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Cover: Muggar Crocodile basking on the banks of Savitri River at Mahad in Maharashtra, India. © Utkarsha M. Chavan.



Crop raiding and livestock predation by wildlife in Khaptad National Park, Nepal

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Abstract: Crop raiding and livestock predation are major conservation problems throughout most protected areas in Nepal, including the Khaptad National Park (KNP). However, no information exists on the extent of crop raiding, livestock predation, and animal attacks among villages surrounding KNP. We conducted a survey of 304 households in 30 villages in four districts (Bajhang, Bajura, Doti, and Achham) in the buffer zone of KNP between 24 May and 20 June 2019, using the snowball sampling technique. All households experienced numerous major incidents of crop raiding between April 2017 and May 2019. Major wildlife involved were Wild Boar *Sus scrofa*, Himalayan Black Bear *Ursus thibetanus*, Rhesus Macaque *Macaca mulatta*, Barking Deer *Muntiacus vaginalis*, Common Leopard *Panthera pardus*, Golden Jackal *Canis aureus*, and Porcupine *Hystrix* spp. Of the 304 households, all had their crops raided over the past two years, 55.5% (n = 169) faced livestock predation, and 2% (n = 6) attacks resulting in death or injury. Over 40% of households reported taking mitigation measures to minimize crop raiding. Common measures such as night guarding, noise making, use of scarecrows, watch dogs, and fencing were practiced. More than half of respondents had negative opinions towards wildlife but they still believed that wildlife should be conserved. There was no or negligible correlation between general opinion of respondents towards wildlife and wildlife conservation with their education, sex, or involvement in natural resources management group. We established baseline information on crop raiding and livestock predation in villages surrounding KNP. Gathered information will be transmitted to relevant authorities to design and implement measures to mitigate such conflicts.

Keywords: Buffer zone, Common Leopard, protected area, Wild Boar.

Abbreviations: BNP—Bardiya National Park | CNP—Chitwan National Park | GCA—Gaurishankar Conservation Area | KCA—Kanchenjunga Conservation Area | KNP—Khaptad National Park | SNNP—Shivapuri Nagarjun National Park.

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Author contribution: AB, S. Shrestha, NA and BPY conceptualized and designed the study. AB, S. Sharma, NK and NS conducted surveys, collected and compiled data. AB performed data analysis. AB and S. Sharma prepared the manuscript. All authors reviewed the manuscript.

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INTRODUCTION

Nepal has designated 23% of its total land mass as protected areas, and approximately 29% of the country's forestland outside protected areas are designated as community forests, managed sustainably by local communities (Acharya et al. 2016). Success of community forestry programs nationwide and the initiation of buffer zone programs surrounding protected areas from 1990s in Nepal created an additional habitat beyond protected areas (Gurung et al. 2008; Acharya et al. 2016). This resulted in an increase in both movement of wildlife in newly developed habitats and consequently the frequency of crop raiding, livestock predation as well as animal and human attacks (Gurung et al. 2008). Conflict between humans and wildlife has become a significant problem on a global scale (Wang & Macdonald 2006) and one of the most complex conservation challenges faced by conservationists and local communities around protected areas (Banikoi et al. 2017). Such conflicts bring many social, economic and ecological consequences and if the damages severely affect the livelihood of local communities, getting their active support for conservation will be challenging (Mishra 1997). Thus, careful planning and management is required if the dual goal of wildlife conservation and support of communities is to be achieved (Madden 2004; Acharya et al. 2016).

The mid-hill mountain zone is under-represented in Nepal's protected system (Acharya et al. 2016). One such protected area that encompasses the mid-hill to lower Himalayan region of Nepal is the Khaptad National Park (KNP). Crop raiding and livestock predation are major conservation problems in most protected areas in Nepal (Banikoi et al. 2017). Various dimensions of human-wildlife negative interactions have been assessed in different protected areas of Nepal, including Gaurishankar Conservation Area (GCA; Awasthi & Singh 2015), Kanchenjunga Conservation Area (KCA; Sherchan & Bhandari 2017), Shivapuri Nagarjun National Park (SNNP; Pandey et al. 2016; Pandey & Bajracharya 2016), Bardiya National Park (BNP; Thapa 2010), and Chitwan National Park (CNP; Banikoi et al. 2017; Lamichhane et al. 2018). However, no information exists on the extent of crop raiding, livestock predation and animal attacks across the buffer zone of KNP.

