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## COMMUNICATION

### ASSESSMENT OF CHANGES OVER A DECADE IN THE PATTERNS OF LIVE-STOCK DEPREDATION BY THE HIMALAYAN BROWN BEAR IN LADAKH, INDIA

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## Assessment of changes over a decade in the patterns of livestock depredation by the Himalayan Brown Bear in Ladakh, India

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**Abstract:** Conflicts between large carnivores and shepherds constitute a major socio-ecological concern across the Himalaya and affects community attitudes and tolerance toward carnivores. We assessed the extent and intensity of Human-Brown Bear interactions in the same villages of Zaskar and Suru Valleys, Ladakh, in the Indian Trans-Himalaya during two time periods (2001–2003 and 2009–2012) through field and questionnaire surveys. During 2001–2003, 180 families of 32 villages in Zaskar, and 232 families of 49 villages in Suru were interviewed, and during 2009–2012, 145 families of 23 villages in Zaskar and 115 families of 33 villages in Suru were interviewed. Overall, 475 (119/year) and 454 (151/year) heads of livestock were reportedly killed by Brown Bears. The surveys of 2009–2012 revealed that livestock depredation in 'doksas' (summer grazing camps) was higher (68 %) compared to the surveys carried out during 2001–2003 (42 %). The increased livestock depredation in doksas might be due to the extended stay and use of pastures by the local communities during spring and autumn. Damage to property in the form of breaking open of doors and windows by Brown Bear were reported during both the surveys. Economic losses and declining tolerance of people may trigger retaliatory killings of Brown Bear in Ladakh. We recommend compensation for livestock loss and improved husbandry practices in the conflict zones for bear-human coexistence.

**Keywords:** Conflict, Himalayan Brown Bear, Human-Brown Bear interactions, field and questionnaire surveys, Ladakh, livestock depredation, Suru, Trans-Himalaya, Zaskar.

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**Author contributions:** Initially SSK conceived the idea in early 2000s and carried out the fieldwork during 2001 to 2003. Later, AM followed the similar habitats and carried out the fieldwork and analysed the data during 2009 to 2012. AM, AAK and SSK wrote, reviewed and approved the article.

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भारतीय वन्यजीव संस्थान  
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## INTRODUCTION

Worldwide, the Brown Bear *Ursus arctos* is the most widely distributed species among the eight species of bears (Servheen 1990; Schwartz et al. 2003; Nawaz 2007). They are distributed in most of the northern hemisphere, including the Palearctic and Nearctic regions of the world (Servheen 1990). They inhabit alpine and sub-alpine mountainous landscapes of Asia, Europe, and North America. Their numbers and distribution range have contracted by more than 50% in Asia during the past century (Servheen 1990). The Himalayan Brown Bear *U. a. isabellinus* (Image 1), a subspecies that represents an ancient lineage of the Brown Bear (Galbreath et al. 2007), has a restricted distribution in the Greater and Trans-Himalayan regions of Jammu & Kashmir, Ladakh, Himachal Pradesh, and Uttarakhand in India (Sathyakumar 2001, 2006). The Himalayan Brown Bear occurs in subalpine forests and alpine meadows in the Greater Himalaya of Jammu & Kashmir, Himachal Pradesh, and Uttarakhand, and in the cold-arid alpine scrub and meadows in the trans-Himalayan regions of Ladakh (Sathyakumar 2003, 2006). Sathyakumar (2001, 2006) reported, through questionnaire-based surveys, Brown Bears are present in 23 protected areas and 35 other localities throughout the northwestern and western Himalayan regions of India.

