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An Ecological Study in the Buffer Zone of the Corbett Tiger Reserve: Tiger Abundance and Cattle Depredation

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ABSTRACT

We studied the problem of livestock depredation by tigers in and around buffer zone of the Corbett Tiger Reserve. Data were collected on all cases of livestock kills by large carnivores in and around buffer zone from October 2002 to September 2003. Secondary data on livestock kills and abundance of tigers were collected from the forest Department. Data were analyzed by standard statistical procedures and using GIS software Arc GIS (8.3). Block wise calculation of tiger abundance based on censuses conducted in 1999, 2001 and 2003 showed that the blocks in south and south east zone of buffer zone had highest concentration of tigers accounting for 36.5%, 43.5% and 44.7% of tiger population. The tiger abundance was positively correlated with ungulate densities. A total of 311 cases of livestock kills and injuries were recorded. A total of 61% livestock kills and 18.6% injuries were by tigers alone in and around buffer zone. The magnitude of livestock kills and injuries showed close resemblance with past pattern documented in 2001 and 2002. While 30.5% of livestock kills were recorded inside the buffer zone boundary, 69.5% livestock kills were recorded from outside the buffer zone. Most of the livestock kills were documented on south and southeast portion of buffers zone where maximum concentration of tigers was recorded in last three censuses. The number of livestock kills showed substantial increase in rainy season as compared to winter and summer. Tigers killed significantly higher number of cows than buffalo in buffer zone. The distribution of livestock kills showed significant differences in terms of sex of prey species, weight categories, vegetation types, topography, tree and shrub cover, distance to water and human settlements. The analysis of 38 tiger scats collected from inside the buffer zone showed that chital and sambar contributed 47.9% and 14.6%, respectively to the tiger diet in buffer zone. The observed dietary pattern based on scat analysis showed a very low contribution of livestock species to the tiger diet which is in contrast with the high level of livestock depredation by the tigers in and around buffer zone of CTR.

Key Words: Buffer Zone, Food Habits, Livestock Depredation, Tiger.

INTRODUCTION

Human-wildlife conflict occurs when wildlife negatively impacts humans or when human activities negatively impact wild animals. These conflicts may take the form of crop damage, livestock depredation and attacks on people by wild animals. The problems are aggravated in developing countries where rapidly growing human and livestock populations are putting increasing pressure on fragile ecosystems resulting in depletion and further fragmentation of natural habitats.

Livestock depredation in and around protected areas is a major conflict, as local people living in and around protected areas depend on them for grazing their livestock. Tigers however, often kill livestock in the absence of sufficient natural prey base. This causes local antipathy towards tiger conservation. Livestock depredation in India has shown a rising trend in the last 50 years, coincident with an increasing tiger population. The buffer zone of CTR is also facing a similar problem. Tiger-human conflict is a big threat to conservation of tigers. Consequently, management of this conflict is the most challenging task for PA managers. However, for tiger conservation to be successful local people's feelings and needs must be taken into consideration and given paramount consideration (Jackson 1999). For a long-term solution of the problem it is therefore, necessary to have thorough understanding of the problem. This can be achieved through a case specific scientific study, which would take into consideration all the aspects of the problem. This paper describes the findings of the investigations carried out on livestock depradation by tigers in and around buffer zone of the CTR.

METHODS

Data Collection

To identify the areas with severe tiger-human conflict, all the cattle kills reported by the villagers were inspected physically to establish the identity of the predator involved and to understand the factors responsible for cattle kill/injury. The predator was identified on the basis of pattern of feeding, pug marks and other indirect signs. Mostly tiger would start feeding from the rump portion. The size of the victim also indicated the predator since leopards mostly preyed on medium sized animals. Data on village, predator species, species killed, health, weight, age-sex and the place of incident were recorded at the time of inspection of each cattle kill. Health of the victim was categorized into poor, average and good while age was categorized into calf, sub-adult and adult. Weight of the animal was categorized into four categories as 50-150, >150-250, >250-350 and >350 kg. Data were also collected on vegetation type, cover condition, topography type, distance to human settlement, distance to water and proportion of kill consumed. The exact location of cattle kill was recorded using a Global Positioning System (GPS, Magellan 310) to identify areas with severe tiger-human conflict and to determine the spatio-temporal pattern of cattle kills in buffer zone of the CTR.