MATERIALS AND METHODS

Study area

Khaptad National Park (29.37°N, 81.15°E; Image 1) is situated in Province 7 of Nepal that covers an area of 225 km² with an elevation range 1,000–3,276 m (GoN/MoFSC 2014). It is the only national park in mid-hill to lower Himalayan region in western Nepal and represents a unique and important ecosystem (DNPWC 2019). KNP harbors dense forest of genus *Shorea*, *Pinus*, and *Alnus* in subtropical zone; *Quercus*, *Aesculus*, *Daphniphyllum*, *Abies*, & *Peceea*, in temperate zone and *Quercus*, *Taxus*, & *Betula* in subalpine zone (DNPWC 2019). It is home to 266 species of migratory and residential birds, 20 species of mammals, 15 species of butterfly, 192 species of flowering plants (Mishra 2000) and 224 species of medicinal plants (Kunwar & Duwadee 2006). The buffer zone in KNP was established in 2006 spreading over four districts (Doti, Achham, Bajhang, and Bajura) and covering an area of 216 km² (DNPWC 2019).

Data collection and analysis

We employed open-ended questionnaires to households in various villages in the buffer zone of KNP using the snowball sampling technique between 24 May 2019 and 20 June 2019 (Image 1). We collected data on five major topics including general socio-economic information of respondents, crop-raiding incidents, livestock predation, animal attacks, and attitude towards wildlife. We took prior informed consent of respondents (generally head of the family) before administering questionnaire. We gathered information on conflict incidences that occurred from April 2017 to May 2019. We performed data analysis using Deducer package (Fellows 2012) in R (R Core Team 2018) and presented mean values with standard deviation. We tested for association between variables by performing Spearman's rank correlation test.

RESULTS

Socio-economic status of respondents

We covered 120 km on foot and surveyed a total of 304 households from various villages across the buffer zone of KNP (Image 1). The highest representation surveyed was from villages in the Bajhang district (32.2%; n = 98), and the lowest representation was from Doti (17.1%; n = 52; Table 1). Majority of the respondents were male (71.7%, n = 218) and average age of the respondent was 44.98 ± 15.35 years (17–82

