Patterns of livestock depredation and human-wildlife conflict in Misgar valley of Hunza, Pakistan

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Abstract

Predators can cause a significant economic damage though preyed on livestock. These conflicts prompt a negative attitude towards their conservation and also leads towards retaliatory killing. Here we composed data from 100 household on livestock using a semi-structured questionnaire survey from 2014 to 2019 on livestock population, depredation patterns, predation count and conservation approaches. The poison regression model showed significant increasesd of predation count at $P<0.05$ among 22 influential factors such as age , gender, occupation, education of respondent, estimated population of predators, threats index for predators and conservation. A total of 364 out of 9270 livestock damaged by predators and non-predatory factors during the last six years. Among them 168 (1.81 %) attributed by wolf, 142 (1.53 %) by snow leopard and 54 (0.58%) by non-predatory factors. Our results showed an increase of 11 % in the overall population and an average of 60 animals were preyed by predators and non-predatory factors each year. The foremost threat to the mammalian predator was retaliatory killing. The guarded grazing and construction of predator-proof corral pens were identified to protect the domestic livestock predation by wolf and snow leopard respectively. This study specifies measures of conservation to minimize human-carnivore conflicts.

1. Introduction

Human-wild conflict is a negative interaction that can cause harm to human life and livelihood as well as the wildlife itself. However, predation is an important factor affecting successful coexistence between human and large carnivores through depredation of livestock [1-4]. Predation on livestock is the primary reason of human-wildlife conflict and consider one of the biggest challenges for the conservation of predators around shared grazing land [5-7]. In Karakoram Pamir mountains predation has emerged a serious issue with fluctuating strength from place to place depending upon wild prey abundance, herd size, herding practices, predator type, and age [8]. An apparent increase in the population of domestic animals invokes an increase in predation that consequently provoke a reciprocal killing of large carnivores by pastoralists and creates a challenge for conservation [8-10]. The carnivores are in decline globally, largely due to conflict with humans, and mollifying conflict is indispensable for tangible carnivore conservation [11]. The population size of large carnivores is gradually declining across the globe due to habitat loss, diseases, hunting, and human persecution [12,13].

Among large carnivores, snow leopard ranked as a top predator than wolf and lynx, while the brown bear is not a fatal predator to livestock [8]. The snow leopard is an endangered flagship species in the highland ecosystem of Central Asia and its status is threatened due to reactive killing, poaching, prey declining and habitat loss [11,14]. The snow leopard and other large carnivores are specialized predators for wild ungulates, and on the opportunity, they also take to kill livestock [15], The depredation of livestock by snow leopard varies with an increase in livestock and wild prey population but spatial and temporal predation differs within and between the land landscape with local conditions and herding practices [16], and (66.6%) depredation of livestock is because of snow leopard [17].

The wolf is the second dangerous predator in Chitral and Khunjerab areas of Pakistan. Wolf diet comprised of livestock (38%), Himalayan ibex (37%), marmots (17%), Ladakhurial, Marco Polo sheep (2%), cape hare (2%) and grass (2%) [18], and (75.1 %) predation of livestock due to wolf [17]. Herders claimed that they could distinguish between a carcass killed by a wolf attack on animal's hindquarters and snow leopard attack on the neck or throat as well as by the presence of predators' tracks on the kill site [19]. Previous studies indicated an economic lost of livestock to predators were valued in the dollar and local prices, an estimated US$ 44,213 in the upper Mustang region[7], US$ 12,252 in Jigme Singye Wangchuck National Park[20], US$445,539 (US$99,009) per year in the Pamir regions[21] and PKR 4,926,596 (USD 51,620) in Hushey valley[22] .These mammalian predators preyed on many livestock in Misgar valley. However, the depredation and its impact not yet been studied in this valley. Furthermore, the Misgar valley is situated adjacent to the Khunjerab National Park (KNP) and livestock of the valley shared their pastures reserves with large carnivores. Therefore, we predicted a high pressure of predation on livestock, which may cause human-carnivore conflict in the valley. Our study focused on the livestock damages by large carnivores, depredation pattern, economical loss, status of predators, perception about predator, threats to predators, temporal predation and conservation strategies in Misgar valley.

