DOI: 10.1007/s00267-002-2790-8

Living Amidst Large Wildlife: Livestock and Crop Depredation by Large Mammals in the Interior Villages of Bhadra Tiger Reserve, South India

M. D. MADHUSUDAN
Centre for Ecological Research and Conservation*
3076/5, IV Cross, Gokulam Park, Mysore 570 002, India
and National Institute of Advanced Studies
Indian Institute of Science Campus, Bangalore 560 012, India

ABSTRACT / Conflict with humans over livestock and crops seriously undermines the conservation prospects of India's large and potentially dangerous mammals such as the tiger (*Panthera tigris*) and elephant (*Elephas maximus*). This study, carried out in Bhadra Tiger Reserve in south India, estimates the extent of material and monetary loss incurred by resident villagers between 1996 and 1999 in conflicts with large felines and elephants, describes the spatiotemporal patterns of animal damage, and evaluates the success of compensation schemes that have formed the mainstay of loss-alleviation measures. Annually each household lost an estimated 12% (0.9 head) of their total holding to large felines, and approximately 11% of their annual grain production (0.82 tonnes per family) to elephants. Compensations awarded offset only 5% of the livestock loss and 14% of crop losses and were accompanied by protracted delays in the processing of claims. Although the compensation scheme has largely failed to achieve its objective of alleviating loss, its implementation requires urgent improvement if reprisal against large wild mammals is to be minimized. Furthermore, innovative schemes of livestock and crop insurance need to be tested as alternatives to compensations.

An elephant in a crop field or a tiger in a cattle pen presents a situation that is doubly perturbing: not only are crops and cattle at risk from hungry wildlife, but so are the elephant and the tiger from angry humans. Throughout the world, conflicts between wildlife and humans undermine their mutual well being and increasingly threaten the conservation of many wildlife species involved. Although of worldwide occurrence (Sukumar 1991, Hoogesteijn and others 1993, Cozza and others 1996, Barnes 1996, Mishra 1997, Naughton-Treves and others 1998), conflicts between humans and wildlife are most intense in the tropics, where wildlife competes directly with a rapidly increasing human demand over scarce land and resources. Almost invariably, the species implicated—and threatened—in such conflicts are large-bodied mammals that are intrinsically rare and extinction-prone (Madhusudan and Mishra 2003).

India is believed to contain over half the world's remaining population of tigers (Seidensticker and others 1999) and Asian elephants (Sukumar and Santiapillai 1996) and holds the greatest promise for the long-term conservation of these species in the wild. Today, populations of these and other large mammal species in India are mostly distributed across the country's network of 540-plus wildlife reserves (Madhusudan and Karanth 2000). Significantly, 69% of these reserves also support resident human populations, mostly poor and disadvantaged, whose overall numbers are estimated to exceed three million (Kothari and others 1995). As a result, India's wildlife reserves support a variety of human land uses, including agriculture, pasturing of livestock, and many direct extractive uses of natural resources. A survey in the late 1980s (Kothari and others 1989) revealed that cultivation, livestock grazing, and extraction of nontimber forest products occurred in 66%, 69%, and 57% of the reserves, respectively. Such a close juxtaposition of tigers, elephants, and other large mammals with humans and their land use has precipitated serious conflicts countrywide over space and resources (for reviews, see Sukumar 1994, Madhusudan and Mishra 2001). The conservation of large and potentially dangerous mammals within India's densely populated wildlife reserves thus poses singular challenges.

India's wildlife managers and academics have, in general, appreciated that losses suffered by humans in such conflicts inevitably erode local goodwill and generate animosity towards conservation efforts. Wildlife managers have therefore instituted several schemes for preventing human–wildlife conflicts (Sukumar 1994, Karanth and Madhusudan 2002) involving physical and behavioral means of excluding large mammals from

KEY WORDS: Human–wildlife conflict; Livestock depredation; Crop raiding; Large mammals; India

*Address for correspondence; *e-mail:* mdm@ncf-india.org

human habitation. In reality, conflicts continue to occur despite such measures. Thus, reparatory measures, such as monetary compensations, are believed to help in assuaging these conflicts. However, in relation to the diversity of socioeconomic and ecological contexts, there are very few assessments (Mishra 1997; Manakadan and Rahmani 1998; Sekhar 1998; Nath and Sukumar 1998) of the extent of monetary losses suffered in wildlife–human conflicts in India, and the effectiveness of compensation schemes in offsetting these losses.

In this paper, I present a case study of livestock depredation by tigers and leopards (*Panthera pardus*) and of crop depredation by elephants in five interior villages of Bhadra Tiger Reserve, southern India. Specifically, I assess the extent and impact of material and monetary losses suffered by resident villagers, examine spatiotemporal patterns in loss suffered in the villages from livestock and crop depredation, evaluate the effectiveness of compensation schemes instituted by the Forest Department to offset such losses to villagers, and discuss the options available to streamline the *post facto* management of conflict between large mammals and humans in India.

