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Original Research Article

Human-Asiatic Black Bear Interactions in the Fringe Villages of Khangchendzonga National Park, Sikkim, Northeast India

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Abstract: Human-black bear interactions have been increasing because of habitat destruction in their global distributional ranges. We investigated human-Asiatic black bear interactions from 2016 to 2018 to assess the damages caused by the black bears in the fringe villages of the Khangchendzonga National Park, Sikkim, India by conducting semi-structured questionnaire survey among 193 inhabitants of 18 villages in the study area. We recorded 393 incidents of Human-Asiatic black bear interactions in the study area. We observed four different types of human-bear interactions viz. (i) crop depredation (62.85%, n=247 incidents), (ii) livestock kill (29.77%, n=117 incidents) and (iii) human casualties incidents (3.31%, n=13 and (iv) properties damages (4.07%, n=16 incidents). Maize (35.62%) and goats (15.52%) were recorded as the highest depredated species in the fringe villages. Most of the crop damages were recorded <400 m and livestock kill between 800m and 1.2km from the edge of the Khangchendzonga National Park. That there is a significant difference in the altitudinal human-black bear interactions (H=6.92, *df*=7, *p*=0.438) and maximum (32%) of incidents were recorded in the elevation ranges of 1501-2000 m asl. About 60% of fringe villages of park fall under the high and moderate-intensity zone of human-black bear interactions. More than 50% of respondents have shown a positive attitude towards the conservation of bears when properties are only damaged, but demanded retaliatory killing of bear during human attack (85%). A suitable conservation strategy may be developed for mitigating the human-Asiatic black bear interaction based on the present findings and in consultation with local inhabitants who are the most vulnerable.

Key words: Conservation, crop depredation, human-bear interaction, human casualties, livestock depletion

Introduction

Wildlife often interacts with humans in diverse ways, however, when such interactions harmfully effect or perceived to affect the lives and properties of the people, then conflicts occur (Woodroffe *et al*., 2005). Thus, human-wildlife conflict refers to the interaction between wild animals and people and the resultant negative impact on people or their resources, or wild animals or their habitat. The negative interaction results in human-wildlife conflicts in various ways viz. crop-raiding, livestock depredation, house damaged and attacks on humans (Thouless, 1994; Woodroffe *et al*., 2005). Human-wildlife interaction (HWI) is emerging as a significant conservation issue in developing countries (Distefano, 2005; Ali *et al*., 2018).

The interaction between human and wildlife species always led to a negative attitude towards the conservation of wildlife species (Bagchi and Mishra, 2006; Aryal *et al*., 2016). HWI with more frequent in and around the protected areas

across the world. In the Indian subcontinent, most wildlife species are inhabited in the protected areas and their adjacent reserve forests which they use as buffer areas or corridors for dispersal. These protected areas or reserve forests either have agricultural lands or settlements of local people in the fringe and even some cases in the protected areas and reserve forests (Karanth *et al*., 2012). Several researchers have reported HWI outside or fringe of the protected areas, particularly in the agricultural fields located adjacent to the protected area (Aryal *et al*., 2016; Khanal *et al*., 2018). It is reported that major causes of interaction between humans and wildlife are crop raiding, livestock killing, house damage, human kill or injury, and also killing or injury of wildlife in retaliation. These interactions happened because of insufficient quality and quantity of food resources in their natural habitats in particular seasons, and habitat loss, degradation, fragmentation, conversion of forest land-use change for different purposes like agricultural, road/rail network, industries, hydropower project, etc. (Graham *et al*., 2005; Athreya and Belsare, 2007; Kabir *et al*., 2014).

Several mammalian species like elephants, leopards, bears, tigers, wild boar, primates and ungulates have direct and indirect negative impact on human properties as well as on a human being in the Indian subcontinent due to human-wildlife interaction (Treves and Karanth, 2003; Bargali *et al*., 2005; Akhtar and Chauhan, 2008; Sarker and Røskaft, 2014; Kumar *et al*., 2019). Among these species, bears are widely distributed and reported from every continent except Africa, Australia, and Antarctica (Nowak and Paradiso, 1983). There are only eight surviving species of bears in the world, out of them four species (viz. Asiatic black bear *Ursus thibetanus*, Sloth bear *Melursus ursinus*, Sun bear *Helarctos malayanus* and Himalayan brown bear *Ursus arctos*) found in Inida (Bargali, 2012) and in Sikkim, only Asiatic black bear (ABB) (*Ursus thibetanus*) is found (Sathyakumar *et al*., 2011). The ABB has a limited global distributional range from Afghanistan to the Baluchistan province of Iran, India, China, Korea, and Japan with a low and isolated population in Taiwan (Cowan, 1972; Sathyakumar and Choudhury, 2007). In India, the species is mainly distributed in the Himalaya and the foothills of Himalaya from Jammu and Kashmir (except Ladakh), Himachal Pradesh, Uttar Pradesh, Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura and some parts of northern districts of the West Bengal (Sathyakumar and Choudhury, 2007; Choudhury, 2013). ABB is listed as 'Vulnerable' in the Red Data Book (IUCN 2016) and in Appendix I of CITES in India since 1990 and in Schedule I of the Indian Wild Life (Protection) Act, 1972 which provide complete protection to the species from hunting and trade.

