NCF Technical Report No. 18

PEOPLE AND PREDATORS

Leopard diet and interactions with people in a tea plantation dominated landscape in the Anamalai Hills, Western Ghats

Swati Sidhu

Divya Mudappa

T. R. Shankar Raman

SUGGESTED CITATION

Sidhu, S., Mudappa, D., and Raman, T. R. S. 2011. People and predators: Leopard diet and interactions with people in a tea plantation dominated landscape in the Anamalai Hills, Western Ghats. *NCF Technical Report #18*, Nature Conservation Foundation, Mysore.

ACKNOWLEDGEMENTS

This study was funded by the Rufford Small Grants Foundation, UK, and the Netherlands Committee of the IUCN, Tropical Rainforest Programme, and to them we are much indebted. We are very grateful to Tamil Nadu Forest Department and plantation managers in Valparai for permissions to carry out this research work. We are grateful to Dr. Uma Ramakrishnan and Dr. S. P. Goyal for guidance and opportunity for laboratory analysis. We thank our field assistants Kannan, Sathish Kumar, Krishna, Anandaraj, and Sathish for their help during field work. We are grateful to the Centre for Electronics Design and Technology (CEDT), Indian Institute of Science, Bangalore, for the CEDT camera traps. We take this opportunity to also thank Drs Ravi Chellam, Vidya Athreya, M. Ananda Kumar, and P. Jeganathan for their help during the study. SS thanks Nisha Luiz and Shakthi Sritharan for translations during interview surveys and Atul Joshi, Dina Nisthar, Eleni Foui, S. Harikrishnan, V. Deepak, and Navya Ramesh for useful discussions during various phases of the study.

CONTACTS

Nature Conservation Foundation

3076/5, 4th Cross, Gokulam Park

Mysore 570002, Karnataka, India

Tel.: +91 821 2515601

Fax: +91 821 2513822

Web: www.conservation.in

Swati Sidhu swati@ncf-india.org, swatisidhu@gmail.com

Divya Mudappa divya@ncf-india.org

T. R. Shankar Raman trsr@ncf-india.org

SUMMARY

Leopards use a wide range of habitats from natural forests to human-dominated landscapes and conflicts sometimes arise from loss of livestock or attacks on people in interface areas. In a fragmented rainforest and plantation landscape in southern India, we examined diet of large carnivores (particularly leopards) using scat analysis with DNA-based identification of predator species, and relative abundance of prey species in different land-uses using transect surveys. Spatio-temporal patterns in conflict and attitudes of local people were analysed from conflict records with the Forest Department and questionnaire surveys in 28 plantation colonies and eight tribal settlements. Large carnivores predominantly (98.1%) consumed wild prey species and domestic prey species contributed <2% to overall prey biomass. Similarly, for leopards four wild prey species (Indian muntjac, Indian spotted chevrotain, sambar, and Indian porcupine) contributed 95.1% of prey biomass, with the rest being minor wild prey species (no livestock in identified scats). In the landscape, wild prey species persisted but varied in relative abundance by land-use type, with forest fragments supporting higher abundances of most species. Employment in plantations was the major source of income for people and only 4.8% of 3213 households in surveyed colonies kept livestock; for these households, livestock rearing contributed to 30% of the average monthly income of INR 6246 (~USD 139). In a 3-year period (2008 – 2010), 32 head of livestock (cow, buffalo, and goat) were reported by respondents as lost to carnivore depredation (economic loss averaging INR 9732 or ~USD 216 per incident). Over the same period, there were eight attacks on people, resulting in three fatalities (all children). Attitudes towards leopards were not affected by incidence of livestock depredation, but related instead to occurrence of attacks on people in the colony.

Livestock depredation at a colony was significantly and positively related to livestock numbers, and interactively with distance from protected area (positive) and number of people (negative). To minimise conflicts, we suggest adoption of a combination of measures including better herding, improved livestock corrals, safety precautions for adults and children at night in estates, and proper waste management, besides protection of habitat remnants that sustain wild prey populations. These will help safeguard human life and reduce economic losses, thereby mitigating conflict and promoting human – leopard coexistence in such landscapes.

1. INTRODUCTION

Humans have been part of natural ecosystems for millennia, but it is in geologically recent times that human impact on the natural world has rapidly increased. The expansion of agriculture along with the loss, alteration, or fragmentation of natural ecosystems has increased the interface between people and wild animals. This is particularly significant for large-bodied animals that range widely to meet their energy requirements (Eisenberg, 1981; Lindstedt *et al.*, 1986), especially when resources are more patchily distributed in space as a result of habitat fragmentation (Madhusudan and Mishra, 2003). Such species, exemplified by mammals such as large carnivores and ungulates, are then likely to encounter people more often, resulting in conflicts such as crop damage, livestock depredation, or attacks on people (Hoare, 1999; Karanth and Madhusudan, 2002; Madhusudan and Mishra, 2003; Michalski *et al.*, 2006). This may also spark retaliatory killings of wild animals, particularly when animal husbandry or subsistence-level agriculture is the main source of livelihood (Oli *et al.*, 1994; Karanth and Madhusudan, 2002; Madhusudan and Mishra, 2003).

Large predator species are known to kill livestock when they are present, especially in areas of low wild prey density, or when livestock are not properly guarded (Mishra, 1997; Mazzolli *et al.*, 2002; Bagchi and Mishra, 2006). Some examples include lions *Panthera leo* in Africa (Bauer and de Iongh, 2005), pumas *Felis concolar* and jaguars *Panthera onca* in south America (Mazzolli *et al.*, 2002, Zimmermann *et al.*, 2005), snow leopard *Uncia uncia* in the Himalaya (Mishra, 1997), and wolves *Canis lupus* and coyotes *C. latrans* in North America (Treves *et al.*, 2002; Windberg *et al.*, 1997). In such instances, conservation goals become particularly challenging when people lose a major part of their income to conflict with wild carnivores, especially if the species involved are endangered (Mishra, 1997; Wang and MacDonald, 2006).

The extent of conflict may depend on the relative abundances of predators, wild prey, and livestock. Conflicts may decrease when predator densities decrease with increasing human population densities (Newmark *et al.*, 1994; Woodroffe, 2000). Conflict may increase with higher predator density, such as following successful reintroduction or protection (Naughton-Treves *et al.*, 2003), although evidence supporting this correlation is lacking from other studies (Conner *et al.*, 1998; Landa *et al.*, 1999; Knowlton, 1999). Increase in livestock depredation may also result from low wild prey availability or high livestock numbers in a landscape (Bagchi and Mishra, 2005). Low wild prey abundance may be caused by hunting for trophies or meat or because of competition for resources with domestic species. Some other factors that are reported to influence conflict are distance to grazing pastures, guarding of livestock, and bad weather (Wang and Macdonald, 2002; Mazzolli *et al.*, 2002). There are also socioeconomic and political dimensions to conflict between humans and predators as the attitudes and responses of local people often depend on their economic and cultural background (Woodroffe, 2000).

Within India, interface areas between people and wild animals occur in and around most protected areas, and conflicts often involve species that are adapted to use of human-use areas in the landscape. Leopard (*Panthera pardus*) is one such species implicated in human-wildlife conflicts across a wide range of forest-cultivation interface landscapes in India, such as in Gir National Park in the west, Uttarakhand and Himachal Pradesh in the North, tea plantations in West Bengal and Assam in the east, to many parts of central and southern India (Madhusudan, 2003; Madhusudan and Mishra, 2003).

Although the leopard is the most widespread of all large felids, it is also the most persecuted in retaliation and poached for body parts (Hunter *et al.*, 2003). Based on its threat status the species has been listed in Appendix I of the Convention for International Trade in Endangered Species of Flora and Fauna (CITES, Simcharoen *et al.*, 2008) and in Schedule I of the Wildlife (Protection) Act of India (Anonymous 2003). Other threats to conservation of the species include loss of habitat or natural prey (Schaller, 1967), and capture and translocation from conflict sites. The last is of particular significance in India, where translocation is still widely practiced by the State Forest Departments in response to leopard attacks on people. On such occasions, forest officials come under severe pressure from the public or the news media to undertake some decisive action and capture and translocation is considered an appropriate response. Translocation may, however, lead to an increase in conflict as it fails to adequately consider aspects of leopard biology such as territoriality, homing instincts, increase in leopard numbers at the site of release or at the original conflict site due to immigration of new individuals (Athreya, 2006; Athreya *et al.*, 2010). There is evidence that leopards are capable of living in human-dominated areas with low levels of conflict in the absence of translocation (Athreya and Belsare, 2006). Further, solutions sought by management and scientists need to consider social norms and cultural ideologies to improve management effectiveness (Manfredo and Dayer, 2004).

In this study, we explore aspects of leopard biology to derive insights for human – leopard coexistence in a fragmented rainforest and plantation landscape in southern India. Our intensive study area, the Valparai plateau in the Anamalai region of the Western Ghats, has witnessed conflict incidents involving both loss of livestock and human life that has caused rising concern among government authorities and local communities (Anonymous, 2008). In 2010 alone, following human injuries and deaths, five leopards were captured from the Valparai plateau and translocated to zoos or released in other sites. Given that translocation may not be the best solution (Athreya and Belsare, 2006, 2007; Athreya *et al.*, 2010) and that site-specific ecological data on leopards is lacking for the region, we carried out field research on leopards to address the following applied ecological questions:

1. What is the relative contribution of domestic and wild prey species in leopard diet in the landscape?

2. What is relative abundance and community composition of wild prey species in different land-use types (tea, coffee, forest fragments, and continuous forests) in the landscape?

3. How is conflict between humans and leopards distributed spatially and temporally? How are factors such as distance from the protected area or forest fragments, and the

numbers of livestock and people in colonies related to incidence of livestock depredation?

We discuss factors that influence human-leopard conflicts and identify potential measures to reduce conflict and promote human-leopard coexistence that are useful in such fragmented landscapes.

2. MATERIAL AND METHODS

2.1. Study area

We carried out this study in the Valparai plateau (220 km2) and surrounding Anamalai Tiger Reserve (958 km2, 10°12´ N to 10°35´ N and 76°49´ E to 77°24´ E, Fig. 1), which lie in the Anamalai Hills of the Western Ghats, a global biodiversity hotspot (Kumar *et al.*, 2004). It adjoins several protected areas within Tamil Nadu and Kerala in the southern Western Ghats. The Valparai region is an undulating plateau that underwent land-use changes in the late 19th and early 20th century from mid-elevation tropical wet evergreen forest into plantations of commercial importance such as tea, coffee, cardamom, and *Eucalyptus* (Fig. 2, Mudappa and Raman, 2007).

