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Original Article

Human-black bear conflict: crop raiding by Asiatic black bear (*Ursus thibetanus*) in Azad Jammu and Kashmir, Pakistan

Conflito entre humanos e ursos-negros: invasão de plantações pelo urso-negro-asiático (*Ursus thibetanus*) em Azad Jammu e Caxemira, Paquistão

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Abstract

Asiatic black bear has long been in conflict with human beings crop raiding is a major cause of this conflict frequently noted in South Asia. Crops raided by black bears affected by temporal, spatial and anthropogenic attributes. Insight in this conflict and its mitigation is vital for the conservation of this threatened species. Present study aimed to evaluate crop raiding by black bears in the mountainous region of Azad Jammu and Kashmir. Field surveys were carried out to observe spatial and temporal crop raiding features between 2015-2020 and data gathered using designed questionnaires randomly tailored in villages nearby the forests. Results revealed that maize was the sole crop raided by black bears. A total of 28-acre area was raided by black bear in the fall season (Aug-November) resulting in a damage of 51 metric tons, whole raiding was carried out at night. Each respondent received crop damage on 0.09 acre with a loss of 0.17 metric ton yield. Crop quantity and area were significantly correlated to each other. District Neelum shared 49% of the total crop loss, while 47% of the maize was raided at the altitudinal range of 2100-2500 m. crop raiding was highly significantly ($\chi 2 = 1174.64; df = 308; p < 0.01$) dependent upon distance to the forest. Linear regression revealed that maize quantity was determined by area, time and the total field area. Farmers faced 3.8 million PKRs loss due to crop damage by black bears. Despite the huge loss, the majority (23%) of the respondents did not respond to the query on mitigation measures indicating a poor adaptation of preventive measures. Preferred strategy to avoid crop damage was making noise (27.8%) when bears attacked their crops. A start of compensation scheme to the farmers is recommended that will have turned their negative attitude into a positive one toward the wildlife and black bear particularly. Study provides a new insight in human-bear conflict, particularly in spatial and temporal context of crop raiding in AJ&K.

Keywords: *Ursus thibetanus*, crop raiding, conflict, ecology, Pakistan.

Resumo

O urso-negro-asiático está há muito tempo em conflito com os seres humanos. A invasão de plantações é uma das principais causas desse conflito frequentemente observado no sul da Ásia: cultivos invadidos por ursos-negros afetados por atributos temporais, espaciais e antropogênicos. A compreensão desse conflito, assim como sua mitigação, é vital para a conservação dessa espécie ameaçada. O presente estudo teve como objetivo avaliar a invasão de culturas por ursos-negros na região montanhosa de Azad Jammu e Caxemira. Pesquisas de campo foram realizadas para observar características espaciais e temporais de invasão de culturas, entre 2015 e 2020, e dados coletados usando questionários desenhados e adaptados aleatoriamente em aldeias próximas às florestas. Os resultados revelaram que o milho foi a única cultura atacada por ursos-negros. Uma área total de 28 acres foi invadida pelo urso-preto na temporada de outono (agosto-novembro), resultando em um dano de 51 toneladas – todo o ataque foi realizado à noite. Cada respondente recebeu danos na colheita em 0,09 acre, com uma perda de 0,17 tonelada de rendimento. A quantidade e a área da colheita foram significativamente correlacionadas entre si. O distrito de Neelum compartilhou 49% da perda total da colheita, enquanto 47% do milho foram invadidos na faixa altitudinal de 2100-2500 m. A invasão de culturas foi altamente significativa ($\chi 2 = 1174,64; df = 308; p < 0,01$), dependente da distância até a floresta. A regressão linear revelou que a quantidade de milho foi determinada por área, tempo e área total do campo. Os agricultores enfrentaram uma perda de 3,8 milhões de PKRs devido a

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danos nas colheitas causados por ursos-negros. Apesar do grande prejuízo, a maioria (23%) dos respondentes não respondeu ao questionamento sobre as medidas de mitigação, indicando má adaptação das medidas preventivas. A estratégia preferida para evitar danos às plantações foi fazer barulho (27,8%) quando os ursos atacaram suas plantações. Recomenda-se o início de um esquema de compensação para os agricultores, que transformará sua atitude negativa em positiva em relação à vida selvagem e ao urso-negro em particular. O estudo fornece uma nova visão do conflito entre humanos e ursos, particularmente no contexto espacial e temporal de invasões de colheitas em AJ&K.

Palavras-chave: *Ursus thibetanus*, saque de plantações, conflito, ecologia, Paquistão.

1. Introduction

Understanding and addressing the crop-raiding-based conflict between humans and wildlife is an important conservation issue, particularly for large mammals. Asiatic black bears are well-known crop raiders in most of their distribution range (Ali et al., 2018; Kazmi et al., 2019; Zahoor et al., 2020). They are topping the list of wildlife species that damage crops in and around parks and reserves in south Asia (Honda and Kozakai, 2020). The exclusion of such a pest species from orchards and agricultural fields is historically evident in the form of ancient walls and barriers. This trend continued to present time and deterrents, barriers and crop guarding improved in various ways.