In Sikkim, human-Asiatic black bear interaction (HBI) has a long history in both the positive and negative perception before and after the state government policy banned open grazing and pastoral practices in the protected areas in 1995. From 2009 to 2016, more than 500 cases of human-black bear interactions were reported in the form of livestock killing, crop depredation, property damage and human injuries (Forest official, Forest Environment and Wildlife Management Department, Govt of Sikkim pers. comm., 2017). Such incidents at the time always led to the retaliatory killing of ABB in its distributional ranges (Stubblefield and Shrestha, 2007) and smuggle the bear body parts to the different parts of the world (Bargali, 2012). In the Himalayan region, it has become an incessant problem for local villagers to guard the agricultural crops and their livestock in fear of black bears (Abbas *et al*., 2015; Jamtsho and Wangchuk, 2016). So far no detailed investigation is conducted on human-Asiatic black bear interaction in the fringe villages of the Khangchendzonga National Park, Sikkim to find out the actual causes and mitigation measures. Therefore, the present study was aimed to investigate the human-Asiatic bear interactions in the fringe villages of the Khangchendzonga National Park, Sikkim, Northeast India to find out the causes of conflicts and to suggest suitable preventive and conservation strategies for the bear as well the protection of properties.

Materials and methods

Study area

The present study was carried intensively in the fringe villages of the Khangchendzonga National Park (KNP), Sikkim from

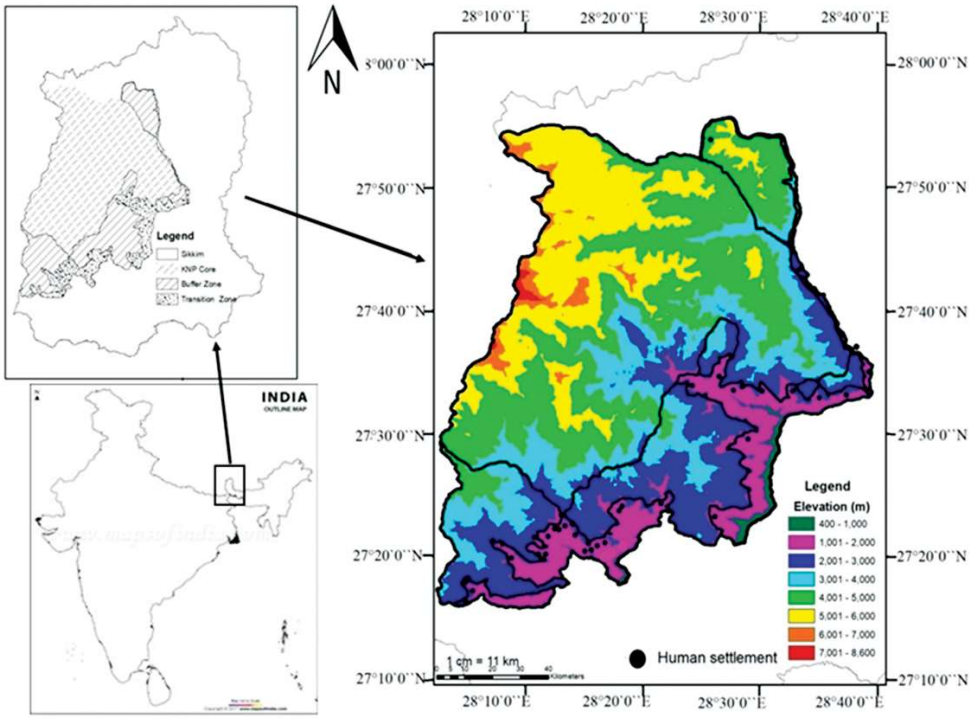

Fig. 1. Human settlements in the fringe and buffer area of the study area-Khangchendzonga National Park.