Study Area

Bhadra Tiger Reserve (hereafter Bhadra) is located at the foothills of the Western Ghats Mountains and stretches across Chikmagalur and Shimoga districts in the southern Indian state of Karnataka. Bhadra covers an area of 495 km^2 and is dominated by moist to dry deciduous forests. It receives over 2000 mm of rain annually, with most of it falling during the southwest monsoon between June and September. Bhadra was designated as a Wildlife Sanctuary in 1974, and included as a Tiger Reserve under the Indian Government's Project Tiger initiative in 1998.

The large mammalian fauna of Bhadra comprises a diverse assemblage of predator and prey that includes large herbivores such as the Asian elephant (*Elephas maximus*), gaur (*Bos gaurus*), sambar (*Cervus unicolor*), chital (*Axis axis*), wild pig (*Sus scrofa*), and muntjac (*Muntiacus muntjak*), and large carnivores such as the tiger, leopard, and the Asiatic wild dog or dhole (*Cuon alpinus*). Greater detail about the wildlife of Bhadra is available in Karanth (1982) and Kumar (2000).

In Bhadra, 16 isolated villages under the administrative control of the State Revenue Department are embedded within a larger forested landscape managed by the State Forest Department. According to records (Government of Karnataka 1992), 736 families (population ca. 3000) own property within these villages. However, the number of families actually residing within these villages is much lower (personal observation). Of these villages, I chose five—Muthodi, Késavé, Maadla, Hipla, and Karvaani—that accounted for over half of the human population resident within Bhadra. Nearly 65% of the resident families in these villages were landless and either tilled land as sharecroppers, worked as wage laborers in coffee estates surrounding Bhadra, or gathered forest produce seasonally for local markets.

Cattle dominate the village livestock, which also includes buffalo, sheep, and goat. Oxen make up the majority of the cattle population and are employed mainly as draft animals in agricultural fields. Cattle are rather unproductive as milk animals and are reared mostly as sources of organic manure used in the crop fields. During the primary growing season (May–November), adult livestock graze exclusively in the surrounding forests, while at other times they may also graze in the fallow cropland. Wet paddy (*Oryza sativa*) cultivation is the dominant agricultural activity in the villages. Most farmers raise a single monsoon-dependent paddy crop, although a small proportion of farmers with access to year-round irrigation raise a second crop during the dry season. A few families also maintain small plantations of coffee (*Coffea robusta*) and areca (*Areca catechu*), in addition to cultivating paddy and pulses.

Although all three large carnivores present in Bhadra—tiger, leopard, and dhole—are capable of killing livestock, it is mainly the solitary and nocturnal felines that cause most of the damage. Elephants are the most important species jeopardizing crops grown in the interior villages. Besides feeding on paddy, elephants are believed to destroy greater amounts of grain by trampling the fields. In addition to elephants, wild pigs also damage paddy crop in villages.

Humans seldom accompany cattle that graze in the forests, whereas goats, sheep, and buffalos always graze under human escort. Livestock, however, are always penned overnight in stalls within human settlements. All villages except Karvaani are ringed by perennial streams, which serve to attract wildlife, including the depredatory species. The crop fields also extend considerable distances (up to a kilometer) from the village. Prior to harvest, therefore, farmers erect treetop lookouts on the periphery of the fields and maintain continuous vigil over their crops. Shouting, beating tin cans, hurling rocks, and bursting firecrackers are the primary methods used to scare off elephants, although it is not uncommon to fire at marauding elephants with shotguns and muzzle-loaders (D.V. Girish personal communication).

Methods

Data Collection

During April–May of 1999, I conducted a survey of 86 households owning livestock in the villages of Muthodi, Késavé, Maadla, Hipla, and Karvaani. The 86 households surveyed accounted for over two thirds of the estimated livestock population and 52% of the total cropland tilled in the five villages. The surveys gathered the following details regarding the livestock holding of each respondent: size and composition of current holding, annual sale or purchase of livestock between April 1996 and March 1999, and annual livestock mortality between April 1996 and March 1999 attributed to predation by large carnivores, and whether such kills occurred within the village or in the adjoining forests. Further, data were gathered on whether victims had filed compensation claims with the Forest Department for livestock losses suffered, as well as reasons for not doing so, where claims were not filed. I also enquired about the outcome of their claims, including the reasons for rejection, if provided.

In order to gather data on crop depredation by elephants, I surveyed 81 households that raised paddy crops in the above villages. I collected information pertaining to the amount of agricultural land owned or tilled by a family, their estimated annual crop production, and their estimated annual crop losses to elephant depredation between April 1996 and March 1999. From each interviewee, I also gathered details of compensation sought and received from the state Forest Department for crop losses. I did not include coffee in the assessments of damage inflicted by elephants. The extent of land under coffee was relatively small, and it was cultivated closer to human habitation. Moreover, since elephants did not feed on coffee, villagers did not perceive them a serious threat to coffee. I also omitted losses to coconut (*Cocos nucifera*), areca nut, garden plants, and other property within the village as they occurred infrequently, and the resultant damage was difficult to quantify.

I systematically cross-verified reported loss of livestock or crops with a local field assistant and randomly with other villagers in order to corroborate the correctness of the information provided. Additional data were gathered on measures adopted by villagers to protect their livestock and crops from wild animals. I also tried to obtain information on reprisal tactics by villagers against marauding large carnivores and crop-raiding elephants. This information was, in general, difficult to obtain, although some interviewees did divulge details of the retaliatory measures used. Anecdotally, I recorded visible injuries (embedded shotgun pellets and shrapnel from muzzle loaders) sustained by elephants in the adjacent forests that could be ascribed to encounters with farmers. From the records of the State Forest Department in Chikmagalur, I obtained details of compensation sought by and paid to the villagers for livestock and crop losses to wildlife between April 1996 and March 1999.

