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Livestock depredation by Bengal tigers in fringe areas of Kaziranga Tiger Reserve, Assam, India: implications for large carnivore conservation

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Abstract: Bengal tigers (*Panthera tigris*) have cohabited with humans in India for centuries. However, with increasing human populations, human–tiger conflicts (HTC) have increased. Impacts of such conflicts are loss of human life, livestock depredations, and retaliatory killings of tigers. Considering that tiger populations are in decline throughout their range, accurate information regarding the magnitude of the impacts of HTC is needed for tiger conservation. We analyzed livestock depredation data collected over 3 years (April 2008 to March 2011) from villages near the Kaziranga Tiger Reserve (KTR) to determine impacts of HTC. During the study period, we documented 518 livestock depredations by tigers. Cattle (*Bos taurus*) were the primary livestock depredated, with a mean loss of 1.2 livestock head per year per household. Livestock depredation was highest in winter ($\chi^2 = 74.2$, df = 3, $P < 0.05$) and occurred mostly at night ($\chi^2 = 44.9$, df = 3, $P < 0.05$). The average interim relief amount paid per depredation was US$27.78, whereas the average interim relief amount paid per year was US$4,726.44. We discuss the significance of our findings for mitigating livestock losses by tigers through improved livestock management and the formation of a core team to oversee conflicts and to implement education programs.

Key words: compensation, conservation, human–wildlife conflicts, human–tiger conflicts, India, interim relief, Kaziranga, livestock depredation, *Panthera tigris*

Bengal tigers (*Panthera tigris*), humans, and their livestock have long cohabited in India. With increasing human populations, human–tiger conflicts (HTC) have increased dramatically (Graham et al. 2005). In India, tigers are among the most common species of large carnivores involved in conflicts (Karanth and Gopal 2005, Barlow et al. 2010, Goodrich 2010, Nyhus and Tilson 2010). Within the tiger's distributional range, conflicts are more severe in the Indian sub-continent where both tiger and human population densities are highest (McDougal 1987). The consequences of HTC may include loss of human life and livestock depredations. These consequences contribute to increased retaliatory killings of tigers (Nikolaev and Yudin 1993, Karanth and Gopal 2005, Miquelle et al. 2005, Nyhus and Tilson 2010). Tigers attack livestock most commonly in areas where natural prey populations have been depleted (Goodrich 2010). Increased HTC has been implicated in declining tiger populations across the species' range (Goodrich et al. 2011); thus, reducing HTC is critical for successful tiger conservation efforts (Treves and Karanth 2003, Woodroffe et al. 2005, Inskip and Zimmermann 2009) and for conserving tiger populations (Kenney et al. 1995, Chapron et al. 2008, Goodrich et al. 2008). In response to the rangewide decline of tiger populations, conservation organizations have increased their efforts to mitigate HTC (Treves and Karanth 2003, Nyhus and Tilson 2010).

The Kaziranga Tiger Reserve (KTR) is an important tiger reserve of the Brahmaputra Valley in Assam, India (Sanderson et al. 2006). Tigers from KTR are considered a source population for the entire region (Jhala et al.

