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COMMUNICATION

LIVING WITH LEOPARD *PANTHERA PARDUS FUSCA* (MAMMALIA: CARNIVORA: FELIDAE): LIVESTOCK DEPREDATION AND COMMUNITY PERCEPTION IN KALAKKAD-MUNDANTHURAI TIGER RESERVE, SOUTHERN WESTERN GHATS

Bawa Mothilal Krishnakumar, Rajarathinavelu Nagarajan & Kanagaraj Muthamizh Selvan

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Living with Leopard *Panthera pardus fusca* (Mammalia: Carnivora: Felidae): livestock depredation and community perception in Kalakkad-Mundanthurai Tiger Reserve, southern Western Ghats

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Abstract: Livestock depredation by large carnivores and retaliatory killings have become worldwide conservation issues. Leopard depredation of livestock across their range undermines public support for their conservation, resulting in contentious coexistence between the leopard and humans. Lack of knowledge on the patterns of livestock depredation often hinders the formulation of effective conservation management policies. We conducted a questionnaire survey on 656 respondents to assess the extent of livestock depredation and their attitudes towards leopards. Leopard kills included goats (49%) as the main prey, followed by the domestic dog (28%), hen (12%), sheep (5%), cow (4%), and cat (2%). Our results show that depredation varied significantly across seasons (KW = 30.33, df = 2, P < 0.05); 47% of domestic animals were killed during monsoon, followed by 33% in winter, and 20% in summer. Leopards killed 49.96% of goats as they grazed, 50% of sheep when tethered at the house, 67% of cows while in the corral, and 59% of dogs while they roamed freely around the house. Though local people experienced significant levels of livestock losses, about 68% expressed positive attitudes towards leopard conservation. Positive attitudes were revealed by their awareness about conservation and by moral consciousness towards killing of animals, which is forbidden in their religion. In the present study site, fodder cultivation and stall feeding would reduce the grazing-related attack. Similarly, simple changes in the husbandry practices such as closed fence type instead of stockade, effectively reduce enclosure-related depredation.

Keywords: Attitude, depredation, human-wildlife interaction, KMTR, Leopard, livestock kill.

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For **Author details** & **Author contribution** see end of this article.

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INTRODUCTION

Globally, the interaction between people and wildlife is ubiquitous and has been one of the main daunting challenges to wildlife conservation (Khorozyan et al. 2015). The ever-increasing human population encroaching habitats of large carnivores has resulted in a major reduction in their habitat which is also essential for their prey species to endure and thrive (Mijiddorj et al. 2018). In consequence, carnivores pose a direct, real or perceived threat to humans and livestock resulting in human and livestock losses (Dhungana et al. 2019). Depredation of livestock is the most frequent between humans and large carnivores (Linnell et al. 2001; Mwakatobe et al. 2013). It becomes extremely grave when rural people reside close to the protected areas and share the space as that of wildlife (Khorozyan et al. 2015). Other influential factors include high predator density following successful reintroduction or conservation effort (Suryawanshi 2013; Sidhu et al. 2017), low density of natural prey (Meriggi & Lovari 1996; Mizutani 1999; Stoddart et al. 2001; Polisar et al. 2003), abundance of livestock (Bagchi & Mishra 2006), rainfall (Patterson et al. 2004; Woodroffe & Frank 2005; Dhungana et al. 2019), livestock husbandry practices (Meriggi & Lovari 1996; Ciucci & Boitani 1998; Stahl et al. 2001; Madhusudan 2003; Ogada et al. 2003), lack of anti-predatory behaviour in livestock (Landa et al. 1999; Bagchi & Mishra 2006), and characteristics of attacked farms, villages, and livestock enclosures (Mech et al. 2000; Ogada et al. 2003). Areas that provide concealment for carnivores to come within range of livestock without being seen (Woodroffe & Ginsberg 1998) is also one of the important influencing factors