2. Materials And Methods

2.1. Study area

Misgar is located in the northwestern region of district Hunza, Gilgit-Baltistan, adjoining to the Khunjerab National Park (KNP) toward north-east. Misgar Valley lies at 36° 46' 34" N and 74° 45' 56" E, at 8000 elevations above sea level. The population of the Valley is consisting of 3000 people. The surroundings borders are Kilik top (4827 m) height, Mintaka top (4727m) height, bordering with China and Afganistan [23]. The vast meadows of the valley provide grazing grounds with a huge number of livestock and wild ungulates and offer an important environment for predators such as wolf, snow leopard and red fox.

2.2. Data collection

Data were collected on various parameters of livestock predation from 100 households out of 270 households in Misgar valley through predesigned questionnaires from April 2014 to October 2019. Predation was examined in the three main pastures (Kilik, Murkushi and Dardee) of Misgar Valley using vantage point during the year April 2019 to October 2019. It is significant to highlight that the data collection involved a survey-based quantitative method to reach the main causes, perceptions, and damages caused by the carnivores. Similar methods were followed in previous studies [22,24]. In this questionnaire survey, we collected the data using the quantitative method on the parameter such as livestock owned, type of livestock and mortality by predators and diseases, predators number and status, threats to wild carnivores, perceptions, and attitudes of people towards carnivore conservations, human-carnivore conflict experience and the financial loss of animals by predators and diseases. In this study human participation was involved and informed concent fom the participants have been obtained before the inception of the study. It is important to note that this study was conducted and implemented

through the approval of the ethics committee of Karakoram International University, Gilgit, Pakistan and all methods were performed in accordance with the relevant guidelienes of the university.

2.3. Statistical Analysis

In this section, in order to model the predation count of snow leopard and wolf the data from 2014 to 2019 was analyzed, we have investigated the range of possible factors that may influence the predation count. The considered factors are related to demographics, seasonal variation, government policies, ecosystem types, economic conditions and so forth. Since predation count can best be model using R Package with poison regression[21], So we have fitted two poison regression models to study the variation in predation count affected by the several considered factors. One poison regression model was appropriated for the snow leopard, while the other for the wolf. Moreover, the stepwise model section algorithm helped in designing the parsimonious model, significantly identifies the influential factors and showing the best model statistical performance.

3. Results

3.1. Population Pattern of Livestock overtime and Depredation losses

The livestock population pattern, year-wise population trend, predation count and losses caused by predators and non-predatory factors from 2014 to 2019 was presented in (Fig. 3A,B**).** Our study revealed a positive increase in the population of goats and sheep than cattle. The study revealed that the loss of livestock by predators and non-predatory factors in three pasture including Kilike, Murkushi, and Dardee. Data collected during the year 2019 showed a higher population of livestock compared with the year-wise data from 2014 to 2018 (Table 1). Interestingly, a total of 300 livestock were killed by predators from 2014 to 2018 and the major species were sheep, goats, yak, and cows. The last five years' data indicated that wolf was found a dangerous predator to damage the sheeps followed goats, cows and yaks in the study area. (Fig.3B). Inversely, in the year 2019, a total of 64 livestock damaged due to predation. The most affected were Yak (22.7%) than Sheep (1.08%), Goat (0.97%), and Cattle (3.92%). The recorded population in the year 2019 was 10 to 11% increase from the average percentage to the population from 2014 to 2018 (Table 1).

Table 1. Year wise population of livestock and their percentages

Livestock	2014	%	2015	%	2016	%	2017	%	2018	%	2019	%
Cattles	89	14.14	98	15.58	65	10.33	98	15.58	126	20	153	24.32
Goats	453	13.34	520	15.34	427	12.58	506	14.9	459	13.52	1029	30.31
Sheep	645	14.35	755	16.8	558	12.41	783	17.42	552	12.28	1200	26.7
Yaks	106	14	82	10.88	120	15.85	145	19.15	150	19.81	154	20.34
Total	**1293**		**1455**		**1170**		**1532**		**1287**		**2536**	

3.2 Economic Value of Livestock Losses

We census livestock population, predation count and also to evaluate the total financial losses due to predation and non - predatory factors in the Misgar valley. The total economic loss arising from livestock depredation during the year 2014 to 2019 was estimated at (13,195,000) PKR (82,468.75(US$). The cost for cattle was approximately (2,480,000 PKR), (15,500 US$), goats (1,860,000 PKP), (11,625 (US$) for Sheep (1,815,000 PKR), (11,343.75 US$) and for yaks (7,040,000 PKP), (44,000 US$). Most losses were attributed to wolves 1, 815,000 PKR (11,343.75 US$) followed by snow leopards and diseases (Table. 2). This study shows cows and oxen were the least choices of predators in the area. Our study indicates that death caused by disease slightly higher in cows and yaks compared with goats and sheep (Figure 3B). In addition, a total of 364 livestock preyed during the last six-year by both predators and diseases, that leads to major economic loss and invoked a retaliatory killing of the carnivores.