In the Himalayan landscapes, local communities generate their livelihoods largely through nomadic pastoralism, horticulture, subsistence farming, and eco-tourism activities (Jaypal 2000; Maheshwari et al. 2010; Maheshwari 2018; Maheshwari & Sathyakumar 2019, 2020); however, due to increase in livestock densities and consequent expansion of pastoralism into new areas that were historically natural and undisturbed habitats, domestic species (e.g., cattle such as cow, yak *Bos grunniens*, dzo-dzomo (yak-cow hybrids), sheep *Ovis aries*, goat *Capra aegagrus* and equids) are more vulnerable to predation by Himalayan Brown Bear, which may lead to retaliatory killing by local communities (Karimov et al. 2018; Maheshwari 2018; Dai et al. 2020). In India, Brown Bears are threatened due to poaching for bear parts and retaliatory killings to reduce livestock depredation (Sathyakumar 2001, 2006) and has significantly contributed to the local declines of the populations of Brown Bear and other large carnivores such as Snow Leopard *Panthera uncia* and Wolf *Canis lupus* in the Himalayan region (Jackson et al. 2001; Spearing 2002; Maheshwari et al. 2010; Can et al. 2014; Maheshwari 2016; Maheshwari 2018; Maheshwari & Sathyakumar 2019, 2020; Dai et al.



Image 1. Brown Bear *Ursus arctos isabellinus*.

2020). Sound scientific research is necessary for making management decisions related to Brown Bears and for sustainable management of their populations (Servheen 1990; Sharief et al. 2020); however, there has not yet been detailed field research on the Himalayan Brown Bears in Ladakh.

We conducted field and questionnaire surveys in Zanskar and Suru valleys of Ladakh, India, during two time periods, viz., 2001–2003 and 2009–2012 to understand the patterns of Human-Brown Bear interactions in order to plan effective conservation and management actions for Brown Bears and their co-existence with local communities.

## MATERIALS AND METHODS

### STUDY AREA

The Zanskar and Suru valleys of Kargil District in the Union Territory of Ladakh (Figure 1) falls within the Trans-Himalayan biotic province (1B) of India (Rodgers et al. 2000). Topographically, the region is mountainous with vast valleys characterised by open and dry steppe vegetation indicating arid conditions. Major vegetation formations include open or desert steppe dominated by grasses, sedges, and dwarf shrubs such as *Ephedra gerardiana*, *Capparis spinosa*, *Salsola collina*, *Stipa klimesii*, *Leymus nutans*, *Eurotia ceratoides*, *Artemisia*