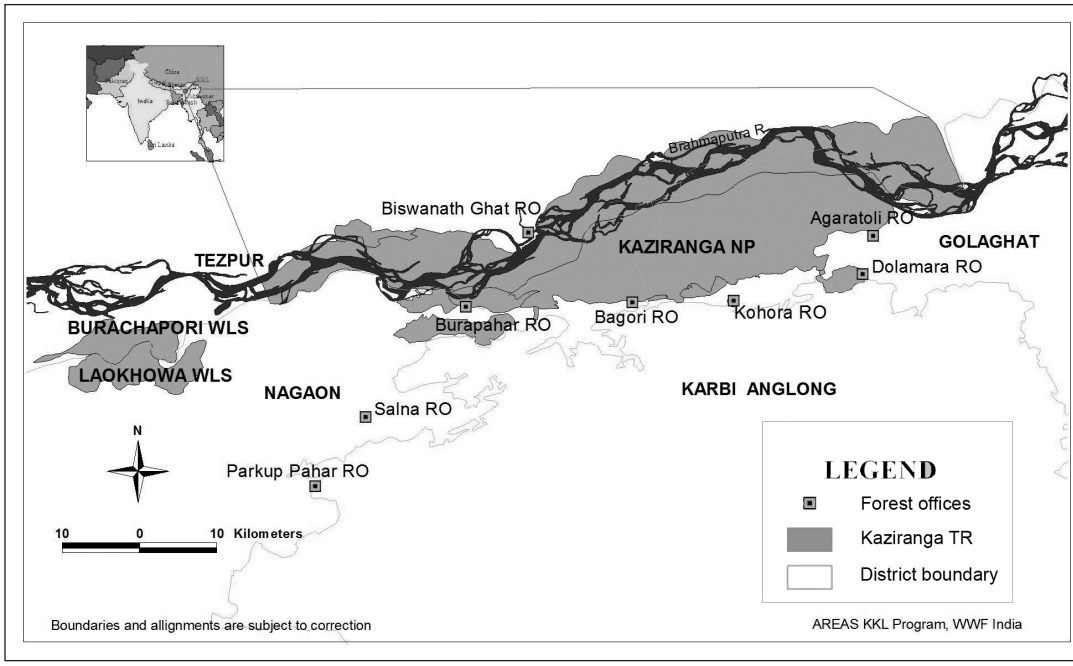

Figure 1. The study concentrated on the fringe areas under the jurisdiction of Agoratoli, Bagori, Burapahar, Biswanath Ghat, and Kohora Range Offices (RO) of Kaziranga Tiger Reserve (KTR), the Dolamara and Parkup Pahar Ranges of Karbi Anglong East Division, the Salna Range, and Laokhowa and Burhachapori Range Offices of Nagaon Wildlife Division. The KTR is an important Bengal tiger (*Panthera tigris*) reserve of the Brahmaputra Valley in Assam, India.

2011). The reserve contains some of the highest densities of tigers (32.6 per 100 km^2) in the world (Karanth et al. 2004, Ahmed et al. 2010). Beginning in 2004, villager attitudes towards KTR, forest department personnel, and tigers became increasingly negative as the number of depredation incidences increased (Bora et al. 2009). In response, in 2008, World Wide Fund (WWF) India's Kaziranga-Karbi Anglong Landscape Conservation Program in Assam initiated an interim relief scheme (IRS).

The purpose of the IRS was to document the magnitude of depredation cases as well as to provide immediate financial relief to villagers against a confirmed case of livestock depredation by tigers. The IRS was a collaboration between the park authorities and local communities, aiming to mitigate HTC in the fringe areas of KTR (Bora et al. 2009). We assumed that the IRS would accurately document the magnitude of tiger depredation incidents, which in turn would reduce the retaliatory anger of the villagers. The IRS was also designed to increase awareness among villagers and other area stakeholders on the need and urgency for tiger conservation. In this paper, we summarize the impacts of HTC in fringe areas of KTR, report on the IRS, and recommend additional measures that could mitigate future HTC. We hypothesized that the IRS would improve community attitudes toward tigers and KTR, and provide immediate information on tiger depredations from affected areas. Thus, partners hoped the IRS would also help to mitigate conflict cases and reduce retaliatory killings of tigers.

Study area

This study focused on the fringe areas under the jurisdiction of Agoratoli, Bagori, Burapahar, Biswanathghat, and Kohora Range Offices (RO) of the KTR Eastern Assam Wildlife Division, the Dolamara and Parkup Pahar Ranges of Karbi Anglong East Division, the Salna Range, and Laokhowa and Burhachapori Range Offices of Nagaon Wildlife Division (Figure 1).

The KTR (26° 34' N to 26° 46' N and 93° 08' E to 93° 36' E) encompasses the administrative districts of Golaghat, Nagaon, and Sonitpur in the state of Assam, India, with the Brahmaputra

River on the northern border and the Karbi Anglong hills on the southern border. The total area of the KTR is 860 km^2, which includes a core area of 460 km^2 as the Kaziranga National Park. The vegetation of the park is classified as 66% grassland, 28% woodland, and 6% aquatic vegetation (Vasu 2003). The KTR lies in the floodplain of the Brahmaputra River, sloping very gradually from east to west against a backdrop of the foothills and peaks of the eastern Himalayas. There are 4 main types of vegetation found here: alluvial inundated grasslands and reed beds, alluvial savannah woodland, tropical moist mixed deciduous forests, and tropical semi-evergreen forests (Talukdar 1995). The riverine habitat consists primarily of dense, tall grassland interspersed with open forests, interconnecting streams, and numerous small flood-formed lakes or beels that cover 5% of its area.

