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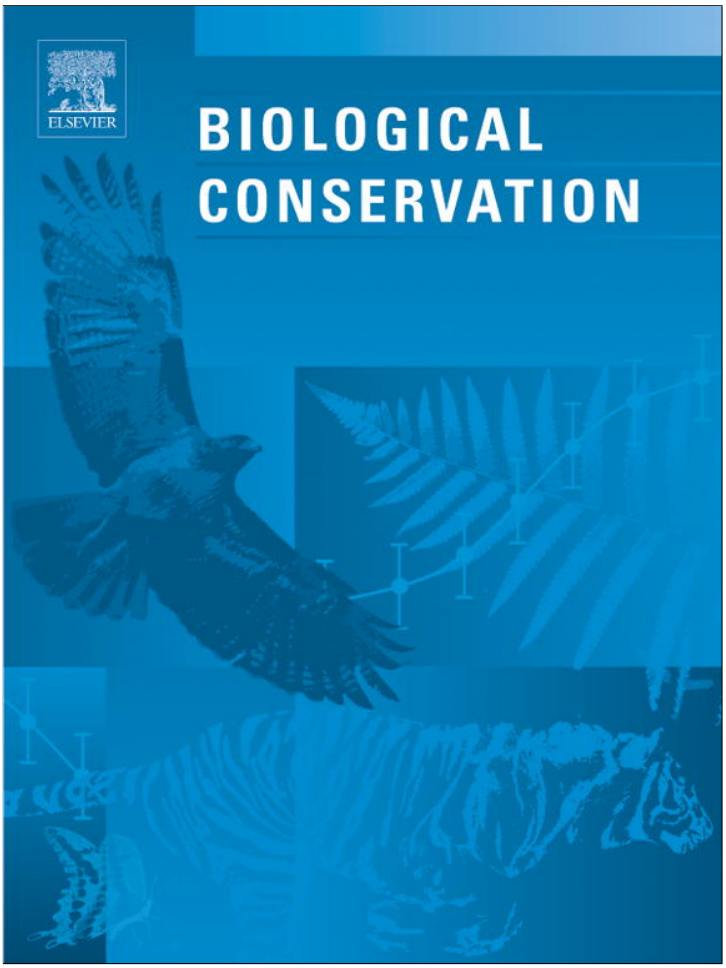

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Biological Conservation 166 (2013) 118–123

Contents lists available at SciVerse ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Human-snow leopard conflicts in the Sanjiangyuan Region of the Tibetan Plateau

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ARTICLE INFO

Article history:
Received 30 January 2013
Received in revised form 3 June 2013
Accepted 19 June 2013

Keywords:
Panthera uncia
Human-wildlife conflict
Traditional use
Livestock depredation
Economic value
Cultural image
Attitude

ABSTRACT

Conflicts between humans and snow leopards are documented across much of their overlapping distribution in Central Asia. These conflicts manifest themselves primarily in the form of livestock depredation and the killing of snow leopards by local herders. This source of mortality to snow leopards is a key conservation concern. To investigate human-snow leopard conflicts in the Sanjiangyuan Region of the Tibetan Plateau, we conducted household interviews about local herders' traditional use of snow leopard parts, livestock depredation, and overall attitudes towards snow leopards. We found most respondents (58%) knew that snow leopard parts had been used for traditional customs in the past, but they claimed not in the past two or three decades. It may be partly due to the issuing of the Protection of Wildlife Law in 1998 by the People's Republic of China. Total livestock losses were damaging (US$ 6193 per household in the past 1 year), however snow leopards were blamed by herders for only a small proportion of those losses (10%), as compared to wolves (45%) and disease (42%). Correspondingly, the cultural images of snow leopards were neutral (78%) and positive (9%) on the whole. It seems that human-snow leopard conflict is not intense in this area. However, snow leopards could be implicated by the retaliatory killing of wolves. We recommend a multi-pronged conservation program that includes compensation, insurance programs, and training local veterinarians to reduce livestock losses.