Data Analysis

From the 1999 census of cattle in the sample villages and additional data available on births, stock supplementation, livestock depredation, and natural mortality, I modeled the dynamics of livestock populations in Bhadra for the preceding three years. Birth rates were calculated as the number of calves (age <1 year) per hundred females. I assumed natural mortality rates in Bhadra to be the same as nationwide averages given in Mishra (1978). Data on stock supplementation and livestock depredation were obtained from the survey.

The chi-squared goodness of fit test (Siegel and Castellan 1988) was used to examine the degree of correspondence between the observed livestock loss in the villages and the expected loss, given their livestock holding. A Spearman rank correlation was used to examine the association between crop loss per unit area and the extent of cropland in a village. Tests were considered significant at $P \leq 0.05$.

The monetary value of cattle was assigned on the basis of an animal's worth, as assessed by applicants filing compensation claims with the Forest Department. Accordingly, the average value of a bullock was estimated at Rs. 3333, a cow at Rs. 2640, and a yearling calf at Rs. 1360 (Rs. 47 = 1 US$). The monetary value of goat and buffalo was estimated in accordance with prevalent market values as Rs. 1000 and Rs. 4000, respectively. For paddy, I used the market rate at the time of the survey (Rs. 6250 per tonne) to assess the monetary value of losses to crop raiding. Figures of household income were taken from the "marginal land-holder" category in a recent survey carried out in the region (National Council for Applied Economic Research 2001)

Results

Livestock Holding, Depredation, and Compensation

Cattle were the dominant livestock species in the villages (Table 1) at 92%, while buffaloes (4%), goats (2%) and sheep (2%) constituted the remainder. Between April 1996 and March 1999, the sampled households attributed a loss of 219 livestock to large carnivore predation (Table 2). In nearly all these cases, the identity of the predator was not readily available. How-

Table 1. Livestock holdings in the villages of Bhadra Tiger Reserve, India (1999)

Village	Cattle[b]			Total cattle	Other livestock[a]	Total livestock	Families sampled	Stock holding per family
	AdM	AdF	Yr+Yg					
Hipla	75	52	34	161	37	198	29	6.8
Karvaani	32	19	16	67	3	70	10	7.0
Késavé	23	15	13	51	0	51	9	5.7
Maadla	100	87	69	256	3	259	28	9.3
Muthodi	13	12	7	32	0	32	10	3.2
Overall	243	185	139	567	43	610	86	7.1

[a]Includes buffalo, sheep and goat.
[b]AdM = Adult male; AdF = adult female; Yr = yearling calf; Yg = young calf.

Table 2. Livestock losses inflicted by large carnivores in Bhadra Tiger Reserve, India (1997–1999)

Village	Incidents (*N*)[a]	Livestock killed (*N*)	Total monetary loss (Rs.)[b]	Annual monetary loss		
				Mean (Rs.)	CV (%)	Per family (Rs.)
Hipla	36	57	164,764.00	59,500.00	16	2,051.72
Karvaani	14	17	51,223.00	19,166.67	81	1,916.67
Késavé	13	29	75,223.00	26,166.67	53	2,907.41
Maadla	58	103	299,208.00	109,333.33	47	3,904.76
Muthodi	10	13	36,611.00	13,333.33	46	1,333.33
Overall	131	219	627,029.00	227,500.00	4	2,645.35

[a]Data from a sample of 29 interviewees in Hipla, 10 in Karvaani, 9 in Késavé, 28 in Maadla, and 10 in Muthodi.
[b]Monetary value of cattle assigned on the basis of appraisal of animals' worth by applicants in compensation claims: adult male = Rs. 3333; adult female = Rs. 2640; yearling calf = Rs. 1360; goat = Rs. 1000; buffalo = Rs. 4000

ever, villagers attributed nearly all kills to tigers and leopards, and none to wild dogs. Of the 219 kills, 216 were of cattle, while 2 goats and 1 buffalo were the only other livestock species killed. The observed frequency of kills in the villages deviated significantly ($\chi^2 = 12.94$; $P = 0.01$) from frequencies predicted from the abundance of livestock in the villages. Késavé suffered disproportionately heavier livestock losses (χ^2 contribution = 48%), while Hipla and Karvaani suffered lower losses (χ^2 contributions = 22% and 20%, respectively) than expected from their livestock abundance. The overall loss from large carnivore kills amounted to 0.9 animals/household/yr, or an estimated annual loss of 12% of the average family livestock holding. In monetary terms, the livestock loss amounted to Rs. 2645/household/yr, which was 14% of the monetary value of the average holding per household, and equivalent to 16% of the average annual household income in the region. The overall annual monetary value of livestock losses to large carnivores in the villages was Rs. 227,500 (approx US$5056).