The KTR also supports significant floodplain biodiversity in the region and holds populations of Indian one-horned rhinoceros (*Rhinoceros unicornis*), Asian elephant (*Elephas maximus*), swamp deer (*Cervus duvaucelli ranjitsinghi*), Asiatic water buffalo (*Bubalus arnee*), and the Bengal tiger. A low mountain range to the south, the Karbi Anglong hills, separated by a national highway (NH-37), provides refuge to animals in times of flood.

There are about 150 villages along the highway and lying within the zone of influence of the reserve (Jhala et al. 2011). These villages comprise around 1,800 households and a population of 8,844 (Das 2011). The communities mostly survive on subsistence agriculture, depending on crop and milk production. In very few cases, villagers have a small income from government employment or tourism-related activities. Tiger depredations in fringe areas of the KTR therefore have a significant impact on their livelihoods. They influence the attitudes of the local communities toward tigers and intensify HTC in the area (Bora et al. 2009). The livestock of households mainly comprised of cattle (*Bos taurus*), buffalo (*Bubalus bubalis*), goats (*Capra hircus*), and sometimes pigs (*Sus scrofa*) and horses (*Equus ferus caballus*; Das 2011).

Methods

We formed a survey team comprised of 2 local villagers, 2 KTR forest department staff, and 2 WWF staff to monitor livestock depredation. The local villagers were selected from different villages, the KTR forest department staff were selected based on their expertise and experience in identifying the predators involved in incidents, and the staff of WWF included a biologist and a field assistant. The team used pre-designed field formats to standardize data collection and recorded photographic evidence. The data collected at the depredation site included name and address of livestock owner, date of depredation (season), time of depredation, type and number of livestock killed, nearest range office, and mode of payment.

The IRS process was initiated by the village representatives who provided information to the local forest office about any livestock depredation occurring in any village within the study area. Following this report, the local forest staff investigated to determine the presence of the predator near the village. The depredation was confirmed by the presence of scat or pugmarks at the attack sites and canine puncture marks in livestock (Schaller 1967, Seidensticker and McDougal 1993, Karanth and Sunquist 1995, Karanth and Sunquist 2000).

Once the depredation was officially documented, the compensation claim was forwarded to the range officer or the divisional forest officer, who evaluated the claim based on the evidence presented. If the case was verified as valid, an immediate interim relief payment was made. The interim relief amount paid to the livestock owners as financial assistance for a tiger depredation was fixed per government guidelines. It was implemented in the field in accordance with the Memorandum of Understanding signed between the KTR authorities and WWF India. The amount varied from US$8 for goats to US$41 for adult cattle or buffalo. The interim relief amount was immediately paid by WWF in cash. In some instances, where the claim made by livestock owners was delayed, payments were made later.

We defined a conflict as any report of interaction between tigers and humans that were responded to and confirmed by the survey team. We categorized conflicts as livestock depredation by tigers, attack on humans by tigers, and tigers killed by humans. Most of the depredations by tigers were single kills, but in