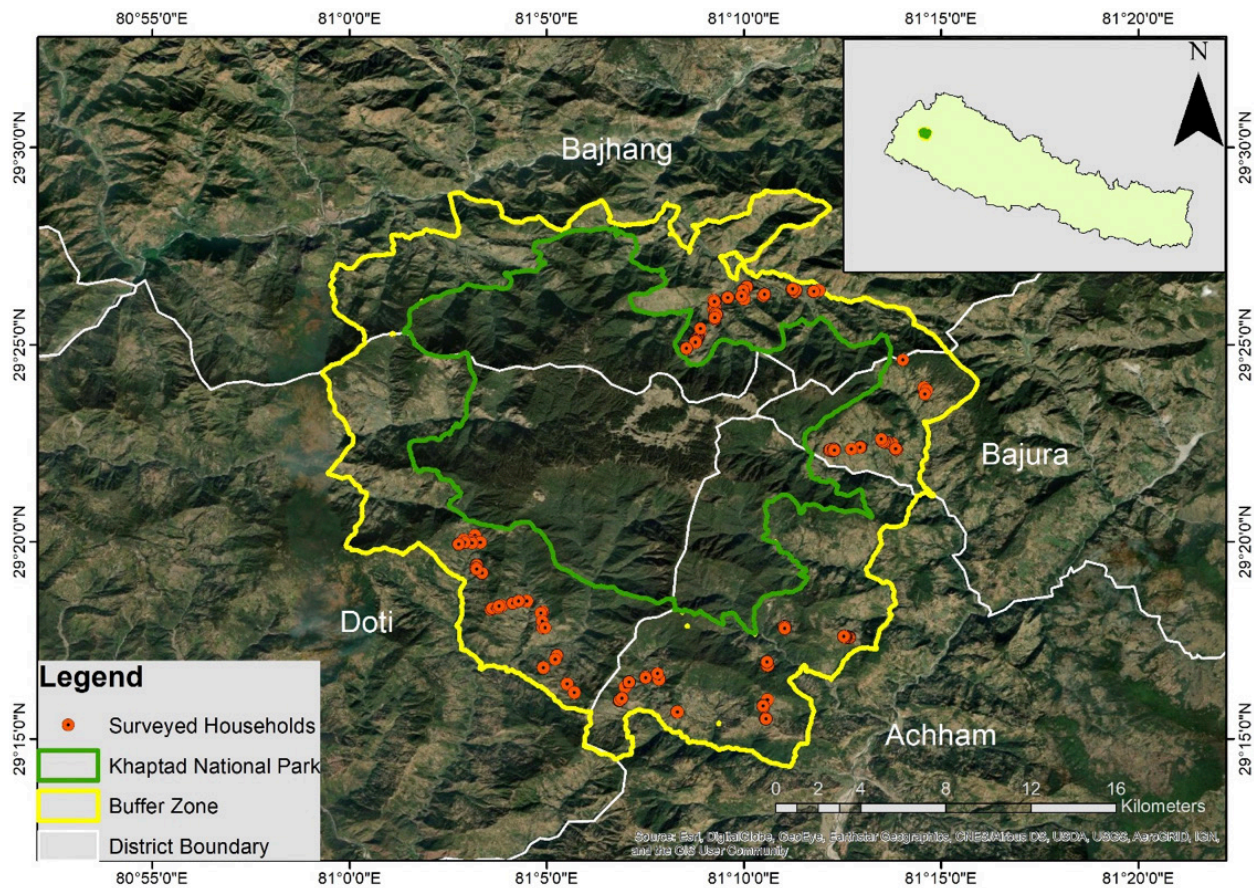


Image 1. Map of Khaptad National Park (also indicated by green shaded area on inset map of Nepal) showing the locations (red circles) where questionnaire surveys were conducted in villages in the buffer zone (indicated by yellow solid line) across four districts – Doti, Achham, Bajura, and Bajhang.

years; Table 1). An average family size was 7.59 ± 2.99 (range = 2–28; n = 304). Although we highly encouraged females to participate in our surveys, female individuals were either shy and nominate males in their house to participate or were occupied with household chores. Around half of respondents (58.6%; n = 178) did not have any formal schooling (Table 1). Agriculture was the dominant occupation (91.1%; n = 277) and average land holding was 1.20 ± 2.43 acres (range = 0.04–36.82 acres; n = 304). Although majority of population were engaged in farming, 34.2% (n = 104) were dependent on remittance as a major source of income (Table 1).

Almost all households were dependent on nearby forest for fodder (99.3%; n = 302) and firewood collection (99.7%; n = 303). A small fraction of respondents (14.15%; n = 43) were involved in natural resources management groups (KNP buffer zone management committee, and community forest users group etc.) with an average involvement of 0.87 ± 2.81 years (range = 0–28 years). Major livestock raised were cows (91.7%; n = 279 households), bulls (66.2%; n = 201 households),

goats (62%; n = 189 households) and buffalos (27.2%; n = 83) with an average holding size of 1.85 ± 1.31 (range = 0–30) for cows, 0.49 ± 0.97 (range = 0–5) for buffalos, 3.52 ± 5.47 (range = 0–60) for goats and 1.18 ± 1.06 (range = 0–6) for bulls.