Crop mast provides sufficient energy in the autumn season, this drive brings bears closer to human settlements and increases conflict with humans (Huygens et al., 2003; Jamtsho and Wangchuk, 2016; Awan et al., 2016). Maize is one of the major sources of food for Asiatic black bears that rely heavily on crop mast particularly in the pre-hibernation period. Black bear dependence on maize increased to a great extent with fluctuating abundance in their natural diet (Malcolm et al., 2014). Crop fields around the forests are an accessible source of food for black bears (Ueda et al., 2018).

Significant crop-raiding by Asiatic black bear noted in Japan (Hashimoto et al., 2003), India (Yadav et al., 2019), Nepal (Panthi et al., 2019), and China (Trent, 2010). Their frequent crop damage adversely impacts farmer livelihood, challenges food security, decreases the tolerance of raiders, and weakens management strategies (Basnett et al., 2021).

Scientific advances gained rich knowledge in crop raiding behavior, raided crop types, (Parathian et al., 2018), however, much of the spatial aspects are yet to be explored. Data on time and spatial patterns of crop damage, particularly close to forests or protected areas, and crop protection strategies provide potentially useful information about species boldness, foraging behavior and highlight the effectiveness of raiding preventive techniques (Bhatia et al., 2016; Honda and Iijima, 2016). Most likely crop-raiding reflects diet proportion of raided crop and its significance to black bear (Malcolm et al., 2014), extent of risk in crop-raiding activity (Honda and Iijima, 2016) and natural food availability and landscape feature (Takahata et al., 2013). Among others, inconsistent availability of forage in autumn is the leading cause of crop-raiding by black bears (Ditmer et al., 2015; Ali et al., 2017). Factors such as habitat destruction, simplification, killing of black bear prey reduced the availability of food in a forest (Ali et al., 2017). Deprived of natural food in forests black bears invaded human settlements and raided cultivated fruits and crops along with the killing of livestock. This condition creates a human-bear conflict in the distributional range of black bears.

Study on crop-raiding lies at the interface between humans and animals in conflict. It would cover temporal and landscape parameters, farmers' perspectives, and mitigation strategies. Despite the extensive literature on ecological investigations of Asiatic black bears, few studies have been noted to explore crop-raiding in Asia, most of these studies explained crop-raiding in terms of economic losses. Scientific exploration on crop reading is an increasing trend in Pakistan. Two studies reported crop damage by black bears in this region (Kazmi et al., 2019; Zahoor et al., 2020), however, extended efforts are required to document crop loss throughout the range of Asiatic black bear. This conflict mitigation needs comprehensive data on species involved in crop-raiding, spatial and temporal parameters of raiding incidents, patterns of raiding, economic losses, and attitudes of farmers. Present study was designed to assess temporal and spatial features of crop raiding and economic losses to the farmers in northern districts of Azad Jammu & Kashmir, providing baseline data for long-term conservation of Asiatic black bear in AJ&K.

2. Materials and Methods

2.1. Study area

Study area located at 33° 48' to 35° 08' N and 73° 16' to 75° 001' E, confined to 5 northern districts of AJ&K at an elevation range of 550 m to 6326 m covering an area of 7485 sq km. (Figure 1). Study area bounded by Gilgit in the north, Indian Occupied Kashmir in the east, Punjab province in the south and Khyber Pakhtunkhawa in the west. This area falls under western Himalaya having rich in biodiversity as compared to southern parts of the State. Topographically this area consists of gentle and steep mountains, rising higher to the north (Neelum valley). Steep slopes often widen out into upper slopes forming alpine pasture uplands. A great deal in elevation gradient (564 to 6326 m) provides a wide range of habitats regardless of the small size of AJ&K (Ali et al., 2007; Qamar et al., 2012; Ali et al., 2016). Study area consisted of the northern district of AJ&K having one fourth of the total state population. Study area was divided into 17 study localities for the convenience in data collection (Figure 1). The mean annual rainfall ranges from 1000 mm to 2000 mm, 30-60% of this precipitation is in the form of snow in northern districts. The snowline in winter is 1200 m, while in summer it rises to 3300 m

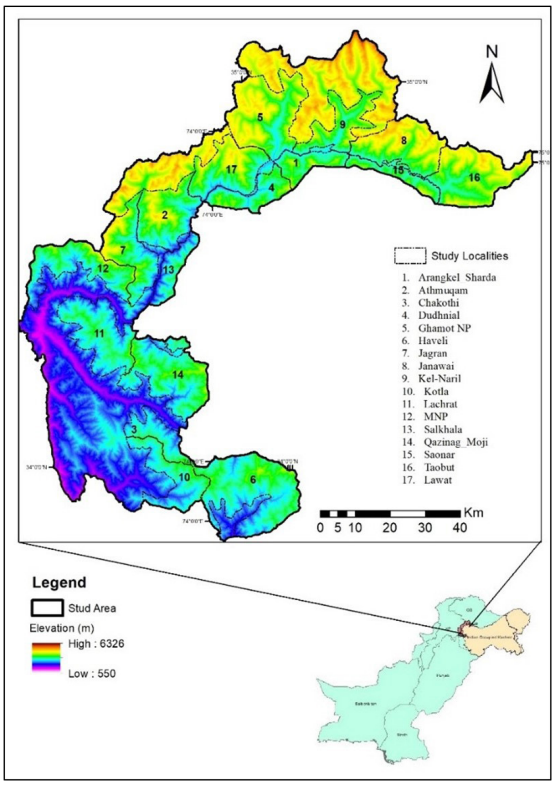

Figure 1. Map of the northern districts of AJ&K (Study Area) showing elevation and the study localities.