Livestock killing by large carnivores seemed to have a significant impact on cattle populations in Bhadra (Table 3). It is important here to note that the livestock population in the villages was male-biased (Table 1), which resulted in low per-capita population growth rates. Births alone were unable to offset losses occurring due to natural mortality and killing by large carnivores. However, annual purchases of cattle were able to annul this decline, and in fact, overcompensated for cattle losses, showing an effective overall increase in cattle populations in Bhadra from early 1997 to 1999.

Of the 83 livestock kills whose location was available, 45 (54%) occurred within the villages, while the remainder occurred in forests adjoining the villages. Interestingly, of the 45 livestock kills that took place within the villages, 44 (98%) were in the post harvest season between November and May, while livestock kills made in the forest peaked in the dry period between March and May (Figure 1).

Compensation was sought for livestock killed in over half the instances (Table 4). Of the 71 applications filed for compensation, 15 cases were compensated for Rs. 17,250. Of the 35 applications rejected by the Forest Department, 10 were rejected because kills occurred on forestland; 3 because the applicants did not possess "proof of land rights"; and 22 for unknown reasons. Twenty-one applications were still pending when these data were collected. Among the 60 cases where villagers did not seek compensation, 19 (32%) involved livestock kills made in forests, 16 (27%) involved the absence of "statement of land rights," while 25 (42%) respondents

Table 3. Dynamics of resident cattle populations in Bhadra Tiger Reserve, India (1996–1999)

Year	Population at year start	Births[a]	Stock purchased	Natural mortality[b]	Killed by large carnivores	Population at year end[c]	Annual rate of increase (%)
1997	519	77	44	18	71	551	5.98
1998	551	75	43	18	73	578	4.78
1999	578	70	11	17	75	567	−1.92
Average annual rate of population increase							2.95

[a]Annual birth rate: 37.6 per 100 females (M.D.M., unpublished data).

[b]Stage specific mortality data from Mishra (1978).

[c]Births/purchases were assumed to occur at the start of a year; mortalities/kills were assumed to occur at the year end (for details, see Methods section).

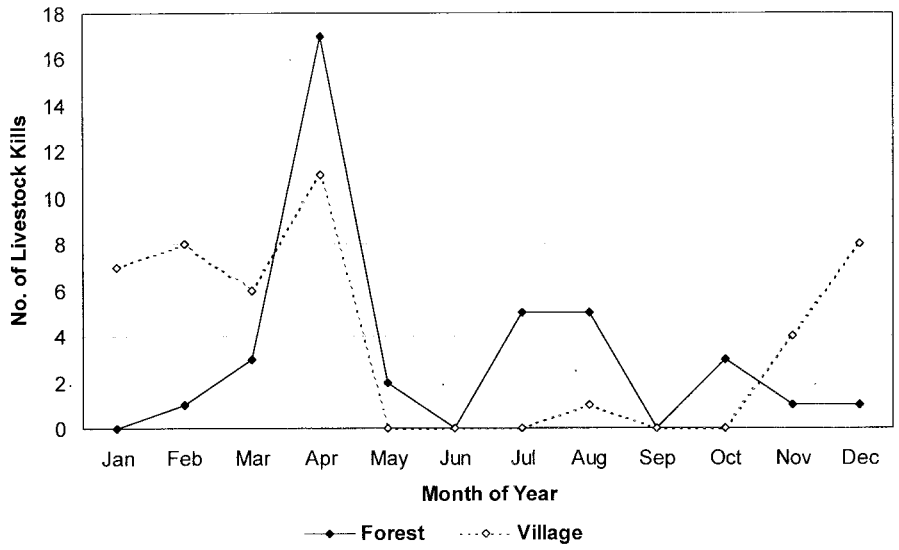

Figure 1. Seasonal variation in frequency and location of livestock kills by large carnivores in Bhadra Tiger Reserve, 1998-1999.

did not specify reasons for not applying. None of the villagers questioned reported instances where forest department officials had solicited bribes in order to dispose of compensation claims.

Compensations awarded by the Forest Department were 3% of the overall loss sustained by the villagers from livestock depredation, and 5% of the loss for which villagers filed claims. A successful claimant for compensation, on average, was awarded 27% of the value sought in the application. Forest Department records also indicated that applications took an average of 180 days (SD = 55 days; $N = 18$) to be processed.

Land Holding, Crop Production, Losses, and Compensation

Sixty-eight (84%) of the 81 villagers interviewed tilled land totalling 146.6 ha. Of them, 49 owned a total of 97.7 ha, at an average holding of 2.0 ha (SD = 2.5 ha) per family. Fifteen families cultivated on encroached land totaling 21.4 ha, or 1.4 ha (SD = 0.7) per family. In addition, 22 interviewees (including those owning land) tilled others' land as sharecroppers. Sharecropped land totaled 27.5 ha, or 1.3 ha (SD = 0.8 ha) per family. Crop productivity averaged 3.4 tonnes/ha (SD = 0.9 tonnes/ha; $N = 66$). Nineteen percent of the interviewees raised a second paddy crop in summer, which contributed 23% of their annual crop production, and 6% of the total output. Sharecroppers returned a share of 1.0 tonnes/ha (SD = 0.4 tonnes/ha; $N = 19$) to land owners, which amounted to approximately a third of their produce.