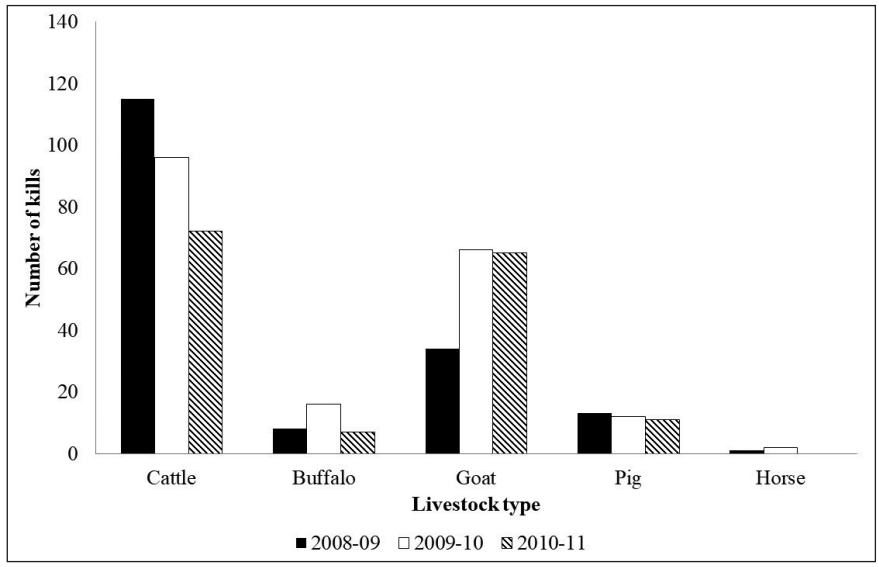

Figure 2. The numbers of different livestock types that made up the total kills by Bengal tigers (*Panthera tigris*) from April 2008 to March 2011 based on incidents verified under the interim relief scheme at fringe areas of Kaziranga Tiger Reserve, Brahmaputra Valley in Assam, India.

some instances we found multiple livestock kills on a single site. Accordingly, we defined a depredation as 1 event that may include multiple kills of livestock. Each depredation was classified by season and time. Seasons were winter (November to February), summer (March to June), monsoon (July to August), and autumn (September to October), and time classified as morning (0500–1200 hours), day (1200–1700 hours), evening (1700–2400 hours), and night (2400–0500 hours).

Data analysis

We recorded HTC data collected by our team from April 2008 to March 2011. The frequency of depredation relative to livestock type was examined using a chi-square goodness of fit test, and a chi-square test of independence was used to determine whether there were seasonal (month by month) or diel variation in the frequency of predation for each livestock type.

Results

We documented 518 cases of livestock depredation during the study period. Tiger depredation on livestock was the most common type of conflict reported (99.2%), followed by attacks on humans (0.6%), and retaliatory killing of tigers (0.3%). More cattle (55%; $n = 283$) were killed by tigers than any other livestock. Other livestock kills reported were goats (22%; $n = 115$), buffalo (16%; $n = 81$), pigs (7%; $n = 36$), and horses (1%; $n = 3$; Figure 2).

More cattle ($\chi^2 = 377.3$, $P = 0.0001$) and buffalo ($\chi^2 = 41.3$, $P = 0.0001$) were killed than other livestock types; however, this reflects their greater availability. We detected seasonal variations in the number of livestock killed with more kills in winter ($\chi^2 = 74.2$, df = 3, $P < 0.05$). The number of livestock killed and the number of depredations were highest during winter ($\chi^2 = 41.7$, $P = 0.0001$), with 40% of depredations occurring in this season (Figure 3). Most depredations occurred at night ($\chi^2 = 44.9$, df = 3, $P < 0.05$). There was no difference in the frequency of depredations in cattle sheds (52%) and on agricultural land or other open places (48%; $\chi^2 = 0.7$, df = 1, $P = 0.68$).

Households in our study on average owned 10 head of livestock. The mean loss of livestock (cows, buffalo, goats, and pigs) due to tiger predation was 1.2 (±0.06) head per year per household that reported depredation cases. The highest number of depredations were reported within the fringe region of KTR, from the jurisdiction of the central range, Kohora ($n = 340$), followed by the Agoratoli ($n = 105$), Bagori ($n = 31$), and Burapahar ($n = 17$) range. Outside of this region, 5 incidents were reported from the Salona range under Nagaon Division, 8