2016-18 (Figure 1). The entire study area falls under the Eastern Himalaya biodiversity hotspot (Myers *et al.*, 2000) and also one among the Global 200 Ecoregions (Olson *et al.*, 2001). The park is located between 27° 30‘ to 27° 55‘ N and 88° 02‘ to 88° 37‘E and covered 2620.00 km^2 (1784 km^2 core zone and 836 km^2 buffer zone) geographical area of the state. The KNP is well connected to the Khangchendzonga Conservation Area in eastern Nepal, Barsey Rhododendron Sanctuary and Maenam Wildlife Sanctuary in the west and south Sikkim and Singalila Biosphere Reserve in Darjeeling district of West Bengal (Tambe, 2007). The park received an average annual rainfall of about 3000 mm and temperature varied from 15°C to -20°C (Tambe, 2007). KNP is surrounded by 26 villages which are either established in the fringe areas of the park boundary or near to the buffer zone. These villages are widely spread in all three ranges of the park viz. Yuksom, Dzongu, and Chungthang and located between less than 1000m asl. and more than 4000m asl. These villages are mostly inhabited by ethnic groups like Lepcha, Bhutia, Nepalese communities. These residents derive most of their basic livelihood through subsistence organic agricultural farming, horticultural practices, tourist guides (trekking) and livestock rearing viz. cattle, yaks, goats, sheep, fishery, piggery, and poultry farming. The major crops cultivated by local people are maize, potatoes and beans, which are mostly for self consumed, but the surplus is sold in the local markets. Besides these crops, they also cultivate cash crops viz. cardamom, finger millet, barley, peas and buckwheat. These local inhabitants highly depend on the neighboring forest resources for fuelwood, ferns, poles, timber, medicinal plants and fodders.

Methods

To know the nature and extent of the human-Asiatic black bear interaction, a semi-structured questionnaire survey was conducted followed by informal interviews among the affected 193 people of 18 villages located in the North, West and South districts of KNP jurisdiction. The villages were selected based on the incident and intensity of HBI. The interviews were conducted in the local language and carried out familiarly by following the guideline as described by Kvale (1996) and Ali

et al. (2018). The entire questionnaires were divided into seven different segments viz. (i) demographic and socioeconomic status of respondents, (ii) different type of crop grown, showing and harvesting time, seasons and damage pattern by black bear, distance of damage from the protected area, (iii) livestock reared by local communities, livestock kills, distance of livestock kill from protected area, (iv) NTFPs collections from the protected area, (v) types of measures used by the local people to reduce the black bear conflict (scientific and traditional), (vi) records of bear attacks on human, damage of property and (vii) perceptions and tolerance towards bears. Various awareness and PRAs (Participatory Rural Appraisal) were also conducted to understand the perception of local villagers towards the ABB conservation and the strategies and measures to prevent the HBI. Direct observation was also made to gather information on the crop damages, livestock kill, human casualties, and property damages together within a geographical area of the questionnaire survey. Based on the information gathered from villagers and direct observation, we mapped the intensity status of HBI using Google Earth and ArcGIS. All the analysis was done by using the open software Minitab (Ver.19).

Results

Status of Human-Black bear Interactions (HBI)

A total of 393 incidents of HBI (Table 1) was recorded through interviewing 193 local villagers inhabiting in the fringe villages of KNP, particularly those who personally suffered from ABB. Among these villagers, (78%) belonged to traditional farmer communities followed by trekkers, guides, herders and hunters (13%) and remaining were Govt. servant, shopkeepers, and others (9%). Most of the respondents (90%) were mentioned the presence of HBI in the fringe area of the park. In all three ranges viz. Yuksom range recorded the highest number (53.94%) of HBI followed by the Dzongu (37.92%) and Chungthang range (8.14%) (Table 1). It is recorded that the crop depredation was the highest (62.85%, n=247) in all three ranges followed by livestock kills (29.77%, n=117), human casualties (3.31, n=13) and property damages (4.07, n=18) (Table.1). As 72% of respondents reported the sighting of ABB between August and November (77%) when the hard mast and agriculture corps were highly available in the agriculture fields located in the fringe areas of the KNP and minimum was in between March and July (21%), and December (2%) (Figure 2) when favourite food was absent in the fringe villages. Local villagers reported that human casualties, mostly occurred (68.7%) during the collection of NTFPs inside KNP followed by traveling between the villages and local market areas (17%), trekking and herding livestock (11.3%) and remaining (3%) of incidents were occurring during chasing and scarring the bears away from the human properties.

Crops depredation

The fringe villagers of KNP, mainly cultivate two types of crops viz. Kharif (August to November) and Rabi crops (April to May). Maximum (90%) crop raiding was recorded in the three months from August to October when maize was fully grown and minimum in March and April (1%) each (Figure 3). The maximum (49.80%) crop depredation was recorded in the Yuksom range followed by the Dzongu (43.32%) and Chungthang range (6.88%) (Table 1). 83% of respondents reported that maize (35.62%) was the highest raided crop by ABB. Other crops like buckwheat (*Fagopyrum esculentum*), finger millet (*Eleusine coracana*), barley (*Hordeum vulgare*), and large cardamom (*Amomum* spp.*)* were also damaged by the black bear. The crop-raiding occurred significantly more often when the agriculture fields close to the edge of the KNP (<400m) (Kruskal–Wallis test H=34.43, p<0.002, df=14) (Figure 4).