Among the big cats, the leopard is the most widespread species (Nowell & Jackson 1996) across Africa, Asia, and from the Middle East to the Pacific Ocean (Jacobson et al. 2016). Presently, it occupies 25–37 % of its historic range (Jacobson et al. 2016). Regardless of large range and greater adaptability, the IUCN Red List assessment (2016) has categorized the species as Vulnerable owing to >30% decline of their population worldwide over three generations (Stein et al. 2016) following habitat loss, hunting, prey reduction, and negative interactions with humans (Ripple et al. 2014; Jacobson et al. 2016). The Indian subspecies, *Panthera pardus fusca*, exists in all the forested habitats of the country, and is absent only in the arid deserts and above the timberline in the Himalaya (Prater 2005; Ramesh 2010). In the Western Ghats, it occupies an area of c. 43,353km^2 (Jhala et al. 2008)

Historically, there is continuous interaction between humans and large carnivores in India (Seidensticker & Lumpkin 1991). Among the large carnivores, the leopard is reported to cause the greatest percentage of livestock depredation in certain regions (Sangay & Vernes 2008; Dar et al. 2009; Karanth et al. 2013; Thorn et al. 2013). This creates a hostile attitude towards leopards among the local people, occasionally leading to the persecution or retaliatory killing of the leopard (Athreya & Belsare 2007; Ogra 2008; Lorraine 2014; Acharya et al. 2016). Conservation of large carnivores is of great concern when local communities present a negative attitude towards them (Lucherini & Merino 2008).

Lack of knowledge on the patterns of livestock depredation often hinders the formulation of effective conservation management policies. An explicit understanding of the extent of livestock depredation inclusive of areas, periods with high levels of depredation, and perception of local communities is crucial to address human-carnivore negative interactions (Dar et al. 2009). Though predation of livestock by large carnivores has been widely studied in India (Badola 1998; Bagchi & Mishra 2006; Allendrof 2007; Ogra 2008; Selvan 2013; Athreya et al. 2013; Bhatia et al. 2013; Suryawanshi et al. 2014; Acharya et al. 2016), the pattern of livestock depredation in the Kalakkad-Mundanthurai Tiger Reserve in Tamil Nadu (hereafter referred as KMTR), remains unclear, hence impeding the development of effective leopard conservation and conflict management strategies.

Basing on the above premise, we investigated the degree of livestock predation by leopard and the attitudes of local communities towards conservation of large carnivores in KMTR. We hypothesized high percentage of livestock depredation during monsoon season as the increased plant productivity would facilitate stalking cover for leopard. Our present study will provide an important baseline for further research and evaluation of conservation initiatives aimed at leopards and carnivores in general. Further, we also proposed the conservation implications of the present study and discussed the practical actions to mitigate the human-leopard interactions.

MATERIAL AND METHODS

Study area

KMTR (900km^2) is located in the Asahmbu Hills, in the Agasthiyamalai region (8.357–8.33° N & 77.169–77.574° E), at the southern end of the Western Ghats, in

Tamil Nadu, India (Figure 1). The terrain is mountainous with elevation ranging 100–1,866 m and the vegetation type ranges from dry thorn scrub to montane evergreen forest. KMTR receives rainfall from both southwest (June–September) and northeast (October–January) monsoons. The annual rainfall is about 3,000mm, and the temperature fluctuates between 17°C and 37°C over a year. KMTR is bordered by agricultural lands with human settlements (about 145 villages) in the east (Arjunan et al. 2006), whereas in the west there are extensive forests of Kerala. The rivers Peyar, Karaiyar, Kavuthalaiyar, Servalar, Chithar, and Pambar and their tributaries drain into a perennial river called the Tamiraparani. The sympatric carnivore species include the Tiger *Panthera tigris*, Leopard *Panthera pardus* and Wild Dog *Cuon alpinus*. The major wild ungulate prey species available to these sympatric carnivores are Gaur *Bos gaurus*, Sambar *Rusa unicolor*, Spotted Deer *Axis axis*, Wild Boar *Sus scrofa*, Nilgiri Tahr *Hemitragus hylocrius*, Barking Deer *Muntiacus muntjak*, and Indian Chevrotain *Moschiola indica*. Additionally, several smaller prey species such as Tufted Grey Langur *Semnopithecus priam priam*, Nilgiri Langur *Semnopithecus johnii*, Bonnet Macaque *Macaca radiata*, Lion-tailed Macaque *Macaca silenus*, Indian Hare *Lepus nigricollis*, Indian Crested Porcupine *Hystrix indica*, Indian Giant Squirrel *Ratufa indica*, Indian Peafowl *Pavo cristatus*, Grey Junglefowl *Gallus sonneratii*, and Red Spurfowl *Galloperdix spadicea* also exist (Johnsingh 2001). The reserve also supports Sloth Bear *Melursus ursinus* and wide diversity of medium and small-sized carnivores such as Jungle Cat *Felis chaus*, Leopard Cat *Prionailurus bengalensis*, Rusty Spotted Cat *Prionailurus rubiginosus*, Common Palm Civet *Paradoxurus hermaphroditus*, Small Indian Civet *Viverricula indica*, Brown Palm Civet *Paradoxurus jerdonii*, Grey Mongoose *Herpestes edwardsii*, Ruddy Mongoose *Herpestes smithii*, Brown Mongoose *Herpestes fuscus*, and Stripe-