Table 2. Economic cost analysis of livestock kill by snow leopard, wolf and diseases in Misgar valley the Part of district Hunza during the past six years 2014- 2019.

	Individual % killed	Unit price (RS)	Total loss price (RS)	Total loss (US$)
Cows	62 (9.85%)	40,000	2,480,000	15,500
Goats	93 (2.74%)	20,000	1,860,000	11,625
Sheep	121 (2.69%)	15,000	1,815,000	11,343.75
Yaks	88 (11.6%)	80,000	7,040,000	44,000
Total	364	155,000	13,195,000	82,468.75

Average estimated price for predated livestock established village conservation schem, 1US$= 160 Rs (Pak rupees)

3.3. Depredation counts and Patterns for Snow leopard and Wolf

We have considered more than 22 different factors from demographics, seasonal information, government policies, ecosystem and economic sectors to model the predation count. Snow leopard and wolf predation counts were separately modelled through poison regression and the final parsimonious model for both species is presented in (Table. 3,4). The final poison model for both snow leopard and wolf contains 22 influential factors and predation distribution is presented in (Fig.2 A-V)

Table 3. Influential factors together with odds ratio and p-values are listed for Snow Leopard Predation.

Snow leopard Predation							
Factors	**Levels**	**Odd Ratio**	**P -Value**	**Factors**	**Levels**	**Odd Ratio**	**P -Value**
Age	Adult	Reference		Visit to pasture other than livestock herding	No	Reference	
	Aged	1.03	0.869		Yes	0.717	0.072
	Young	0.16	<0.001	Threat for snow leopard	High	Reference	
Occupation	Farmer	Reference			Low	1.179	0.346
	Government employee	6.081	<0.001		Medium	0.578	0.076
	Private employee	7.173	<0.001	Major threats for wildlife	Climate change	Reference	
					Habitate destruction	0.773	0.585
Gender	Female	Reference			Illegal hunting	0.391	<0.001
	Male	0.652	0.042		Illegal hunting &habitate destruction	0.185	<0.001
Yearly. Income	Below 50,000	Reference		Reduce wildlife threats	Laws for conserevation	Reference	
	Above 50,000	0.055	<0.001		Gov.rules	1.646	0.046
Reason to sell livestock	For migration	Reference			Local community	1.1	0.714
	For basic need	0.921	0.799	Dangerous predator for livestocks	Snow leopard	Reference	
	For education	1.141	0.039		Wolf	0 1.335	125
Income from Livestock	50,000 to 100,000	Reference		Predator attack on livestocks	Exposed to predator	Reference	
	Above 100,000	1.387	0.137		Favorite food	3.207	<0.001
						1.038	0.862
	Below 50,000	4.501	<0.0001		Natural prey reduction		
Organization support for treatment	Govt. support	Reference		People opinions importance of wildlife	Balance ecosystem	Reference	
	No org. support	0.389	0.015		Economic importance	9.12	<0.001
Number of snow leopard	1-5	Reference			No importance	0.083	0.25
	Above 5	0.43	<0.001		Tourism	6.98	<0.001
Snow leopard status	Absent	Reference		Seasonal predation	Autumn	Reference	
	Common	2.788	0.005		Spring	1.425	0.302
	Rare	1.74 2	0.07		Spring and summer	0.834	0.552
Measures to save livestock from attack of predators in pastures	Guarded dogs	Reference			Summer	0.759	0.305
	Guarded grazing	1.638	0.051		Summer and Autumn	2.208	0.008
	Predator proof corrals	0.549	0.002		Winter	1.799	0.023
Condition sheds in pasture	Protected	Reference					
	Unprotected	0.466	0.003				

Table 4. Influential factors together with odds ratio and p-values are listed for Wolf predation