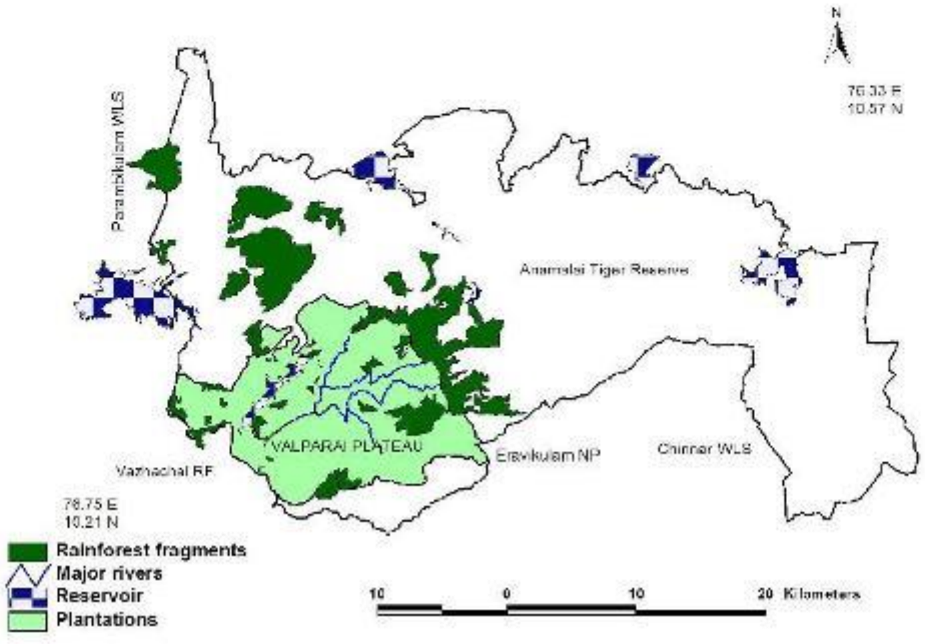

Figure 1. The study are showing Valparai plateau (light green) and surrounding Anamalai Tiger Reserve. Rainforest fragments are shown in dark green, and water bodies in blue.

At present, around 75% of the cultivated area on the Valparai plateau is dominated by tea plantations, with the remaining comprising of other forms of land-uses including remnant forest fragments on private land (Mudappa and Raman, 2007). The plateau, with an altitudinal range between 800 m and 1100 m above sea level, receives a mean annual rainfall of 3500 mm, majority of which falls during the south-west monsoon between June and September. The main natural vegetation type in this region is classified as mid-elevation tropical wet evergreen forest of *Cullenia exarillata – Mesua ferrea – Palaquium ellipticum* type (Pascal, 1988).

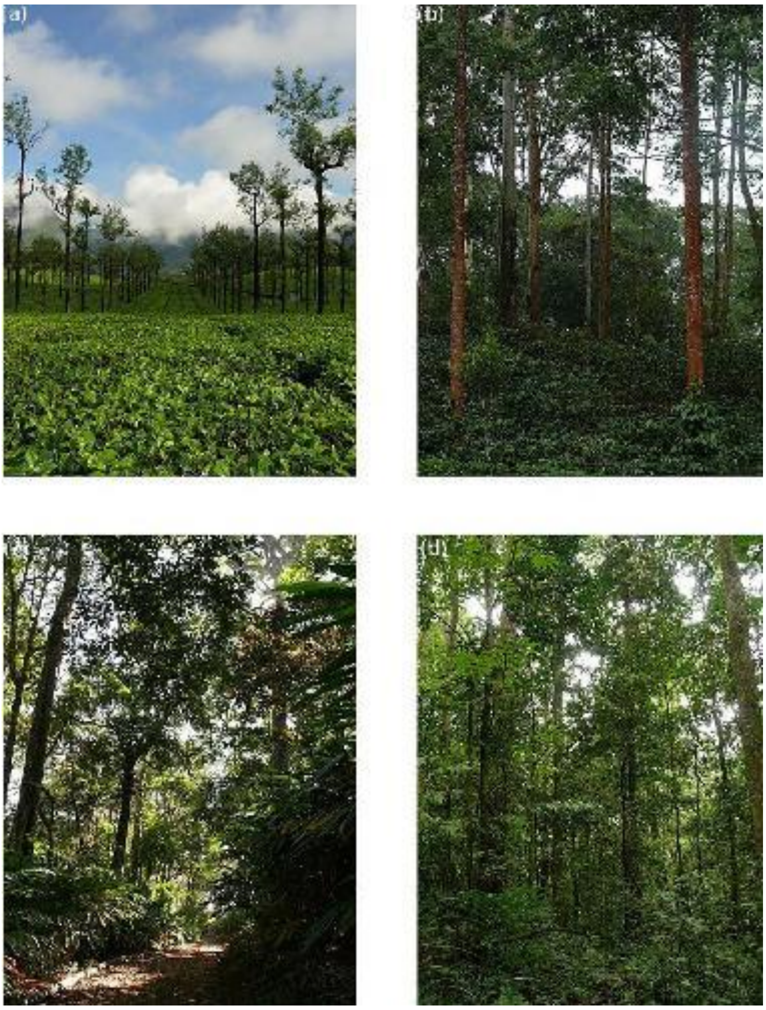

Figure 2. Land-uses in the study area: (a) tea plantation, (b) coffee plantation, (c) cardamom plantation, (d) tropical evergreen forest.

Main study carnivores in Valparai and surrounding protected area include leopard, tiger *P. tigris*, and dhole *Cuon alpinus* (Fig. 3). Besides sloth bear *Melursus ursinus*, another large carnivore, other small carnivore species that occur are brown mongoose *Herpestes fuscus*, stripe-necked mongoose *H. vitticollis*, brown palm civet *Paradoxurus jerdoni*, leopard cat *Prionailurus bengalensis*, Nilgiri marten *Martes gwatkinsi*, small Indian civet *Viverricula indica*.

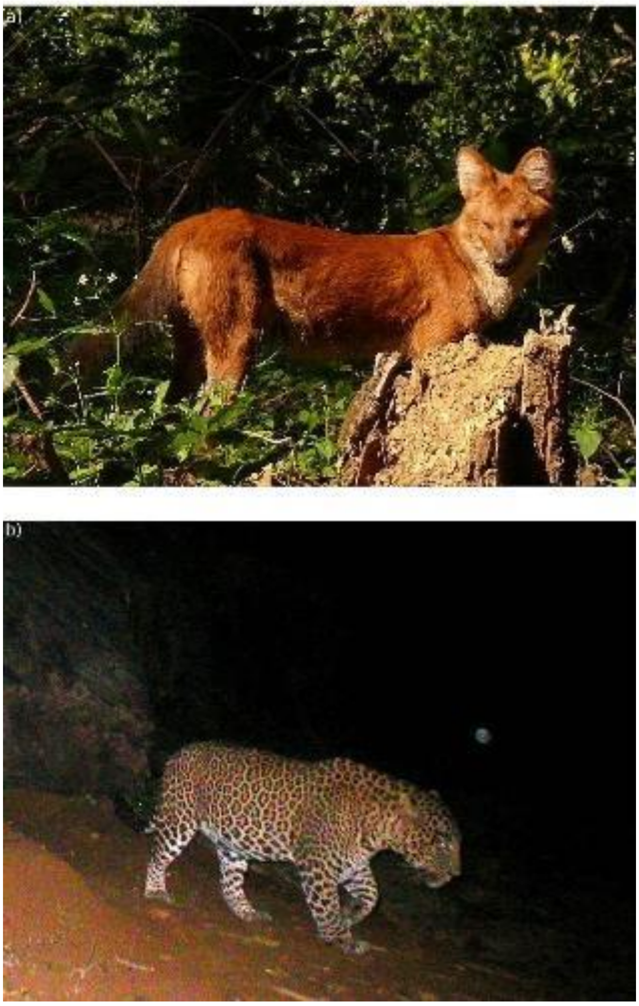

Figure 3. Large carnivores: (a) dhole, and (b) leopard.

Other mammal species from the study region are Asian elephant *Elephas maximus*, bonnet macaque *Macaca radiata*, black-naped hare *Lepus nigricollis*, dusky-striped squirrel *Funambulus sublineatus*, gaur *Bos gaurus*, Indian giant squirrel *Ratufa indica*, Indian muntjac *Muntiacus muntjak*, Indian porcupine *Hystrix indica*, Indian spotted chevrotain *Moschiola indica*, lion-tailed macaque *Macaca silenus*, Nilgiri langur *Semnopithecus johnii*, sambar *Cervus unicolor*, and wild pig *Sus scrofa* (Fig. 4).

Figure 4. Some herbivore mammal species in the Anamalai Hills: (a) Indian porcupine, (b) Indian spotted chevrotain, (c) Indian munjtac, (d) wild pig, (e) sambar, and (f) gaur.

2.2. Mammal abundance survey

Mammals were surveyed along 42 line transects of 2 km length, located in randomly selected 2 km × 2 km grids overlaid on the study area. These transects were located in different land-use types: tea plantations (15 transects), coffee plantations (13), and forest fragments (8). We also sampled 6 transects within the adjoining Anamalai Tiger Reserve (Figure 5). One transect in a cardamom plantation was grouped with coffee plantation transects as these plantations are grown under a canopy of mixed native and alien shade tree species. Tea plantations, in contrast, were open monocultures with a sparse canopy of the alien silver oak *(Grevillea robusta)* trees planted in well-separated rows. While all direct sightings of potential prey species were recorded on transects, relative abundance data were based on counts of indirect signs of mammals such as pellets (porcupine), track marks (sambar, Indian muntjac, Indian spotted chevrotain, gaur), scats (civets and large carnivores), dung piles (Asian elephants), and feeding signs (stripe-necked mongoose) occurring within 1 m on either side of the transect line. All transects were surveyed twice between November 2009 and June 2010, during the relatively drier months preceding the 2010 south-west monsoon. Transects were surveyed in the morning between 0600 h and 1030 h with average sampling duration of each transect being around one and a half hours. Two observers carried out the surveys, one recording direct sightings and the other indirect signs.

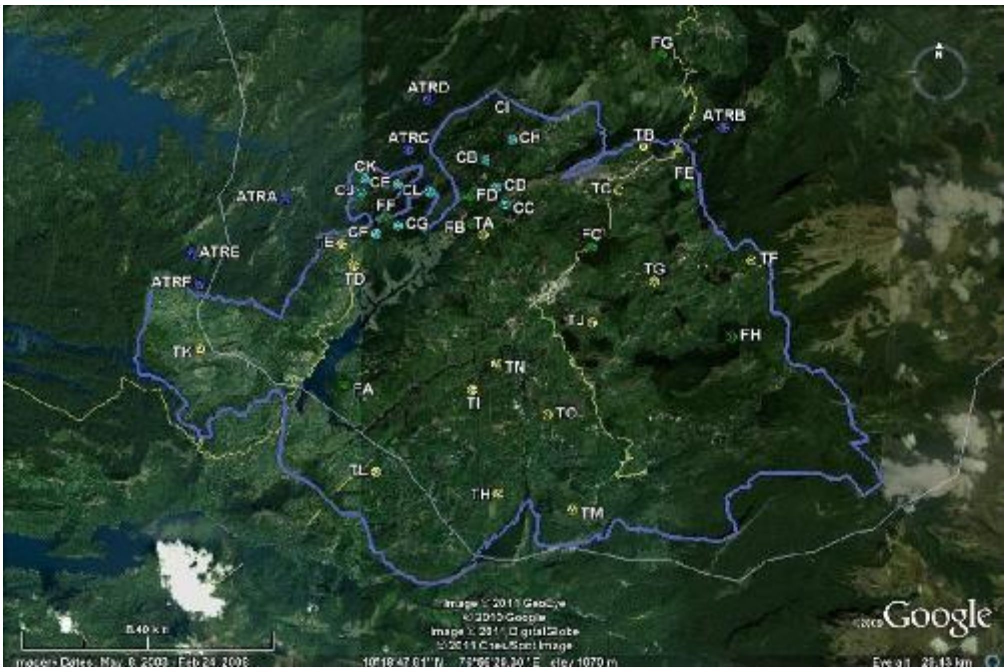

Figure 5. Transect sampling points in Valparai plateau (boundary in dark blue). Transect locations are indicated by different-coloured dots for different land-uses. Tea plantation transects are in yellow, coffee plantations in light blue, forest fragments in green, protected area in dark blue.