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1. Introduction

Human-carnivore conflicts are universal, and people's near ubiquitous negative behavior to carnivores in the conflicts are a major challenge to biodiversity conservation (Woodroffe et al., 2005). The conflicts are difficult to understand and manage, because they are influenced by many factors, including religious values, the cultural and economic value of carnivores and their body parts, and the economic loss imposed by the carnivore damage (Dickman, 2010; Michael and Ashley, 2004). As a consequence, it is important to identify the degree of influence of these factors in order to lay a foundation for designing of specific conservation programs and policies.

The endangered snow leopard is a keystone species in the mountain ecosystems of Central Asia and the Tibetan Plateau, and it is threatened by retaliatory killings, poaching, a decline of prey species, and habitat degradation (McCarthy and Chapron, 2003). Human-snow leopard conflicts are common throughout their range, and have been studied in Afghanistan, Bhutan, Xinjiang Province in China, India, Mongolia, Nepal and Pakistan (Hussain, 2003; Ikeda, 2004; Mishra, 1997; Mishra and Fitzherbert, 2004; Sangay and Vernes, 2008; Schaller et al., 1987). Unlike many other large carnivores, snow leopards do not attack humans (Inskip and Zimmermann, 2009). Their main conflicts with humans typically relate to the depredation of livestock, and the associated economic loss. Livestock losses to snow leopards may account for a significant portion of the annual income for many people, so retaliatory killing for depredation, as one of the great causes of snow leopard killing, has become a major threat to snow leopards survival (Bagchi and Mishra, 2006).

The Tibetan Plateau is thought to be the evolutionary origin of snow leopards (Deng et al., 2011) and it makes up about half of their global range. The Sanjiangyuan Region on the Tibetan Plateau contains the largest contiguous snow leopard habitat in China, and the second largest nature reserve in China – Sanjiangyuan National Nature Reserve. We chose this region to investigate, for the first time on the Tibetan Plateau, conflicts between local herders and snow leopards and other sympatric carnivores. From 2009 to 2011, we conducted semi-structured household interviews across the Sanjiangyuan Region to get answers on traditional use, livestock depredation, and overall attitudes of local herders to snow leopards and other carnivores. The resulting information

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0006-3207/$ - see front matter © 2013 Published by Elsevier Ltd.
http://dx.doi.org/10.1016/j.biocon.2013.06.024

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details the various aspects of the conflicts, and helps us propose specific solutions to reduce the conflicts.

2. Methods

2.1. Study area

The study was conducted in the Sanjiangyuan Region in the Qinghai Province, China (N31°39′–36°12′, E89°45′–102°23′). It lies in the eastern part of the Tibetan Plateau, with an area of about 0.36 million km^2 (Fig. 1). The altitude ranges from 3335 to 6564 m, and include extensive plains and mountain such as Kunlun, Anyemaqin, Tanggula, and Bayan. Notably, this region includes the headwaters of three of Asia's largest rivers, the Yangtze, Yellow and Mekong, which combine to provide water to more than a billion people downstream (Editorial Commitee of Ecological Environment of Sanjiangyuan Nature Reserve, 2002). The Sanjiangyuan National Nature Reserve was established in 2002. It has 18 protection zones, with an area of about 0.15 million km^2 (Fig. 1).

A total of 85 species of mammals, 237 species of birds and 48 species of amphibians and reptiles have so far been identified (Editorial Commitee of Ecological Environment of Sanjiangyuan Nature Reserve, 2002) in the Sanjiangyuan Region. In addition to snow leopards, other large and medium carnivore species in this area include gray wolves (*Canis lupus*), Tibetan brown bears (*Ursus arctos*), Eurasian lynx (*Lynx lynx*), red foxes (*Vulpes vulpes*), Tibetan foxes (*Vulpes ferrilata*), Chinese mountain cats (*Felis bieti*) and Pallas' cats (*Otocolobus manul*).

There are altogether 4 prefectures in the Sanjiangyuan Region, including 16 counties and one township, with a total human population of about 0.56 million. Tibetans account for more than 90%, with the remainder being Han, Hui people and others. Most of the people are engaged in some form of herding. We surveyed 144 households in 14 counties for this study.