Livestock kill

During the study periods, (n=117) livestock kills and attacks were reported by respondents in the fringe villages as well as in the core area of KNP. The maximum (64.96%) of livestock kills were reported in the Yuksom range (West district) followed by the Dzongu range (25.64%) and Chungthang range (9.40%) in the North district of KNP (Table 1). Livestock killing was recorded throughout the year except in January, February and June, with a maximum in September-November

Table 1. The contributions of the different type HBI in the three different ranges of KNP.

Type of HBI	Khangchendzonga National Park and its surrounding areas							
	Yuksom Range (West district)		Dzongu Range (North district)		Chungthang Range (North district)		Total	
	Number of cases reported	Percentage of total cases (%)	Number of cases reported	Percentage of total cases (%)	Number of cases reported	Percentage of total cases (%)	Number of cases reported	Percentage of total cases (%)
A. *Crop depredation*								
Maize	77	62.6	49	45.79	14	82.35	140	47.95
Finger millet	7	5.69	3	2.8	3	17.65	13	4.45
Barley	2	1.63	11	10.28	-	-	13	4.45
Buckwheat	14	11.39	9	8.41	-	-	23	7.88
Gauva	5	4.07	16	14.95	-	-	21	7.19
Squash	11	8.94	7	6.54	-	-	18	7.29
Cardamom	7	5.69	12	11.21	-	-	19	6.51
Total	**123**	**100**	**107**	**100**	**17**	**100**	**247**	**100**
B. *Livestock kill*								
Goats	32	42.11	19	63.33	10	90.91	61	52.14
Yak	6	7.89	0	0	1	9.09	7	5.98
Horses	3	3.95	0	0	-	-	3	2.56
Sheep	22	28.95	3	10	-	-	25	21.37
Poultry	9	11.84	2	6.67	-	-	11	9.4
Cattle	4	5.26	6	20	-	-	10	8.55
Total	**76**	**100**	**30**	**100**	**11**	**100**	**117**	**100**
C. *Human causalities*								
Human injury	7	100	6	100	-	-	13	100
D. *Property damages*								
Liquor storage house	1	16.67	4	66.67	3	50	8	50
Cattle shed & farm	5	83.33	2	33.33	1	50	8	50
Total	**6**	**100**	**6**	**100**	**4**	**100**	**29**	**100**
Grand total (A+B+C+D)	**212**	**53.94**	**149**	**37.92**	**32**	**8.14**	**393**	-

(65%) followed by March-August (32%) and (3%) in December (Figure 3). Goats (52.14%) were the most preferred killed livestock by ABB followed by the sheep (21.37%), horses (9.4%), cattle (8.55%), yak calf (5.98%) and poultry (2.56%). Livestock attacks by ABB occurred significantly more often between 0.8km and 1.2km closer to the boundary of KNP (Kruskal –Wallis test H=26.13, p<0.023, df=14 á=0.05) (Figure 5). During the survey, many of the respondents mentioned that ABB also killed pack animals during the trekking and pastoral time inside the KNP.

Human casualties and property damages

Of the 393 incidents of HBI, total of 29 incidents of human casualties and property damages were recorded. Of them, 13 nos. of human casualties and 16 nos. of property damages were recorded. Of the 13 human casualties, a maximum of 9 nos. occurred outside the buffer areas, particularly in transition zone area where agricultural activities, fodder collection, and travelling from one village to another village while 4 incidents of human casualties were occur inside the buffer and core zone of KNP when villagers visited the park for the collections of NTFPs and

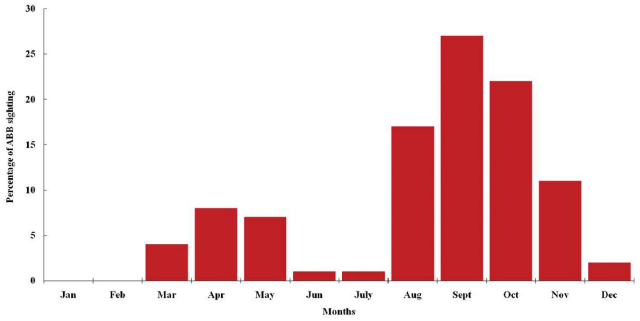

Fig. 2. The percentage of the Asiatic black bear sighting by local villagers and personal observation in the different month in the study area.