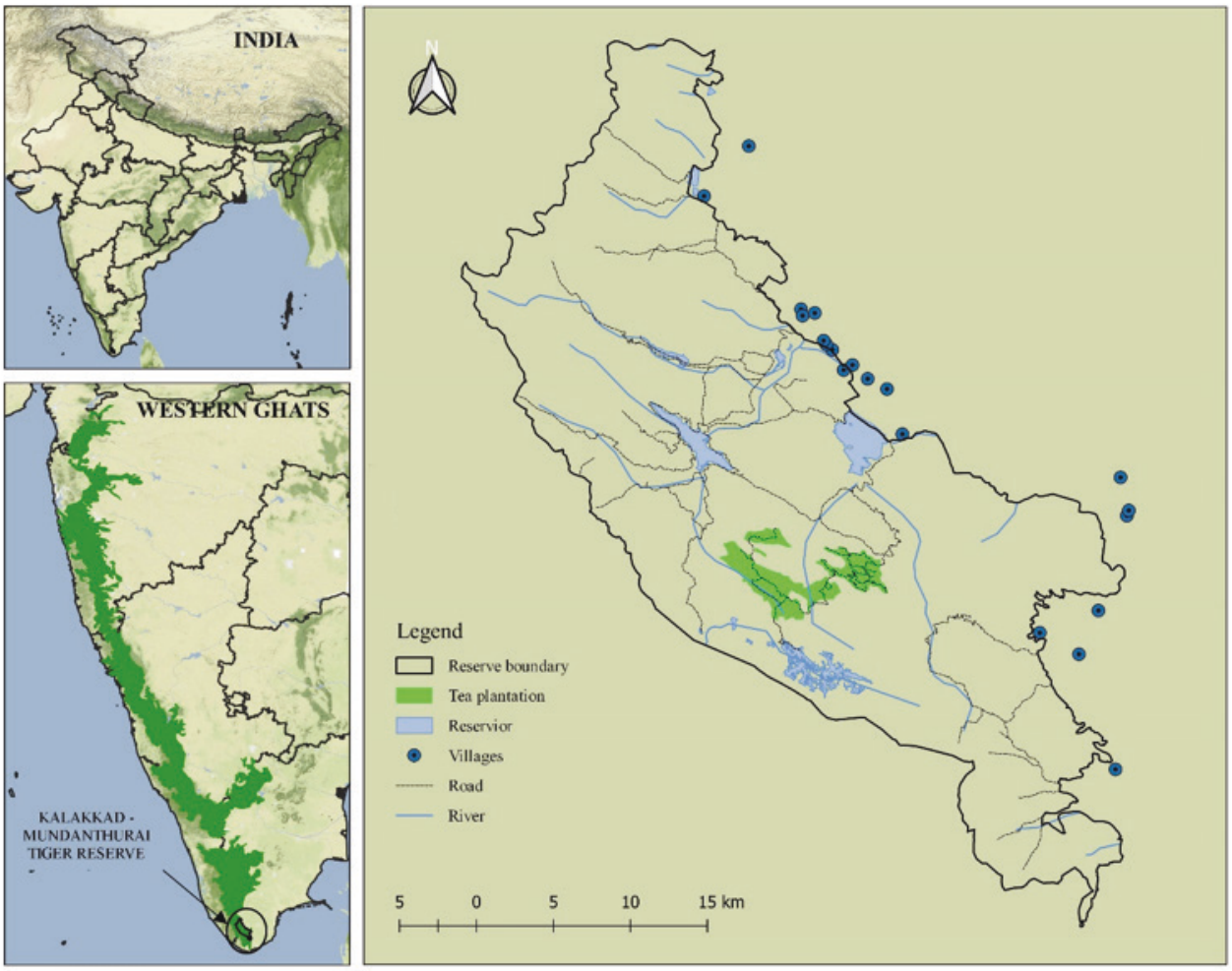

Figure 1. Location of surveyed villages in the periphery of Kalakkad-Mundanthurai Tiger Reserve.

necked Mongoose *Herpestes vitticollis* (Mudappa 1998; Johnsingh 2001; Mudappa et al. 2007). The people inhabiting in this region are either agro-pastoralists or pastoralists. Local people raise cattle, sheep and goats, herded them during the day to the foothill of KMTR and brought back home.

Data collection and analyses

The data for the present study were collected between the years December 2016 and December 2018. The sample included 19 randomly selected villages along one kilometer distance from the eastern boundary of the reserve. Incidents of livestock depredation and the attitudes of local residents were investigated through questionnaires distributed to 656 respondents. Majority of the livestock graze at the foothills of KMTR, usually attended by herdsman, and occasionally by domestic dogs. Respondents included resident adults (≥ 18 years old) were interviewed (Suryawanshi et al. 2014). All the interviewees were assured of anonymity, and were priory informed of the aims and objectives of the study, befor their participation in the interview. The questionnaire was divided into two sections, wherein the first section provided information on the following aspects to assess the pattern of predation: (1) species of livestock killed (goat, sheep, dog, hen, and cow), (2) season, (3) activity of livestock at the time of kill (grazing, corral, tethered at house, untethered at house, and guarding), and (4) attack by large carnivore on family members within the previous three years. The second section was structured questionnaire that was scored as described by Suryawanshi et al. (2014) to understand the attitudes of the local people towards conservation of leopards. The