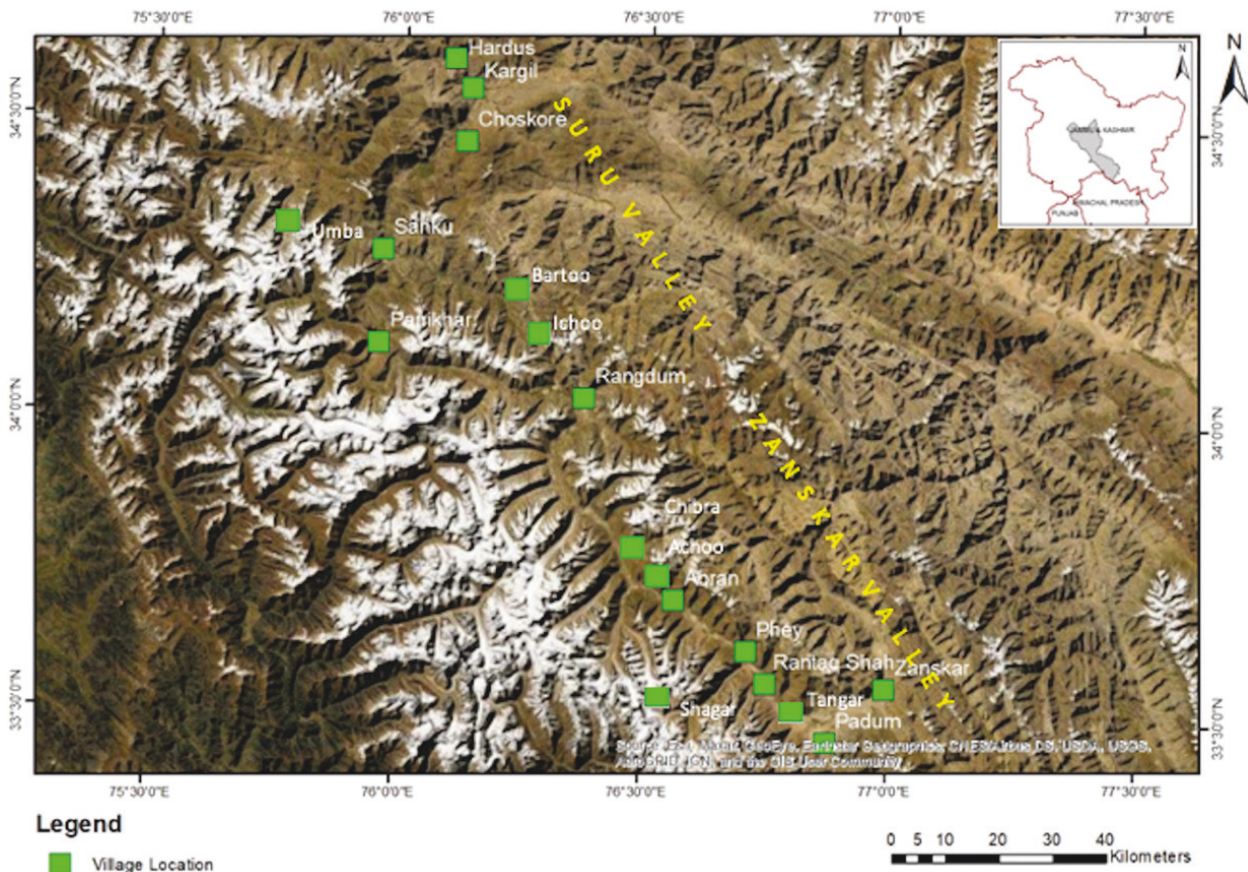


Figure 1. Map of the study area showing major villages interviewed to gather information on livestock depredation by Brown Bear in Kargil.

*macrocephala*, *Hippophae rhamnoides*, *Myricaria elegans*, and *Caragana species* (Kala 2011; Maheshwari 2016). Large mammals that co-exist with Brown Bears in the Kargil Himalaya include the Snow Leopard, Wolf, and Ibex *Capra ibex*. The elevation in the study area ranges 3,400–7,510 m with significant land surface under permafrost coverage (Maheshwari 2016). The climate in the study area is largely dry with extreme cold conditions throughout the region (Maheshwari 2016).

The Suru Valley forms a major portion (4,500 km<sup>2</sup>) of Kargil District (Figure 1) and it is characterised by steep and rocky mountains, wide valleys with human habitations and agriculture/horticulture lands. Rivers Suru and Drass drain the valley which join the Indus flowing in the north (Maheshwari 2016). The Zaskar Valley (3,000 km<sup>2</sup>) is the region located south of Pensi La (4,400 m) and it is characterised by large valleys with human habitations and agriculture/horticulture lands and surrounded by mountains. Zaskar River drains the valley and joins the Indus at Nimmo (Maheshwari 2016). The Zaskar Valley is bordered by the Great Himalayan high mountains to the south and west. Traditionally, the local communities are involved in subsistence agriculture

and agro-pastoral based lifestyle, they cultivate the land along the course of the drainage system, wherever artificial irrigation from mountain streams is possible. Kargil is one of the sparsely populated regions in India and settlement pattern is just along the river valleys and a few broad valleys (Maheshwari 2016). The human population in the study area is dominated by Buddhists (in Zaskar Valley) and Muslims (in Suru Valley) with human density of 8 persons/km<sup>2</sup> for Kargil District (Census of India 2011).

## METHODS

### Characterization of human-bear interaction: (a) semi-structured interviews.

We carried out field and questionnaire surveys for 75 days during the summer months of 2001 (40 days), 2002 (20 days) and 2003 (15 days) in Zaskar and Suru valleys to assess the extent and intensity of Brown Bear-Human interactions. The surveyed localities include most of the villages along the main Kargil-Padum motor road and in the side valleys of Sanku, Uмба, Rangdum, and Padum that are representative of the Zaskar and Suru valleys. We repeated these surveys in the same

villages (as it was conducted during 2001–2003) during the summer months of 2009–2012 (90 field days). Informal semi-structured interviews (Sathyakumar 2001; Maheshwari et al. 2014; Dai et al. 2020) were used to collect information on livestock holdings and livestock depredations from the villagers.