Most elephant damage to paddy occurred in the month before harvest. Between April 1996 and March 1999, interviewees attributed a total crop loss of 114.7–118.7 tonnes to elephants, at an annual loss of 38.9 tonnes, or approximately 14% of the total annual crop production (Table 5). In monetary terms, the overall annual loss to interviewees was estimated at Rs. 243,167 (or US$5404), which was 11% of the monetary value of their annual production. The annual loss per family

Table 4. Details of compensations awarded for livestock depredation by large carnivores in Bhadra Tiger Reserve, India (1997–1999)

Village	Incidents (*N*)			Successful claims[a]			Total compensation awarded as %: total loss claimed[b]	Time taken (days)
	Total	Seeking compensation (%)	Receiving compensation (%)	Sought (Rs.)	Awarded Rs.	Awarded %		
Hipla	36	44	11	12,000.00	3,650.00	30	4	196
Karvaani	14	21	0	NA[c]	0	0	0	-
Késavé	13	92	23	16,000.00	3,250.00	20	5	172
Maadla	58	55	10	36,700.00	8,950.00	24	5	181
Muthodi	10	80	20	NA	1,400.00	-	5	NA
Overall	131	54	11	64,700.00	17,250.00	27	5	183

[a]Successful claims sought refers to claims honored by the Forest Department; successful claims awarded refers to the amount paid by the Forest Department so far against valid claims

[b]Total loss claimed refers to all claims made by villagers to the Forest Department, including those that were rejected on various grounds (see text for details)

[c]NA = not available

Table 5 Crop losses inflicted by elephants in Bhadra Tiger Reserve, India (1997-1999)

Village	Incidents (*N*)[a]	Land (ha.)		Annual productivity (T/ha)	Annual loss (T/ha)	Ratio of loss to productivity (%)	Annual monetary loss (Rs.)[b]		Annual loss per family (Rs.)
		Owned	Share-cropped				Mean	CV (%)	
Hipla	41	46.01	4.86	4.05	0.54	13	69,750.00	38	5,103.66
Karvaani	26	14.97	0.00	2.82	0.35	12	28,750.00	74	3,317.31
Késavé	16	9.71	4.86	2.97	0.84	28	52,166.67	7	9,781.25
Maadla	53	43.75	16.59	3.46	0.32	9	79,666.67	14	4,509.43
Muthodi	7	4.65	1.21	3.19	0.64	20	12,833.33	74	5,500.00
Overall	143	119.1	27.5	3.43	0.47	14	243,166.67	30	5,101.40

[a]Data from a sample of 23 interviewees in Hipla, 9 in Karvaani, 9 in Késavé, 23 in Maadla, and 4 in Muthodi.

[b]Monetary value of paddy computed at the prevailing market rate of Rs. 6250 per tonne.

amounted to Rs. 5101, which was 11% of the monetary value of their annual production, and approximately 30% of the average annual household income in the region. Crop loss per unit area was inversely correlated with the extent of cropland across the five villages (r_s = 0.90, P = 0.037, N = 5).

In 63 of 143 cases of crop losses to elephants, victims applied for compensation. None of the villagers from Karvaani and Muthodi applied for compensations, although they accounted for a quarter of all crop-raiding incidents. Of the 63 who applied, 37 (59%) cases were awarded compensation totalling Rs. 29,800. Fifteen (24%) applications were rejected for reasons unknown to applicants, and 11 (17%) were still pending before the Forest Department. Among the 80 cases where victims did not apply for compensations, 39 (49%) did not do so because the losses occurred on encroached land for which they did not have relevant legal documents, 14 (18%), owing to the lengthy bureaucratic process involved in obtaining compensation, while 8 (10%) did not apply since they were sharecroppers without access to the relevant land documents, and 19 (24%) did not specify reasons for not applying. No villager reported solicitations of bribe by Forest Department officials involved in the processing of compensation claims.

According to the Forest Department records, between April 1996 and March 1999, 67 cases of crop loss from elephants totaling 52.8 tonnes were compensated at Rs. 53,090. This worked out to 14% of the monetary value of crop loss for which villagers had filed claims with the Forest Department and 7% of the monetary value of total crop loss sustained by interviewees during the same period. Successful applications were awarded approximately 44% of the claimed amount. The Forest Department, on average, took 77 days (SD = 21; N = 37) in order to fully process an application for compensation of crop loss.

Discussion

Wildlife–Human Conflict in Bhadra: Spatiotemporal Patterns

The results indicate that villagers in Bhadra experience substantial livestock losses to large carnivores and crop losses due to elephants. Indeed, in the absence of livestock purchases, predation by wild carnivores appears to be causing livestock population declines in the villages (Table 2).

The seasonal patterns of livestock losses (Figure 1) have interesting implications for managing conflict with large felines. I posit that even routine human activity and vigilance, although not specifically conceived to keep away large carnivores, may achieve a considerable level of deterrence. As my data show, over half (54%) the livestock kills occurred within villages, with 98% of them occurring between harvest and sowing. A possible explanation for this trend is that the daytime presence of humans in crop fields and a continuous nocturnal vigil on the periphery of fields against elephants during the growing season may deter large felines from entering villages to kill livestock. Indeed, during the agricultural season, just one kill occurred within the villages as compared to 15 kills in the forest during the same time. After harvest, daytime human activity in the fields decreases and cattle begin to feed in the crop fallows. Nocturnal vigil on the periphery of crop fields is also abandoned. This emboldens large felines to enter villages and kill livestock in fields during the day and in their stalls at night: 33 kills occurred in villages in the fallow season (November to March) as compared to just three in the forests. During April, at the height of the dry season, when village cattle must go farther into the forests to forage, the kills peak in the forests.