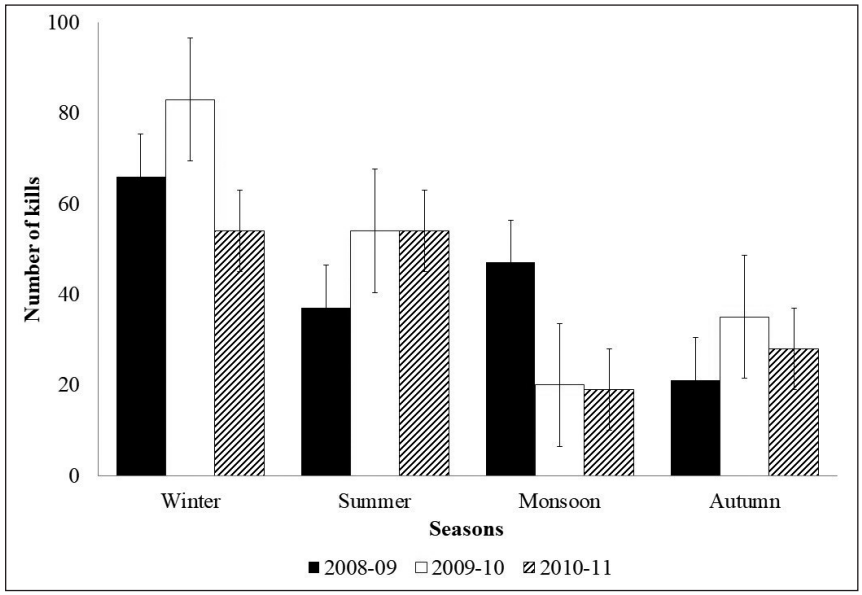

Figure 3. Seasonal livestock depredation by Bengal tigers (*Panthera tigris*) from April 2008 to March 2011 based on incidents verified under the interim relief scheme at fringe areas of Kaziranga Tiger Reserve, Brahmaputra Valley in Assam, India.

incidents from the Dolamara range under Karbi Anglong East Division, and 12 incidents from the Golaghat Division during the study period. The average interim relief amount paid per case was around US$27.78, and the average interim relief amount paid per year amounted to US$4,726.44.

We recorded a single case of a tiger attacking humans near Bagori range, resulting in 2 injured humans and 3 fatalities. The police and forest department personnel eliminated the tiger in that case. In all other depredation cases, the tiger was not sighted and all of the evidence collected was from indirect signs.

Discussion

The results of our study indicate that HTC are increasing in the KTR region. Most conflicts include loss of livestock (primarily cattle) and have serious implications for both villagers and tigers. Conflicts between humans and wildlife in India are escalating due to increasing human population, loss of natural habitats, and in some regions, increasing wildlife populations because of successful conservation programs (Rodgers 1989, Saberwal et al. 1994). We also attributed the increase in tiger depredation cases from the first year to the second year to an increase in the number of people reporting depredations, as local communities became more aware of the IRS. Because the informant network team responded to all depredation reports, this also increased the confidence of the local communities in the IRS process.

Conflicts between tigers and humans result from the tiger's need for large areas of forest habitat (Sunquist 1981) and abundant large prey (Smith et al. 1998). Where native prey is available, tigers usually avoid livestock (Sunquist 1981, Miquelle et al. 1996, Stoen and Wegge 1996, Karanth 2003, Andheria et al. 2007). Most studies of human–carnivore conflict report loss of natural prey species (McDougal 1987, Kolowski and Holekamp 2006, Gurung et al. 2009, Gusset et al. 2009) as the major reason for livestock depredation.

The tiger density at KTR is one of the highest in India, with reports of 16 tigers per 100 km^2 (Jhala et al. 2011). The KTR therefore is a major source of tigers to surrounding landscapes. Tigers are known to move between KTR and Karbi Anglong hills (Jhala et al. 2011) and between KTR and Brahmaputra islands (Borah et al. 2010). This could be a reason for the large number of depredation cases within the study area.

In Bhutan, between October 2003 and December 2005, 1,375 livestock kills were reported and attributed to tigers, leopards (*P. pardus*), snow leopards (*P. uncia*), or Himalayan black bears (*Selenarctos thibetanus laniger*). Of

these, 263 (19%) livestock kills were by tigers (Sangay and Vernes 2008). Cattle were the most common livestock killed by tigers in the study area, similar to that reported in other areas (Madhusudan 2003, Wang and Macdonald 2006, Sangay and Vernes 2008). In Russia, dogs (*Canis familiaris*) are killed more frequently than livestock (Goodrich et al. 2011). Although livestock are consumed by tigers, various studies in India's protected areas have found that it only constitutes a small portion (0.45–12%) of their overall diet (Biswas and Sankar 2002, Bagchi et al. 2003, Reddy et al. 2004, Andheria et al. 2007).