(Akbar, 2017. The minimum and maximum temperature are -2 °C and 45 °C respectively (Ashraf et al., 2012), with significant variations between different regions (Akbar, 2017). Average maximum temperature ranges from 20°C to 32°C while the average minimum temperature range is -4 to 07 °C. Altitudinal variation established a variety of ecological niches which are best suited for a range of wildlife species. Species diversity is more common in northern parts as compared to the southern region of AJ&K. The presence of many of the high altitude lakes, streams and rivers support several Coldwater fisheries and host migratory birds during their migration (Ali et al., 2019). Prominent animal species of the study area included *Eupetaurus cinereus*, *Catreus wallichii*, *Anthropoides virgo*, *Canis lupus*, *Panthera pardus*, *Ursus thibetanus*, *Tragopan melanocephalus* and *Ursus arctos* (Qamar et al., 2011; Qamar et al., 2012; Khan et al., 2012).

2.2. Methodology

2.2.1. Questionnaire survey

Data gathering through questionnaires and formal discussion with farmers, knowledgeable local persons are a rapid and reliable method used worldwide in conflict based studies (Sathyakumar, 2001; Hwang et al., 2002; Røskaft et al., 2007; Stubblefield and Shrestha, 2007; Vittersø et al., 2016; Dai et al., 2020). Random distribution of human settlements across the study area was a central hurdle to using systematic sampling on the proportion size of entire households in each village, thus random sampling of respondents was used following Rehman et al. (2020). Seasonal and opportunistic surveys were carried out in the study area from 2015 to 2020 in randomly selected villages adjacent to the forests, natural habitats of black bear and having a confirmed damage reports or sightings of black bear in that area (Karanth et al., 2012; Perveen and Muhammad, 2013; Wahid et al., 2017). Key personals including hunters, staff of the Wildlife department and elder farmers were targeted in each survey to avoid bogus and exaggerated information (Naha et al., 2020; Perveen and Muhammad, 2013; Wahid et al., 2017). Questionnaires were administered face to face to randomly selected households in communities associated with the protected (National Parks and Game Reserves) as well as non-protected areas (Ali et al., 2018; Karanth et al., 2012; Mir et al., 2015). Each household was considered as a sampling unit where interview was restricted to one person (preferably older or head of the family) per household (Mir et al., 2015).

Questionnaire were based on both open and close-ended questions (Karanth et al., 2012) to facilitate respondents' discussion surrounding the reasoning behind their answers (Dai et al., 2020; Liu et al., 2011) and asked in two frequently spoken local dialects *viz. Hindko* and Urdu to retrieve information easily (Ali et al., 2018; Waseem et al., 2020). The questionnaire was covering information on the demographic of respondents, nature and extent of conflict (temporal and topographic information of crop raiding), bear population and distribution, mitigation measures (Liu et al., 2011). Written responses were preferred to avoid misunderstandings due to illiteracy. Seasonal and opportunistic surveys were carried out in randomly selected villages of the study area. Only those villages were focused which were located near the forests, natural habitats of black bears with confirmed damage reports or sightings of black bears.

Crop damage surveys were carried out from September to earlier November. This season is known as ripening and harvesting for crops in the study area. Crop raiding attributes were investigated by using 309 questionnaires excluding those who did not respond (5%; n=24) or reported no damage (34%; n=166) to their crops. Damaged area of the fields was measured with a measuring tape and converted into Marla that is a famous land measuring unit used to quantify land at a small scale in the study area. This measurement was further converted into an Acre (1 Acre = 50 Marla) to obtain an easy and understandable context of crops and their damage. Total agricultural area (under cultivation) was asked to the respondent (owner). Distance to the forest and aspect was also recorded using a range finder and GPS. Using questionnaires, data were collected on crops and crop-raiding aspects such as total cultivable land owned, types of crops grown, crop damage (both in terms of area and quantity), time and stage of crop raided, aspect and distance to the nearest forest, estimated economic losses and mitigation measures adapted to reduce crop depredation by black bear.

3. Results

3.1. Agricultural fields and irrigation

The study area consisted of mountainous regions following steep or gentle slopes and comparatively low plain areas. Crops were growing on small terraces on hilly areas, forest ballets, and small beds leveled by embankments. Fields covering a total of 153 acres were investigated, most (77%) of them were rain-fed while the least (23%) fields were irrigated fields watered through locally built water channels or irrigation pipes provided by the Local Government (Table 1).

3.2. Raided area

A total of 27.5-acre areas of cultivated crops were raided by black bears in the study area, Taobut locality faced the highest (21.9 acres) destruction of fields, while Chakothi received the lowest (0.08 acre) damage of crop field. This result in the total damage of 51.08 tonnes of maize crop, maximum (10.8 tonnes) crop was destroyed at Taobut region followed by MNP (8.94 tonnes) and Qazinag region (8.80) while least (0.3 tonne) maize was damaged at Chakothi locality (Table 1). District Neelum received almost half of the crop damage while Bagh received least (3%) of the total crop damage (Figure 2). Attitudinally, a total of 87% of crops were raided between the range of 2000 to 3000 m, most of the crop-raiding events were recorded at 2001-2500 m (Figure 3). Crop fields were distributed more (35%) on the southern aspect, however, an association between crop raiding and aspects was non-significant ($\chi 2 = 344.45; df = 308; p < 0.05$).