We interviewed a minimum of five families in a village and if livestock depredations due to Brown Bear were reported by even one of these five families, then we sampled at least 30% of the total families living in that village (Sathyakumar 2003). Villagers living in doksa (seasonal nomadic settlement used by agro-pastoral communities to shelter their livestock during summer in the Greater and Trans-Himalaya of India; Maheshwari 2013) were also interviewed. To reduce and avoid overestimation of livestock depredation, we employed participatory rural appraisal (PRA), a standardised approach for collecting data on large carnivore-human interaction using the semi-structured interview technique of PRA (Maheshwari et al. 2014). We conducted informal meetings in public places (e.g., community centres) and personal visits to the villages, to explain study objectives to local communities. Meetings were open to all. We recorded people's complaints about wildlife damage, especially damage by Brown Bears. Following these meetings, a semi-structured questionnaire format was developed in line with preliminary interviews. Interviews were then carried out in all the villages, doksa and seasonal settlements that were known to experience frequent conflict incidents. Our sampling involved face-to-face interviews with villagers and reflected first-hand experience and knowledge. Moreover, through personal interaction, we believe it was generally possible to judge the authenticity of the claims or cross check them, thus improving overall reliability (Maheshwari et al. 2014).

#### **Characterization of human-bear interactions: (b) field survey.**

To understand the spatial distribution of livestock predation by Brown Bear, the GPS locations of the predation cases were recorded during the surveys and a kernel-density transformation were adopted to understand predation density across the study area. It provides a median to visualize point pattern to detect hotspots (O'Sullivan & Unwin 2003). Kernel-density estimation provides a map of estimates of local intensity of any spatial process from a set of observed occurrences (Bailey & Gatrell 1995). A development gradient representing the conflict intensities through varying densities of conflict was created (Worton 1989) using kernel-density tool in ArcGIS 10.5 (ESRI 2016). The

method begins by centring a bivariate probability density function with unit volume (i.e., the 'kernel') over livestock predation locations. A regular grid is then superimposed on the data and a probability density estimate was calculated at each grid intersection by summing the overlapping volumes of the kernels. A bivariate kernel probability density estimator (i.e., a 'utilization distribution') was then calculated over the entire grid using the probability density estimates at each grid intersection (Kernohan et al. 2001). The resulting kernel probability density estimator would have relatively large values in areas with many observations and low values in areas with few. We calculated the distribution using the fixed kernel estimator with least squares cross validation (LSCV) as the smoothing parameter, with a sample size  $\geq 30$ . This search radius (bandwidth) is computed specifically to the input dataset using a spatial variant of Silverman's rule of thumb that is robust to spatial outliers (Silverman 1986).

## **RESULTS**

### **Interviews distribution**

In total, 412 respondents from 81 villages were interviewed during the 2001–2003 survey. It comprised 180 respondents from 32 villages of Zanskar, and 232 respondents from 49 villages of Suru. Additionally, in Zanskar, 16 villagers living in eight doksas were also interviewed. Whereas, during second time survey (2009–2012), 145 respondents representing 23 villages of Zanskar and 115 respondents from 33 villages of Suru Valley were interviewed and a total of 20 villagers in doksas were also interviewed in Zanskar Valley.

### **Livestock holding**

The overall livestock population had increased by about 9% (from 2001 to 2010; Table 1) which was mostly due to increase in the numbers of cattle (18%), sheep and goats (10%), and the decline in the numbers of equids (7%). Further, shepherds reported a marginal shift in the increased use of high-altitude pastures (at doksa) during spring and autumn as compared to the 2001–2003 surveys.