For the quantification of past trends of cattle kills, data from the forest department for the years 2001 and 2002 were also collected. To delineate the blocks on the basis of tiger abundance, block-wise census data for the year 1999, 2001 and 2003 were also collected from the forest department.

The diet composition of tigers was studied through scat analysis as well as the investigation of kills of natural prey. Scats were collected on all line transects and during random searches carried out in different blocks. Road network of the buffer zone of CTR was also searched regularly for the collection of scats. Precaution was taken to differentiate tiger scats from leopard scats as they were also found in the study area. The size and the sign of scratches were used to differentiate tiger scats from leopard scats. Scats were collected in self-sealing bags, which were marked with the date of collection and the location with the help of permanent marker. Fresh scats were dried before the bag was sealed. During the study period 39 scats of tigers were collected from the buffer zone of CTR.

Major riverside areas were monitored for kills of natural prey at a gap of 3-5 days. Care was always taken to accurately identify the correct predator responsible for the kill. Leopard mostly tried to hide the kill under dense vegetation. At the same time, other factors such as feeding, killing pattern and indirect signs were also taken into consideration for the identification of the predator. Tigers made deep and large puncture marks on the victim's neck. At the time of inspection of kill, data were collected on (a) species, (b) sex, (c) age and (d) physical condition of prey killed. Data were also collected on topography, distance to water and human settlement and other vegetation factors which play an important role in predation. The distances wherever kills were dragged were also noted. However, sufficient number of kills could not be located during the study period. 14 natural kills by tiger were found during the study.

Data Analysis

To delineate forest blocks in terms of intensity of livestock depredation by tigers, number of kills in each forest block were taken into consideration for ranking of blocks in low, medium and high categories of cattle depredation using the Forest Department data. A block having 1-5 livestock kills was given low rating whereas blocks having >5-15 livestock kills were given medium rating. Block with >15 cases of livestock kills were considered as having high intensity of cattle depredation. To delineate the blocks on the basis of abundance of tiger, block-wise tiger densities (number of individual tigers per 100 km^2) were calculated from the forest department data. Based on the density values blocks were rated as having low tiger density (1-5 tigers/100 km^2), medium tiger density (>5–15 tigers/100 km^2) and high tiger density (>15 tigers/100 km^2). The past data on cattle kills and tiger densities were plotted block wise using software Arc GIS (version 8.3). The locations of all cattle killed and injured by tigers during the current investigation were also plotted on the digitized map of buffer zone of CTR.

The dry scats were teased with forceps, and then the scats were washed thoroughly. Sixteen hairs were picked up randomly for final analysis. The hair samples were first dried and washed in alcohol for 5-10 minutes. Then the hair were mounted on the slide in xylene and examined carefully under the binocular microscope. The characteristic medullary patterns of the hair sample were then compared with the reference slide of mammalian hair sample. The prey composition of the tiger diet was extrapolated in terms of the frequency of occurrence of a prey in the scats (F_i) which was calculated as:

$$F_i = (n_i/N) \times 100$$

where, n_i is the number of scats in which the i_{th} species occurred and N is the total number of scats analyzed. Although the frequency of occurrence of prey species indicates how common a prey species was in the diet of the carnivore, percent occurrence provides a better indication of the relative contribution of the particular species in the diet of the carnivore (Ackerman et al. 1984). The percent occurrence of a prey species was calculated as a percentage of ocurrences of all species. The composition of a particular species in the kills consumed by the tiger was calculate as percent proportion of kills of a species in the total number of kills.