questionnaire in the second section included the following questions: 1) Do you support the conservation of leopards in KMTR? 2) Would you like to see a leopard in your village or agricultural land? 3) Do you think the conservation of these animals is beneficial for the environment of KMTR? 4) What should be done when a leopard kills your livestock? The total of scores could vary from -2 to 2, with -2 signifying the most negative attitude on a relative scale and 2 signifying the most positive reply. Attitude scores of -1 and -2 was considered negative and 0 was considered unsure, whereas scores > 1 were considered positive (Suryawanshi et al. 2014). To determine the difference in livestock depredation by leopards, the Kruskal-Wallis one way ANOVA was used. All the analyses were conducted in R v. 3.5.2. (R development Core Team 2018).

RESULTS

Livestock depredation by leopard

Of the 656 respondents, 62.3% (n = 409) were males and 35.1% were females (n = 230). Among female respondents 2.6% (n = 17) refused to participate. The oldest respondent was 95 years old, and the mean age was 47.0 ± 12.3 SD. During 2017–2018, a total of 233 domestic animals were reportedly killed by leopards. Leopards primarily killed goat *Capra aegagrus hircus* (49%), followed by domestic dog *Canis lupus familiaris* (28%), hen *Gallus gallus domesticus* (12%), sheep *Ovis aries* (5%), cow *Bos taurus* (4%), and cat *Felis catus* (2%) (Figure 2). Livestock depredation was recorded in all the surveyed villages. Among the sampled villages, we found Pethanpillaikudiyiruppu (27%), Anavankudiyiuruppu (17%), and Vembaiyapuram (12%) to be highly prone to depredation. According to the respondents in 19 villages, none of the fatal attacks on human beings or kills by large carnivores had occurred in the park in the last three years.