3.3. Raided quantity

On average each respondent received 0.09-acre field damages resulting in a loss of 0.17 tonne maize to each respondent. Taobut locality received highest (0.38 acre/respondent) area damage as compared to Saonar-Borinar (0.12 acre/respondent) and MNP (0.10 acre/respondent) (Table 2). Likewise, the highest (0.64 m tonne/respondent) maize was damaged in the Taobut region followed by Saonar (0.20 m tonne/respondent) and MNP (0.14 m tonne/respondent). Regression showed a significant relationship between the amount of crop raiding and aspect and estimated black bear population (Table 2).

Crop damage by black bears was significantly ($\chi 2 = 1174.64; df = 308; p < 0.01$) associated with the distance to the forests, fields which were adjacent to the forest received the higher loss. Crop fields were located at an average distance of 276 m from the forest, maximum raiding events were recorded within the distance of 1.2 km, while the minimum distance from the forest was 50 m (Figure 4). Fields were evenly distributed to all aspects in the study area, however, their number and size were getting smaller near the forest. Crop field sizes and their distance to the forest are highly negatively correlated (r=-0.113, p<0.01). Linear regression analysis showed that

Table 1. Crop area investigated, crop damage and the estimated economic losses to the farmers in study localities of the study area during 2015-2020.

Locality	Fields Examined (Acre)			Raided Area (Acre)	Quantity Damaged (Tonne)	Estimated Loss (PKRs)	Average Field Distance from the forest (m)
	Irrigated	Rain-fed	Total				
Arangkel-Sharda	1.4	6.5	7.9	1.28	2.36	159300	329
Athmuqam	0.4	1.2	1.6	0.18	0.44	29700	371
Chakothi	1.0	0.0	1.0	0.08	0.30	20250	250
Dudhnial	1.0	3.7	4.7	0.69	1.16	78300	354
Ghamot NP	0.7	8.2	8.8	1.05	2.34	157950	384
Haveli	0.9	4.2	5.2	0.48	1.18	79650	365
Jagran	0.6	1.0	1.6	0.18	0.56	37800	325
Janawai-Marnat	6.1	7.5	13.7	2.32	4.47	301725	186
Kel-Naril	0.0	1.1	1.1	0.16	0.36	24300	300
Kotla-Bagh	0.0	5.6	5.6	0.54	1.36	91800	238
Lachrat	0.0	2.6	2.6	0.45	0.98	66150	311
MNP	2.8	34.9	37.6	6.08	8.94	603450	225
Palri-Salkhala	0.1	1.1	1.2	0.11	0.36	24300	320
Qazinag GR	4.3	19.5	23.8	4.00	8.80	594000	294
Saonar-Borinar	3.6	7.5	11.2	2.88	5.07	342360	224
Tao Butt	11.1	10.8	21.9	6.39	10.80	729000	259
Tehjian-Lawat	0.4	3.2	3.6	0.69	1.60	108000	233
	34	**119**	**153**	**27.5**	**51.08**	**3448035**	

able 2. Average crop raided area, damaged quantity and economic losses incurred to each respondent in the different localities of the study area during study period.

Locality	Total Area (acre)	Raided Area (Acre)	Quantity (tonne)	Price (PKRS)	US Dollar
Arangkel-Sharda	0.56	0.09	0.17	11379	74.37
Athmuqam	0.23	0.03	0.06	4243	27.73
Chakothi	0.25	0.02	0.08	5063	33.09
Dudhnial	0.36	0.05	0.09	6023	39.37
Ghamot NP	0.40	0.05	0.11	7180	46.93
Haveli	0.30	0.03	0.07	4685	30.62
Jagran	0.81	0.09	0.28	18900	123.53
Janawai-Marnat	0.55	0.09	0.18	12069	78.88
Kel-Naril	0.53	0.08	0.18	12150	79.41
Kotla-Bagh	0.47	0.05	0.11	7650	50.00
Lachrat Forest range	0.29	0.05	0.11	7350	48.04
MNP	0.61	0.10	0.14	9733	63.61
Palri-Salkhala	0.24	0.02	0.07	4860	31.76
Qazinag GR	0.39	0.07	0.14	9738	63.65
Saonar-Borinar	0.45	0.12	0.20	13694	89.51
Tao Butt	1.29	0.38	0.64	42882	280.28
Tehjian-Lawat	0.30	0.06	0.13	9000	58.82
Average	0.50	0.09	0.17	11159	72.93

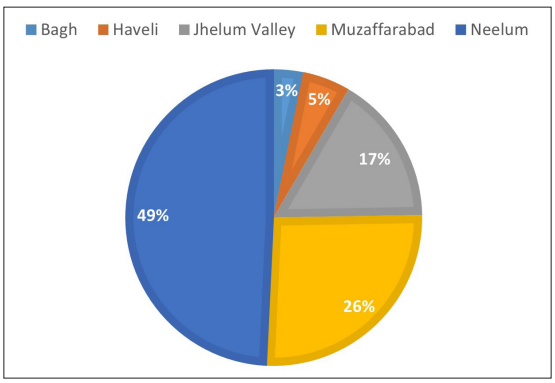

Figure 2. Comparison of crops damage recorded in the northern districts of AJ&K during study period.