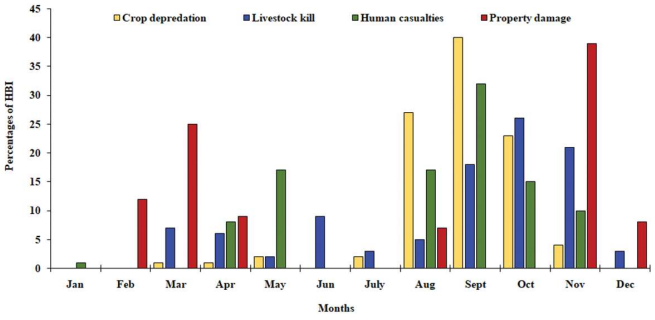

Fig. 3. The crop depredation, livestock kill, human casualties and property damage by ABB in different months during the study periods.

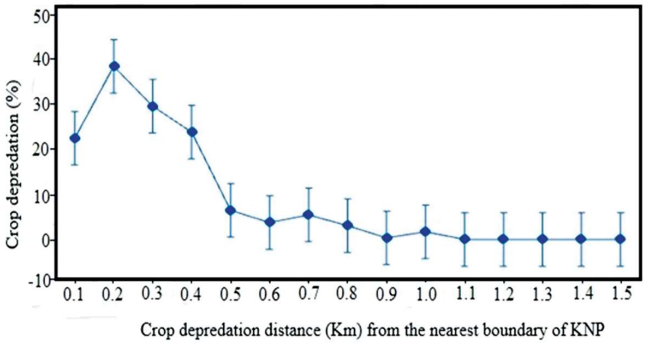

Fig. 4. The percentage of crop depredation by the ABB from the nearest distant boundary of KNP.

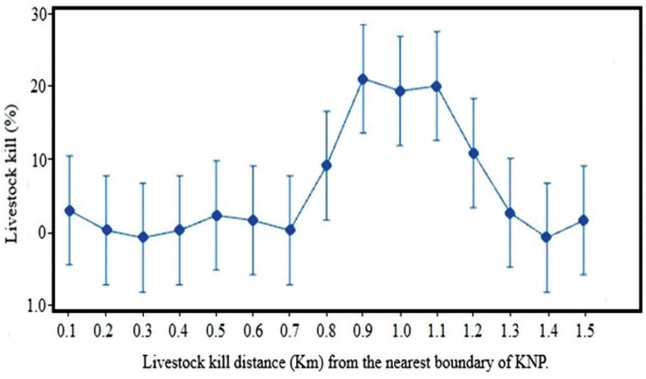

Fig. 5. The percentage of livestock killed by ABB from the nearest distant of the boundary of KNP.

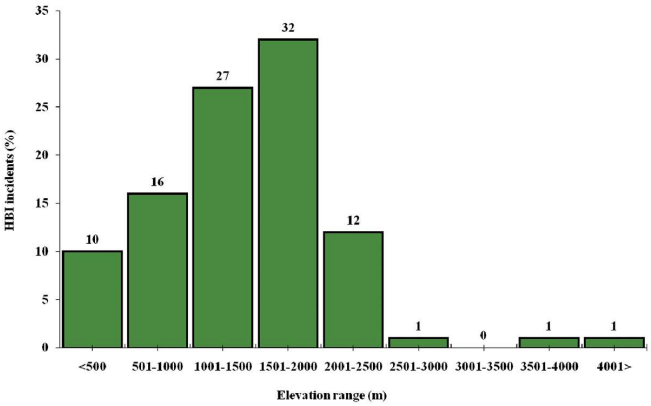

Fig. 6. Distribution pattern of HBI incidents at different elevation zones in and around KNP (n=193) during study periods.

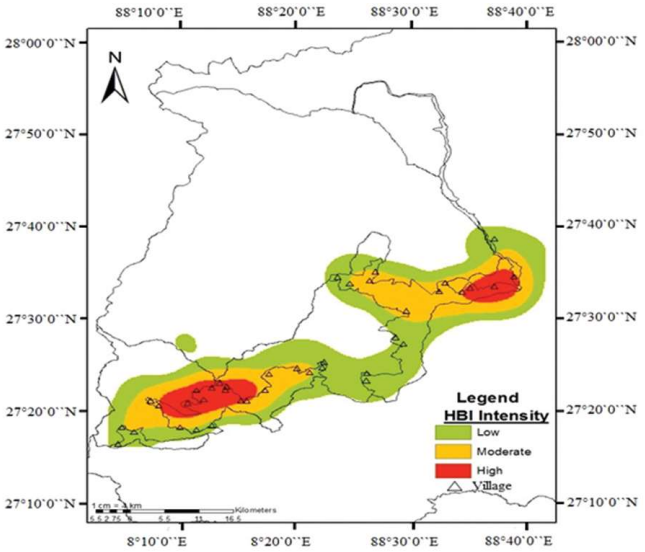

Fig. 7. A map showing the intensity of HBI occurred in and around of KNP along with the location of villages.