There was significant difference in livestock depredation by leopards among various seasons (KW = 30.33, df = 2, $P < 0.05$). About 47% (n = 108) domestic animals were killed during monsoon, followed by 33% (n = 74) in winter and 20% (n = 46) in summer (Figure 3). Correspondingly, 29% (n = 66) attacks were during day time and 71% (n = 162) during night, and the difference was marginally significant (KW = 45.82, df = 1, $P < 0.05$). The presence of a herdsman while livestock were grazing did not deter leopard attack, in any of the cases. About 58% (n = 108) livestock had been depredated while grazing and 25% (n = 47) while in the corral. In terms of location of livestock prior to attack, 50% (n = 54) of goats were killed while grazing, whereas, 50% (n = 6) sheep were killed when tethered near to the house, 67% (n = 6) cows were killed in the corral (Figure 4), and 59% (n = 38) dogs had been killed while roaming freely around the house (Figure 5). There was significant difference in location of livestock depredation among goats (KW = 50.3, df = 3, $P < 0.05$) and dogs (KW = 36, df = 3, $P < 0.05$), whereas this was not significant in case of sheep (KW = 3.5, df = 3, $P > 0.05$) and cows (KW = 5.15, df = 3, $P > 0.05$).

Local people's attitude

Despite the livestock depredation, the respondent's (68%) overall attitude towards conservation of leopards was generally positive, while 22% were unclear about conservation. There was significant difference between gender, with the males exhibiting more support towards

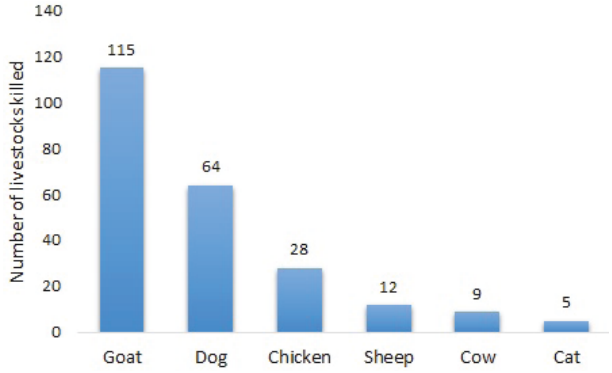

Figure 2. Total number of different domestic and livestock animals killed by leopard from December 2016 to December 2018 in the periphery villages of Kalakkad-Mundanthurai tiger reserve, Tamil Nadu, India.

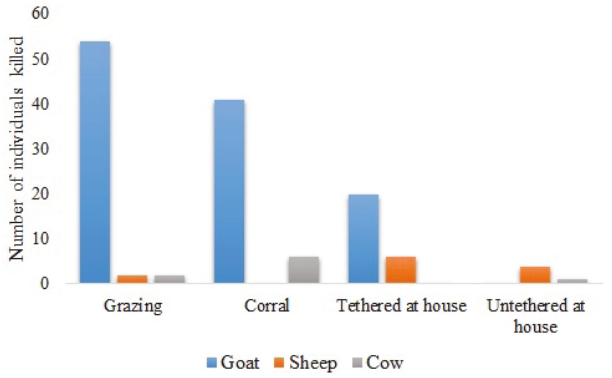

Figure 4. Number of livestock and domestic animals killed in different locations around the house by leopard in Kalakkad-Mundanthurai Tiger Reserve.

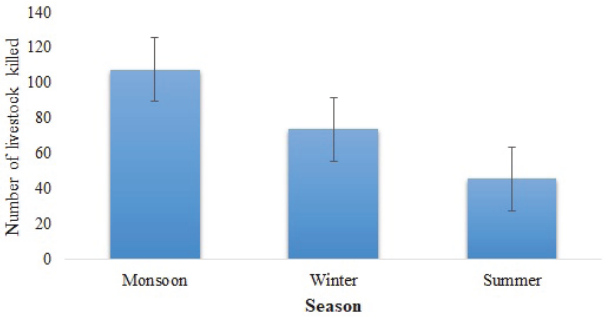

Figure 3. Seasonal variation (Mean±SD) in livestock and domestic animals killed by leopard in the periphery villages of Kalakkad-Mundanthurai Tiger Reserve during the study period.