RESULTS AND DISCUSSION

Tiger Abundance

Table 1 provides the trends in tiger abundance in the buffer zone of CTR from 1999 to 2003. The number of blocks with, no tigers as well as, with low abundance of tigers, decreased between the years 1999 to 2003. Forest blocks with medium abundance of tigers had initially come down in 2001 and then increased by 2003. Although in 1999 only one forest block of the buffer zone had high abundance of tigers, by 2001 there were two forest blocks with high abundance. The census data of 2003 also identifies only two blocks with high tiger abundance.

Table 1. Block-wise abundance of tigers in the buffer zone of Corbett Tiger Reserve.

Year	Nil (%)	Low (%)	Medium (%)	High (%)
1999	9 (34.6)	5 (19.2)	11 (42.3)	1 (3.9)
2001	9 (34.6)	7 (26.9)	8 (30.8)	2 (7.7)
2003	7 (26.1)	2 (7.7)	15 (57.7)	2 (7.7)

Source: Forest Department census data.

Apart from changes in the number of blocks under different density categories, there were changes observed even in the spatial distribution of these categories. Figure 1a and 1b provides spatial relative abundance of tigers in different blocks of the buffer zone of CTR during 2001 and 2003. While in the northwest there was an improvement from 2001 to 2003, in the northeast, some of the blocks, which were under high or medium tiger density in 2001, showed lower tiger densities. The density of tigers in the forest blocks in the southern portion of the buffer zone also showed improvement in 2003 compared to 2001. A comparison of three censuses viz-a-viz different zones of the CTR showed that the blocks in south and south east accounted for 36.5%, 43.5% and 44.7% of tiger population in year 1999, 2001 and 2003, respectively. The north west and south west had the lowest numbers of tigers recorded in three censuses. The abundance of tiger in 46 blocks showed significant positive correlation with chital (r_s = 0.37, N = 46, P<0.01), sambar (r_s = 0.40, N = 46, P<0.01), hog deer (r_s = 0.37, N = 46, P<0.01), nilgai (r_s = 0.40, N = 46, P<0.01) and wild pig (r_s = 0.37, N = 46, P<0.01). However tiger abundance did not show any significant correlation with different ungulate species except wild pig (r_s = 0.60, N = 11, P<0.05) when only 11 blocks of south and south east zone of buffer zone were taken into consideration.