In the villages surveyed, the overall area under crops seemed to be an important determinant of crop losses per unit area. Larger villages such as Maadla and Hipla that had a greater extent of cropland (Table 5) suffered lower crop losses per hectare than villages such as Muthodi and Késavé. The greater perimeter–area ratio of smaller villages (Muthodi and Késavé: 19.2 km/km^2) compared with larger villages (Maadla and Hipla: 8.9 km/km^2) is likely to have enhanced their vulnerability to raids by elephants. Késavé, in particular, appeared to be among the most seriously affected by both livestock and crop losses. Annually, villagers in Késavé lost nearly a fifth of their livestock and over a quarter of their crop to animal damage, which appears to have been an important factor in the emigration of many families from there.

Living Amidst Large Wildlife: What Does Biology Tell Us?

Large mammal biology conveys a simple but vital point with respect to conflicts between humans and wildlife: a certain level of conflict is inevitable in any interface between humans and large mammals (for a detailed discussion, see Madhusudan and Mishra 2001). Therefore, it is unreasonable to treat conflict as an aberration, rather it must be recognized at the very outset that conflict can, at best, only be managed, and never eliminated.

While conflict might not be entirely unexpected, it is important to recognize that anthropogenic pressures on wildlife and their habitat can precipitate the problem. In Bhadra itself, a study showed that the palatable herb cover was 30% lower and palatable shrub biomass was 25% lower in plots that were heavily grazed by village cattle compared with plots with low levels of livestock grazing (Madhusudan 2000). Such a decline in biomass of palatable forage could lower carrying capacity of the area for elephants and wild ungulate prey of large felines, in turn provoking intensified crop-raiding and killing of livestock by big cats. In general, the intense removal of biomass from wildlife habitat could depress carrying capacities for large mammals to levels where it intensifies their natural tendency to raid crops and kill livestock (Madhusudan and Mishra 2001).

Of Compensations and Insurance

Several studies in India have discussed preventive measures to manage conflict between humans and wildlife (Sukumar 1991, 1994; Mishra 1997, Sekhar 1998, Nath and Sukumar 1998, Karanth and Madhusudan 2002). Still, there are no documented successes in preventing all possible conflict between humans and wildlife. Considering the reality of wildlife damage, it is imperative to examine *post facto* options available to manage emergent conflicts. Indian wildlife law does not sanction the killing of species such as the elephant, tiger, or leopard for reasons such as livestock or crop depredation (Sawarkar 1986, Anon 1997). Given that either the prevention of all wildlife damage or the destruction of problematic wildlife is not achievable, reparatory measures become important in managing conflicts. Compensation programs have sought to evaluate and offset monetary costs to humans in such conflicts. But have these programs succeeded?

Before addressing this question, it is important to understand how the present system of compensation works. In order to be considered for compensation, the putative victim is required to file a complaint with the

Table 6 Details of compensations awarded for crop losses inflicted by elephants in Bhadra Tiger Reserve, India (1997–99)

Village	Incidents (*N*)			Successful claims[a]			Total compensation awarded as % total loss claimed	Time taken (days)
	Total	Seeking compensation (%)	Receiving compensation (%)	Sought (Rs.)	Awarded			
					Rs.	%		
Hipla	41	29	20	24,250.00	10,775.00	44	13	69
Karvaani	26	—	—	—	—	—	—	—
Késavé	16	56	31	11,250.00	3,750.00	33	4	86
Maadla	53	79	45	85,750.00	38,565.00	45	19	78
Muthodi	7	—	—	—	—	—	—	—
Overall	143	44	26	121,250.00	53,090.00	44	14	78

[a]Successful claims sought refers to claims honored by the Forest Department; successful claims awarded refers to the amount paid by the Forest Department so far against valid claims.

[b]Total loss claimed refers to all claims made by villagers to the Forest Department, including those that were rejected on various grounds (see text for details)

Range Forest Officer (RFO) of the concerned Forest Range immediately. In order to claim compensation for crop damage, as well as livestock loss, victims are expected to attach valid documents establishing their rights over the land where the loss occurred. Present procedures of claim verification require an investigation report, statements from local witnesses and the village council corroborating the loss, and an evaluation of the loss by a section forester. Thereafter, the claim has to be ratified by the RFO, and then verified and endorsed by the assistant conservator, before obtaining a final sanction from the deputy conservator. The deputy conservator is constrained by a government order (Government of Karnataka 1995) to pay an arbitrary maximum compensation of Rs. 1000 for a given instance of livestock depredation or crop damage. Higher claims are again subject to a ceiling of Rs. 2000 and require approval from the conservator; claims even higher than these are referred to the chief conservator.