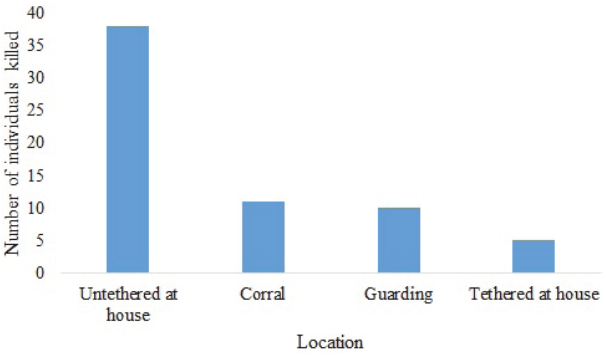

Figure 5. Number of dogs killed by leopard in different locations in the periphery villages of Kalakkad-Mundanthurai Tiger Reserve.

leopard conservation than females (χ^2 = 55.4, df = 2, P < 0.05). About 74% of the respondents opined to not wanting the leopard within the village or agricultural land, while 2% differed with this, and there was no significant difference between the genders (χ^2 = 7.3, df = 2, P>0.05). Among the respondents, only 5% of them showed positive attitudes towards support large carnivore conservation in KMTR, while 51% were unsure and 44% exhibited negative attitudes. There was significant difference between gender, with the males being more aware of large carnivore conservation in KMTR than females (χ^2 = 67.1, df=2, P < 0.05). Respondents were asked about their views on livestock predation by leopard. Of them, only 27% replied that leopard should be translocated to another area, while 26% replied could not do anything about it, 18% accepted their livestock loss, 13% were unsure about this and finally 8% of each respondents replied leopards should be eliminated from their area and they also require food. In the interest of examining the level of interaction following the translocation programme, the effectiveness of such operations were questioned. For which 72% respondents replied the programmes being inefficient. Out of 136 livestock (goat, sheep, and cow) depredation, only 25% people had applied for compensation, while 75% did not. In most instances, people were dissatisfied with the compensation provided by the forest department for livestock losses.

DISCUSSION

Livestock depredation by leopard

Our study showed that leopards mostly predated on medium-sized livestock, such as goats and sheep (54% of all killings), and hence it is concurs with the report of Sangay & Verne (2008), and Dar et al. (2009). Though, leopard kill wide range of prey species, from arthropods to adult sambar or gaur (Seidensticker 1976), they usually prefer prey species weighing between10–40 kg (Hayward et al. 2006) and 2–25 kg (Lovari et al. 2013). The optimal body size of goats (5–25 kg; Lovari et al.

2013) combined with their non-defensive behaviour, and the relative ease of killing and lugging to a safe place after extermination (Kabir et al. 2013) may have contributed to higher goat depredation rates in KMTR.

It was found that among the sampled villages, Pethanpillaikudiyiruppu, Anavankudiyiuruppu, and Vembaiyapuram were highly prone to livestock depredation. Davidar (2018) reviewed the terms used in human-wildlife conflict. As the areas located close to the forest boundary and frequently had significant livestock depredation and therefore the areas are considered as conflict hotspots. More incidents of depredation occurred during monsoon compared with summer. This could be ascribed to highest rainfall during monsoon resulting in increased vegetation cover such as shrub and undergrowth which provide good cover for leopards (Balme et al. 2007) as recorded elsewhere (Patterson et al. 2004; Kolowski & Holekampt 2006). Though livestock was killed in corral or shed, 58% of livestock kill were reported when grazing near the forest boundary, since animals grazing near protected areas expose them to predators. Such grazing associated losses are common elsewhere, and often difficult to limit or alter (Karanth & Nepal 2012; Karanth et al. 2012), however, it is suggested that cultivation of fodder and stall feeding could be effective against such grazing associated depredation. Livestock in corrals are usually safe against predators (Kaczensky 1999), but still suffer predation in KMTR. In the present study, it was observed that the corral or shed was covered on four sides with a palisade to a height averaging four feet either with a top cover or the shed had only the top cover. Thus, imperfect sheds with restricted movement of livestock made them vulnerable to predation at night compared with daylight. Similar depredation patterns were observed in the Bandhavgarh Tiger Reserve (Chouksey et al. 2017), Pir Lasoora National Park (Kabir et al. 2017), and the Macharia National Park (Kabir et al. 2013; Dar et al. 2009). Even with such experience, the livestock owners did not appear to improve the shed to reduce further loss (Krishnakumar pers. obs. 2018), and were more likely to devote time and resources to improve their livestock protection strategies. Husbandry practices can significantly impact the risk of livestock predation by large carnivores (Ogada et al. 2003; Stein et al. 2010). Therefore, fencing livestock instead wooden stockade could effectively reduce enclosure related depredation.