Crop raiding

All of the surveyed households (n = 304) had experienced numerous incidents of crop raiding between April 2017 and May 2019. Most of the households had experienced crop raiding so frequently during the harvest season that they couldn't recall the exact number of incidents during that time frame. Major crops included rice, corn, wheat, barley, millet, and potatoes. Major wildlife responsible for crop raiding were Wild Boars *Sus scrofa*, Himalayan Black Bears *Ursus thibetanus*, Rhesus Macaque *Macaca mulatta*, Barking Deer *Muntiacus vaginalis*, and porcupines *Hystrix* sp. (Table 2). Rhesus Macaques, Porcupines, Himalayan Black Bears, and Wild Boars were frequent crop raiders and responsible for more than 80% of the raids claimed by households

Table 1. Detailed information on socio-economic attributes of respondents (n = 304) across villages in the buffer zone of the Khaptad National Park, Nepal.

Variable	Variable categories	n	Percentage
Education Level	Illiterate	178	58.6
	Primary	43	14.1
	Lower-secondary	10	3.3
	Secondary	43	14.1
	Higher secondary	22	7.2
	Bachelors	8	2.6
District	Achham	93	30.6
	Bajhang	98	32.2
	Bajura	61	20.1
	Doti	52	17.1
Major occupation	Agriculture	277	91.1
	Service	14	4.6
	Business	7	2.3
	Student	6	2
Main source of income	Agriculture	170	55.9
	Remittance	104	34.2
	Others	30	9.9

(Table 2). Respondents ranked Rhesus Macaques as first, Wild Boars as second, Himalayan Black Bears and porcupines as joint third based on burden to households considering crop-raiding frequency, severity of damage and economic loss incurred (Table 3). Majority of respondents suggested that population of crop-raiding wildlife (98.4%; n = 299) and trend of crop-raiding frequency (97.7%; n = 297) were both increasing.

Livestock depredation

A large number of respondents (55.5%; n = 169) reported their livestock being killed/injured between 2017 and 2019 (Table 4). Common Leopard *Panthera pardus* and Golden Jackal *Canis aureus* were the two species most frequently involved in livestock predation, and some by Himalayan Black Bears (Table 4). Almost all respondents suggested that population of wildlife involved in livestock predation (98.4%; n = 299) and frequency of livestock depredation (98.4%; n = 299) were both increasing. Majority of respondents (78.3%; n = 238) employed herders to graze their livestock in nearby grasslands to discourage wildlife, whereas a small number (1.3%; n = 7) let their livestock graze without a herder. However, we did not find any correlation ($p = 0.23$; $P < 0.05$) between grazing system (presence/absence of herder) and incidents of livestock predation.

Table 2. Major wildlife involved in and total cases of crop raiding across villages in the buffer zone of the Khaptad National Park, Nepal.

Wildlife	Cases involved	Percentage
Wild Boar	301	99
Rhesus Macaque	296	97.4
Porcupine	255	83.9
Himalayan Black Bear	252	82.9
Barking Deer	100	32.9
Golden Jackal	60	19.7
Himalayan Goral	26	8.6
Himalayan Thar	20	6.6
Others	7	2.3

Animal attacks

Only 2% (n = 6) households had cases of animal attacks. Out of the six, four cases were of injury and all involved Himalayan Black Bears and two cases involved loss of human life that resulted from attacks by Common Leopards. Although attacks on human are low, respondents mentioned that they had to live under constant fear of being attacked by wildlife while performing their daily chores such as collecting fodder and firewood, and taking livestock for grazing.