Livestock depredation occurred more often during winter (November to February) compared to other seasons. During winter, agricultural activities are generally at a peak with paddy harvesting, followed by cultivation of cash crops in the study area. Therefore, livestock are left free to graze and browse (personal observation), increasing the probability of being taken by tigers. Similar observations of greater livestock loss during the peak cropping season were reported by Sangay and Vernes (2008).

Depredations were also more frequent at night (2400–0500 hours). Nocturnal vigil of the crop field is usually abandoned after harvesting, which may have resulted in increased depredation at night. It is therefore possible that unattended livestock was at more risk of attack by tigers in the area. We also noted that livestock owners do not usually put up vigil during the night due to cold weather in the winter.

Other studies have found inadequate herding practices as a large contributor to livestock attack throughout the Himalayan region (Oli et al. 1994, Mishra 1997, Ikeda 2004, Wang and McDonald 2006, Namgail et al. 2007). Others have found depredation to be highest in seasons when livestock were free-ranging (Johnson et al. 2006, Sangay and Vernes 2008, Li et al. 2009). However, studies in Russia attributed physical stress and low prey availability to the increase in depredation by Amur tigers (*P. t. altaica*) in winter (Goodrich et al. 2011). The depredation patterns reported here were comparable to many other countries (Chowdhury and Sanyal 1985, McDougal 1987, Nyhus and Tilson 2004, Karanth and Gopal 2005, Sangay and Vernes 2008, Gurung et al. 2009, Barlow et al. 2010, Nyhus and Tilson 2010).

Most of the livestock depredation occurred in Kohora and the central range of KTR where it connects to the mainland. This area harbors high prey and tiger populations (Karanth and Nichols 1998). The majority of the fringe villages of KTR are also located near Kohora. These could be the primary reason for the high number of depredations in the area. Besides Kohora, the Agaratoli area also had a high depredation rate. This area is close to the Brahmaputra River and there are number of small riverine islands that act as corridors for the dispersing tigers from KTR. These riverine islands often have sheds where the locally bred livestock are contained (Borah et al. 2010).

There was only 1 case of a tiger injuring and killing humans during the study period. That particular individual tiger was eliminated and was the only case of a tiger being killed within the study period. The incident of a tiger being killed was provoked by local people present in the area, trying to investigate the conflict (personal observation), rather than being a direct case of retaliatory killing due to livestock predation. Similar trends of humans provoking a tiger to attack have also been observed in Russia (Matyushkin 1985, Nikolaev and Yudin 1993, Goodrich et al. 2011), Nepal (Gurung et al. 2009), and Bangladesh (Barlow et al. 2010). Various studies have found that >50% of tigers that attacked humans had physical impairments (Gurung et al. 2009) or injuries related to conflict with other large cat species (Hoogesteijn et al. 1993, Loveridge et al. 2010). However, in this case, no such impairments or injuries were evident on the tiger.

Prior to initiation of the IRS, livestock depredations were contributing directly to the economic losses for the farmers, evoking a strong negative response. The average livestock holding of households from our study area was 10 head of livestock, and the average loss to depredation was 1.2 head/household/year. This loss was greater than that observed in Nepal (0.7 head per household per year; Oli et al. 1994), Pin Valley National Park (0.6 head per household per year; Bagchi and Mishra 2006), or Jigme Singye Wangchuck National Park, Bhutan (0.1 head per household per year; Wang and Macdonald 2006). Because almost all the

households within our study area are dependent on subsistence agriculture, if a farmer loses a cow, buffalo, or any other livestock, particularly during the ploughing season, it has a profoundly negative impact on potential income. This raises the antagonism between the local communities and the predator involved (Bagchi and Mishra 2006) and potentially leads to retaliatory killing of tigers.