The dog was the most killed domestic animal than livestock, as 59% of them were killed when roaming freely around the house. Since the dog is reared for the purpose of guarding, it is left untethered, making it vulnerable to predation which can be easily killed and dragged. In addition, the dog plays a significant role in the diet of leopards across India (Mukerjee & Mishra 2001; Edgaonkar & Chellam 2002; Athreya et al. 2004). In spite of the fact that dogs are impotent against a leopard attack, local villagers rear dogs believing that livestock losses would be higher without dogs, and that a leopard would attack humans in the absence of dogs. This kind of thinking has been observed in Iran also (Khorozyan et al. 2017).

Local people's attitudes

The support of local people and their contribution to the conservation of carnivores is mostly due to the value they place on large carnivores (Gusset et al. 2009). In the present study, majority of the respondents presented an optimistic attitude towards the leopard and its conservation. This may be attributed to awareness about conservation, and to some extent, moral conscience or being forbidden by their religion to kill animals, and may help potential long-term conservation of this species in the reserve. More positive attitudes towards leopard conservation were observed among men when compared with women, and is probably ascribed to greater fear about carnivores in women (Zaffar et al. 2015), who tend to dislike fearsome species (Schlegel & Rupf 2009). In most cases, men tended to have a more positive attitude towards conservation than women (Butler et al. 2003; Røskaft et al. 2007). Majority of the respondents were disinclined to see the leopard either in their village or agricultural land due to fear. All the respondents expressed dissatisfaction over the existing compensation scheme, and were unwilling to report cattle losses by predators to the local wildlife authority due to the long administrative process that resulted in delayed payments, insufficiency in amount, and precondition for applying compensation such as difficulties in verifying leopard attacks.

The capture and translocation of problematic animal is the existing mitigation policy and is most widely used in India, besides the compensation payment (Athreya et al. 2010). In KMTR, the forest managers are often forced to remove animals in response to complaints from people. But such translocation programme does not appear to reduce the level of negative interactions, however, 27% of the respondents expressed that the depredating leopard should be translocated, may be because in certain villages, it had not been translocated so far. Translocation of carnivores can have undesirable effects (Athreya et al. 2010), as majority of post translocation studies have reported that such animals

perish due to capture-related stress, injuries, and extensive post release movements (Linnell et al. 1997; Miller et al. 1999; Letty et al. 2007). Moreover, following translocation, carnivores often reappear at the captured site in a relatively short time (Rogers 1988). A few studies have reported that translocated carnivores continue to engage in greater negative interactions (Stander 1990; Bradley et al. 2005).

The high proportion of livestock loss is attributed to leopards in the present study area, and hence is of prime concern. Educating people to improve livestock husbandry skills is highly recommended. Although people are infuriated due to livestock depredation by leopards, they do not persecute them as in other parts of central Asia (Mishra & Fitzherbert 2004) because of strict statutes. Considering the increasing number of depredations by leopards in human-dominated habitats outside KMTR, where communities might incur significant economic loss, the conservation of leopards will depend on support from local communities. This can be ensured by addressing the issue of human-leopard interactions in an effective manner. It is also emphasized that assessing the extent of predation alone is not likely to lead to effective conservation planning as people are hostile towards wildlife officials. Field experience has shown that crop damage is a significant responsible factor for negative attitude towards the staff of the forest department, so reducing crop damage could have a strong positive effect.

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