Mitigation measures

From the 304 respondents, almost half of the households (41.4%; n = 126) reported to have used some form of mitigation measures to minimize crop raiding. Guarding crops during night by kudo (Nepali: Burning fire) was the most common measure (65.8%; n = 83) and considered most effective. This practice was used to prevent crop raiding by Himalayan Black Bears and Wild Boars, but proved tiresome and put villagers at risk from potential wildlife attacks. Noise making using metal utensils was the second most used practice (46.03%; n = 58). Approximately 18.25% (n = 23) of households used scarecrows which worked only for the initial few days. Some household used watch dogs (11.9%, n = 15) to chase wildlife (*Rhesus macaques*) during the daytime. Dogs were ineffective, as they were often outnumbered by the macaques. Similarly, some households (7%; n = 10) fenced their farm, but proven ineffective against macaques and Wild Boars. Stone fence was found to be comparatively more effective than wood and bamboo fencing, but was time consuming and expensive to set up. Interestingly, one (0.79%) respondent worshipped 'Hanuman' (Nepali: Hindu Monkey god) during harvest season and believed it helped to prevent crop raiding by monkeys.

Table 3. Crop raiding wildlife ranked by respondents (n = 304) based on burden to them across villages in the buffer zone of the Khaptad National Park, Nepal.

Wildlife	Respondent (n)	Percentage	Rank
Rhesus Macaque	140	46.1	1
Wild Boar	127	41.8	2
Himalayan Black Bear	18	5.9	3
Porcupine	18	5.9	4
Golden Jackal	1	0.3	5

Table 4. Major wildlife involved in and total cases of livestock predation across villages in the buffer zone of the Khaptad National Park, Nepal.

Wildlife	Cases involved	Percentage
Common Leopard	121	39.8
Golden Jackal	39	12.8
Himalayan Black Bear	5	1.6
Others	4	1.3

Attitude toward wildlife

Around half of respondents (53%; n = 198) had a negative opinion towards wildlife (Table 5). Nonetheless, a good proportion of respondents (52.7%; n = 160) still believed that wildlife should be conserved. Majority of respondents (85.2%; n = 259) agreed that if appropriate compensation was provided for their loss, it would encourage them towards wildlife conservation (Table 5). These respondents generally cited “wildlife also has right to live despite the trouble they are causing us by raiding our crops and depredating on our livestock” as a reason for their support for wildlife conservation. Similarly, 84.2% (n = 254) of respondents agreed that if provided with effective measures to alleviate crop-raiding and livestock predation and if the intervention worked effectively, it would encourage them in wildlife conservation. Half of the respondents (51.6%; n = 157) positively believed that their community could benefit from eco-tourism based on wildlife and landscape (forest, alpine meadows) in this region. Whereas 45.7% (n = 139) were neutral in their opinion and mentioned that they had no idea about how eco-tourism could benefit their community and therefore chose to remain neutral.

There was no or negligible correlation between general opinion of respondents towards wildlife and their education ($\rho = -0.30$; $P < 0.05$), sex ($\rho = -0.20$; $P < 0.05$) or involvement in any sort of natural resources management group ($\rho = -0.05$; $P > 0.05$). Similarly, there

Table 5. Attitude of respondents (n = 304) towards wildlife involved in crop raiding, livestock predation and animal attacks across villages in the buffer zone of the Khaptad National Park, Nepal.

Factor	Value	Respondent (n)	Percentage
What is your general opinion on wildlife involved in conflicts?	Strongly positive	4	1.3
	Positive	108	35.5
	Neutral	31	10.2
	Negative	161	40.8
	Strongly negative	37	12.2
In your opinion, should wildlife be conserved?	Strongly positive	2	0.7
	Positive	158	52
	Neutral	81	26.6
	Negative	48	15.8
	Strongly negative	15	4.9
Would appropriate compensation encourage you in wildlife conservation?	Strongly positive	26	8.6
	Positive	233	76.6
	Neutral	26	8.6
	Negative	17	5.6
	Strongly negative	2	0.7
Would implementation of conflict mitigation measures encourage you in wildlife conservation?	Strongly positive	14	4.6
	Positive	242	79.6
	Neutral	40	13.2
	Negative	8	2.6
	Strongly negative	0	0
Would wildlife based eco-tourism be beneficial to your community?	Strongly positive	12	3.9
	Positive	145	47.7
	Neutral	139	45.7
	Negative	7	2.3
	Strongly negative	1	0.3

was no or negligible correlation between opinions of respondents on wildlife conservation and their education ($\rho = -0.30$; $P < 0.05$), sex ($\rho = -0.28$; $P < 0.05$) or involvement in any sort of natural resources management group ($\rho = -0.09$; $P < 0.05$). These findings indicate that negative attitude of respondents towards wildlife and their conservation is most likely due to negative impacts from crop-raiding and livestock predation over other factors.