2.2. Semi-structured household interview

We plotted 15 × 15 km grid cells in the whole Sanjiangyuan Region (n = 1511), and then stratified the grid cells into three levels according to rock coverage, a proxy for likely snow leopard habitat (Li et al., 2013). We then randomly sampled 5% of the grid cells in each level with the Hawth's analysis tools in the ArcGIS 9.2 (Beyer, 2004), and conducted 1–3 semi-structured household interviews per grid cells. The households were selected randomly near the most probable snow leopard habitat.

Individuals were questioned on the household's numbers of each type of livestock, and the number and age of each livestock type lost to predation in the past year. We also asked them, as far as they know, whether snow leopard parts had been used traditionally by Tibetans and how they were used. In order to understand the cultural images of snow leopards, we asked them to talk about any folklore they knew about snow leopards. In order to identify their attitudes toward snow leopards and other sympatric wildlife, we asked them which species they disliked the most on their pastures. We also interviewed several local Tibetan doctors on the traditional use of snow leopard parts in Tibetan medicine.

In the process of the interview, we tried our best to minimize the chances of response bias. We usually found a local guide to accompany with us during the household interviews. Those questions related to potential illegal behavior would be asked in a smart way, for example we would ask 'whether snow leopard parts had been used traditionally by Tibetans' instead of 'whether you would kill snow leopards and use them by tradition'. We would also crosscheck their answers by asking similar questions in different ways, or by asking our local guides or their neighbors.

2.3. Data processing

The interviewees tended to be imprecise, often giving approximate values (e.g. "7 or 8") for the number of livestock. In such cases, we took the mean of the numbers given (e.g. "7.5"). For the same reason, the livestock only fell into five categories, including adult yak, juvenile yak, adult sheep (goats were rare and thus merged with sheep in the analyses), juvenile sheep and horse (The juvenile here is approximately under 1 year old, and adult means approximately older than 1 year old). The value of each was calculated as US$ 928.8, 139.3, 123.8, 31.0, 464.4 respectively, according to the average price of Qinghai livestock market in 2011 (measured by the official exchange rate in 2011: 6.46 RMB per US dollar).

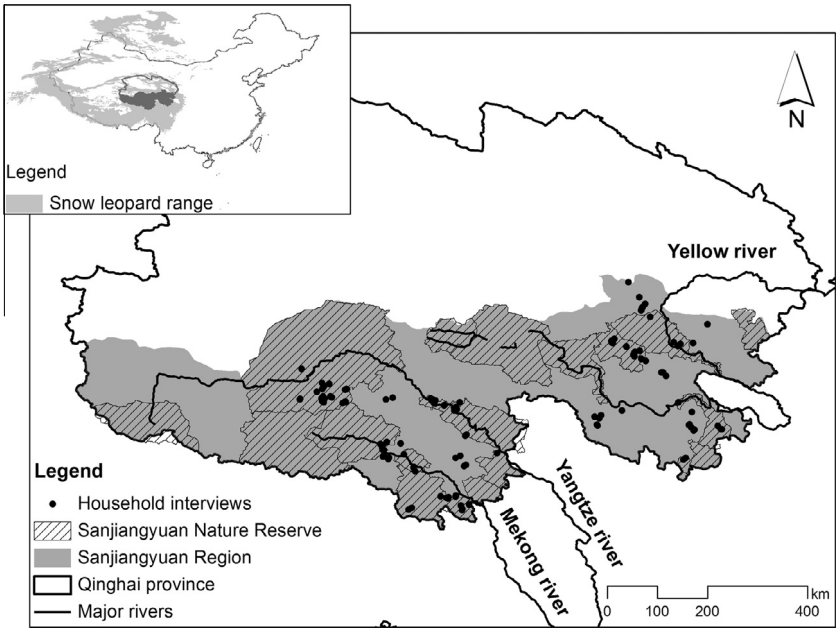

Fig. 1. Study area. Sanjiangyuan Region lies in the southern part of Qinghai province in China, along the eastern part of Tibetan Plateau with an area of about 0.36 million km^2. Sanjiangyuan National Nature Reserve was constructed in 2002, and it has 18 protection zones.

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To characterize the nature of folklore about snow leopards, we grouped all the folklore into three categories: positive (with approving words), negative (with derogatory words) and neutral.