Wolf Predation							
Factors	**Levels**	**Odd ratio**	**P-value**	**Factors**	**Levels**	**Odd ratio**	**p- value**
Education	Basic education	Reference		Visit to pasture other than livestock herding	NO	Reference	
	Higher education	0.032	<0.001		Yes	0.001	0.008
	Illiterate	0.011	<0.001	Threat for wolf	High	Reference	
Age	Adult	Reference			Low	50.7	<0.001
	Aged	0.795	0.002		Medium	3000	<0.001
	Young	3.5	<0.001	Laws for wildlife	NO	Reference	
Occupation	Farmer	Reference			Yes	0.003	<0.001
	Government Employee	0.056	<0.001	Reduce wildlife threat	Laws for conservation	Reference	
	Private Employee	0.034	<0.001		Gov.Rules	0.036	<0.001
Gender	Female	Reference			Local community	0.162	0.774
	Male	0.039	<0.001	Dangerous predator for livestock	Snow leopard	Reference	
Yearly income	Below 50,000	Reference			Wolf	0.087	<0.001
	Above 50,000	0.001	<0.001	Predator attack on livestock	Exposed to predators	Reference	
Reason to sell livestock	For migration	Reference			Favorite food	2.34	<0.001
	For basic need	0.009	<0.001		Natural prey reduction	0.689	0.149
	For education	0.003	<0.001	People opinion importance of wildlife	Balance ecosystem	Reference	
Estimate income from livestock	50.000 - 100,000	Reference			Economic importance	9.12	<0.001
	Above 100,000	0.005	0.004		No importance	0.083	0.25
	Below 50,000	0.028	0.064		Tourism	6.98	<0.001
Number of wolf	1 -30	Reference		Seasonal predation	Autumn	Reference	
	Above 30	0.017	0.016		Spring	0.068	0.826
Wolf status	Absent	Reference			Spring and summer	0.472	0.453
	Common	0.193	<0.001		Summer	0.878	0.145
	Rare	0.31	0.541		Summer and autumn	0.002	<0.001
Measures to save livestock attacks Predator in pasture	Guarded dog	Reference			Winter	0.006	<0.001
	Guarding grazing	6.23	<0.001				
	Predator proof corrals	0.43	<0.001				

3.4 Socio-Economics and Demographic Characteristics of Respondents

The variation in snow leopard's predation counts was modelled through stepwise poison regression. Influential factors affecting the snow leopard and wolf predation counts are presented in (Table.3,4). In our study the responded age was categorized into three groups; 55 % were adults, 40 % were aged while 5 % were young (Fig.2A). Compared to adults, the young respondent had observed 0.016 times lesser the snow leopard predation counts with the p-value <0.001. Study contains 60 % male and 40% female

(Fig.2B). Compared to the female respondent's male respondent observed 0.652 times less snow leopard predation counts. Models for wolf showed the same kind of results (Table. 4). Of the total respondents, those who perceived increasing predation by snow leopard comprised 44% farmers, 29 % of government employees and 27% private employees. Farmers were considered as reference profession, as profession gets government employee the snow leopard predation is likely to increase by 6.081. Similarly when profession get private sector employ the snow leopard predation gets increased by 7.173 times (Table 3). We observed the same outcome in a wolf model for occupation (Table.4). The education of the respondents was divided into three groups, 44% illiterate and 38% with basic education and 18 % were holding higher education qualification (data was not shown). The model showed that basic education was considered as the reference category and higher and illiterate, the predation of the wolf was increased 0.032 compared with higher education and increased 0.11 with illiterate (Table. 4).

3.5 Estimate Income from Livestocks

The income came from agriculture and livestock and its impact on predation modelled against the predation count. Here, we evaluate the economic status of respondents and investigated their yearly income, livestock owns and livestock sold. In modelling the yearly income of the respondent was categorized into two groups, below 50,000 income were 4% and above 50,000 were 96%. (Fig. 2D). In the model below 50,000 income considered as the reference category and the yearly income of the respondent appeared significant compared to the above 50,000 income of the respondent, the snow leopard predation increased by 0.055 times (Table 3,4).