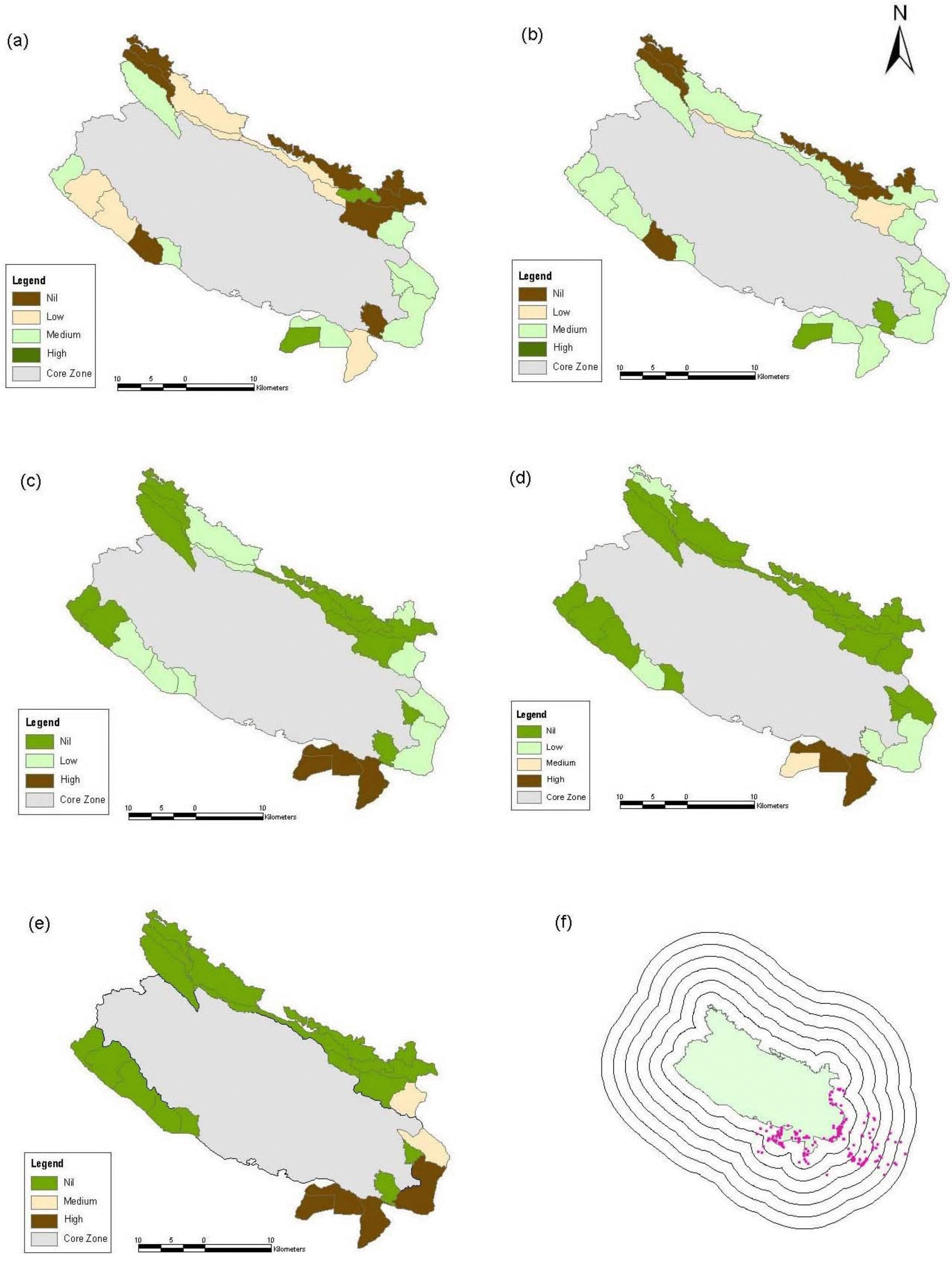

Figure 1. Tiger density (individuals/100 km^2) in 2001 (a), 2003 (b), Livestock kills in 2001 (c), 2002 (d) and 2003 (e), Livestock kills recorded in present study in 4 km buffers (f) in buffer zone of the Corbett Tiger Reserve.

Livestock Depredation

The mapping of intensity of livestock depredation, based on the forest department data for the years 2001 and 2002, is provided in Table 2. There were 14 blocks with no livestock kills, 9 blocks with low number of kills and 3 blocks with high incidences of livestock kills during 2001. During 2002 the number of block without livestock kills increased substantially from 14 to 19 whereas the number of blocks with low number of livestock decreased from 9 to 4. There were only 2 blocks with high levels of livestock depredation in 2002. Figures 1c, 1d and 1e provide the spatial representation of intensity of livestock depredation. Most of the affected forest blocks were in the southeast of the buffer zone. All the blocks in the north, east and the west of the buffer zone either had no cattle depreda-

Table 2. Year-wise intensity of livestock depredation by tiger in the buffer zone of Corbett Tiger Reserve.

Year	Nil (%)	Low (%)	Medium (%)	High (%)
2001	14 (53.9)	9 (34.6)	0 (0)	3 (11.5)
2002	19 (73.1)	4 (15.4)	1 (3.9)	2 (7.7)

Source: Forest Department census data.