3. Results

3.1. Respondents demography and livestock holdings

Between 2009 and 2011, we interviewed 144 households throughout the Sanjiangyuan Region, covering 41 villages in 14 counties in 4 prefectures. All households were Tibetan, because we only interviewed with households who lived near probable snow leopard habitat, where only Tibetans lived there. The respondents had a mean age of 47 years (range 17–81 years). Most respondents (86%) were herders, with the remainder being primarily doctors, monks and businessmen. Men accounted for 94%. Eighty-eight percent had never been to school. All of them spoke Tibetan and 70% did not understand Mandarin-Chinese.

Livestock were owned by 138 of 144 households, including yaks, sheep, horses and goats. Among them, 136 households had 14,041 yaks, with an average number of 98 yaks per household (range: 15–350); 63 households had 10,670 sheep/goats, with an average number of 74 sheep/goats per household (range: 3–750); 95 households raised 464 horses, with an average number of 3 horses per household (range: 1–23) (Table 1).

3.2. Traditional use of snow leopards

In the household interview, we asked whether snow leopard parts had been used for traditional purposes by Tibetans. Forty-two percent of the respondents answered "No" to this question, but the remainder (58%) responded that snow leopard parts had been used for traditional practices in the past, but not in the past two or three decades. Among the 58% of affirmative respondents, 44% said that snow leopard bones could be used in their traditional medicine; 10% said that snow leopard skins could be used to make cushions, coats, hats or belts for warmth or decoration; 4% said that snow leopard parts were sold to Han people who came to collect leopard bones for Chinese medicine. Among all of those interviewed, 15% clearly said that they knew snow leopards had great financial value.

3.3. Livestock losses

The 144 households we interviewed reported 984 yaks (747.5 adults and 236.5 juveniles), 1651.5 sheep/goats (1121 adults and 530.5 juveniles) and 20 horses lost to depredation and diseases in the past year, with an economic loss of US$ 891,757 (US$ 6193 per household) (Table 2). Among them, snow leopards took 10% responsibility, while wolves and diseases contributed 45% and 42%, respectively (Fig. 2).

Table 1
Livestock numbers.

	Yak	Sheep/goat	Horse
Households[a]	136	63	95
Range of number of livestock per household	15–350	3–750	1–23
Average number of livestock per household[b]	98	74	3
Total number of livestock	14,041	10,670	464

[a] The number of households who owned yaks, sheep/goats or horses.
[b] "Average" was calculated by dividing "Total" by the number of interviewees (144).

Of the 138 households who owned livestock, in the past year 118 alleged that they had lost livestock to various carnivores and birds of prey, including wolves, snow leopards, brown bears, lynx, foxes, feral dogs, Chinese mountain cats and golden eagles (Table 2). These losses equate to a total of US$ 516,726, with an average of US$ 3588 per household. Specifically, snow leopards were blamed in 53 households for the loss of 133 yaks (72 adults and 61 juveniles) and 191.5 sheep/goats (125.5 adults and 66 juveniles), with a direct economic loss due to snow leopards of US$ 92,957 (US$ 646 per household) (Table 2). By comparison, 116 households reported they lost 464 yaks (321.5 adults and 142.5 juveniles), 779.5 sheep/goats (510 adults and 269.5 juveniles) and 18 horses to wolves in the past year. This is a direct economic loss of US$ 398,320 (US$ 2766 per household). Other species, including brown bears, feral dogs, foxes, lynx, Chinese mountain cats and golden eagles caused a total loss of US$ 8034, 6037, 3251, 1548, 155 and 124, respectively (Table 2).

In addition to livestock depredation, 51 households reported 367 yaks (348 adults and 19 juveniles) and 442 sheep/goat (382 adults and 60 juveniles) lost to various livestock diseases, with a direct economic loss of US$ 375,031 (US$ 2604 per household) (Table 2).

3.4. Cultural image and attitudes towards snow leopards

Of the 144 respondents, 38% knew of folklore pertaining to snow leopards. Among them, 78% of the folklore was neutral, while 9% was positive and 13% was negative (Fig. 3). The positive folklore generally had the premise that snow leopards are the guardians of sacred mountains, so we should not hurt them; there are fewer snow storms and no livestock disease where snow leopards dwell; and snow leopards are clever. Negative ones generally included that snow leopards would rotate their tails to attract people and then eat them or that snow leopards would lure in and eat people by putting their tails on the head to imitate a waving monk.