2.3. Scat analysis

During transect surveys and supplementary visits, 147 scats belonging to large carnivores (leopard, tiger, or canid) were collected. Whereas leopards were observed using plantations and the vicinity of Valparai town and estate colonies, tigers have been reportedly sighted in plantations only in locations close to protected area boundary. It is therefore possible that some scats collected from plantations closer to the protected area may have belonged to tigers. We assume that canid scats collected during our field surveys were most likely of dholes, as the scat samples were collected from areas farther away from colonies. During scat collection, 40% by volume of each scat was left behind in the field as scats may have been used for marking territory. All scats collected for diet analysis were washed in water over a sieve and sun-dried. These were then analysed for predator diet using indigestible remains of prey species, particularly hairs, bones, quills, and feathers. From each scat, 20 items were chosen at random (Mukherjee *et al.*, 1994) and hairs were identified based on external morphology, cuticular and medullary patterns, and ratio of medulla to cortex in cross-section, with the help of a microscope and comparing with photographs of reference slides.

2.4. Predator identification

A small portion from the field-collected scat was stored in ethanol (Merck company) for DNA-based identification of predator species (leopard, tiger, canid). A total of 102 scats were analysed for predator identity (remaining scats had disintegrating boli and were unsuitable for DNA analysis). This was done to examine potential dietary preferences of leopards as compared to other large carnivores. The scat samples were stored at room temperature until DNA extractions. Identification of leopard and tiger was based on a primer that distinguishes between the two species. DNA was extracted using QIAGEN stool kit (QIAGEN, Inc.). DNA extractions were carried out in a separate pre-PCR room under sterile conditions to avoid contamination. Negative controls were included to check for contamination. DNA was extracted from the outer layer of the scat, which is known to contain epithelial cells or mucous. The primer that amplified NADH4 region of the mitochondrial DNA was used during PCR. A 10 µl reaction mix containing 5 µl of QIAGEN multiplex PCR buffer mix (QIAGEN, Inc.), 1 µl (4 mg/ml) of Bovine Serum Albumin, 1 µl (2.5 µM) of primer (Applied Biosystems), and 3 µl of DNA extract was used for amplification. PCR was carried out under following conditions: an initial denaturation (95°C for 15 minutes), 65 cycles of degradation (94°C for 30 seconds), annealing (50°C for 30 seconds) and extension (72°C for 35 seconds), followed by a final extension (72°C for 10 minutes) in an Eppendorf thermocycler. One reaction mix without sample DNA was used as PCR negative in each reaction cycle to monitor contamination. The PCR products were visualized under UV rays after gel electrophoresis in 2% agarose gel. Samples that show positive amplification for leopard produce bands at 130 basepair (bp) and 200 bp under ultraviolet (UV) light on agarose gel, whereas tiger shows as 88 bp and 110 bp bands. Scats that did not yield a positive result for leopard or tiger were tested if belonging to the canid family using canidspecific primer. We, however, did not distinguish between canid species (dholes and domestic dogs).

2.5. Conflict data collection using government records and interview surveys

For understanding spatial and temporal patterns in conflict in the study region, we carried out interviews of respondents from local communities. Based on conflict records (human injuries, loss of human life, compensation claims towards depredation of livestock) obtained from the Forest Department between 2000 and 2010, plantation estates were identified for interview surveys. Multiple colonies were surveyed in a given estate (Fig. 6). Within a colony, we interviewed households that kept livestock and others that did not. In total, 126 households were sampled in Valparai plateau in 28 colonies. Also, we surveyed 35 households in 8 tribal settlements inside the adjoining protected area.

At colony level, we identified households that reported monetary loss to predators (livestock injury and death). We gathered information on all losses attributed to predators, whether actual or perceived. Perceived losses include cases of unintentional and possibly mistaken attribution of livestock loss to depredation (Mishra, 1997).

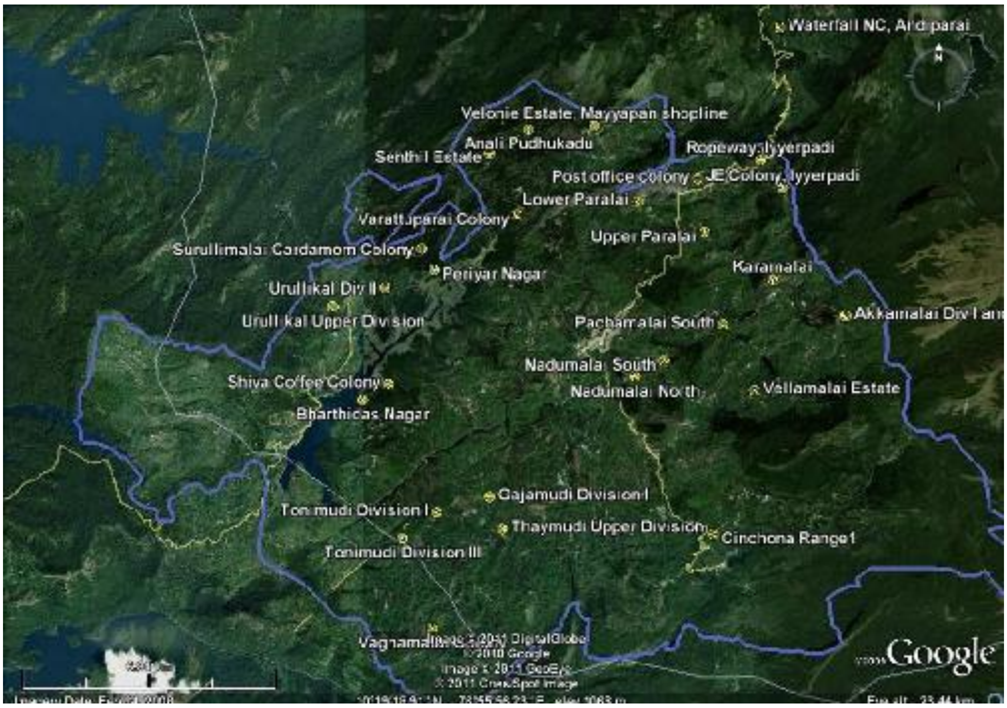

Figure 6. Colonies where interviews were conducted on Valparai plateau. Boundary of the plateau is shown in dark blue.

Surveys at household level identified livelihood sources available to a household, importance of livestock for household economy, economic losses to conflict with large predators, attitudes of people towards wildlife, and acceptable solutions for resolving conflict with wild animals. Additionally, information was gathered on time spent each day in grazing livestock, distance between shed and pasture, husbandry practices such as day guarding when grazing, and condition of livestock corral (open or closed). Data on human and livestock numbers at colony level were also noted. Finally, we assessed attitudes of local communities towards leopards by asking interviewees the following question: what are the major problems for your household? If leopard was mentioned as a problem, we defined it as negative attitude towards the species.

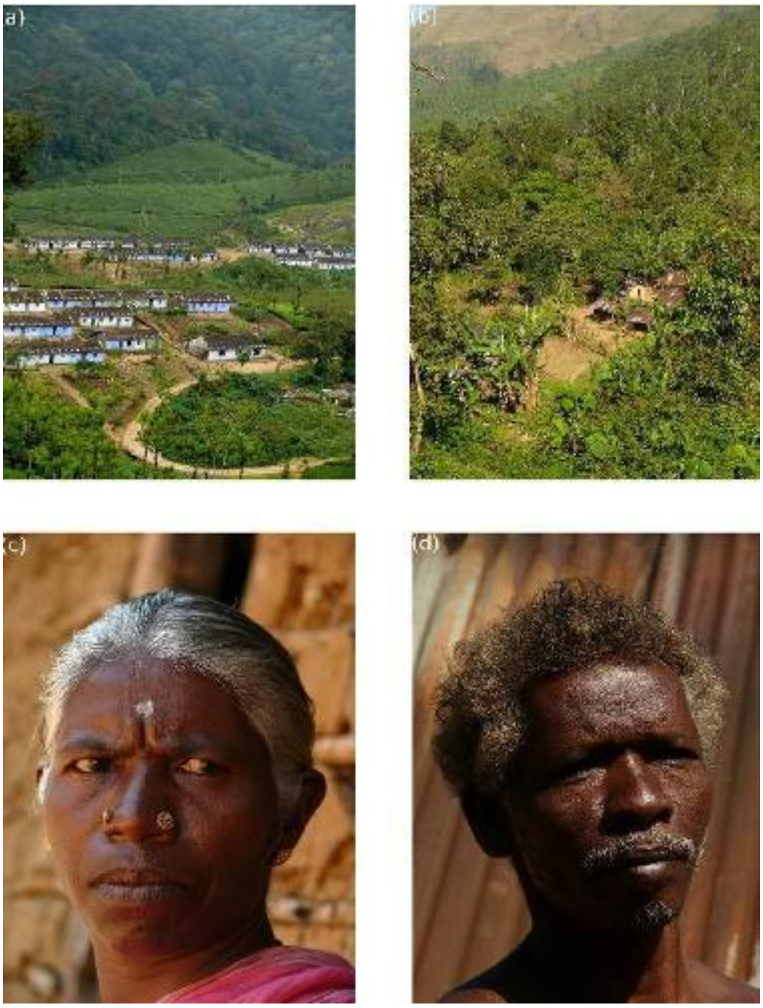

Figure 7. (a) Estate colony surrounded by tea plantation and in proximity to a rainforest fragment, (b) tribal settlement surrounded by home gardens and forest, (c) Kamachi, a Kadar woman, and (d) Velchami, a Kadar man.

2.6. Data analysis

As the number of detections was too few for distance sampling density estimation, we estimated encounter rates of species per transect from direct sightings. A detection was defined as an individual or cluster of individuals of a species sighted on a transect. Indirect evidence from signs was used to assess use of habitats/land-uses by calculating from the sampled strip (2 km x 2 m or 0.4 ha) the sign density expressed as number of signs per 0.4 ha. Statistical significance of differences among the four major land-uses in abundance indices was assessed using one-way ANOVA followed by Tukey's HSD test.

Frequency of occurrence (percentage of scats containing remains of a given prey species) was estimated from the number of times a prey item (defined as remains of any prey species) was found in predator scats. As frequency of occurrence tends to overestimate importance of smaller prey species due to their larger surface area to volume ration compared to larger prey species, we applied a correction using Ackerman's formula (Floyd *et al.*, 1978; Ackerman *et al.*, 1984). This formula relates the mass (Y) of consumed prey represented by one field-collectible scat to the average body mass (X) of the prey species. We applied the correction formula developed for cougars ($Y = 1.980 + 0.035X$) for scats of leopards and large carnivores (as we expect most scats to belong to leopards), and the formula developed for wolves (Y = 0.035 + 0.020X) was used for dholes. After applying the correction, we also obtained relative biomass and numbers of each consumed prey species with average body mass >2 kg.

From interview data, we analysed contribution of livestock to the household economy and the reported losses to depredation. To understand the effects of potential factors influencing livestock loss in colonies on the Valparai plateau, we used a generalized linear model (GLM) approach, with poisson errors and a log link function (Crawley, 2007). During analyses, the number of depredation events in a colony, which resulted in injury or loss of livestock was treated as the response variable, while the number of people in the colony, number of livestock, distance of the colony to the nearest protected forest boundary, and distance to nearest forest fragment edge were included as potential explanatory variables. Starting with a full model that included all explanatory variables and all interaction terms, we carried out model simplification removing non-significant effects one at a time, to arrive at the best minimum model (Crawley, 2007). We used chi-squared test of independence with Yates' correction for continuity to test whether household attitudes towards leopards was significantly influenced by occurrence of the following factors: attacks on humans in the colony, depredation of livestock in the colony, depredation of livestock at household level, or direct encounter with a leopard. The null hypothesis was of independence or no effect in each case. Statistical analyses were performed using the R statistical and programming environment (The R Development Core Team, 2009, version 2.10.1).