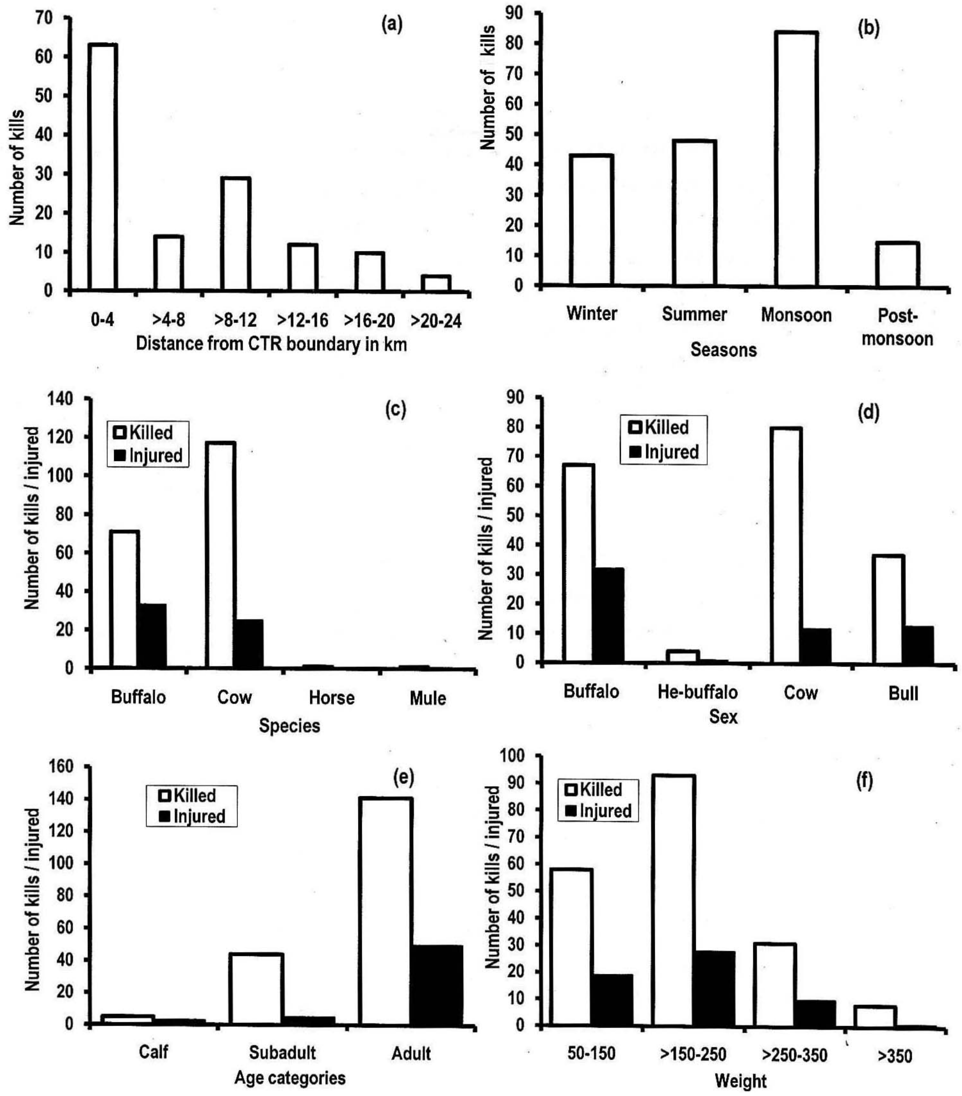

Figure 2. Number of livestock kills and injuries in different distance categories (a), seasons (b), species (c), sex (d), age categories (e) and weight (f) recorded in and around buffer zone in the CTR.

tion or low-level of cattle depredation. Number of blocks free of livestock depredation in the north of the buffer zone, increased from 2001 to 2002. Similar trends were observed in the blocks of both east and west of the buffer zone, between these years.

Figure 1f provides spatial pattern of livestock kills recorded during this study in the year 2003. The locations of kills and injuries showed close resemblance with the past pattern of cattle kills and injuries. There was increase in number of forest blocks under high intensity of livestock depredation by tigers in the east and south east of the buffer zone. However there was a slight reduction in livestock depredation in both northwest and southwest of buffer zone of the CTR.