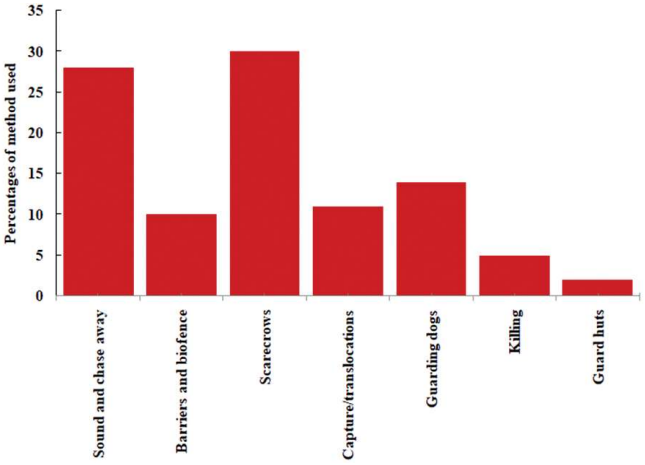

Fig. 8. Different methods practiced by the local villagers to avoid and minimize HBI.

herding their livestock. Maximum (75%) human casualties were reported from August to November followed by May (17%) and April (8%) (Fig. 3). Apart from human casualties, 16 incidents of property damage viz. damage of the local liquor shop, cattle shed and farms occurred in human habitation areas. Maximum human casualties and property damages were recorded in the Yuksom forest range (44.83%) followed by Dzongu (41.38%) and Chungthang forest range (13.79%).

Altitudinal distribution and intensity zone mapping of HBI

We also collected data on incidents of HBI at different elevation pattern based on the respondents interview. We found a significant difference in the altitudes of HBI ($H=6.92$, $df=7$, $p=0.438$) which happened between <500m and 4000m asl. The maximum (32%) of incidents of HBI were recorded in the elevation ranges of 1501-2000m asl. followed by 1001-1500m asl. (27%), 501-1000m asl. (16%), 2001-2500m asl. (12%), <500 m asl (10%) and remaining 3% were recorded above 2500 m asl (Figure 6). Maximum (46%) incidents of HBI were occurred in the night, followed by early morning (28%), late evening (23%), and remaining (3%) during the daytime. After the assessments, we used ArcGIS 13 and Google Earth Pro to understand the intensity of HBI in and around KNP. The intensity was recorded in the three different zones: high, moderate, and low-intensity zones. It was analyzed that out of the 26 villages established in and around KNP buffer areas, 9 villages occur within the high HBI intensity zone, 5 villages in the moderate-intensity zone, and remaining (12) villages come within the low-intensity zone (Fig. 7).

Preventive measures used by fringe villagers for avoiding and minimizing HBI

During the questionnaire survey, respondents reported the use of a few traditional preventive methods which are the most common to avoid and minimize HBI. Over 80% of respondents mentioned to uncontrolled the bear during the crop-raiding and livestock attack. However, they practiced some traditional methods viz. scarecrows (30%), chasing and scaring by drumming, bamboo hitting sound (28%), guarding dogs (14%), capture and translocation (11%), physical barriers (wooden logs, stone, bio fence) (10%), retaliatory killing/ shooting (5%) and guarding by making huts in the farmlands (2%) to avoid or minimize HBI (Fig. 8). Plantation of bamboo species like *Arundinaria hookeriana* and *Thysanolaena maxima* were used as a bio-fencing around the farmland. Respondents reported that the translocation of ABB was done when it was stuck in the farmhouse or injured during the chase away by villagers and was unable to move from the conflicted areas. The translocation of Asiatic black bears was done by capturing them by forest department personals in collaboration with the villagers and subsequently release back into the forest area of the KNP far away from human settlement.

Peoples attitude towards conservation

Attitude and perception of local people towards conservation of ABB reported that about 55% (n=106) of respondents have shown a positive attitude towards the bear conservation and 16% (n=31) have shown a negative attitude due to high economic loss and the remaining respondents 29% (n=56) showed neutral status. However, in case of a bear attack on the human being, their attitude changed and 85% of respondents demanded the retaliatory killing of bear in those situations.