One hundred and twenty-four respondents answered the question "which species do you dislike most if they appear in your pasture"? Some respondents mentioned more than one species, so we calculated percent of respondents and percent of responses respectively (Table 3). In the order from most to least percent of respondents, the animals which local herders disliked most were wolves (63%), brown bears (31%), rodents (8%), snow leopards (6%), blue sheep (3%), white-lipped deer (3%) and caterpillar (2%), whereas 9% people said they did not dislike any species (Table 3).

4. Discussion

4.1. Tibetans' traditional use is not a threat to snow leopards

Unlike herders from Kyrgyzstan, Kazakhstan, Mongolia and Xinjiang-China (Dexel and Deutschland, 2002), Tibetans rarely used the snow leopard skins to make hats, coats or decorative wall mountings. Based on our interviews, Tibetans in the Sanjiangyuan Region do not like using snow leopard skins because snow leopard hairs are too long, easily shed, and the spots too indistinct. In their opinions, snow leopard skins are not as beautiful or favored as tiger (*Panthera tigris*) and common leopard (*Panthera pardas*) skins. We attended several large congregations in the Sanjiangyuan Region in 2010 and 2011, and did not see any clothing that used snow leopard skins and tiger skins, but saw two leopard skins.

Snow leopard bones were used in the past, especially in traditional Tibetan medicine. As reported by Qinghai Medicines Inspection Office and Qinghai Tibetan Medicine Institute, the canine teeth of leopards (including snow leopards, common leopards and clouded leopards, similarly hereafter) function as anti-swelling

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Table 2
Status of livestock losses.

Cause	Species	No. of house-holds	Livestock loss					
			Yak		Sheep/Goat		Horse	Economic loss
			Adult	Juvenile	Adult	Juvenile		Total (US$) (Per household[a])
Depredation	Wolf	116	321.5	142.5	510	269.5	18	398320 (2766)
	Snow leopard	53	72	61	125.5	66	0	92,957 (646)
	Brown bear	24	4	11	22.5	0	0	8034 (56)
	Feral dog	2	0	0	48	3	0	6037 (42)
	Fox	7	0	0	0	105	0	3251 (23)
	Lynx	11	0	0	8	18	0	1548 (11)
	Mountain cat	2	0	0	0	5	0	155 (1)
	Golden eagle	1	0	0	0	4	0	124 (1)
	Unknown	4	2	3	25	0	2	6300 (44)
	Total	118	399.5	217.5	739	470.5	20	516726 (3588)
Disease		51	348	19	382	60	0	375031 (2604)
Total		144	747.5	236.5	1121	530.5	20	891757 (6193)

[a] "Per household" was calculated by dividing "Total" by the number of interviewees (144).

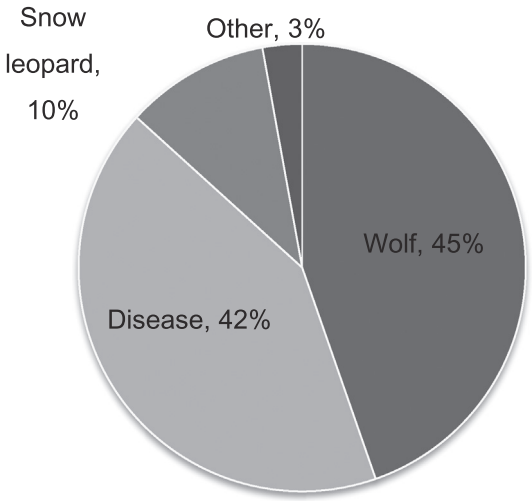

Fig. 2. Livestock losses composition ratio. In the Sanjiangyuan Region, snow leopards took 10% responsibility of the livestock losses in the past year, while wolves and diseases constituted 45% and 42%, respectively.