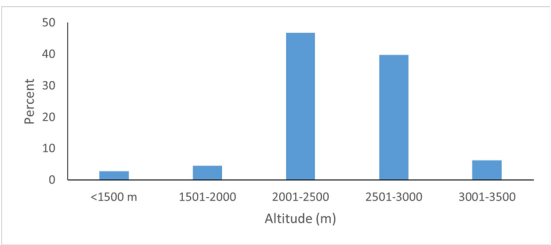

Figure 3. Crop damage recorded at different altitudinal classes during study period in the study area.

crop raiding by the black bear was significantly dependent and predicted by raiding time, field area and the cultivatable area of farmers (Table 3). A large number (39.3%) of respondents did not respond to the question regarding what they used to reduce crop raiding by black bears. The majority of the respondents (65%) did not figure out why black raided their crops in the study area and left the question unanswered or opted that they don't know about the reason. A considerable percentage (15.9%) thought that crop raiding was an easy way for the black bear to gain fat for the upcoming hibernation period. The least (5.9%) of the respondents opinionated that crop raiding is a natural part of the bear diet (Figure 5).

3.4. Economic losses

Maize is a cash crop cultivated in the study area. Bears raided 51.08 tonnes of maize crop of worth 3.8 million PKRs (US$=25052) in the study area during the study period. This loss was calculated as PKRs 12323 (US$=80.54) for each farmer in the study area. The locality Taobut was the most affected locality facing 0.8 million PKRs economic losses and each respondent faced a loss of PKRs 42882 (US$=280.28) in this locality during the study period (Table 2). On the whole, the black bear conflict in the study area caused economic loss worth 27.27 million PKRs to the respondents during the study period.

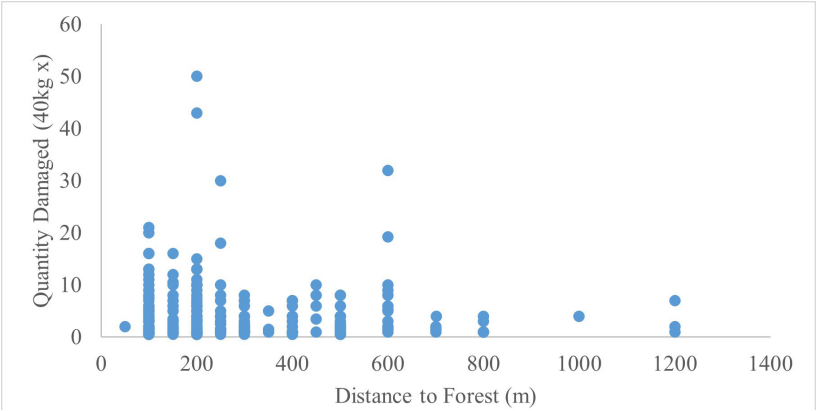

Figure 4. Comparison of the quantity of maize damaged and the distance fields from adjacent forests in the study area during study period.

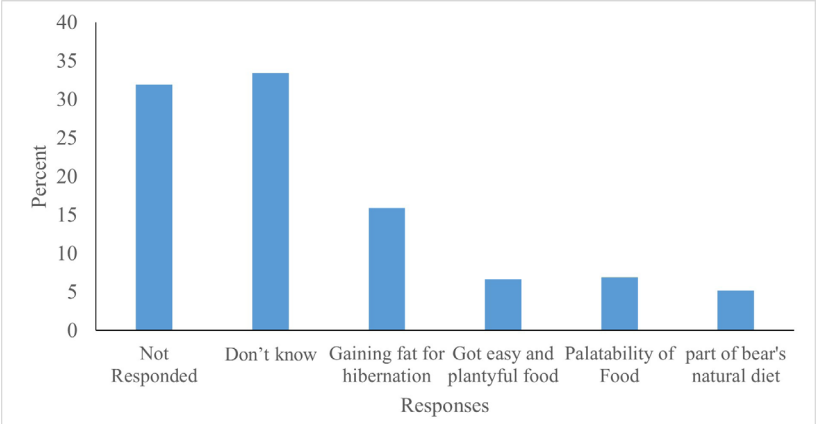

Figure 5. Comparison of the respondent's opinion on the causes of black bear attacks on crops in the study area, during study period.

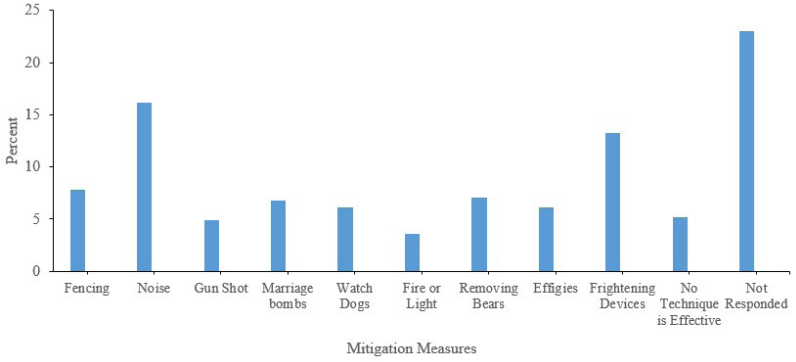

Figure 6. Preventive measures adapted by the local people in the study area to avoid black bear damage on crops during study period.