Factor such as reason to sell livestock was categorized into three categories, for migration 28%, for basic need 13% and education 59% (Fig.2E). In the model, the reference category was migration compared with the basic need and appeared non-significant with basic need and weak significant with education (Table 3). In wolf predation model education shown highly significant with both categories with $p \leq 0.000$. (Table.4). Estimated income from livestock categorized into three groups, 50,000-100,000 income occupy 43%, above-100,000 income 22% and below-50,000 income 35%. (Fig.2F). In the model, 50,000-100,000 used as reference category shown non-significant with above-100,000 and highly significant with below 50,000.(Table.3). However, the model designed for wolf shown 50,000 -100,000 income was statistically significant with above 100,000 income of the respondents (Table.4). Livestock treatment and vaccination (LTV) last six years categorized into two, No vaccinated 72% and Yes vaccinated 28%. In the model, the reference category was NO, statistically significant with Yes at $P < 0.05$ (Table 3,4)

3.6. Predators and their Perceived Population trend

The respondents' perceptions about the current status and population trends of mammalian predators are given in (Fig 2K). The perceived predators status and populations were categorized into two groups, the respondents who sighted snow leopard 1-5 time were 82% and above-5 time was 18% (Fig.2 J). As the model illustrate that 1-5 time used as the reference category and compared with above-5 time with $P<0.000$ (Table 3). Similarly, the estimated population of wolf categorized in two, 20-30 times seen the wolf was 79% and above 30 were 21%. The reference category was 20-30 times, compared with above-

30 predation increased 0.017 times showed significant at P<0.05 (Table 4). We categorized the presence of predators into common, rare and absent. Out of 100 respondents, 85% respondent believed Snow leopard is common, 2% believed absent and 13% believed rare, similarly for wolf 2% said absent, 89% said common and 9% said rarely. Likewise, 77% of respondent thought brown bear is rare, 10% thought common and 13% thought absent. In the model, we chose absent as reference category and compared with common and rare has revealed highly significant with common at P<0.000.

3.7. Perceptions towards Human-Carnivores Conflict

Out of 100 respondents, most of the respondents 63% ranked snow leopard as the dangerous predator, 37% sited the wolf as a dangerous predator (Fig 2L). In the model, we used snow leopard as the reference category and compared with the wolf, predation increased 1.335 times and statistically significant at P<0.000 (Table3,4). Of the total respondents, 24% respondent agreed on livestock exposed to predator, 23% said livestock is the favourite food and 53% said its natural prey reduced (Fig. 2M). The model showed that exposure to predator considered as the reference category and predation was increased 3.207 times compared with favourite food and statistically significant at P< 0.000 and non-significant in comparison with natural prey reduction (Table 3).Of the total respondents who perceive the importance of predators comprised 51% consider no importance and 49% considered important. Among them 9% of respondents thought predators are important to balance ecosystem, 21% believed predators have economic importance and the majority of the respondents 52% assumed that predators have no importance. However, 18% said that the presence of predators is important for tourism (Fig. 2N). In the model, we used the balanced ecosystem as the reference category and compared with economic importance and found that predation increased 9.12 time and also increased 0.356 times with tourism. Statistically, it was highly significant at P<0.000 (Table 3). Our analysis revealed similar results in the model for the wolf shown in (Table 4).

3.8. Threats towards Wild Predators

A total of 100 respondents ranked the predators into three kinds of threats index, low, high and medium. Among them, 69 % respondents believed there is low threat for the snow leopard in the study area, 5% respondents believed there is a medium threat and 26% responded thought there is a high threat to the snow leopard (data not shown). In the model, the high threat was chosen as the reference category and compared with low and medium depredation decreased 1.179 and 0.578 with p-value 0.346 and 0.076 respectively (Table 3). Similarly, 57% of respondents ranked wolf as low threatened, 13% ranked medium and 30% ranked high (Figure 2P). The model for wolf indicated depredation decreased 50.7 times compared with low with P<0.001. Similarly, predation decreases 3000 times compared with medium with P< 0.001 (Table. 4).In response to the question about major threats, 14% of respondents believed climate change, 5% habitat destruction, and 54 % believed illegal hunting and 27% both illegal hunting and habitat destruction. In our model, climate change was used as a reference category and compared with illegal hunting and both illegal hunting and habitat destruction, depredation increased 0.391 and 0.185 times with P<0.001 (Table. 3,4)

3.9. Temporal Predation

In order to evaluate the temporal predation, we divided our responses into five groups. Of the total respondent's perceived predation occurred in winter season 22%, in summer 21%, in autumn 17%, in spring 15%, in both spring and summer 13%, summer and autumn 12% in spring (Fig. 2Q).In the poison regression model autumn used as the reference category and compared with summer and autumn predation by snow leopard increased 2.208 times and also increased 1.799 times compared with winter (Table 3). Autumn used as the reference category in the wolf model and compared with summer and autumn predation by wolf increased 0.002 times and predation also increased 0.006 times compared with winter with $P<0.01$ (Table 4).