3. RESULTS

3.1. DNA analysis

Of 102 large carnivore scats analysed, we identified predator species in 57 scats as being leopard or canid (dhole and domestic dogs). The low success rate in identifying scats using DNA-based analyses was mainly as a result of including several extremely old scats with disintegrated boli. Scat samples that had at least some portion of bolus intact yielded better results.

Eleven scats could not be identified in the field but of the remaining 46 scats that had field as well as DNA-based identification, 36 scats (78.3%) showed matching identification (i.e., field identification of predator species corroborated by DNA analysis), 10 scats showed incorrect identification in field. Seven scats that were identified as leopards in field turned out to be canids, while 3 that were identified as canids, were found to be leopards. Therefore, there was a higher probability of misidentifying a canid scat as belonging to leopard.

3.2. Diet analysis

In 147 scats analysed for large carnivore diet, 206 different prey items were found, with 31% of scats containing remains of two prey species and 5% containing remains of three prey species. Muntjac and Indian spotted chevrotain had the highest frequency of occurrence followed by unidentified rodents (Table 1). Muntjac, sambar, and Indian spotted chevrotain were the three most important prey species in terms of relative numbers (82.5%) and relative biomass (83.95%) consumed by large carnivores (Table 1). The percentage of domestic species in large carnivore diet was low both in terms of relative numbers (1.95%) as well as relative biomass (5.30%) consumed.

Analysis of scats confirmed to be of leopards or canids through DNA analysis (34 leopard scats and 23 canid scats), showed differences in their diet (Tables 2 and 3). Indian muntjac was the important prey species for leopards (40.27%) and canids (49.17%). In addition to Indian muntjac, leopards consumed Indian porcupine, Indian spotted chevrotain, and sambar (54.83% in terms of relative biomass). For canids, sambar alone contributed 42.74% in terms of relative biomass consumed, while porcupines were not recorded in their diet.

The preferred prey size for leopards was just above 30 kg with most prey biomass being obtained from prey species within a weight range of 3 kg to 125 kg.

Table 1. Large carnivore diet in Valparai region in terms of frequency of occurrence (percentage of scats containing remains of a given prey species), relative number of individuals and relative biomass of a given prey species consumed. *N* is number of scats in which remains of a given prey species were found. Ackerman's *Y* is a correction factor used in the analyses. Total number of scats used in the analysis was 147.

Prey species	*N*	Frequency of occurrence (%)	Average body mass (kg)	Ackerman's *Y*	Scats produced /kill	Relative numbers consumed (%)	Relative biomass consumed (%)
Indian muntjac	67	45.58	21	2.72	7.73	21.71	36.71
Sambar	26	17.69	125	6.36	19.67	3.31	33.35
Indian spotted chevrotain	33	22.45	3	2.09	1.44	57.48	13.89
Nilgiri langur	6	4.08	12.5	2.42	5.17	2.91	2.93
Wild pig	1	0.68	37	3.28	11.3	0.22	0.66
Indian porcupine	10	6.8	14.5	2.49	5.83	4.3	5.02
Mongoose	2	1.36	2.55	2.07	1.23	4.07	0.84
Bonnet macaque	2	1.36	6.5	2.21	2.94	1.7	0.89
Black-naped hare	1	0.68	2.2	2.06	1.07	2.34	0.42
Cattle	2	1.36	125	6.36	19.67	0.25	2.57
Goat	3	2.04	25	2.86	8.76	0.86	1.73
Dog	2	1.36	15	2.51	5.99	0.84	1.01
Unidentified rodent	31	21.09	-	-	-	-	-
Unidentified bird	4	2.72	-	-	-	-	-
Unidentified	16	10.88	-	-	-	-	-

Table 2. Leopard diet in terms of frequency of occurrence of different prey species in scats, relative number of prey individuals and prey biomass consumed. *N* is the number of scats in which remains of a prey species were found. Total number of scats used for the analysis was 34.

Prey species	*N*	Frequency of occurrence (%)	Average body mass (kg)	Ackerman's *Y*	Relative numbers consumed (%)	Relative biomass consumed (%)
Indian muntjac	14	41.18	21	2.72	18.95	40.27
Indian spotted chevrotain	8	23.53	3	2.09	58.24	17.68
Sambar	2	5.88	125	6.36	1.06	13.45
Porcupine	9	26.47	14.5	2.49	16.15	23.7
Nilgiri langur	1	2.94	12.5	2.42	2.02	2.56
Bonnet macaque	1	2.94	6.5	2.21	3.55	2.34
Unidentified rodent	7	20.59	-	-	-	-
Unidentified bird	3	8.82	-	-	-	-
Unidentified mammal	2	5.88	-	-	-	-

Table 3. Canid diet in terms of frequency of occurrence of different prey species in scats, relative number of prey individuals and prey biomass consumed. *N* is the number of scats in which remains of a prey species were found. Total number of scats used for the analysis was 23.

Prey species	*N*	Frequency of occurrence (%)	Average body mass (kg)	Ackerman's *Y*	Relative numbers consumed (%)	Relative biomass consumed (%)
Indian muntjac	13	56.52	21	0.46	53.58	49.17
Indian spotted chevrotain	5	21.74	3	0.09	30.12	3.95
Sambar	2	8.7	125	2.54	7.72	42.15
Nilgiri langur	2	8.7	125	0.29	8.67	4.74
Unidentified rodent	6	26.09	-	-	-	-
Unidentified bird	1	4.34	-	-	-	-
Unidentified mammal	2	8.7	-	-	-	-

3.3. Mammal surveys

Comparison of encounter rates of mammals from direct sightings revealed patterns of variation across land-use types (Table 4).

Table 4. Detections and encounter rates (detections / 2 km) of various mammal species in the four major land-use types surveyed in the Anamalai hills. *Nd* – number of detections, *Ni* – number of individuals, *Er* – encounter rate, SE – standard error of encounter rate.

Species	Tea plantation		Coffee plantation		Forest fragment		Protected Area	
	Nd **(*Ni*)**	***Er*** **(SE)**	***Nd*** **(*Ni*)**	***Er*** **(SE)**	***Nd*** **(*Ni*)**	***Er*** **(SE)**	***Nd*** **(*Ni*)**	***Er*** **(SE)**
Asian elephant	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	0.08 (0.08)
Bonnet macaque	0	0 (0)	8	0.29 (0.11)	1	0.06 (0.06)	1	0.08 (0.08)
Brown mongoose	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	0.06 (0.06)	0 (0)	0 (0)
Dhole	0 (0)	0 (0)	1 (2)	0.04 (0.04)	0 (0)	0 (0)	0 (0)	0 (0)
Dusky-striped squirrel	0 (0)	0 (0)	1 (1)	0 (0)	2 (2)	0.13 (0.13)	0 (0)	0 (0)
Gaur	1 (2)	0.03 (0.03)	6 (28)	0.25 (0.15)	0 (0)	0.31 (0.19)	1 (19)	0.08 (0.08)
Indian giant squirrel	0 (0)	0 (0)	51 (55)	1.79 (0.31)	57 (59)	3.5 (0.6)	55 (56)	4.58 (0.61)
Indian spotted chevrotain	0 (0)	0 (0)	0 (0)	0 (0)	3 (3)	0.13 (0.09)	0 (0)	0 (0)
Jungle-striped squirrel	17 (19)	0.57 (0.13)	12 (13)	0.21 (0.10)	1 (1)	0.06 (0.06)	2 (3)	0.17 (0.11)
Lion-tailed macaque	0 (0)	0 (0)	0 (0)	0 (0)	6	0.38 (0.13)	1	0.08 (0.08)
Indian muntjac	5 (7)	0.17 (0.08)	20 (24)	0.63 (0.14)	6 (7)	0.31 (0.12)	1 (1)	0.08 (0.08)
Nilgiri langur	0 (0)	0 (0)	53	1.96 (0.14)	17	1.06 (0.19)	32	2.67 (0.28)
Sambar	0 (0)	0 (0)	2 (2)	0.04 (0.04)	4 (5)	0.25 (0.15)	4 (4)	0.25 (0.13)
Stripe-necked mongoose	4 (4)	0.13 (0.08)	1 (1)	0.04 (0.04)	1 (1)	0.06 (0.06)	0 (0)	0 (0)
Wild boar	2 (2)	0.07 (0.05)	2 (2)	0.08 (0.02)	0 (0)	0 (0)	0 (0)	0 (0)

Encounter rates of Indian giant squirrel and Nilgiri langur were highest inside the protected area. Sambar encounter rate was highest in protected area and forest fragments. All direct sightings of Indian spotted chevrotain were within forest fragments while Indian muntjac encounter rate was highest inside coffee plantations.

Based on indices of indirect signs, relative abundances were found to vary significantly with land-use for several species (Table 5). For Indian spotted chevrotain, an important prey species for large carnivores in Valparai region, use of protected forest was found to be higher than tea and coffee plantations. Similarly, sambar, another important prey species, was found to be using tea plantations less when compared to coffee plantations, forest fragments, and protected forests. For Indian muntjac, use of coffee plantations was higher than tea plantation, whereas Indian porcupine, an important prey for leopards, used tea plantations more than other land-use types. Black-naped hare, a small herbivore species, was found to be using only tea plantations and avoided coffee plantations, forest fragments, and protected forests. Asian elephants used protected, contiguous forests significantly more than plantations surveyed during this study. Comparisons of the number of large carnivore scats per hectare (mean ⍰} SE) revealed no statistically significant difference between land-use types: forest fragment, 0.50 (⍰} 0.28); coffee, 0.92 (⍰} 0.26); tea, 0.83 (⍰} 0.17), and protected forest, 0; (ANOVA $F_{3, 78}$ = 2.571, df = 3, P = 0.06).

Table 5. Abundance indices of mammal species derived from indirect evidence inside different land uses in the Valparai plateau. Tabled values are mean number of signs (per 0.4 ha) with standard errors in parantheses. Values superscripted with different alphabets were significantly different from each other by Tukey's HSD test (P < 0.05).