DISCUSSION

Our findings revealed that crop-raiding is widespread and frequent in villages in the buffer zone of the KNP. Our findings corroborate with other studies and identify Wild boars, Rhesus macaques, porcupines and Himalayan

black bears as main crop raiding wildlife among various protected areas in Nepal (Thapa 2010; Awasthi & Singh 2015; Pandey & Bajracharya 2016; Pandey et al. 2016; Banikoi et al. 2017; Sherchan & Bhandari 2017; Lamichhane et al. 2018). Almost all respondents in our study area mentioned that frequency of both crop raiding and livestock predation have increased over time. Although almost all respondents believed that the wildlife populations involved in crop raiding and livestock predation are also increasing over time, respondent's idea on increasing population of crop-raiding wildlife could very well be based on the increasing frequency of crop-raiding incidents, and as such should be treated cautiously.

Crop raiding with varying levels of magnitude have been reported from various protected and human dominated landscapes in Nepal. Awasthi & Singh (2015) assessed crop-raiding incidents by wildlife in GCA and reported that 84% of households surveyed ($n = 170$), had their crops raided by monkeys, porcupines and Himalayan Gorals. Himalayan Black Bears were also involved in crop-raiding to a smaller extent, but there were no cases on conflicts involving Wild boars in GCA (Awasthi & Singh 2015). In KCA, Civet, Barking Deer, porcupines, squirrel and monkeys have been reported to be frequent crop raiders (Sherchan & Bhandari 2017). The same study also reported recent involvement of Himalayan Black Bears since 2010, but no involvement by Wild Boars. Gurung (2002) identified Wild Boar, Himalayan Black Bear, monkey and porcupine as the major crop raiders in SNNP. Similarly, Ulak (1992), Kattel (1993), and Poudyal (1995) all reported Wild Boar as the frequent crop raider. Maize was the most raided crop by wildlife in SNNP. Although the crops raided varied among regions, the major crops raided included rice, wheat, corn, millet, barley, and potato (Ulak 1992; Kattel 1993; Poudyal 1995; Gurung 2002; Awasthi & Singh 2015; Sherchan & Bhandari 2017). In protected areas of low-land Nepal, such as BNP, CNP and Parsa National Park, Elephants are the main crop raiders (Thapa 2010; Pandey & Bajracharya 2016; Banikoi et al. 2017; Lamichhane et al. 2018).

Protected areas in central and western mid-hill regions of Nepal (SNNP and KNP) appeared to have very high extent and frequency of crop raiding involving Wild Boars and Himalayan Black Bears. Respondents in villages surrounding KNP revealed that crop damage caused by wildlife, like the Wild Boar, was historically low. Traditionally, hunting kept the Wild Boar population in check, but the establishment of the KNP increased the forest area and made it illegal to own a gun and hunt

wild animals, thus increasing crop raiding frequency. The increase in forest area would reduce the forest proximity to farms, which has been determined as one of the factor associated with wildlife damage to crops (Genov et al. 1996; Geisser 2000; Saj et al. 2001; Naughton-Treves et al. 2003; Linkie et al. 2007).