### **Livestock predation by Brown Bear**

Data from 2001 to 2003: The average livestock predation by brown bear was of 3.15 (29.05 $\pm$ 1.65) animals per household (i.e., on average 151 livestock/annum were reportedly killed by brown bear for those sampled families). Majority of the incidences took place

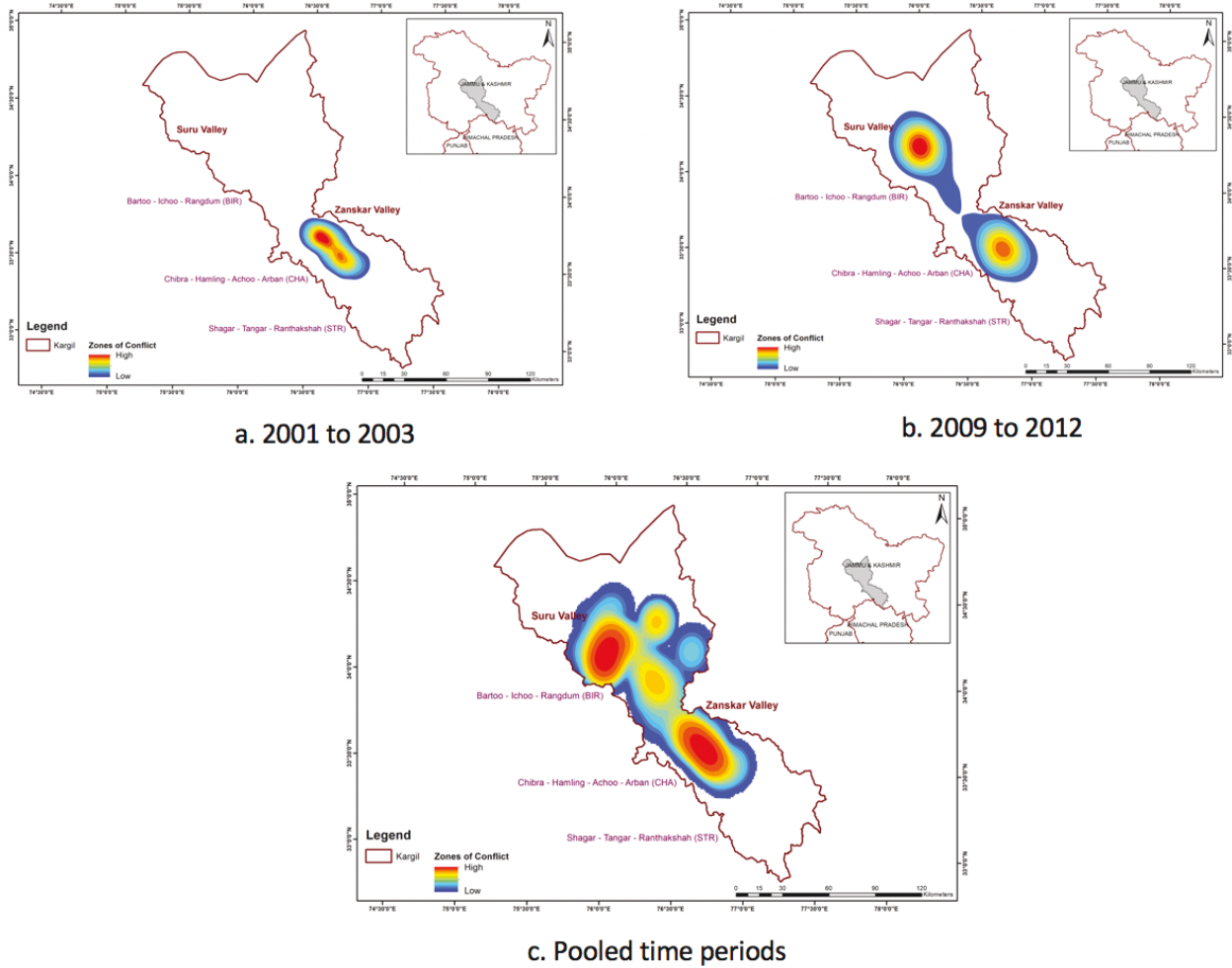


Figure 2. Map showing Brown Bear-Human interactions in Kargil through kernel distributions of the events of livestock depredation during 2001 to 2003 (a), 2009 to 2012 (b), and 2001 to 2012 (c).

Table 1. Livestock holdings in the Brown Bear habitats surveyed in Zanskar and Suru valleys during 2001 and 2010.