Species	Tea plantation	Coffee plantation	Forest fragment	Protected Area	$F_{3,37}$	P
Indian muntjac	2.00a (0.46)	5.20b (1.51)	3.19 a,b (0.85)	3.83 a,b (0.62)	3.422	0.030
Indian spotted chevrotain	0.37a (0.14)	0.46a (0.29)	0.94a,b (0.18)	1.75b (0.52)	3.746	0.020
Sambar	0.50a (0.26)	4.63b (1.06)	6.56b (1.45)	6.00b (1.01)	11.471	<0.001
Porcupine	1.53a (0.35)	1.00b (0.37)	0.06b (0.07)	0.25b (0.08)	5.714	0.002
Wild boar	0.17 (0.12)	0.13 (0.12)	0	0	0.911	0.445
Black-naped hare	2.17a (0.49)	0b	0b	0b	13.488	<0.001
Gaur	0.17 (0.09)	0.42 (0.37)	0.69 (0.46)	1.25 (0.41)	1.847	0.156
Mongoose	1.67a (0.49)	0.42b (0.04)	0.06b (0.07)	0.17b (0.08)	6.895	0.001
Civet	0.10a (0.09)	0.88a,b(0.49)	2.06b (0.99)	1.00a,b (0.16)	3.284	0.030
Elephant	0.77a (0.35)	1.25a (0.55)	4.12a,b (1.77)	6.42b (1.34)	6.020	0.002
Sloth bear	0.03 (0.03)	0.33 (0.35)	0	0	1.257	0.303

3.4. Human-leopard conflict

3.4.1. Livestock depredation

Estate labour work was the major source of employment for people in the colonies on Valparai plateau, being the primary source of income for 117 out of 126 interviewed households. Dependence on estate work was significantly lower (14 of 36 households) for people in tribal settlements in comparison to estate colonies (χ^2 = 47.05, df = 1, P = 0.01). The average annual household income for estate colonies was INR 64,527 (⍰} 2,802.2 SE) and INR 34,186 (⍰} 5,778.5 SE) for tribal settlements. Livestock rearing was an important secondary source of livelihood for colonies on Valparai plateau, whereas, agriculture was important for tribal settlements. Out of the 3213 households in the 28 sampled colonies on Valparai plateau, 153 households (4.8%) kept livestock (cattle, buffaloes, goats). Based on data gathered from 35 livestock-keeping households in these colonies, we found livestock to be an important source of income for this group as most of these households derived up to 30% of their income from livestock rearing (Fig. 8). This translated to an average of INR 1,881 of the average monthly total household income of INR 6,246 for livestock-dependent households. The total numbers of livestock in these 28 colonies were 648 animals with livestock holdings as small as 2 animals to as large as 181 animals (mean of 23.14 ± 3.94 SE per colony). During the same time, overall holdings of different livestock species in Valparai region were as follows: 1,754 cattle, 77 buffaloes, 134 goat, 6,598 fowl, 11 ducks, 693 dogs, and 3 donkeys (18th Livestock Census conducted by Government Veterinary Hospital of Valparai, 2010).

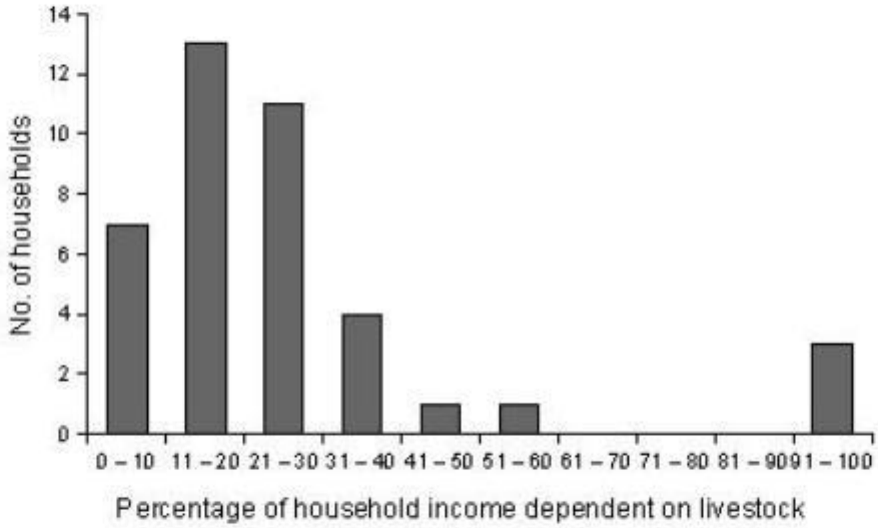

Figure 8. Dependency on livestock for income among 40 households that keep livestock in plantations of Valparai plateau.

Between 2000 and 2010, the Forest Department paid compensation for livestock depredation in 16 instances (cow and buffalo) in Valparai region. Based on data collected in 28 colonies through our interviews for the same time period, we found an additional 36 incidents of livestock (cow, buffalo, goat) injury and loss reported due to large carnivores (***Annexure 1***). Of these 36 incidents, livestock were unguarded in 30 and 27 occurred during late evenings or at night. In the 52 recorded incidents over the last 11 years, 5 animals were injured and 55 animals died. In the last three years (2008 – 2010), 32 animals were reportedly lost to depredation as against another 22 animals lost to still birth, sickness, accident, and snake bite. The perceived depredation amounts to an economic loss of an average of Rs. 90,833 (± 6,233.9 SE) per year with a mean loss of Rs. 9,732 (± 1,317.2 SE) per incident. For the 32 animals that were reported as lost to depredation, compensation claims were made in 6 instances, but compensation was received from the government in only one case (8.4% of the perceived loss amount).

We used a generalized linear model (GLM) analysis to explore significant correlates of livestock depredation in colonies on the Valparai plateau. The final model contained three explanatory terms: number of livestock, a two-way interaction term between number of livestock and distance to PA boundary, and a three-way interaction term between number of livestock, distance to PA boundary, and number of people (Table 6). This model showed a positive relationship between number of depredation events in a colony and number of livestock, which interacted positively with distance to protected area, but negatively when numbers of people were, included (Table 6). The final model had a null deviance of 57.53 at 28 *df* and a residual deviance of 25.25 at 25 *df* (AIC = 73.96).

Table 6. Coefficients of the final generalized linear model (GLM) relating number of depredation events in a colony as the response variable with the following predictors: L – number of livestock in the colony, P – number of people in the colony, and PA – distance from the colony to protected area boundary (km). The model revealed significant effects of number of livestock (L), two-way interaction between L and PA (L: PA), and a three-way interaction between L, PA, and P (L: PA: P).

	Estimate	**Standard error**	***Z* value**	***P***
(Intercept)	-0.9496	0.3332	-2.850	0.004
L	0.0756	0.0134	5.615	0.000
L:PA	0.0490	0.0105	4.643	0.000
L:PA:P	-0.0002	0.00003	-5.486	0.000

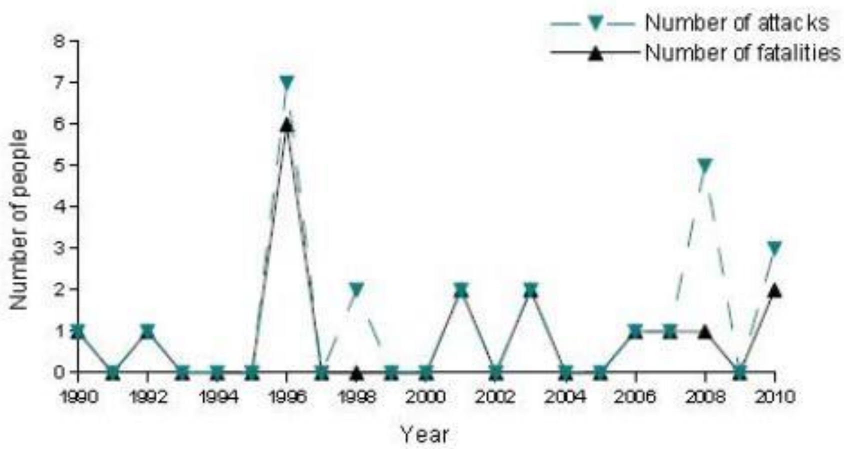

Figure 9. Number of people who were attacked (inverted triangle, dashed line) by leopards and the number of deaths (vertical triangle, complete line) over a 20-year period (1990 – 2010) in the Valparai plateau, Anamalai Hills.

3.4.2. Human and leopard deaths

We collated data on human injuries and deaths due to large carnivores from the Forest Department records and during our study. In last 20 years, there were 22 incidents in which humans were attacked by a large predator. In these 22 instances, 25 people were attacked resulting in 8 injuries and 17 deaths over the last 20 years (Fig. 9). During the same time, 15 leopards died under non-natural or human-induced circumstances, including road accident, getting caught in barbed-wire fence, and drowning in an open water tank (Tamil Nadu Forest Department records). Between 2001 and 2010, 14 people were attacked by leopards, resulting in 9 deaths. In eight of the above cases where age of the person was known, six were children below 10 years of age (***Annexure 2***). Also, all attacks on humans that occurred between 2008 and 2010 took place during late evenings, mostly after 1700 h (unpublished data).

3.4.3. Attitude towards leopards

None of the households in tribal settlements viewed the leopard as a problem. For colonies in plantation estates, we reject the hypothesis that the effect of attacks on people in colony is unrelated to attitude towards leopards ($\chi2$ = 7.033, *df* = 1, *P* = 0.008). More people had negative attitude towards leopards in colonies with previous attack on people than in colonies with no attacks on people. In contrast, the attitude towards leopards appeared unrelated to direct encounters with leopards (χ_2 = 3.321, df = 1, *p* = 0.068), livestock depredation in colony (χ_2 = 0.205, *df* = 1, *P* = 0.651), or livestock depredation at household level (χ_2 = 0.012, *df* = 1, *P* = 0.914).

4. DISCUSSION

In this study, we explored large carnivore diet and local community livelihoods in the fragmented rainforest – plantation landscape of the Valparai plateau, in order to understand interactions between humans and leopards in this region. Previous studies on conflict with large carnivores emphasize the role of high livestock densities in the environment leading to relatively higher consumption of domestic prey species (Bagchi and Mishra, 2006; Michalski *et al.*, 2006). Also, lax husbandry practices such as use of improper corrals at night or grazing of unguarded livestock at longer distances away from corrals have been shown to result in conflict with large carnivores (Mazzolli *et al.*, 2002; Wang and Macdonald, 2006). Similarly, our study found that livestock numbers at a colony was one of the important factors influencing the number of depredation events in a colony. There was higher dependence of large carnivores on wild prey species as most wild prey species persist in this landscape. Most depredation events occurred when the livestock were unguarded, suggesting a potential to reduce number of depredation events through better husbandry practices. Attitudes of people were found to be affected by the presence of attacks on people in a colony but not so by livestock loss to predators. It is important to follow measures that reduce interactions between large predators and people in order to reduce attacks on people, which in turn helps maintain the tolerance of local communities towards these endangered species.

4.1. Large carnivore diet

Livestock contributed 10 – 12 % in terms of relative biomass consumed by tigers in Pench NP and Ranthambore NP (Biswas and Sankar, 2002; Bagchi *et al.*, 2003). In Spiti, 40 – 58 % of snow leopard diet consisted of livestock species (Bagchi and Mishra, 2006). Leopards, like other large carnivores, are known to prey on domestic animals when they are available in the environment as a resource (Mukherjee and Mishra, 2001; Vijayan and Pati, 2001; Edgaonkar and Chellam, 2002; Athreya *et al.*, 2004). Our study reveals a minor role of livestock and dominant role of wild prey species in large carnivore diet in Valparai region comparable to leopard diet within some protected areas (Edgaonkar 2008). Wild prey comprised 98.1% of the total prey biomass consumed by large predators. Using results on 57 scats that were identified using DNA based methods, we found leopard and canid diet in Valparai to comprise mainly wild prey species. Although requiring confirmation from larger samples, there appeared to be some differences among prey species being consumed by the two large carnivores with leopards mostly consuming Indian muntjac, Indian spotted chevrotain and Indian porcupine, whereas the canids mainly consumed Indian munjtac followed by sambar. Against assumption, the canids were also found to prey on Nilgiri langur, an arboreal primate, possibly by hunting or scavenging from leopard kills. Consumption of domestic prey by large carnivores is minor, in which scavenging may also have a potential role.