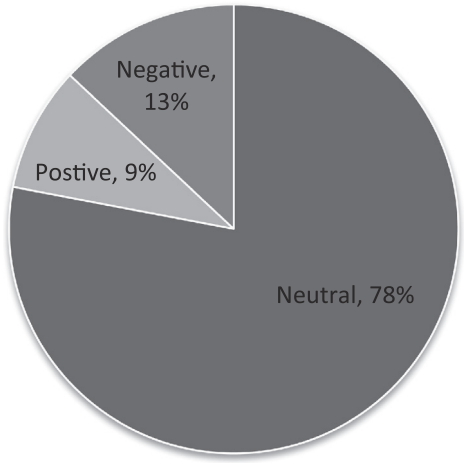

Fig. 3. Culture image of snow leopards ($n = 144$). Thirty-eight percent of respondents knew about folklore pertaining to snow leopards. Among them, 78% of the folklore was neutral, while 9% was positive and 13% was negative.

and analgesia, which make them useful for toothaches; leopard bones are thought to dispel wind and cold and strengthen muscles and bones, which make them useful for arthralgia, backache, bone marrow diseases, anthrax and dog bites; the ashes of leopard bones reportedly can be used to remove tumors; leopard meat is thought to ward off evil spirits, and so was used to treat mental disorders; the hair could be used to stop bleeding, and would be used in conjunction with black bear galls and brocades (Qinghai Medicines Inspection Office and Qinghai Tibetan Medicine Institute 1996). In spite of these traditional Tibetan medical uses, Tibetan doctors told us that they seldom used snow leopard parts in their medicine in the past, because of a lack of raw materials.

Table 3
Species that local herders disliked most if they appeared in their pasture ($n = 124$, multiple-choice).

Category	Count	Percent of responses (%)	Percent of cases (%)
Wolf	78	50	63
Brown bear	38	25	31
Rodent (Marmot, Pika, Rat)	10	6	8
Snow leopard	7	5	6
Blue sheep	4	3	3
White-lipped deer	4	3	3
Caterpillar	3	2	2
None	11	7	9
Total	155	100	125

In 1998, the Law of the People's Republic of China on the Protection of Wildlife was issued, and the snow leopard was listed as a first class protected animal at the national level. This means that anyone who kills and/or sells snow leopard parts might be sentenced to more than 10 years in prison. This appears to have dissuaded local people from using them. There seems to be currently no demand for snow leopard parts by households, and a return to the Tibetan traditional use does not appear to be a threat to snow leopards in the Sanjiangyuan Region.

4.2. Snow leopards caused relatively few livestock losses in this area

Our results showed that the alleged livestock losses to snow leopards in the past year in the Sanjiangyuan Region constitute 1.3% of total livestock per household (1.8% of sheep/goats and 0.9% of yaks). This percentage is lower than that in Nepal, Pakistan, Gya-Miru Wildlife Sanctuary in India and Taxkorgan Nature Reserve in Xinjiang, China and Kibber Wildlife Sanctuary in India (Hussain, 2000; Mishra, 1997; Namgail et al., 2007; Oli et al., 1994; Schaller et al., 1987) (Table 4). Most of the respondents did not reportedly kill wildlife, and we only found cases of 3 herders

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Table 4
Livestock depredation by snow leopards in 1 year in different areas.

Study area	Percent of livestock holdings[a]			Data sources
	Sheep/ Goat (%)	Yak (%)	Total (%)	
Taxkorgan NR, Xinjiang, China	7.6	1.7	5.9	Schaller et al. (1987)
Annapurna Conservation area, Nepal	9.8	2.9	2.6	Oli et al. (1994)
Kibber Wildlife Sanctuary, India[b]	14.9	12.9	12.0	Mishra (1997)
Baltistan, Pakistan			2.0	Hussain (2000)
Gya-Miru Wildlife Sanctuary, India	2.2	3.3	2.9	Namgail et al. (2007)
Sanjiangyuan, Qinghai, China	1.8	0.9	1.3	Our study

[a] Some of these numbers were calculated according to the reported data in previous studies. Snow leopards only prey on yaks and sheep/goats in the Sanjiangyuan Region, but they also eat horses, donkeys and other livestock which we do not show in this table.
[b] This study did not differentiate losses caused by snow leopards and wolves.

involved in killing 6 snow leopards in the previous 3 years throughout the whole Sanjiangyuan Region (Li et al., 2013). It indicates that the intensity of human-snow leopard conflict in this area is likely to be relatively low.