The local communities were not completely satisfied with the amount being paid under the interim relief scheme, since it fails to compensate for the full value of the loss. However, the IRS amount paid seemed to help minimize retaliatory killings. Since the IRS was initiated, there has not been a single case of retaliatory killings of tigers due to livestock depredation (personal observation). We have also ensured that the government money for compensating such depredations is provided to the owners as soon as possible (i.e., within a week, which otherwise used to take 6–12 months).

Different measures have been suggested to mitigate HTC (Goodrich 2010). Although improving livestock management could be a significant way to minimize livestock depredation, it is uncertain whether the local villagers would be willing to implement this unless they are provided with technical or financial assistance. Another alternative is to replace local livestock breeds with more efficient breeds of livestock with higher milk production and which can be reared within an enclosure (Goodrich 2010). With proper awareness and incentives, this approach can continue to mitigate HTC in Assam.

High levels of conflict occur in areas where tigers and people overlap (Karanth and Madhusudan 2002, Nyhus and Tilson 2004, Smith et al. 2010). To decrease conflicts, a zoning system whereby people and their livestock are excluded from critical tiger habitats and movement corridors, along with human relocation programs (Karanth and Madhusudan 2002) may be feasible. However, this would require strong political willingness and backing to implement.

The IRS of WWF India, initiated along with the Assam forest department, provides compensation to the villagers for losses of livestock to depredation, emergency medical expenses to people when attacked by tigers, or *ex gratia* to a family that has lost a member due to a tiger attack. Compensation programs usually aim to improve local acceptance of tigers and other predators, thereby reducing retaliation killing (Goodrich 2010), often with mixed results (Nyhus et al. 2003, 2005). The main reasons for the failure of such programs is usually unsustainably high payout costs, difficulty in verifying all the claims, a high number of false claims, government corruption, and the difficulty of making timely payments in village areas (Madhusudan 2003, Karanth and Gopal 2005, Nyhus et al. 2005).

Our study suggests that government managers, researchers, and local people can work together to formulate a conservation management strategy that suits the needs of both wildlife and people. The strategy should adopt and articulate proactive policies addressing wildlife conflict and damage issues. Policy formation and evaluation should be integrated through mutually agreed upon goals that serve as measures of policy effectiveness (Hewitt and Messmer 1997). We also believe that a desirable management strategy should be evidence-based. It should explore methods to improve livestock management and the feasibility of a sustainable compensation scheme or insurance program. Engaging farmers in managing HTC and developing ways of enabling them to benefit from the existence of tigers in places like KTR will be the most successful approach. With declining tiger populations in the wild, fatality rates associated with HTC would have an important bearing on the persistence of small, isolated populations (Chapron et al. 2008, Nyhus and Tilson 2010). With all 13 tiger range countries committing to increasing their tiger populations (Walston et al. 2010), tiger conflicts are likely to increase (Karanth and Gopal 2005). Therefore, effective interventions in HTC are necessary and should become a key component of management strategies wherever tigers remain.

Management implications

Since the IRS was initiated, there has not been a single case of retaliatory killings of tigers due to livestock depredation. This observation, in concert with an increase in reporting of depredation events, may suggest that initial implementation of the IRS has been a success.

We believe that continued success of the IRS will require stable funding to be sustained on a long-term basis. A system should be implemented that provides incentives for local farmers to improve animal husbandry techniques and practices, reducing losses due to depredation by tigers. Successfully mitigating conflicts also requires an understanding of the behavior of both tigers and people where they overlap in resource use. It should include effective awareness campaigns focusing on HTC and highlighting issues in areas with tiger depredation cases. Lastly, we recommend formation of a permanent core team to oversee HTC cases, in line with the government-sponsored Tiger Response Team formed in Russia. We believe that resolution of HTC will require implementation of careful managerial strategies that achieve the dual goals of wildlife conservation and sustainable livelihood for villagers.

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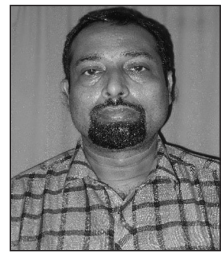

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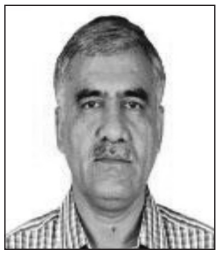

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