Leopard diet has been studied in different ecosystems in various continents and leopards are known to prey on animals of varying size (Hayward *et al.*, 2006). In Africa, leopards prey mainly on medium-sized (20 – 80 kg) ungulates in savannah habitats

(Pienaar, 1969; Bailey, 1993), while consuming smaller prey (<5 kg) more often in rainforests, possibly due to differing abundance and profitability (Ray and Sunquist, 2001). Studies in Nagarhole, India, show leopards to select medium-sized prey (31 – 175 kg, Karanth and Sunquist, 1995). Leopards also take substantial small-sized prey in the 5-30 kg range (Karanth and Sunquist, 1995; Ray and Sunquist, 2001; Hart *et al.*, 1996). Leopards are morphologically adapted to kill large prey with an optimum or preferred prey size of 23 kg (Hayward *et al.*, 2006). Choice of prey is influenced by prey availability, abundance, and vulnerability (Emmons, 1987; Iriarte *et al.*, 1990). The preferred prey size consumed by leopards in the study area (30 kg) is comparable to that reported from elsewhere in the world.

4.2. Prey community in plantation – forest fragment landscape

Sambar is known to prefer hilly areas with high tree density (Kushwaha *et al.*, 2004). Similarly, we find that relative abundance of sambar was higher in protected area, forest fragment, and coffee plantations, habitats with higher tree densities, when compared to tea plantations. Teng *et al.* (2004) in Hainan Island, China, reported that Indian muntjac preferred shrub grasslands and dry savannah for foraging while also using taller trees with larger canopies, taller shrubs, and denser shrub canopy cover for bed sites. Similarly, we find that Indian muntjac had higher abundance of indirect signs in coffee plantations which provide a mix of tall shrubs and trees and open patches of grasses. Indian spotted chevrotain reportedly prefers habitats with grass-covered rocky hill slopes, forests, and often occurs close to water sources (Raman, 2004). Heydon and Bulloh (1997) reported that densities of related species *Tragulus javanicus* and *T. borneanus* were negatively correlated with disturbance of forest habitat, and positively correlated with availability of potential food resources such as large fruiting *Ficus* trees. Our study shows that the abundance of indirect signs of Indian spotted chevrotain was significantly higher inside protected area, which potentially has more food and water resources, when compared to tea and coffee plantations.

Forest fragments play a very important role in this tea plantation dominated landscape as abundances of indirect signs for Indian muntjac, sambar, and Indian spotted chevrotain, important prey species, were lower in tea plantation itself. Based on our results, we stress the importance of maintaining these rainforest fragments in the Valparai landscape in maintaining the prey community at an abundance level which is reflected in large carnivore diet. This is critical in reducing the number of negative interactions between humans and leopards in this landscape.

4.3. People and predators

For households in Valparai plateau, estate work was the dominant source of livelihood. Livestock contributed to the income of 4.8% of the households in the sampled colonies. The small proportion (<5%) of households keeping livestock coupled with the sporadic nature of incidents (<1 reported incident/month over the entire area during 2008 – 2010) make this a landscape with relatively low overall conflict with leopards.

Depredation-related losses per incident to households that maintained livestock were equivalent to 13% of the annual earnings. Wang and Macdonald (2006) studied depredation of livestock by leopard, tiger, Himalayan black bear (*Ursus thibetanus*), and dhole in Jigme Singye Wangchuk National Park in Bhutan and reported an annual loss due to depredation equalling two-thirds of the annual income of households (among those that reported livestock loss). In the Indian trans-Himalaya, economic loss to a household due to depredation to snow leopard and wolf amounts to 52% of the average annual per capita income (Mishra, 1997). Our study finds loss to depredation as amounting to 49.7% of average annual per capita income to households keeping livestock. Although, the figures are comparable to previous studies, the communities in the previous studies were pre-dominantly agro-pastoralists while the community in Valparai is primarily dependent on estate labour. Between 2000 and 2010, out of the 40 households that reported their livestock to be lost to large carnivores, ten households applied for and three received compensation. Most people preferred to not claim for compensation because they believed it to be a very time-consuming process.

Livestock depredation at a colony increased with increase in number of livestock and this relationship was more pronounced for colonies that were farther away from the protected area but reversed with increase in number of people. Bagchi and Mishra (2006) reported increased livestock depredation by snow leopards at higher livestock densities from the Indian trans-Himalaya. Similarly, Michalski *et al.* (2006) observed predation by jaguars and pumas to be positively affected by bovine herd size and proportion of forest area but negatively with distance to nearest riparian forest in a fragmented Amazonian forest landscape.

According to Kellert (1996) attitudes towards animals are a consequence of basic values of nature and wildlife reflected in demography, experience, and activity, the species' physical and behavioural characteristics, people's knowledge of the species, and human – animal interactions. Naughton-Treves *et al.* (2003) studied attitudes of bear hunters, livestock producers, and general residents towards wolves in Wisconsin and found social identity as a better indicator of tolerance than individual encounters with the predator. Bagchi and Mishra (2006) reported that a community with higher livestock loss but less dependence on livestock was more tolerant to snow leopards as compared to a community with lower livestock loss but higher dependence on livestock. We found no effects of livestock depredation and direct encounter with leopards on attitude of people towards leopards. In Valparai, dependence on livestock as means of livelihood is relatively low as most people work in the plantations and hence livestock depredation may not substantially influence attitudes towards leopards.

Mostly the cattle in estate colonies are guarded by an estate-employed herder during grazing hours (usually for 7 hours per day). Often, cattle remain unguarded for a couple of hours during the evening before the owners return from work inside plantation estates. The shed used as a corral for cattle overnight was found to be open many times during our surveys. On some occasions, livestock were killed by a predator in an open corral at night. Also, many times when a livestock was believed to be killed by a large predator, it was unguarded. Following better husbandry practices such as closed corrals for livestock will reduce the existing interface between people and predators. Most of the colonies have open garbage dumps next to houses. These attract stray animals such as dogs and wild animals such as wild boar, which in turn may attract leopards leading to increased encounters between people and leopards. It is necessary to have garbage dumps that are closed and away from the houses.

In colonies where people had been attacked by leopards in the past, however, more people had a negative attitude towards leopards. During interview surveys, many people believed that attacks on humans had increased in the recent past, which was consistent with the widespread misconception (or misinformation) that leopards were being brought from elsewhere and released into the Valparai landscape. Data on human deaths due to large predators showed that these were more or less spread across a period of 20 years with no evidence of increase in recent times. Most incidents of human deaths involved children and happened in late evenings. During evening hours, it is important that adults accompany and supervise children when walking through the tea plantations and discourage them walking alone.

Most households that believe leopard to be a problem sought capture of the leopard and translocation as a remedy to reduce conflict. This was also the primary response of the State Forest Departments, resulting in capture and translocation of 9 individual leopards over a 38 month period spanning the study (Table 7). Several individuals suffered injuries and translocations were made to new locations distant from the home range of the individual. Studies of translocated leopards in Maharashtra have shown that such translocations may actually induce attacks on humans close to release sites and may lead to increase in conflicts (Athreya *et al.*, 2010). Based on this study, the authors have suggested that conflict reduction may preferably target measures such as more effective compensation procedures to pay owners for the livestock lost due to carnivore predation, improving methods to protect livestock, and encouraging greater social acceptance of the presence of carnivores in human dominated landscapes.

Table 7. Details on translocation of leopards captured in Valparai between December 2007 and January 2011 in response to attacks on people. In the following table, ATR is Anamalai Tiger Reserve and WLS is Wildlife Sanctuary.

No.	Year	Date	Sex	Age class	Capture location	Release site	Injuries
1	2007*	20 December	Male	Subadult	Velonie estate	Topslip, ATR	On face
2	2008^	26 March	-	-	Valparai town	Vandalur zoo	On face
3	2008*	24 April	Male	Subadult	Anali estate	Vandalur zoo	Severe on face, especially near eyes
4	2010*	January	Male	Adult	Tonimudi	-	-
5	2010*	5 May	Male	Adult	Tonimudi	Amaravathi, ATR	Minor injury on the face
6	2010#	31 May	Female	Adult	Malakiparai	Wayanad WLS	On face
7	2010#	6 June	Male	-	Malakiparai	Wayanad WLS	-
8	2010^	November	Male	Adult	Thaymudi	Sathyamangalam WLS (probable)	-
9	2010^	22 December	Male	Adult	Gajamudi	Sathyamangalam WLS	On face and chest

* – translocations in response to attacks on people, which led to death of the victim,
^ – translocations in response to attacks leading to injury to the victim, and
# – translocations in response to mere sighting of a leopard around settlement.

A leopard tranquilised at the outskirts of Valparai town being carried to a cage as townspeople crowd around and watch.

5. CONCLUSIONS AND RECOMMENDATIONS

Our study finds, that in the commercial plantation dominated region of Valparai plateau that is surrounded by protected areas, large carnivores predominantly feed on available wild prey. Livestock depredation is occasional and is perceived to cause an estimated loss of 13% of the annual household income per incident among those households that keep livestock (<5% of sampled households). In general, colonies with more livestock had higher number of depredation events. Distance to protected area and numbers of people in a colony were found to interact with livestock numbers and influenced the number of depredation events in a colony. Monetary losses to large predators were found to have no effect on people's attitudes toward leopards. However, in colonies where people were injured or died due to leopards, more people had negative attitude towards the species. Valparai acts as a refuge and corridor for large mammal populations and adjoins the newly-formed Anamalai Tiger Reserve. It is important to deal with the issues relating to human-leopard conflict for long-term conservation of large carnivores. In this regard, management strategies that consider leopard biology as well as take a proactive approach towards reducing encounters between people and leopards must be preferred. Based on our understanding, we suggest some recommendations for better management:

• As large carnivores are predominantly dependent on available wild prey species and rainforest fragments act as refugia for these mammals within the tea and coffee plantations, Forest Department and private landowners should both continue to protect and assist in recovery or restoration of these forest fragments.

• Cattle guarded by day by herders are often returned to colonies before their owners return from work. Many depredation events occurred during evening hours while owners were still away. It is important that cattle are guarded or secured in corrals until owners return from work to reduce losses to depredation.

• During our surveys, several night sheds used as livestock corrals were found to be open. Livestock were attacked at night in such open corrals in some incidents. Constructing night corrals that are closed and away from colonies can help minimise such attacks as well as encounters between people and leopards.

• As an alternative to compensation, livestock insurance schemes that reimburse losses to depredation expediently should be considered and implemented for continued support of local communities for large carnivore conservation.

• Most attacks on people were on young children and occurred in late evening. It is important that children are accompanied and supervised by adults at these hours.

A leopard captured in Valparai with injuries on its face from the metal bars of the cage in which it was

• Most estate colonies have open garbage dumps close to labour housing, which attracts stray dogs and wild boar (potential prey of leopards). It is important that garbage facilities are away from colonies but accessible and closed, with procedures for segregation, periodic collection, and appropriate disposal. Other measures such as provision of attached toilets in labour housing with running water supply (as an essential facility for welfare of workers and to avoid risk from answering nature's call in the open due to non-availability of functional toilets) and carrying flashlights at night (as a mandatory safety measure to reduce direct encounters with leopards) should be discussed with local communities and estate management and their adoption encouraged.