3.5. Mitigation measures

A variety of preventive measures ranging from fencing to killing of black bears were adapted by the respondents to avoid human-black bear conflict in the study area. The most preferred strategy was making noise (27.8%), either made by whistling, gunshots, or the use of marriage bombs. A considerable (23%) number of respondents did not adapt any preventive measures or did not respond to this query, while the use of fire was least (3.6%) adapted method to prevent the bear from depredation or crop raiding (Figure 6).

4. Discussion

4.1. Crop raiding

Studying crop raiding by the Asiatic black bear in northern districts of AJ&K involved insight into the

parameters of crop raiding events and dynamics of raiding. The degree of risk bears eager to take access to maize revealed the relative importance of this food source to them. The intensity of crop raiding may be affected by the availability of natural food, distance to the forest, human activities in the landscape (Bhatia et al., 2016), mitigation strategies (Ueda et al., 2018) and boldness of the raiding animal (Honda and Iijima, 2016).

Most (77%) of the fields in the study area were rain-fed. Water channels are hard to build due to the ruggedness of the area, distant water sources (streams or springs) and low level of water in springs. Springs are of two types; i) those which have a consistent water level, and ii) seasonal springs in which water level decrease or dry in summer when watering of crops is required. Maize is the chief crop grown in the study area. Though rice, wheat, and barley cultivated in the vicinity of some major towns (Muzaffarabad, Leepa, Garhi Dupatta) however, these crops were never raided by black bears. Potatoes, beans, pea, tomato, spinach and radish etc. are grown in the area were not reported to be damaged by black bears. Potatoes and radish were typically cultivated at high altitudes, in alpine regions, where bear distribution is least. Studies conducted in MNP (Kazmi et al., 2019) reported maize as the only crop raided by black bears in AJ&K.

Maize can grow in arid regions and have high nutritional value (Manen et al., 2012), ripens in the fall season when bear enters in hyperphagia period of pre denning. Previous studies, in accordance with the findings of this work, reported that maize was only crop raided by black bears in MNP (Kazmi et al., 2019) and Moji (Zahoor et al., 2020) in AJ&K, Mansehra (Ali et al., 2018) and Northern areas of Pakistan (Fakhar-i-Abbas et al., 2014). A similar trend was recorded in neighboring countries where maize was recorded the most raided crop in Sikkim, India (83%) (Basnett et al., 2021) and China (62%) (Liu et al., 2011). Water scarcity led to low crop production (ranged between 1.92-2.88 tonnes/acre) in the study area as compared (3.2-3.9 tonnes/acre) to the irrigated fields in Pakistan (Ali et al., 2017) and India (Maikhuri et al., 2001). Shaheen et al. (2015) reported an average 0.37 tonne/acre production of maize in Pir Panjal range, AJ&K. Variation in maize production could be attributed to differences in agricultural practices (i.e. use of fertilizers), availability of water, climatic conditions, and altitude. Higher altitudes have harsh weather, degraded soil and receive low precipitation.

Area available to agricultural activities in a locality was significant to the total area of that locality (χ^2 784.19, df=16, p<0.01). Neelum is the largest district in AJ&K that comparatively have low human population. Most of the area is covered with forests and villages are close to the natural habitats which enhances the opportunity of raiding crops. The population of Bagh, Haveli and Jhelum valley is distributed in the form of small villages across the mountains. Such patchy distribution restricts bear's free movement and dedicated forest habitats. The amount of crop raiding was significantly predicted by the timing of raiding, cultivated area and damaged or raided area (Table 3), these variables could determine 78% of the crop raiding activity of black bear in the study area.

4.2. Spatial features

A total of 51 tonnes of maize was damaged by black bears in the study area. Crop raiding was heavily recorded at localities Taobut and Saonar (Table 2) that might be due to the high population density of black bears in these areas. Both the localities are adjacent to each other, located at LoC and villages are surrounded by forests, an average field distance to the forest is lower (259 m and 224 m for Taobut and Saonar respectively) (Table 2). The type, availability and juxtaposition of crops and forest is a key factor associated with crop raiding (Retamosa et al., 2008; Takahata et al., 2013). Results revealed that most of the fields raided by Asiatic black bears were near to the forest, i.e. less than 200-400 m and indicated a significant invasion of agricultural activities into the natural forests or bear habitat. The majority of these fields were marginal and bears took advantage of close distance to the forest. Central fields were rarely raided despite having better crop production. Crops are also plentiful food sources at a short distance, have high crude protein content and palatability (Retamosa et al.. 2008; Takahata et al., 2013; Ali et al., 2015; Ditmer et al., 2015). Basnett et al. (2021) reported a maximum (90%) of damage at the distance of 400 m and a sharp decline in raiding intensity was noted beyond this distance to the forest. A similar trend in crop raiding was noted in America (Warburton and Maddrey, 1994; Ditmer et al., 2015), Japan (Huygens et al., 2003; Takahata et al., 2013) and India (Basnett et al., 2021). In District Diamer of GB, black bears raided 0.16 tonne crops and fruits in 2013 (Ali et al., 2015). Ali et al. (2017) reported an annual loss of loss 2.4 ha in Kaghan valley (Pakistan),

TTable 3. Linear regression model showing crop damage was dependent upon different factors in the study area.