Discussion

The increasing rate of human-black bear interacts directly or indirectly affecting the population of Asiatic black bear in their distribution region. HBI is also increasing widely in the KNP and its surrounding areas likewise in the Kashmir (Choudhury, 2008) and Dachigam landscape (Charoo *et al.*, 2011; Sathyakumar *et al.*, 2013) due to habitat destruction and fragmentation, unplanned industrial activity and NTFP collection from the bear'habitats. The human settlement and development projects near the protected areas are other anthropogenic factors which enhance the human-bear conflicts (Sathyakumar and Choudhury, 2007; Ali *et al.*, 2018; Baruch-Mordo *et al.*, 2008). Incidences of HBI were found in the fringe villages of

all the three forest ranges of KNP during the study periods, about 83% of incidences found in the two ranges alone viz. Yuksum and Dzongu Ranges. The higher incidences of HBI in these ranges could be due to several reasons, including increased competition for the scarce natural food resources between people and ABB, expansion of agricultural activities and cropping pattern, less availability of rangeland, high rainfall, and snowfall that attracts both human and wildlife populations. Similar factors like habitat destruction/unavailability of food and lack of shelter in the forest (90%) are also reported by Singh (2007) in Jammu & Kashmir. Ogutu *et al.* (2014) have reported that the number of human-wildlife conflict frequencies are generally linked to the spatial distribution of wild animals, which are determined by the availability of climatic and biological factors and human settlement and risks. Our finding reveals that the major four types of HBI, namely crop-raiding, livestock killing, human casualties, and property damage in the fringe villages of the KNP during the study periods. Among these, crop-raiding was the highest reported incidents of HBI followed by livestock killing in the fringe villages, which are closer to the boundary of the KNP. Generally in Sikkim, human-wildlife interactions are happening since humans started altering the natural habitats of wildlife for agricultural field extension, NTFPs collection, and other infrastructure development projects. As the human growth is expanding in India, there is a high probability that crop-raiding will also remain as a major form of conflicts due to loss and degradation of the prime habitats of species by the human to fulfill their growing demands (Sillero-Zubiri and Switzer, 2001).

Our results show that maize was the most damaged crops by ABB in the fringe area of the KNP between August and October. This could be due to the large scale cultivation of maize crop by villagers in the study area, which provides easy food availability to bears in the pinch period or seasonal availability of hard mast fruits and nuts in the forest area. When the hard mast and nuts were less produced in a particular year in the bear' habitats inside KNP, the high incidents of HBI were recorded in the fringe villages closed in the park. Thus, less hard mast fruits availability in the KNP directly led to more HBI in the fringe villages of KNP. The present findings are supported by Bashir *et al.* (2018) who have reported that the incidents of human-bear conflict usually increase during the autumn in the Khangchendzonga, because in this period bears become very active and travel a long distance in search of food to store more body fat before going to hibernate. Hwang *et al.* (2010) have reported that the shortage of wild fruits (particularly hard mast) in this season in the natural habitats influence the movement of the bear towards human habitation looking for food and consequently increase the chance of conflict. Similarly, Kozakai *et al.* (2011) stated that in Japan black bears travel larger distances in search of alternate quality food during the autumn season from the poor mast habitat area which leads to conflicts between human and bears. Similarly, Sunar *et al.* (2012) also reported that bears are more active from August to November and they travel a great distance in search of quality and quantity foods. In our observations and local people's responses, ABB are sighted throughout the year, even in December and January. It means ABB from Eastern Himalaya hardly hibernate for longer period as compared to Western Himalaya, especially Jammu & Kashmir and Himachal Pradesh, where ABB goes for hibernation during the winter season (Sathyakumar *et al.*, 2013).

We recorded that livestock killing was the second largest form of HBI in around KNP and surrounding villages, which causes a high economic loss for the fringe villagers. Goats and sheeps are the most suffered livestock, accounting for more than (37.91%) of the whole HBI. All the livestock attacks and kill were recorded in the open areas like pastoral areas and open farms and sheds where livestock kept during the night hours. Livestock killing recorded the highest between September to November which could be related to agriculture practice, management of livestock rearing in the fringe village, and may be due to the abundance of natural food items in their habitats. We observed that bears had eaten only certain body parts of the livestock like the stomach and upper neck parts in most of the cases of livestock kills. All kills were recorded nearby area where livestock was kept and the distance

between leftover spot (kill spot) and animal kept was not more than 100 m. Local people reported that the bears, which escaped from the traps or frightened from human activities, caused more damage to the livestock as well as to humans residing in the fringe villages. The local people of fringe villages directly depend on animal products which are the major source of income. To compensate for the lossing of livestock and crop depredation by wild animals, Sikkim Govt. has already implemented a compensation scheme. However, the compensation has either not been given timely or delayed in the affected villages as believed by the local people.