A total of 311 cases of injuries and kills made by tigers and leopards were recorded during this study period. Out of these, tigers had killed 190 cattle and injured 58, while leopards had killed 44 cattle and injured 19. The distribution of kills in relation to buffer zone boundary differed significantly. There were 58 kills (30.5%) inside the buffer zone which were significantly less than expected by chance and 132 kills (69.4%) were outside the buffer zone which were significantly higher than expected by chance (χ^2 = 27.8, d.f. = 1, $P<0.001$). The mapping of kills within a 4 km radius buffers generated through Arc GIS from the boundary of the CTR showed that the number of kills generally decreased as the distance from the CTR boundary increased with the exception of distance category 8-12 km. There were a total of 63, 14, 29, 12, 10 and 4 kills in 0-4, 4-8, 8-12, 12-16, 16-20 and 20-24 km distance categories, respectively (Figure 2a). The longest distance at which a livestock kill was recorded was 23 km from the buffer zone boundary.

The distribution of kills in 4 km radius circles from CTR boundary differed significantly (χ^2 = 107.3, d.f. = 5, $P<0.001$). There were significantly higher number of livestock kills than expected in 1-4 km and 8-12 km distance categories and remaining distance categories had significantly less number of livestock kills than expected by chance. Figure 2b provides the seasonal distribution of livestock kills. The distribution of kills differed significantly between seasons (χ^2 = 50.7, d.f. = 3, $P<0.001$). There were 43 and 48 livestock kills during winter and summer season, respectively. The number of livestock kills increased substantially during monsoon (n = 84). Only 15 kills were recorded during post monsoon season. Out of 190 livestock kills, 24 (12.6%) were killed deliberately by tigers and 166 (87.3%) kills appeared to be accidental.

The tigers killed 71 buffaloes, 117 cows and one horse and mule each (Figure 2c). The distribution of livestock kills differed significantly between buffaloes and cows (χ^2 = 10.6, d.f. = 1, $P<0.01$). Tigers killed more cows (62.2%) than expected by chance and significantly less number of buffaloes (37.7%) than expected by chance. The pattern of injuries, however, did not differ significantly between livestock species (χ^2 = 1.1, d.f. = 1, $P>0.05$). Tigers injured 56.8% of buffaloes and 43.2% of cows, respectively. The pattern of livestock killing by tigers differed significantly between sexes (χ^2 = 76.7, d.f. = 3, $P<0.001$, Figure 2d). Tigers killed more buffaloes (35.6%) and cows (42.5%) than expected by chance. In case of injuries, tiger injured significantly higher number of buffaloes (55.1%) as compared to cows, he-buffalo and bulls which were injured significantly less than expected by chance. The distribution of livestock kills differed significantly between different age categories (χ^2 = 154.8, d.f. = 2, $P<0.001$). Majority of the prey killed comprised of adult livestock (74.2%) and number of calves killed or injured was very low (Figure 2e). Similarly majority of injuries by tiger were recorded for adult livestock ((86.2%). The livestock killed by tigers showed significant differences in terms of weight (χ^2 = 84.5, d.f. = 3, $P<0.001$, Figure 2f) and health (χ^2 = 63.9, d.f. = 3, $P<0.001$, Figure 3a) of the animals. Majority of the livestock killed and injured belonged to weight categories 50-150 and 150 to 250 kg and were found to be in average health. A similar pattern of injuries by tiger was recorded for weight and health categories.

Factors such as type of vegetation, tree cover, shrub cover, topography, availability of water and distance to human habitation also had significant influence on the pattern of livestock kills. The number of livestock killed differed significantly between vegetation types (χ^2 = 250.2, d.f. = 8, $P<0.001$). Significantly higher than expected number of kills (43.1%) were recorded in mixed vegetation type followed by riverine and plantation habitat (Figure 3b). The number of livestock killed differed significantly between tree cover (χ^2 = 49.3, d.f. = 4, $P<0.001$) and shrub cover categories (χ^2 = 32.8, d.f. = 4, $P<0.001$). While significantly higher than expected number of the kills were recorded in areas with 0-20%, and 40-60% tree cover, minimum number of kills were located in areas with >80% tree cover (Figure 3c). In case of shrub cover, the number of livestock kills was highest in areas with 0-20% shrub cover followed by 60-80% and 20-40% shrub cover (Figure 3d).