Model	B	Std. Error	β	*t*	*p value*
(Constant)	-0.092	0.094		-0.974	0.331
Crop Raiding Time	0.215	0.031	0.169	6.858	0.000
Field area raided by Asiatic black bear	1.085	0.050	0.658	21.574	0.000
Direction of the field to the forest	0.025	0.022	0.022	1.119	0.264
Distance to the forest nearby	-0.041	0.028	-0.031	-1.483	0.139
Total cultivatable land	0.064	0.009	0.180	7.261	0.000
Estimated black bear population	0.001	0.006	0.002	0.090	0.928

most of the maize crop was attacked at a medium altitude (2001-2500 m). This raiding pattern is similar to the bear distribution and population status in the study area.

4.3. Temporal features

Black bears remain active throughout the day or night depending upon food availability, temperature, season and human interference. Livestock depredation of black bear was recorded round the clock, however, crop raiding was noted only at night. Nocturnal behavior in crop raiding might be attributed to the feeding strategy of the Asiatic black bear wherein it avoids risk of being spotted by farmers in the study area. This behavior could also be related to feeding on clumped foods in a short time, importantly, night activity could be an energetic adaptation to increase body fat when sufficient high-fat content food is available (Huygens et al., 2003; Hwang and Garshelis, 2007). Black bears raided crops at night and most (76%) of attacks were noted at the first half of the night. Several speculations could describe this behavior. A trivial watch and ward at night help bear to move near fields freely (Scotson, 2012) and feed *ad labitum*. Nocturnal activity may be a thermoregulatory-energetic adaptation (Hwang and Garshelis, 2007) to greatly increase body fat, especially in years when hard mast (rich in fat) is prevalent. When feeding on clumped foods, gut capacity may be filled in a short time, necessitating more frequent interruptions of feeding bouts, resulting in a more uniform distribution (but lower level) of feeding activity throughout the day (Trent, 2010). Several studies on bears reported time as an important factor influencing crop raiding behavior in black bears (Warburton and Maddrey, 1994; Retamosa et al., 2008; Takahata et al., 2013; Ditmer et al., 2015).

Crop maturation in the study area is noted in autumn (September to November), which is the hyperphagia period of black bears. Crop raiding started in August (at a minimal rate) and reached its peak in September at the ripening and harvesting of maize. Basnett et al. (2021) recorded 90% of the crops raiding in August to September in Sikkim that is inline to the present study. This pre-denning period requires an amassed amount of fat sufficient to go through the hibernation period. Lack of fat deposition could affect cub production and their growth (Ditmer et al., 2015; Koike and Hazumi, 2008). Facing the shortage of natural foods in their habitat bears adapted to crop raiding as an alternative tactic that enabled them to accumulate fat rapidly. Ditmer et al. (2015) supported this perspective and believed that bears seek crops as calories-rich alternatives in America.

It is noteworthy that human-black bear conflict continuously increased in the study area (Figure 3). The possible reasons were increase in bear population, expansion of herding and agricultural activities in natural habitats and shortage of natural food. Firstly, the black bear population is thought to be increased in recent decades. Sighting of black bears varied significantly $\left(\chi 2 = 63.706; df = 1; p < 0.01\right)$ and the majority (68.6%) of interviewees claimed that they saw black bears in their areas. High sightings indicate the viability and abundance of black bears in the study area. After installation of a barbed fence at LoC from Indian held Kashmir terminated the usual movement of bear across LoC. Indian held Kashmir harbors denser forests and natural habitat of black bear as compared to AJ&K. Respondents believed that population trend was decreased immediately after fencing at LoC (during 2000-2004), however, in the presence of a viable population stock and relatively low competition for a resource, the population rose to the level that significantly felt to the rural communities of the study area. Secondly, human invasion in the bear's natural habitat is also evident. Villages are expanding, crops are cultivated closer to forest boundaries that provide bears an opportunity to forage on them. Lastly, the continued foraging of Asiatic black bears on crops, despite facing the high levels of risk, indicates pre-denning hyperphagia. Mature maize grains are an easy source to gain fat for hibernation period. Crop raiding at night indicated a mixed behavior. Bears belonging to high population density localities (Taobut and Saonar) decided to feed on maize despite they detected farmer's presence and irrespective of the risk they incurred. In localities with low black bear density (Kel, Athmuqam and Qazinag) the human guarding of maize fields proved to be a repellant for black bears.

4.4. Mitigation strategies

The effectiveness of preventive measures depends on the seasonality and novelty of the intervention. There were several measures adopted by local people to prevent bear attacks including installing solar lights, barb wire, wall construction, noise and preventive gunshots. Night vigilance is one of the effective measures (Fakhar-i-Abbas et al., 2014), but other measures may not help to reduce the human-bear conflict (Dai et al., 2019). Deterrents are globally used to protect crops from wild raider animals. Farmers at a global scale use a wide range of techniques based on their availability, efficiency and cost-effective features. Deterrence, based on their operation, are classified as active, passive, vigilant, lethal, non-lethal, sensory, repellent etc. and have a species-specific use (Anthony et al., 2010; Hill, 2016; Naha et al., 2020; Scotson et al., 2014; Ueda et al., 2018). Though electric wire fencing, traps and repellents deter a wide range of attacking animals (Anthony et al., 2010), none of them are used in the study area.