In reality, difficulty of access to forest offices and nonavailability of concerned staff make the seemingly simple act of filing a compensation claim an onerous task. The insistence on producing documents of land rights to support claims of livestock loss is without basis. In fact, this "requirement" has ensured that none of the livestock kills in Karvaani, where almost all families have encroached land and therefore do not have access to this document, have been compensated to date (Table 4). Similarly landless families have had poor success in obtaining compensation for livestock kills. The bureaucratic claim verification and approval procedure takes more than ten weeks to be completed; my data showed that compensations for livestock kills took six months, on average, to be discharged (Table 4). The filing and follow-up of compensation claims also require significant financial investment (mostly for travel to forest offices, but occasionally on bribes to obtain land records) on the part of the claimants. Finally, compensations, even if awarded, offset only a miniscule proportion of the loss sustained by the victim (Tables 4 and 6). Thus, compensation programs, in their current form, have achieved little of their implicit objective of helping victims of wildlife damage. As a result, it also seems unlikely that compensation programs have improved the conservation prospects of marauding wildlife species in these areas: villagers in Bhadra still do poison livestock kills occasionally, and elephants still carry injuries from encounters with angry farmers.

So, should compensations be abandoned? Sixty-nine percent of the respondents in the village surveys wanted to see the continuance of the compensation program despite the fact that it undervalued losses, so long as the process was quicker and less bureaucratic. Timing is of serious concern as losses absorbed over time tend to get compounded. For example, a villager who loses a ploughing bullock at the onset of the crop season, and cannot afford replacement, jeopardizes his crop in addition to losing an animal.

Compensation, as a policy, recognizes and addresses the monetary aspects of damage by wildlife, although serious problems exist in delivering policy to action. Without a doubt, compensations need to be more realistic and responsive if they are to help in assuaging conflict. Implementation procedures need to be streamlined, but yet verify the veracity of claims and estimate the extent of loss. In Bhadra, the Forest Department has been extremely forthcoming on this count and has endeavored to bring down the time from application to compensation to five weeks from present levels. However, considering the cash-strapped condition of governments, it is unrealistic to envision on-par

compensation policies that keep pace with the escalation in crop or livestock value.

The compensation scheme is based on the premise that all responsibility for losses and compensation rests entirely with the Forest Department. It must be recognized that a part of the responsibility for minimizing conflicts must rest with local villagers, whose use of adjoining wildlife habitat is a key determinant of the intensity of conflicts. By and large, villagers appreciate this logic and seem willing to make small investments to protect their livestock and crops from wildlife. It is here that protective measures for livestock and crops hold considerable promise as an alternative to compensations. Insurance programs can be envisioned with a one third share of premiums from three interest groups: the villagers interested in securing their livestock and crops, the Forest Department, as the custodian of wildlife, and nongovernmental organizations interested either in the well-being of rural communities and/or wildlife. Under such a split, the actuarially fair insurance premium that a villager in Bhadra would have to pay annually per head of livestock and per acre of paddy could be as low as Rs. 125 (US$2.60) and Rs. 223 (US$4.60), respectively. Such a collaborative insurance program currently underway in the trans-Himalaya has shown encouraging results (Charudutt Mishra, personal communication).

The advantages of such a program would be (1) an explicit recognition that the responsibility for conflicts is shared; (2) possibilities of monetary compensation on par with market value; (3) a lower likelihood of false claims when premiums are shared; and (4) relieving the overburdened Forest Department of additional responsibilities and permitting them to focus on protecting wildlife and their habitat. However, this proposition requires closer examination, particularly into its economic aspects, and must be attempted on an experimental basis before larger scale changes are sought.

Conclusions

The conservation of large and potentially dangerous mammals carries a definite economic cost to humans in terms of damage to livestock and crops. This cost is levied disproportionately on human communities residing in and around large mammal habitat. While it is imperative to offset these costs, it is also important to recognize that strong linkages exist between human impacts on wildlife and their habitat, and the damage inflicted by wildlife upon human communities. In India's wildlife reserves, where human presence and land use is extensive, it is important to link realistic and responsive loss alleviation packages in the short term with longer-term measures geared to significantly minimize human impacts on large mammal habitat. In this context, voluntary relocation programs—where villagers have agreed to relocate to areas outside the park in return for satisfactory packages offering land, amenities, and better access to socioeconomic opportunities—do hold great promise for the villagers as well as for wildlife.

Conflict has gone hand in hand with the presence of large wildlife all over India. Still, India is truly remarkable in its ability to retain a vast complement of its large mammal fauna even under its existing socioeconomic and demographic milieu and to hold the greatest promise for the conservation of species such as the tiger and Asian elephant. This is attributable to no small extent to India's unique traditions of tolerance against these losses. Culture has certainly advanced the limits of tolerance to economic losses, but cannot do so indefinitely. Economics has begun to eclipse cultural symbolism in this age of markets, and one must recognize this reality in conserving large mammals. Yet, whatever the economic and administrative means of tackling wildlife–human conflict, they must be seen not as substitutes to India's tolerant traditions, but as important means of strengthening them.