3.10. Conservation Strategies

The conservation approaches adopted to protected livestock from the attack of predators during grazing. Of the total respondents, those who perceived decreasing predation by snow leopard and wolf comprised predator-proof corrals pens 49%, guard dog 32%, and guarded grazing 19% (Fig.2R). In the model, we used the guarded dog as a reference category and compared with predator-proof corrals pens and guarded grazing predation decreased 0.549 and 1.638 times with $P<0.001$ (Table.3). In the model of the wolf, Predation decrease 6.23 time compared with guarded grazing and 0.43 times with predator's proof corrals. These both factors were highly significant at $p<0.001$ (Table.4). Shelters of livestock recognized as protected and unprotected. Of the total respondents' majority, 86% thought livestock unprotected in the pasture and only 14% of thought livestock protected in the pasture (Fig. 2S). In model protected used as a reference category and predation was increased 0.466 times compared with unprotected and statistically highly significant at $p<0.00$ (Table.3). In response to the question of what steps need to maintain wildlife,50%, preferred government rules need to implement, 37% denoted local community involvement and 13% favoured enforcement of laws for conservation (Fig. 2T). In the model for the snow leopard laws for conservation used as reference category compared with government rules that indicate the killing of snow leopard decreased 1.646 times with $P<0.044$. However, in the model for wolf laws for conservation compared with government rules that indicate 0.036 times decreased in the killing of the wolf with $P<0.001$ (Table.3, 4). The locally developed organization managed compensation to the communities to maintain the mammalian predators in the valley. Of the total respondent's those who did not receive compensation (87%) and received was (14%) from a locally based community organization. The respondents who replied Yes, furthered categorized into two groups, those who compensated 1000-6000 (13%) and above-6000 (1%) (Fig.2V). In the model, No used as a reference category and compared with yes then the predation increased 0.42 times and shown significant at $P<0.000$ (Table 3,4).

4. Discussion

4.1. Patterns of Livestock Predation

Every year snow leopard, wolf, and other wild carnivores kill many livestock consequently a significant loss for the poor communities in such a remote area. The predators are killed by nomadic in retaliation

[8,25]. Our present study revealed a positive trajectory that shows an increase in the population of livestock in the last six-year. Population census during the year 2019 indicated an approximate 10 to 11% increase compared with the average percentage of last five year from 2014 to 2108 (Table.1). However, the present study also showed an increasing pattern of livestock loss to predation rate (3.92%) of total livestock was with in previously reported studies around the world [26,27] .

4.2. Economic Impact of Predation on Local Population

The average financial loss due to predation (~US$ 82,468.75),(13,195,000 PKR) characterized 15.08% cash income of the house hold. The same kind of patterns of livestock losses was presented from other countries in Asia 17 % in China [27], (19.8 % in Pakistan, [28]; 17 % in central Bhutan,[20]; and 11 % in India [29]. These results have shown that income from livestock has a pivotal role in the livelihood of the respondents, who have less earning capacity in the study area. The damages caused by a predator to livestock would create a conflictual condition in the area and is indicating a major threat to wild carnivores in this area. However, this risk could be mitigated by initiate conservation strategies though compensate for the losses of the people.

4.3. Perception towards Carnivores

In the Karakoram Pamir Mountain predation of livestock is one of the major issues with varying intensity from area to area, rely on abundance, herd size and herding practice, predator type and age. Snow leopard, wolf, and lynx were thought to be dangerous predators, while the brown bear was reported as less fatal to livestock [8]. Similarly, the present study revealed that the snow leopard and wolf were the most dangerous predator in the study area. However, lynx was not being noticed in this area and the brown bear was also less fatal in this area. A previous study indicated that wild carnivores preyed selectively upon different livestock species corresponding to the size of the predator about the size of their prey, prey preference, and abundance [30]. Our findings are consistent with these previous studies. We found that most of the sheep were preyed by wolf and goats and yaks were hunted by a snow leopard. However, cattles were not observed to be hunt by any carnivores in the pastures of the study area and, the cattles were affected by different diseases that also affect their population size.