Results revealed that a maximum (27%) respondents preferred to make noise when bear attacks were detected (Figure 6). Shouting, gunfire, or use of marriage bombs are common methods to create disturbance but these methods were adopted following LoC situation. Near to LoC noise could be made by shouting only while the use of marriage bombs or guns prohibited due to sensitivity and security reasons. Standing guard at night and use of light as a frightening device is more common in LoC adjacent areas. A small number of respondents (7.8%) used fencing to protect their livestock in the study area. Waseem et al. (2020) reported that fencing was adapted as a preventive measure of bear attack by 35% of the respondents in Mansehra, Pakistan. Basnett et al. (2021) reported that scarecrow (30%) and making noise (28%) were the best strategies to avoid crop raiding in Sikkim, India.

Wire fencing is expensive and low-income communities could not afford it (Honda and Iijima, 2016). Instead, local people used a barrier made up of branches or wooden sheaths but it could not deter black bears from crop raiding, and such types of barriers are effective against livestock only. Installation of light devices around the field were found useful in some places. Blinking lights and moving effigies may increase the perceptions of risk associated with crop damage to the level where bears would be frightened to enter the field. There were some limitations to using light as repellent, firstly, most of the bear range was recorded at LoC where blackout at night was a daily practice and blinking lights could mess up with security features. Secondly, the electricity supply was much more limited in the rural areas of AJ&K as compared to the urban areas. The provision of solar panels could be a solution to areas situated far away from LoC. Apart from shouting or gunfire, tin cans were also used to produce noise. Small tin cans having fewer stones in them are hung with a rope tied to the balcony or window of the house. This rope is periodically, or in the presence of a raiding animal, pulled with a jerk that produces a loud rattling sound which is felt louder in a calm environment. Raiding animals may disturb and run away, however, this method was used in the fields closer to the houses. Black bears are the most intelligent carnivore that have behavioral plasticity, probably due to their generalist adaptability, they selected raiding time carefully when risk was minimum.

Guarding is frequently and primary crop and livestock protection technique that involves vigilance and patrolling and is considered to be an effective method used in the study area. During the active (ripening) period of crop foraging, one or more farmers used to remain present in fields and scan forest edges and patrol around corrals and crop fields. At the detection of raider animals, they would become responsive, mostly in the form of shouting, whistling, threatening animals through gunfire, chasing with dogs, throwing objects and using torches (Wallace, 2010). Damage in the presence of watch and ward could be due to the reason that most of the raiding were recorded at night. Guarding is labor-intensive and requires considerable steady efforts. Guarding individuals might forego their education and social or resting time during the protection of crop fields (Honda and Iijima, 2016). Being a hard task and night activity, guarding is carried out solely by males. Female-only families could suffer greater crop losses as it is considered depraved and unsafe for women to be present outside of the home at night and actively respond to crop raiding animals.

4.5. Economic losses

Economic loss influences human-bear conflict and intensifies it to a significant level in the local communities (Doan-Crider et al., 2017) especially when crop concerned has financial significance (Ueda et al., 2018). Maize is a major crop that fulfills the nutritional requirements of the farmer. Grains are grounded on locally built watermills to make corn flour, which is one of the important food components of local people. The maize plant is also used as fodder for cattle. Black bears damaged the maize crop causing a loss of 3.8 million PKRs (US$=25052) in the study area, each respondent tolerated loss caused by black bears up to PKRs 12323 (US$=80.54). This would be a huge loss for the communities having the least level of income. Ali et al. (2015) estimated crop damage worth 0.14 million PKRs in Kaghan valley, Pakistan. Fakhar-i-Abbas et al. (2014) reported bears caused damage up to 28400 US$ (4.3 m PKRs) to the local farmers and herders in Northern Pakistan. Economic losses to the communities in present study were recorded higher as compared to KP (Ali et al., 2015), Northern Pakistan (Khan et al., 2012; Fakhar-i-Abbas et al., 2014) and Indian held Kashmir (Charoo et al., 2011). This difference could be due to high density of Asiatic black bear, ineffective preventive measures adopted by farmers and the spreading of agricultural fields in the natural habitats of Asiatic black bears. These economic losses urged farmers to adopt some mitigation measures to reduce bear attacks. Greater income losses to the local people make them more receptive to invest in preventive measures to mitigate and avoid future conflict, this phenomenon may lead to higher chances of coexistence of humans with predators (Miller et al., 2016).

5.Conclusion

Asiatic black bear is a key species that lives in temperate forests of northern AJ&K and involved in conflict with human beings. Conservation of black bear is challenging in AJ&K. Being a rural and low-economy community, people's foremost preference is their earnings. Any loss or economic damage to the local people can drive them to a pervasive negative attitude toward black bears that would likely hamper efforts on adapting conservation measures. Adaptation of mitigation measures and their effectiveness to deter black bears required a separate inclusive study. For an instant solution, provision of materials and assistance on field guarding practices, electric fences, deterrent devices and watchdogs would lessen this conflict.

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