• In most cases, translocations of leopards as a measure for dealing with human-leopard conflict must be avoided. This results in injuries to the animal and may lead to increase in incidence of conflict both at capture location and release sites (Athreya *et al.*, 2007; 2010). Proactive measures to ensure avoidance of encounter with leopards should be discussed with local people. In case of sighting of a leopard near human settlement or non intentional attack on people leading to injuries, translocations should not be carried out. It is important to research the cause of attack and based on the cause, decide a response measure. The scientific basis for pin-pointing a 'problem animal' for removal remains weak in most cases (Linnell *et al.* 1999). Translocation can be carried out in case of human death but only by a team of trained staff proficient in capture, handling, and translocation of leopards. Management of crowds when translocation is being carried out plays a very important role by reducing unnecessary trauma to the captured animal or injury to people in the crowd. Detailed guidelines for measures leading to reduction in conflict and dealing with conflict are provided by Athreya and Belsare (2007) as well as in the *Guidelines for Human – Leopard Conflict Management* issued by the Ministry of Environment and Forests (MoEF 2011) and available here: http://moef.nic.in/downloads/publicinformation/ guidelines-human-leopard-conflict-management.pdf

REFERENCES

Ackerman, B. B., Lindzey, F. G., and Hemker, T. P. (1984). Cougar food habits in Southern Utah. *Journal of Wildlife Management* 48: 147 – 155.

Anonymous (2003). T*he Wildlife (Protection) Act, 1972 as amended up to 2003*. Wildlife Trust of India, New Delhi and Natraj Publishers, Dehra Dun.

Anonymous (2008). Panther trapped near Valparai, taken to Vandaloor zoo. *The Hindu* 17 April 2008.

Athreya, V. R. (2006). Is relocation a viable management option for unwanted animals?—The case of the leopard in India. *Conservation and Society* 4: 419-423.

Athreya, V. R., and Belsare, A. V. (2006). 'Carnivore conflict': Support provided to leopards involved in conflict-related cases in Maharashtra. Wildlife Trust to India, New Delhi.

Athreya, V. R., and Belsare, A. V. (2007). *Human-leopard conflict management guidelines.* Kaati Trust, Pune. India.
http://environmentportal.in/files/Conflict%20management%20manual.pdf

Athreya, V. R., Thakur, S. S., Chaudhuri, S., and Belsare, A. V. (2004). A study of the man-leopard conflict in the Junnar Forest Division, Pune District, Maharashtra. Submitted to the Office of the Chief Wildlife Warden, Nagpur. Maharashtra Forest Department and Wildlife Protection Society of India, New Delhi.
http://www.ncra.tifr.res.in/~rathreya/JunnarLeopards/

Athreya, V. R., Thakur, S. S., Chaudhuri, S., and Belsare, A. V. (2007). Leopards in human dominated areas: a spill over from sustained translocations into nearby forests? *Journal of the Bombay Natural History Society* 104: 45-50.

Athreya, V., Odden, M., Linnell, J. D. C., and Karanth, K. U. (2010). Translocation as a tool for mitigating conflict with leopards in human-dominated landscapes of India. *Conservation Biology* 25: 133-141.

Bailey, T. N. (1993) *The African leopard: Ecology and behaviour of a solitary felid.* Columbia University Press, New York.

Bauer, H., and de Iongh, H. H (2005). Lion (*Panthera leo*) home ranges and livestock conflicts in Waza National Park, Cameroon. *African Journal of Ecology* 43: 208–214.

Bagchi, S., Goyal, S. P., and Sankar, K. (2003). Prey abundance and prey selection by tigers (*Panthera tigris*) in a semi-arid, dry deciduous forest in western India. *Journal of Zoology* 260: 285–290.

Bagchi, S., and Mishra, C. (2006). Living with large carnivores: predation on livestock by the snow leopard (*Uncia uncia*). *Journal of Zoology* 268: 217-224.

Biswas, S., and Sankar, K. (2002). Prey abundance and food habit of tigers (*Panthera tigris tigris*) in Pench National Park, Madhya Pradesh, India. *Journal of Zoology* 256: 411–420.

Conner, M. M., Jaeger, M. M., Weller, T. J., and McCullough, D.R. (1998). Effect of coyote removal on sheep depredation in northern California. *Journal of Wildlife Management* 62: 690–699.

Crawley, M. J. (2007). *The R Book*. John Wiley & Sons Ltd, Chichester, West Sussex, England.

Edgaonkar, A. (2008). Ecology of the leopard (*Panthera pardus*) in Bori Wildlife Sanctuary and Satpura National Park, India. PhD thesis, University of Florida, Gainesville.
http://www.carnivoreconservation.org/files/thesis/edgaonkar_2008_phd.pdf

Edgaonkar, A., and Chellam, R. (2002). Food habit of the leopard, *Panthera pardus*, in the Sanjay Gandhi National Park, Maharashtra, India. *Mammalia* 66: 353-360.

Eisenberg, J. F. (1980). The density and biomass of tropical mammals. Pp. 35-55 in Soule, M. E. and Wilcox, B. A. (eds) *Conservation Biology: An Evolutionary-ecological Perspective*. Sinauer Associates, Sunderland, MA.

Emmons, L. H. (1987). Comparative feeding ecology of felids in a Neotropical rainforest. *Behavioural Ecology and Socio-biology* 20: 271-283.

Floyd, T. J., Mech, L. D., and Jordan, P. J. (1978). Relating wolf scat contents to prey consumed. *Journal Wildlife Management* 42: 528–532.

Hart, J. A., Katembo, M., and Punga, K. (1996). Diet, prey selection and ecological relations of leopard and golden cat in the Ituri forest, Zaire. *African Journal of Ecology* 34: 364–379.

Hayward, M. W., Henschel, P., O'Brien, J., Hofmeyr, M., Balme, G., and Kerley, G. I. H. (2006). Prey preferences of the leopard (*Panthera pardus*) *Journal of Zoology* 270: 298–313.

Heydon, M. J., and Bulloh, P. (1997). Mousedeer densities in a tropical rainforest: the impact of selective logging. *Journal of Applied Ecology* 34: 484 – 496.

Hoare, R. E. (1999). Determinants of human-elephant conflict in a land-use mosaic. *Journal of Applied Ecology* 36: 689 – 700.

Hunter, H., Balme, G., Walker, C., Pretorius, K., and Rosenberg, K. (2003). The landscape ecology of leopards (*Panthera pardus*) in the northern KwaZulu-Natal, South Africa: A preliminary project report. *Ecological Journal* 5: 24 – 30

Iriarte, J. A., Franklin, W. L., Johnsin, W. E., and Redford, K. H. (1990). Biogeographic variation of foods habits and body size of the America puma. *Oecologia* 85:185-190.

Karanth, K. U., and Madhusudan, M. D. (2002). Mitigating human-wildlife conflicts in southern Asia. Pp. 250-264 in Terborgh, J. Van Schaik, C., Davenport, L. and Rao, M. (eds) *Making Parks work: Strategies for preserving tropical nature*. Island Press, Covelo, California.

Karanth, K. U. and Sunquist, M. E. (1995). Prey selection by tiger, leopard and dhole in tropical forests. *Journal of Animal Ecology* 64: 439–450.

Kellert, S. R. (1996). *The value of life: Biological diversity and human society*. Island Press, Washington, D.C.

Knowlton, F. F., Gese, E. M., and Jaeger, M. M. (1999). Coyote depredation control: an interface between biology and management. *Journal of Range Management* 52: 398–412.

Kumar, A., Pethiyagoda, R., and Mudappa, D. (2004). Western Ghats and Sri Lanka. Pp. 152–157 in Mittermeier R. A., Gil, P. R., Hoffmann, M., Pilgrim, J., Brooks, T., Mittermeier, C. G., Lamoureux, J., and da Fonseca, G. A. B. (eds). *Hotspots revisited-Earth's biologically richest and most endangered ecoregions*. CEMEX, Mexico.

Kushwaha, S. P. S., Khan, A., Habib, B., Quadri, A., and Singh, A. (2004). Evaluation of sambar and muntjak habitats using geostatistical modelling. *Current Science* 86: 1390 – 1400.

Landa, A., Gudvangen, K., Swenson, J. E., and Roskaft, E. (1999). Factors associated with wolverine *Gulo gulo* predation on domestic sheep. *Journal of Applied Ecology* 36: 963–973.

Linnell, J. C. D., Odden, J., Smith, M. E., Aanes, R., and Swenson, J. E. (1999). Large carnivores that kill livestock: Do problem animals really exist? *Wildlife Society Bulletin* 27: 698- 705.

Lindstedt, S. L., Miller, B. J., and Buskirk, S. W. (1986). Home range, time, and body size in mammals. *Ecology* 67: 413 – 418.

Madhusudan, M. D. (2003). Living amidst large wildlife: livestock and crop depredation by large mammals in the interior villages of Bhadra tiger reserve, south India. *Environmental Management* 31: 466 – 475.

Madhusudan, M. D., and Mishra, C. (2003). Why big, fierce animals are threatened: conserving large mammals in densely populated landscapes. Pp. 31–55 in Saberwal, V. and Rangarajan, M. (eds) *Battles over nature: science and the politics of conservation*. New Delhi: Permanent Black.

Manfredo, M. J., and Dayer, A. A. (2004). Concepts for Exploring the Social Aspects of Human–Wildlife Conflict in a Global Context. *Human Dimensions of Wildlife* 9: 317–328.

Mazzolli, M., Graipel, M. E., and Dunstone, N. (2002). Mountain lion depredation in southern Brazil. *Biological Conservation* 105: 43–51.

Michalski, F., Boulhosa, R. L. P., Faria, A., and Peres, C. A. (2006). Human–wildlife conflicts in a fragmented Amazonian forest landscape: determinants of large felid depredation on livestock. *Animal Conservation* 9: 179–188.

Mishra, C. (1997). Livestock depredation by large carnivores in Indian trans-Himalayas: conflict perceptions and conservation prospects. *Environmental Conservation* 24: 338–343.

MoEF (2011). Guidelines for human – leopard conflict management. Ministry of Environment and Forests, Government of India, New Delhi.