Number of families and their livestock details	2001		2010	
	Zanskar	Suru	Zanskar	Suru
No. of families surveyed	180	232	145	115
Cattle (cow, yak, dzo-dzomo)	1379	989	1651	1154
Sheep and goats	1489	1249	1628	1389
Equids (horses /mules/ donkeys)	834	747	849	619

in the villages (n= 257; 54 %) followed by doksa (n= 200; 42 %) and livestock night shelters (n= 19; 4 %) (Table 2). Brown Bears preyed mainly on young ones of cow, yak and dzo-dzomo (age= <1 year; n= 248; 52 %) and goat and sheep (n= 195; 41 %). Most of the depredations were reported during summer (n= 195; 63 %) and to some extent in spring (n= 87; 28 %). Locals reported

Table 2. Comparison of livestock predation by brown bear at various sites in Ladakh during two time periods, 2001 to 2003 and 2009 to 2012. Key: BIR- Bartoo-Ichoo-Rangdum, STR- Shagar-Tangar-Ranthakshah, CHA- Chibra-Hamling-Achoo-Arban.

Livestock predation across sites	2001 to 2003	2009 to 2012
<b>Doksas</b>	200	309
<b>Villages</b>	257	145
<b>Night shelter</b>	19	-
Livestock predation conflict hotspots		
<b>BIR</b>	-	173
<b>STR</b>	208	281
<b>CHA</b>	267	-

visual encounters of Brown Bears on livestock kills (n= 153; 37 %) or have confirmed it based on tracks and signs (n= 259; 63 %) found near kills and their predation behaviour.

Data from 2009 to 2012: The average livestock predation was of 4.56 (44.34±2.65) animals per household (i.e., 119 livestock/annum were reportedly killed by brown bear for the sampled families). Majority of the incidences took place in doksas (n= 309; 68 %) followed by villages (n= 145; 32 %; Table 2). Brown Bears preyed mainly on sheep and goats (n= 245; 54 %) followed by young ones of cow, yak and dzo-dzomo (age= <1 year; n= 209; 46 %). Most of the depredations were reported during summer (n= 185; 66 %) and spring (n= 95; 34 %). Locals reported more frequent Brown Bear visual encounters on livestock kills in Zanskar Valley (n= 177; 68 %) than Suru Valley (n= 83; 32 %).

#### Spatial patterns in Brown Bear-Human conflicts:

Data from 2001 to 2003: In Zanskar, two conflict zones were identified (i.e., Shagar-Tangar-Ranthakshah areas (STR) and Chibra-Hamling-Achoo-Abran areas (CHA); Figure 1a). The Brown Bear was reported to have preyed upon 6.3 % (total livestock population 3,301 in sampled families) and 7.9 % (total livestock population 3,386 in sampled families) of the livestock population of CHA and STR, respectively (Table 2).

Data from 2009 to 2012: We recorded two-conflict zones viz., one in Suru (Bartoo-Ichoo-Rangdum; BIR) and another one in Zanskar (Shagar-Tangar-Ranthakshah; STR) (Figure 2b). The Brown Bears were reported to have preyed upon 5 % (total livestock population 3,450 in sampled villages) and 7.3 % (total livestock population 3,840 in sampled villages) of the livestock population of BIR and STR, respectively (Table 2).

#### Trend in Brown Bear-Human interactions

A kernel distribution of the events determined three interaction zones, viz., BIR, in Suru and CHA and STR in Zanskar Valleys in both the time periods (Figure 2c). During the period 2009 to 2012, the total livestock loss due to Brown Bears (including both valleys) was of 6.5 % (n= 7,290), of which Zanskar and Suru reported 6.9 % (n= 3,840) and 6.1 % (n= 3,450) livestock loss, respectively. Similarly, in 2001 to 2003, the total livestock loss due to Brown Bears (including both valleys), was of 6.8 % (n= 6,687), of this, Zanskar and Suru reported 6 % (n= 3,310) and 7.5 % (n= 3,386) of their livestock loss respectively.

