cattle, such as jersey and jersey-cross, that can be stall fed at home and that are more productive than the local cattle, and educating farmers on protection measures, would help them avoid (or at least reduce) depredation by wild predators.

Herd management by stall feeding and tethering on the farm is a common practice of farmers to protect their cattle from wild predators in view of the chronic shortage of manpower in rural Bhutan (Wang and Macdonald 2006). Johnsingh *et al*. (2007) reported that guarding cattle while grazing was one of the common protection measures practiced in Toebesa Gewog; however, it appears that this practice is now declining in the Gewog. For example, the people of the Eyamoo village did not lose a single livestock because, even though they let the cattle graze in the forest during the day, the cattle was always guarded by a herder, and stall fed at night. However, guarding cattle, as in the Eyamoo village, is an exception. Because herd management has been identified as a factor affecting predation rate in other parts of the world as well (Oli *et al*. 1994; Mishra 1997; Linnell *et al*. 1999), it is evident that managing herds carefully would actually reduce the rate of depredation as in the Eyamoo village in Toebesa Gewog.

Other studies noted that an increase in the dhole population led to a decrease in the population of wild pigs (Wangchuk 2004; Wang *et al*. 2006; Thinley *et al*. 2011). However, Selvan *et al*. (2013) and Johnsingh (1992) argued that the wild pig is a more difficult species for dholes to hunt than are ungulate species because of their protective group behaviour, indicating that wild pigs are not an important prey for dholes. Nonetheless, when dholes were poisoned in Bhutan during the 1970s and early 1980s because they were considered a pest (Wangchuk 2004; Wang and Macdonald 2006), farmers reported that the population of wild pigs increased. According to Wang and Macdonald (2006), dholes were reintroduced in Bhutan in the early 1990s in an effort to solve the problem of wild pigs in the country, and currently a sizeable dhole population is getting re-established. However, there is no evidence that the wild pig population has decreased. According to farmers, the wild pig population has continued to increase. Thus, whereas the presence of dholes has apparently no major effect on the wild pig population, it has a noticeable effect on livestock. The resentment of most farmers (68%) towards dholes must therefore be attributed to livestock loss, consistent with our findings on farmers behaviour change as reported by Wang *et al*. (2006) in JSWNP. Although the annual losses reflected per household are not significantly higher than in many other regions, farmers stated their losses as being significant. Livestock losses such as those in Toebesa are likely to generate a hostile attitude towards conservation. This can become a critical issue in Bhutan, which, on one hand, places a priority on conservation, but where, on the other hand, more than half of the population are subsistence farmers (69%) that depend on natural resources for their livelihoods.

## Conclusions

Cropping and livestock keeping are major sources of livelihoods for farmers in the Gewog. The impact of predation of livestock by dholes and other predators on livelihoods is significant, and can negatively affect the attitude of farmers towards wildlife and, hence, towards conservation efforts. The search for a solution to human–wildlife conflicts is therefore necessary. We conclude, on the basis of our research, that one of the solutions to reduce livestock depredation by wildlife species is to change the livestock herding patterns.

Dholes are the principal predator of livestock in Toebesa Gewog, followed by common leopards, and then tigers. The findings of this study showed that more cattle were killed in forests than in villages or on farms, which indicates that leaving animals in the forest without a caretaker is the major cause of losses of cattle to dholes. Depredation by dholes occurred mainly in the absence of herders, with cattle ranging freely in forests. The average loss of livestock to dhole was 0.19 animals per household. Given that the sale of livestock products contributes as much as 21% to the total annual income of farmers in the Gewog, we conclude that dholes have a significantly negative impact on some households through lost income.

Our findings that livestock depredations by dholes inside the villages and on farmed plots were significantly fewer than in forests present a clear opportunity for improvement in livestock management. Therefore, creating greater awareness among all farmers concerning the risks of allowing cattle, especially the local breed, to graze unattended in forested areas could induce them to keep their livestock in their farms and, thus, minimise losses to wild predators, especially that of dholes. Improving guarding practices may mitigate human–wildlife conflicts in villages by reducing losses to dholes in the forest and to leopards on farms.

In addition to poor guarding practices, declines in the various prey species may have been an additional cause of an increase in livestock depredation. More research on prey species and their availability, on dhole habitat, on its diet, and on its prey selection is, therefore, highly recommended. We also recommend identifying predator hotspots through numbers of livestock killed and frequency of predator sightings so that such areas can be avoided by farmers.

The literature suggests that negative attitudes of farmers towards conservation can be attributed to crop and livestock damage caused by wildlife. Improving farmers' livelihoods by reducing the depredation risk through improved livestock rearing practices can also serve the cause of wildlife conservation. Moreover, literate farmers tend to exhibit relatively more-favourable conservation attitudes, which confirms that education and awareness-raising are important strategies for enhancing conservation activities (Oli *et al*. 1994; Gillingham and Lee 1999; Wang *et al*. 2006). Reducing depredation risk may, in the long run, also serve Bhutan's developmental philosophy of middle path, which otherwise could be weakened (or even lose credibility) if farmers perceive that conservation is practiced at their cost.

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