Common Leopards and Golden Jackals were mostly involved in livestock predation in villages surrounding KNP. Adhikari et al. (2018) also reported Common Leopards as the major livestock depredator in Panchase protected forest in the mid-hill region of western Nepal. In Chitwan National Park, Tigers and Common Leopards were involved in >90% of reported livestock depredation ($n = 2213$) between 1998 and 2016 (Lamichhane et al. 2018). The same study also reported that livestock predation by Common Leopards was higher than tigers between 2014 and 2016. Leopards are generalist predators, consuming wide variety of prey, including ungulates, carnivores, rodents, bird and fish. Lack of natural prey and poor husbandry makes domestic animals more vulnerable to attacks by wildlife (Shehzad et al. 2015). A nation-wide survey between 2010 and 2014 showed that the Common Leopard and Himalayan Black Bear along with the Tiger, Elephant, and Rhinoceros as major drivers of attacks on human (death and injury) in Nepal (Acharya et al. 2016).

Due to success of community forestry in Nepal, the spatial distribution of both Common Leopards and Himalayan Black Bears has increased (Acharya et al. 2016). Since these two species have wider distribution in mid-hill region of Nepal, including the buffer zone of the KNP, they are found to be responsible for majority of crop raiding, livestock predation and animal attacks outside protected areas (Acharya et al. 2016). Common Leopards are known to adapt well in human-modified landscapes as well (Acharya et al. 2016). Although more than half of respondents had their livestock predated, they had more negative feelings towards crop-raiding wildlife than those involved in livestock depredation. Livestock predation was only occasional, but crop-raiding occurred frequently all year round.

As the crop yields were severely impacted by the wild animals such as Wild Boars and Rhesus Macaque, we found locals using combinations of measures to minimize crop raiding. Farmers often produced loud noise or fire to deter crop raiding wildlife. Pandey & Bajracharya (2016) reported similar techniques used by the locals during their study in Shivapuri National park. However, they reported that producing loud noises and flames were only effective for shorter period. Saraswat et al. (2015) reported the use of loud noise from

firecrackers, tin cans and dogs to chase away macaques in India. However, such measures were not effective in preventing/minimizing crop raiding (Saraswat et al. 2015). Sterilization of macaques were also tested in Himachal Pradesh of India, but they were not effective either (Saraswat et al. 2015; Anand & Radhakrishna 2020). Sekhar (1998) reported watch tower was the most effective and safer measure in Rajasthan, India but according to our respondents it was not financially feasible in KNP. Farmers worshipping “Hanuman” the monkey god during the harvest season were also reported across India. Sekhar (1998) and Saraswat et al. (2015). In other regions of Nepal techniques like mesh wire fencing, electric fencing, beehive fencing and chilly fencing, trenches are being used (Banikoi 2012; Lamichhane et al. 2018). Habitat enrichment program which addresses the food shortage faced by the Rhesus Macaque by planting of fruit plantations in forests might help them to reduce dependence on human crops (Anand & Radhakrishna 2020).

In general, respondents had negative attitudes towards KNP and blamed the national park for their losses and believed that the national park prioritized wildlife over residents and their crops. Respondents also complained that process of receiving compensation from the national park was lengthy and financially burdensome. For instance, respondents from some villages had to travel 2–3 days to reach the KNP office just to file a case for compensation. So, respondents had to spent good amount of money to pay for their food and accommodation. In many cases, respondents also mentioned that the compensation received for dead livestock, especially horses was less than the actual price of the lost animal. We did not, however, verify these claims with the KNP authority.

CONSERVATION RECOMMENDATIONS

During the survey, we observed that most of the respondents were not fully aware of process and paperwork required to claim compensations from KNP office for the economic loss they had incurred due to crop raiding, livestock predation and animal attacks. We distributed brochures (in Nepali) explaining process for claiming compensations to villagers during our survey and was received positively. We recommend that KNP office and the KNP buffer zone management committee take steps to raise awareness among villagers regarding the process in claiming compensation. Similarly, to the possible extent, the KNP office should

consider simplifying and shortening the compensation process since some of the villagers had to travel 2–3 days to claim compensation. Site and species-specific mitigation measures could be put in place. Exchange of best practice and success stories between farmers from different villages mediated by the KNP office and buffer zone management committee could be helpful in promoting human-wildlife coexistence and fostering healthy park-people relation.

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