Compared to the alleged livestock losses attributed to wolves or disease in this area, snow leopards also caused much lower losses. Wolf related mortality of livestock totaled four times the losses attributed to snow leopards. This figure may actually be a low estimate for the entire region given that we only interviewed households near snow leopard habitat. Clearly wolves are a larger cause of conflict.

Disease also caused about four times the number of the alleged livestock losses as snow leopards (Table 2). Based on the interviews, most disease related mortalities were caused by common and treatable diseases. Livestock deaths may have resulted because the herders could not contact a veterinarian in time or the veterinarian did not have the experience or proper medication with which to treat the disease.

4.3. The relative neutral perception of snow leopards by local herders

Snow leopards may not have historically had much conflict with local herders, which may be reflected in the neutral (78%) and positive (9%) cultural images in snow leopard folklore (Fig. 3). Correspondingly, only 6% respondents disliked snow leopards most, which are much less than people who disliked wolves (63%), brown bears (31%) or rodents (8%). In turn, the relative neutral perception of snow leopards may lead to more tolerance from local herders, and win more support for snow leopard-related conservation activities (Consorte-McCrea, 2011).

4.4. Conservation implications

In all, we found that snow leopards were seldomly used by Tibetan tradition nowadays, and they caused relatively few livestock losses in the Sanjiangyuan Region on the Tibetan Plateau. Correspondingly, local herders had a relative neutral perception of snow leopards, and we found only 3 local herders killed 6 snow leopards in the past 3 years throughout the whole Sanjiangyuan Region (Li et al., 2013). Therefore, we may conclude that the human-snow leopard conflict is relatively low in this area.

However, snow leopards could be implicated by the negative behavior towards wolves. Because the alleged total livestock losses caused by wolves were damaging there, and wolves ranked first in the animals which local herders disliked most, local herders showed negative behavior to the wolves. We found several cases of local herders using poison or traps to kill wolves, but unintentionally also killed snow leopards. One reason may be that snow leopards have a habit to return to unfinished kills. Considering that human-wolf conflict is so universal, the retaliatory killing of wolves might be a potential threat to snow leopards. Besides, the big losses of livestock to disease may reduce herders' resilience to livestock depredation by carnivores like wolves and snow leopards.

This highlights that human-wildlife conflict is not a simple problem that can be solved by addressing a single species. A realistic solution will require an integrative approach. Qinghai Province has already started a financial compensation scheme in 2012. Based on our findings, Shanshui Conservation Center also has already launched a pilot insurance program to enhance local herders' herding practice and compensate for their economic losses in Nangqian County in the Sanjiangyuan Region since 2011. The positive cultural image of snow leopards may also be used in snow leopard conservation. Shanshui Conservation Center have cooperated with 4 monasteries in the Sanjiangyuan Region since 2009, where the Rinpoche, Khenpos were requested to emphasize the special value of snow leopards and other wildlife in their religious convocations in combination with the folklores we collected. We also suggest proving pertinent training to the community veterinarians in these remote areas.

Our detailed information of influencing factors and conservation implications of human-snow leopard conflicts laid a foundation for the future snow leopard and sympatric carnivores' conservation programs in the Sanjiangyuan Region on the Tibetan Plateau. Considering the economic and culture similarities, this information could be more or less generalized to other places on the Tibetan Plateau, covering about half of the snow leopard range.

Acknowledgments

We thank Panthera, the International Snow Leopard Trust and Shanshui Conservation Center for their financial support for this research. We also thank Qinghai Forestry Department and Sanjiangyuan National Nature Reserve Administration for all aspects of their support. We would like to extend our appreciation to Gama caiwang, Renzeng duojie, Gala, Dawa jiangcai, Zhaduo, Zhaxi sange, Jiahua sandan, Zhaxi duojie, Ouyao, Caidan, Nacuo from Sanjiangyuan Region for their help in the interviews. We are thankful for Byron Weckworth and George Schaller who helped in giving suggestions and clarifying the English writing.

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