4.4. Detection and Seasonal Pattern of Predators

Din *et al.,* (2019) reported the average highest sighting of snow leopard (1.6+0.15) and an average wolf sightings (3.9 ± 0.32) at Pakistan Pamir. The present study shows that both of these predators are common in the study area. The respondents who sighted snow leopard 1-5 time were 82% and above-5 time were 18%. We compared 1-5 with above-5 time shown highly significant at $P<0.000$ respectively. However, the respondent who sighted wolf 20-30 times were 79% and above 30 were 21%. However, majority of the respondents 85% thought snow leopard is common and 89% said wolf is the common predator. Several previous studies indicate a varied temporal predation trend for predators and the present study also revealed a similar pattern [7,21,24]. In our study, most of the respondents 22% believed

predation of livestock occurs in winter followed by summer (21%), autumn (17%) and spring 15%. Our data showed low temporal kill compared with the study of (Li et al., 2013), indicated predation were most common in autumn (37.2 %) and summer (36 %), which corresponds with livestock being moved to a higher elevation to graze in the pasture.

4.5. Challenges for Conservation

Human-wildlife conflict is one of the growing challenges in biodiversity conservation specifically in the underdeveloped countries [31].The major threats are facing large carnivores include human persecution, human population growth, reducing of prey, hunting and retaliation of people due to livestock predation [32]. The present model also indicated that these said factors significantly affect the wild carnivores. A previous study described the best way to mitigate livestock attacks by leopards, in which very few respondents (18%) favoured improved animal husbandry including leopard-proof pens and increased guarding in the field, habitat restoration 36%, moving leopard to more remote places from villages (27%), do nothing (4%) and leopard removal from the study area (45%) [24]. Besides, a community-based insurance scheme along with an awareness program in school was initiated to manage human-wildlife conflict. We found a similar kind of findings in the present study and most of the respondents 40% favoured predator-proof corrals pens, 32% guard dog, 19% believed guarded during grazing to protect their livestock from wild predators. Furthermore, a small fraction of the respondents have been compensated on predation of livestock and models revealed that response YES was compared with NO has shown significant at $P<0.05$. This study revealed that the loss of livestock would be compensated through insurance, in turn, it would reduce retaliation towards predators in the study area. Besides illegal hunting of wildlife as a game or due to conflict by the local people, climate change events leading to disasters, soil erosion, drought, and ecosystem imbalance are considered the most emerging threats for wildlife [33]. Conservation of wildlife as a major food chain component and source of ecosystem service is the need of the time. This study provides bases for conservation management and policymaking for sustainable ecosystem services.

Conculsion

Our finding indicated that the population of livestock tend to increase during the last six years. However, the population census showed 10 to 11% increase in the year 2019. This study showed 364 livestock killed by the predator and diseases during the last six-year from 2014 to 2019. We found 64 livestock lost due to predators and diseases in the year 2019, and the most affected animals were yak (22.72%). The average financial loss estimated at (US$ 17,500),(2,800,000 PKR). Interestingly, majority of the respondents 82% sighted the snow leopard and 79% respondent seen a wolf in the pasture. Similarly, 85% believed snow leopard and 89% supposed wolf is the common predator in the pastures of the valley. Of the total respondents, 63% ranked snow leopard, and 37% thought wolf as dangerous predator in the study area. Importantly, 53% of respondents acknowledged the reduction of natural prey is the cause of predation of livestock. Of the total respondents who perceive the importance of predators comprised 51%, and consider no importance 49%. 69 % of respondents believed there is a low threat for the snow leopard,

and 57% of respondents ranked wolf as low threatened 54 % believed illegal hunting, and 27% both illegal hunting and habitat destruction recognized as a major threat to the predators. Of the total respondent's perceived predation occurred in winter season 22%, in summer 21%, in autumn 17%, in spring 12%. Of the total respondents, those who perceived decreasing predation by snow leopard and wolf comprised predator-proof corrals 49% and guarded grazing 19%. We highly recommend developing organization at the local level for managing compensation to the communities to maintain the mammalian predators in the Misgar valley.

Declarations

Aknowlegement

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Conflict of Interests

The authors declare no conflict of interest.

Authors contributions

1. Rubina Bano contributed to the conception and design of the study. She conducted field surveys and also collected the data.
2. Akbar Khan make subtantail contribution to the conception and design of the study and supervised the project. He involoved in writing of the paper and develop the figures and tables.
3. Tahir Mehmood performed the statistical analysis
4. Waqas Sami involved in interpretation of the data.
5. Muhammad Zafar Khan desig the material and method
6. Saed Abass develop the GIS map of the study area and also helped in design the project.
7. Arshad Ali Shedyi contributed in the draft of the paper

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