## DISCUSSION

Local communities were primarily concerned for the livestock depredation and damage to their properties by the Brown Bear in Zanskar and Suru valleys. Both

led to economic losses in the local communities, and possibly therefore, retaliatory killing cannot be ruled out. Spearing (2002) reported that three Brown Bears were killed in Zanskar in retaliation during 1998–2001; however, we did not register any such case during the study duration. Retributory killing of Brown Bear have been reported from the neighbouring state of Himachal Pradesh, India in which the migratory shepherds (gaddis) often kill Brown Bears to reduce livestock predation (Sathyakumar 2001; Rathore & Chauhan 2007; Sharief et al. 2020). Rathore (2008) reported that livestock depredation by Brown Bear ranged from 2.2 % to 12.9 % livestock/annum in Kugti Wildlife Sanctuary, Himachal Pradesh, India. There had not been any cases of attacks on humans by Brown Bear in Himachal Pradesh (Rathore 2008); however, during the 2001–03 survey, first-hand accounts of Brown Bear attack on humans (in 2001) was recorded from a villager in Abran Village (Zanskar Valley; Sathyakumar 2003). In Sanjiangyuan of the Tibetan Plateau, the Tibetan Brown Bears *Ursus arctos pruinosus* were estimated to damage properties more significantly than livestock depredation (Dai et al. 2020). Whereas, in our findings there is a comparatively more loss (almost 132 heads of livestock annually) of livestock in Kargil. This disparity is explained by the poor guarding practices and unsupervised livestock grazing in the Indian Himalaya region (Rawat 2007; Maheshwari 2016). We observed that most people around Zanskar kept dogs to guard the livestock but efficiency of such measures was limited, which are widely used probably lead to habituation to brown bear (Sathyakumar 2001; Ambarlı & Bilgin 2008; Rathore 2008; Can et al. 2014; Maheshwari 2018).

#### Pattern of Brown Bear-Human interaction

We estimated a decline of 37 % (n= 152; from 2001–2003 to 2009–2012) in the number of respondents who reported cases of Brown Bear-Human interaction. Although there was an 18 % increase in the total number of livestock holdings by the respondents, the livestock loss to Brown Bear remained almost the same. The present study also made an attempt to understand the presence of Brown Bear with livestock predation caused by it in the conflict zones. During 2009–12, we recorded 88 evidences of Brown Bear with 6 % livestock loss in BIR and 31 evidences of Brown Bear with 9 % livestock loss in STR of the total livestock population in both the conflict zones. This high number of Brown Bear evidences and low levels of conflict may be due to improved livestock husbandry practices in BIR. Government owned livestock (sheep and goats) were not depredated by any wild carnivore as 5–6 staff members of the Sheep



Husbandry Department guarded the animals efficiently. Moreover, damage frequency seems to have increased in the summer pastures due to unsupervised grazing of the livestock, which in turn was caused by many residents either moving to big cities for better jobs or opportunities in the eco-tourism sector in Zanskar range.

## CONCLUSION AND PERSPECTIVES

Livestock is one of the major sources of livelihood for the agro-pastoral communities in Kargil and Zanskar (Maheshwari 2016; Maheshwari & Sathyakumar 2020). Due to a lack of proper infrastructure and poor guarding practices, livestock is more exposed to Brown Bear depredation in Kargil and Zanskar. In addition, unsupervised grazing of cattle and horses in hill slopes or nullas (streams in narrow valleys) and sheep and goat grazing by children are two of the key contributing factors for Brown Bear depredation in Kargil and Zanskar Himalaya. We propose adoption of adult supervised livestock grazing at the village level and improved predator proof livestock corrals and night shelters for reducing Brown Bear depredations (Maheshwari & Sathyakumar 2020). Since the Brown Bear population is declining throughout most of its range in southern Asia, and their population is still small, the species have poor growth potential, and a relatively low genetic diversity (Nawaz 2007). It requires a continuous field and genetic monitoring. Maintaining and improving the connectivity with adjacent populations in Pakistan and India will be of utmost importance for its long-term survival. We also recommend payment of compassionate grants for livestock loss and improved husbandry practices in the interaction zones for bear-human coexistence.

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