Acknowledgments

I am grateful to the Chicago Zoological Society for funding my fieldwork. I acknowledge the villagers of Bhadra for participating in my survey, and the officials of the Karnataka Forest Department for permissions and access to their official records. I am indebted to Aparajita Datta, P. K. Dinesh, D. V. Girish, Robert John, N. V. Joshi, K. Ullas Karanth, Kumara, D. Yatish Kumar, Charudutt Mishra, K. Radhakrishna, T. R. Shankar Raman, Shivaswamy, Anindya Sinha, and Venkatesha for help in the field and outside. I also thank Dave Martin and Eric Gese for their comments on the manuscript.

Literature Cited

Anon. 1997. The Wildlife (Protection) Act, 1972. Natraj Publishers, Dehra Dun, 158 pp.

Barnes, R. F. W. 1996. The conflict between humans and elephants in the central African forests. *Mammal Review* 26:67–80.

Cozza, K., R. Fico, L. Battistini, and E. Rogers. 1996. The damage- conservation interface illustrated by predation on domestic livestock in central Italy. *Biological Conservation* 78:329–337.

Government of Karnataka. 1992. Bhadra Wildlife Sanctuary: acquisition, rehabilitation, and resettlement project. Unpublished report.

Government of Karnataka. 1995. Government Order No. FEE-100-FWL-89(9) dated 17 July 1995.

Hoogesteijn, R., A. Hoogesteijn, and E. Mondolfi. 1993. Jaguar predation versus conservation: cattle mortality by felines on three ranches in Venezuelan Ilanos. Pages 391–406 *in* H. Dunstone and M. L. Gorman (eds.), Mammals as predators. Symposia of the Zoological Society of London, Number 65. Clarendon Press, London.

Karanth, K. U. 1982. Bhadra Wildlife Sanctuary and its endangered ecosystem. *Journal of the Bombay Natural History Society* 79:79–86.

Karanth, K. U., and M. D. Madhusudan. 2002. Mitigating human–wildlife conflicts in southern Asia. Pages 250–264 *in* J. W. Terborgh, C. P. van Schaik, L. Davenport, and M. Rao (eds.), Making parks work: strategies for preserving tropical nature. Island Press, Washington, DC.

Kothari, A., P. Pande, S. Singh, and D. Variava. 1989. Management of wildlife sanctuaries and national parks in India: a status report. Indian Institute of Public Administration, New Delhi, 298 pp.

Kothari, A., S. Suri, and N. Singh. 1995. Conservation in India: a new direction. *Economic and Political Weekly* 30:2757–2765.

Kumar, D. Y. 2000. Bhadra Wildlife Sanctuary: management plan for 2000–2005. Karnataka Forest Department, Chikmagalur, India. Unpublished report.

Madhusudan, M. D. 2000. Sacred cows and the protected forest: a study of livestock presence in wildlife reserves. Centre for Ecological Research and Conservation, Mysore.

Madhusudan, M. D., and K. U. Karanth. 2000. Hunting for an answer: is local hunting compatible with wildlife conservation in India? Pages 339–355 *in* J. G. Robinson and E. L. Bennett (eds.), Hunting for sustainability in tropical forests. Columbia University Press, New York.

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

Manakadan, R., and A. R. Rahmani. 1998. Crop damage by blackbuck *Antilope cervicapra* at Rollapadu Wildlife Sanctuary, Andhra Pradesh. *Journal of the Bombay Natural History Society* 95:408–417.

Mishra, C. 1997. Livestock depredation by large carnivores in the Indian Trans-Himalaya: conflict perceptions and conservation prospects. *Environmental Conservation* 24:338–343.

Mishra, S. N. 1978. Livestock planning in India. Vikas, New Delhi.

Nath, C. D., and R. Sukumar. 1998. Elephant-human conflict in southern India: distribution patterns, people's perceptions and mitigation methods. Asian Elephant Conservation Centre, Bangalore.

National Council for Applied Economic Research. 2001. South India: Human development report. Oxford University Press, New Delhi, 442 pp.

Naughton-Treves, L., A. Treves, C. A. Chapman, and R. W. Wrangham. 1998. Temporal patterns of crop-raiding by primates: linking food availability in croplands and adjacent forest. *Journal of Applied Ecology* 35:596–606.

Sawarkar, V. B. 1986. Animal damage: predation on domestic livestock by large carnivores. *Indian Forester* 112:858–866.

Seidensticker, J., S. Christie, and P. Jackson. 1999. Riding the tiger: tiger conservation in human-dominated landscapes. Cambridge University Press, Cambridge, 383 pp.

Sekhar, N. U. 1998. Crop and livestock depredation caused by wild animals in protected areas: the case of Sariska Tiger Reserve, Rajasthan, India. *Environmental Conservation* 25:160–171.

Siegel, S., and N. J. Castellan. 1988. Nonparametric statistics. McGraw-Hill, Singapore, 399 pp.

Sukumar, R. 1991. The management of large mammals in relation to male strategies and conflict with people. *Biological Conservation* 55:93–102.

Sukumar, R. 1994. Wildlife-human conflict in India: an ecological and social perspective. Pages 303–317 *in* R. Guha (ed.) Social ecology. Oxford University Press, New Delhi.

Sukumar, R., and C. Santiapillai. 1996. *Elephas maximus:* status and distribution. Pages 327–331 *in* J. Shoshani and P. Tassy (eds.), The Proboscidea: the evolution and paleoecology of elephants and their relatives. Oxford University Press, New York.