The human casualties have also reported during the NTFPs collection (viz. fruits of *Machilus edulis, Castonopsis hystrix, Machilusod oratissima,* Mushroom, *Diplazium stoliczkae,* fodder trees (*Brassiopsis mitis*, *Ficus hokari, Ficus nemoralis, Celtis tetrandra*) and bamboo (*Arundinaria* spp., *Dendrocalmus* spp. and *Phyllostachys aurea*) from the buffer zone of the KNP and its surroundings which lead to competition between ABB and humans. Because some food plant species of bears such as fruits of *Machilus edulis, Castonopsis hystrix, Machilus odoratissima,* Mushroom, *Diplazium stoliczkae* (Basnett *et al*., 2020, communicated revised ms). were overlap with NTFPs. Damages of local people's properties were also observed during the study period like liquor shop, sheds of goats and sheep, and temporary farm of poultry. Apart from ABB, some other wild animals like wild boars, porcupine, deers, macaques and yellow-throated marten had also damaged the crops. It was recorded and observed that in the recent few years the agricultural cropping pattern in the fringe villages of KNP and its surrounding area had replaced from maize to large cardamom (*Amomum* spp.) in a large scale plantation which might have forced to ABB towards human settlements to a greater extent in search of foods in the pinch period. Traditional methods such as scarecrows, chasing and scaring by sound, physical barriers (wooden logs, stone, biofencing), guarding dogs and guarding by making huts in the farmlands were used to keep away the bears from the human-occupied area or their properties. Similar kinds of traditional methods were also applied for controlling blue bull (*Boselaphus tragocamelus*) in Rajasthan, India (Meena et al., 2014). It was recorded that the most of HBI was occurred after sunset and early morning or before sunrise. Generally, the Asiatic black bear is diurnal inhabit, however, they performed their activities during the night hours. This could be due to degraded habitat quality in their natural home or lack of food availability in a particular season and bear foraged on easily available food resources outside their habitats. Hwang and Garshelis (2007) have reported that the activity pattern of bear also varies due to seasonal change in the habitats.

Conclusion and Recommendations

The present study shows that KNP and its surrounding forest areas hold a healthy population and wide distribution of ABB. Crop-raiding could be an overwhelming situation for those subsistence farmers who lose most of their crops or a substantial part of it. Therefore, protecting and reducing crop damage by wildlife and ABB, in particular, can strengthen the livelihoods of people. More than 60% of fringe villages of KNP falls under the high and moderate-intensity zone of HBI. These may be headed towards serious consequences, for both humans and for the ABB in these areas shortly. Therefore, urgent action to be taken to understand the actual causes and consequences of the interactions between humans and ABB, and suggest to formulate both immediate and long-term appropriate management and conservation action plan for both bear and human being and its related resources in consultation with local people, particularly affected ones to mitigate the HBI in the study area. The following recommendations are suggested based on the present study:

- Plantation of fodder and hard mast trees, especially preferred by ABB as food, by the local or government nearby the human settlements should be either avoided or replaced by other plantations crops that are not favoured by black bears such as rhododendron or other species. Because during the less hard mast fruit availability inside the KNP, it easily attracts the bear towards the hard mast trees planted nearby human settlements.

- Anthropogenic factors leading to degradation and fragmentation of bear habitats should be identified and accordingly the appropriate habitat conservation and management strategies should be developed.
- Crop rotation and agricultural practices may play an important role in decreasing HBI in the fringe villages. Therefore, farmers should be encouraged for the plantation or cultivation of fewer bear preferred crops to avoid the movement of species towards fringe village areas.
- Forest Department along with local and regional NGOs should initiate the training and capacity building program to create a passionate conflict management team among local people to respond to conflict situations, including bear rescue, translocation, and regular site-specific data collection on HBI, which could be further used for formulating a management action plan.
- Traditional methods used by local people need an intensive study to check its effectiveness. However, along with traditional methods some modern techniques, such as non-preferred crop cultivation, live/biofencing, chilli rope, use of automatic alarm systems or trip alarm, solar electric fencing (Wahed *et al.* 2016), noxious smoke, such as burning animal dungs with chilli seeds or powder (Chong *et al.,* 2005; Hedges and Gunaryadi, 2009) should be tested in the study area, which has successfully delivered the positive results to control human-wildlife conflicts.
- Compensation amount should be provided timely to affected people to avoid the development of negative approach towards ABB and its conservation.
- Awareness and capacity building programs should be initiated in every affected village by emphasizing ABB's ecology, causes of interactions, and its role in the preservation and conservation of local biodiversity of the area and its importance for local people's livelihood.
- Finally, long-term research and regular monitoring of ABB and conservation issues must continue to understand the trend of HBI in the area which could be useful for long-term planning of management.

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