http://moef.nic.in/downloads/publicinformation/ guidelines-human-leopard-conflict-management.pdf
Mudappa, D., and Raman, T. R. S. (2007). Rainforest restoration and wildlife conservation on private lands in the Western Ghats. Pp. 210-240 in Shahabuddin, G. and Rangarajan, M. (eds) *Making Conservation Work.* Permanent Black, Ranikhet.
Mukherjee, S. and Mishra, C. (2001). Predation by leopard *Panthera pardus* in Majhatal Harsang Wildlife Sanctuary, W. Himalayas. *Journal of the Bombay Natural History Society* 98: 267– 268.
Mukherjee, S., Goyal, S. P., and Chellam, R. (1994). Standardisation of scat analysis techniques for leopard (*Panthera pardus*) in Gir National Park, Western India. *Mammalia* 58:139-143.
Naughton-Treves, L., Grossberg, R., and Treves, A. (2003). Paying for tolerance: rural citizens' attitudes toward wolf depredation and compensation. *Conservation Biology* 17: 1500–1511.
Oli, M. K., Taylor, I. R., and Rogers, M. E. (1994). Snow leopard *Panthera uncia* predation of livestock-an assessment of local perceptions in the Annapurna Conservation area, Nepal. *Biological Conservation* 68: 63–68.
Pascal, J. P. (1988). Wet evergreen forests of the Western Ghats of India: Ecology, structure, floristic composition and succession. Institute Francais de Pondichery, Pondicherry.
Pienaar, U. V. (1969). Predator-prey relationships amongst the larger mammals of the Kruger National Park. *Koedoe* 12: 108-176.
R Development Core Team (2009) R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-9000051-07-0, URL http://www.R-project.org
Raman, T. R. S. (2004). Mouse Deer (*Moschiola meminna* Erxleben, 1777) in *Ungulates of India*. Envis Wildlife and Protected Areas 7 (1), Wildlife Institute of India, Dehradun.
Ray, J. and Sunquist, M. E. (2001). Ecological separation within an African forest carnivore community. *Oecologia* 127: 395-408.
Schaller, G.B. (1967). *The deer and the tiger: a study of wildlife in India.* University of Chicago, Chicago.
Simcharoen, S., Barlow, A. C. D., Simacharoen, A., and Smith, J. D. (2008). Home range size and day time habitat selection of leopards in Huai Kha Khaeng Wildlife Sanctuary, Thailand. *Biological Conservation* 141: 2242-2250.
Teng, L., Liu, Z., Song, Y-L., and Zeng, Z. (2004). Forage and bed sites characteristics of Indian muntjac (Muntiacus muntjak) in Hainan Island, China. *Ecological Research* 19: 675-681.
Treves, A., Jurewicz, R. R., Naughton-Treves, L., Rose, R. A., Willging, R. C., and Wydeven, A. P. (2002). Wolf depredation on domestic animals in Wisconsin, 1976–2000. *Wildlife Society Bulletin* 30: 222–230.
Vijayan, S., and Pati, B. P. (2002). Impact of changing cropping patterns on man-animal conflicts around Gir Protected Area with specific reference to Talala sub-district, Gujarat, India. *Population and Environment* 23: 541–559.
Wang, S. W., and Macdonald, D. W. (2006). Livestock predation by carnivores in Jigme Singye Wangchuck National Park, Bhutan. *Biological Conservation* 129: 558–565.
William, D., Newmark, W. D., Manyanza, D. N., Gamassa Deo-Gratias, M., and Sariko, H. I. (1994). The Conflict between Wildlife and Local People Living Adjacent to Protected Areas in Tanzania. Human Density as a Predictor. *Conservation Biology* 8: 249-255.
Windberg, L. A., Knowlton, F. F., Ebbert, S. M., and Kelly, B. T. (1997). Aspects of coyote predation on Angora goats. *Journal of Wildlife Management* 50: 226–230.
Woodroffe, R. (2000) Predators and people: using human densities to interpret declines of large carnivores. *Animal Conservation* 3: 165–173.
Zimmermann, A., Walpole, M. J., and Leader-Williams, N. (2005). Cattle ranchers' attitudes to conflicts with jaguar *Panthera onca* in the Pantanal of Brazil. *Oryx* 39: 406–412.

ANNEXURE 1: Details of past depredation incidents in Valparai for years 1999 – 2010.

No.	Year	Month	Owner's name	Livestock Species	Age class	Injury/ Death	Number of animals	Economic loss (INR)	Compensation received (INR)	Colony name	Suspected predator	Source
1	1999	April	Gnansekar	Cow	Calf	Death	1	3700	2000	Kavarkal estate	Leopard	FD*
2	2000	NA	Murgesan	Cow	Calf	Injury	1	1500	0	Velonie Lower Division	Leopard	Self
3	2000	NA	Murgaiya	Cow	Calf	Death	1	5000	0	Vaghamalai	Leopard	Self
4	2000	January	Shangavel	Cow	Adult	Death	1	14000	2000	Valparai town	Leopard	FD
5	2000	February	Thangamani	Cow	Adult	Death	1	14000	2000	Stanmore	Leopard	FD
6	2001	March	Malaiswami	Cow	Adult	Death	1	14000	2000	Parali	Leopard	FD
7	2001	March	Ibrahim	Buffalo	Adult	Death	1	14000	2000	Urullikal	Tiger	FD
8	2001	April	Malpani	Cow	Adult	Death	1	14000	2000	Vellamalai	Leopard	FD
9	2001	June	Velaidum	Cow	Adult	Death	1	14000	2000	Iyyerpadi II Division	Leopard	FD
10	2002	NA	Swamidas	Cow	Adult	Death	1	15000	0	Lower Paralai	Leopard	Self
11	2003	NA	Swamidas	Cow	Calf	Death	1	6000	0	Lower Paralai	Leopard	Self
12	2003	January	Vadivel	Cow	Calf	Death	1	4000	2000	Karamalai	Leopard	Self
13	2003	June	Chinnathai	Cow	Calf	Death	1	3700	2000	Lower Paralai	Leopard	FD
14	2003	June	Kanthavel	Cow	Calf	Death	1	3700	2000	Lower Paralai	Leopard	FD
15	2003	December	Sirinivasan	Cow	Calf	Death	1	3700	2000	Waterfall estate	Leopard	FD
16	2005	December	Chandanamary	Cow	Calf	Death	1	3700	2000	Nallarjathu	Leopard	FD
17	2007	November	Punnaiyan	Cow	Calf	Death	1	3000	0	Lower Paralai	Leopard	Self
18	2007	November	Jyothi	Cow	Calf	Death	1	3000	0	Lower Paralai	Leopard	Self
19	2007	September	Arumugam	Cow	Calf	Death	3	12000	6000	Lower Paralai	Leopard	FD
20	2007	NA	Jaikarnan	Cow	Adult	Death	1	12000	0	Varattuparai	Leopard	Self
21	2007	NA	Anthonyamma	Cow	Calf	Death	1	2500	0	Urulikal Upper Division	Leopard	Self
22	2008	August	Suresh	Cow	Adult	Death	1	30000	0	Upper Paralai	Leopard	Self
23	2008	NA	Mary	Cow	Calf	Death	1	7000	0	Lower Paralai	Leopard	Self
24	2008	January	Palaniappan	Cow	Adult	Death	1	17000	0	Varattuparai	Tiger	Self
25	2008	March	Rajamma	Cow	Adult	Injury	1	5000	0	Varattuparai	Leopard	Self
26	2008	NA	Farzeenia	Cow	Calf	Injury	1	2000	0	Anali Pudhukadu	Leopard	Self
27	2008	NA	Farzeenia	Cow	Calf	Death	1	2000	0	Anali Pudhukadu	Leopard	Self
28	2008	September	Kumar	Cow	Calf	Death	2	8000	4000	Vaghamalai	Dholes	Self
29	2008	January	Mallika	Cow	Adult	Death	1	14000	2000	Paraimedu Rottikadai	Leopard	FD

No.	Year	Month	Owner's name	Livestock Species	Age class	Injury/ Death	Number of animals	Economic loss (INR)	Compensation received (INR)	Colony name	Suspected predator	Source
30	2008	September	Durai	Cow	Adult	Death	1	14000	2000	Anali Pudhukadu	Leopard	FD
31	2009	April	Chinnaswami	Cow	Calf	Death	1	5000	0	Ropeway Iyyerpadi	Leopard	Self
32	2009	November	Muthuswami	Cow	Calf	Death	1	10000	0	Office Iyyerpadi	Leopard	Self
33	2009	NA	Saraswathi	Cow	Calf	Death	1	3000	0	Urulikal Division II	Leopard	Self
34	2009	NA	Chitra	Cow	Calf	Death	1	3000	0	Karamalai	Leopard	Self
35	2009	NA	Palaniswami	Cow	Adult	Death	1	13000	0	Vaghamalai	Leopard	Self
36	2009	June	Arumugam	Cow	Adult	Death	1	20000	0	Bharathidas Nagar	Dholes	Self
37	2009	NA	Marimuthu	Cow	Adult	Death	1	20000	0	Nadumalai South	Leopard	Self
38	2009	NA	Ramesh	Cow	Adult	Death	1	13000	0	Akkamalai	Leopard	Self
39	2009	February	Selvaraj	Cow	Adult	Death	1	14000	2000	Injiparai Upper Division	Dholes	FD
40	2010	July	Vellaiswami	Cow	Calf	Death	1	8000	0	Office Iyyerpadi	Leopard	Self
41	2010	February	Punnaiyan	Cow	Calf	Death	1	3000	0	Upper Paralai	Leopard	Self
42	2010	September	Jyothi	Cow	Adult	Death	1	15000	0	Upper Paralai	Leopard	Self
43	2010	May	Natraj	Cow	Adult	Death	1	10000	0	Lower Paralai	Leopard	Self
44	2010	NA	Rajamma	Cow	Calf	Death	1	1000	0	Varattuparai	Leopard	Self
45	2010	June	Balamma	Cow	Calf	Death	1	1500	0	Vellamalai Top	Leopard	Self
46	2010	NA	Gayathri	Cow	Calf	Death	1	3000	0	Urullikal Upper Division	Leopard	Self
47	2010	February	Kolindaras	Cow	Calf	Death	1	1500	0	Periyar Nagar	Leopard	Self
48	2010	September	Kanthavel	Goat	Adult	Death	6	12000	0	Periyar Nagar	Leopard	Self
49	2010	NA	Raja	Cow	Adult	Death	1	8500	0	Periyar Nagar	Leopard	Self
50	2010	June	Punnaiah	Cow	Adult	Death	1	12000	0	Periyar Nagar	Leopard	Self
51	2010	June	Suresh	Cow	Calf	Death	1	450	0	Bharathidas Nagar	Dholes	Self
52	2010	June	Meghana	Cow	Calf	Death	1	0	0	Bharathidas Nagar	Dholes	Self
53	2010	September	Muthulakshmi	Cow	Adult	Death	1	4000	0	Bharathidas Nagar	Dholes	Self

* FD is Tamil Nadu Forest Department

ANNEXURE 2: Details of attacks on people by large carnivores that resulted in either injury or mortality for years 1990 – 2010

No.	Year	Month	Name	Sex	Age	Injury/ Death	Location	Suspected predator
1	1990	December	Vayouri	Male	NA	Death	Anali Estate	Leopard
2	1992	February	Harikrishnan	Male	7	Death	Waterfall estate	Leopard
3	1996	February	Krishnakutty	Male	NA	Death	Valparai town	Leopard
4	1996	September	Saraswathi	Female	NA	Death	Sirikundra	Tiger
5	1996	September	Santhosam	Male	NA	Death	Sirikundra	Tiger
6	1996	September	Pandiyan	Male	NA	Death	Sirikundra	Tiger
7	1996	February	Narayanan	Male	NA	Death	Valparai town	Leopard
8	1996	April	Krishnan	Male	31	Injury	Cinchona	Tiger
9	1996	April	Perumal	Male	53	Death	Cinchona	Tiger
10	1998	December	Subramanium	Male	41	Injury	Lower Paralai	Leopard
11	1998	December	NA	Female	NA	Injury	Valparai town	Leopard
12	2001	June	Selvan	Male	7	Death	Plenty Valley	Leopard
13	2001	September	Muthu	Male	NA	Death	Balaji Estate	Leopard
14	2003	March	Devaki	Female	NA	Death	Balaji Estate	Leopard
15	2003	March	NA	Female	21	Death	Thalanar	Leopard
16	2006	August	Ramya	Female	NA	Death	Velonie	Leopard
17	2007	December	Kaushalya	Female	7	Death	Velonie	Leopard
18	2008	January	Geetha	Female	NA	Injury	Valparai town	Leopard
19	2008	April	Gayathri	Female	5	Death	Anali Estate	Leopard
20	2008	August	Vanaraj	Male	NA	Injury	Valparai town	Leopard
21	2008	November	Thyagarajan	Male	NA	Injury	Sholayar estate	Leopard
22	2008	April	Sinnaraj	Male	41	Injury	Gajamudi esate	Leopard
23	2010	January	Mugeswaran	Male	5	Death	Tonimudi	Leopard
24	2010	April	Manishankaran	Male	9	Death	Tonimudi	Leopard
25	2010	November	Sharanya	Female	9	Injury	Thaymudi	Leopard