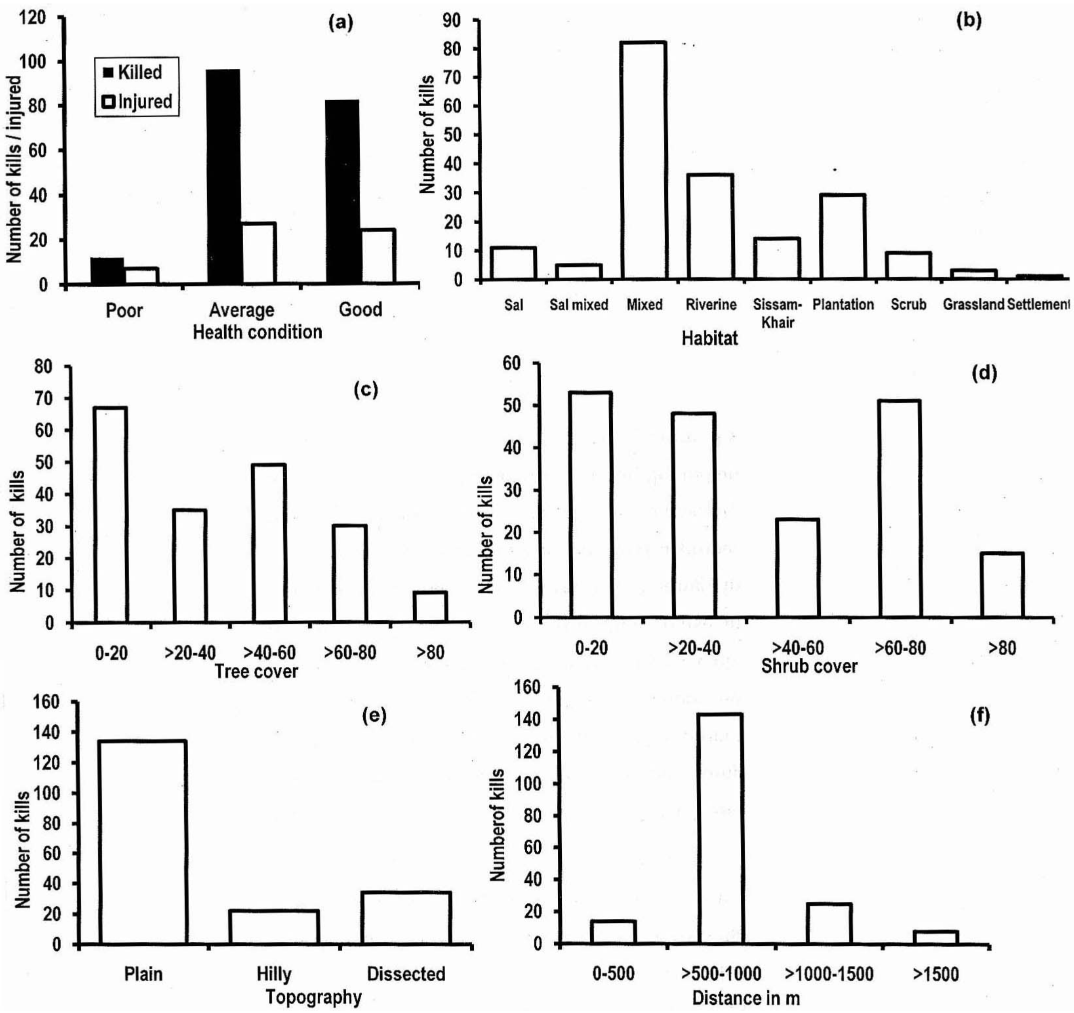

Figure 3. Number of livestock kills and injuries viz.-a-viz. health condition (a), habitat (b), tree cover (c), shrub cover (d), topography (e) and distance from human settlement (f) recorded in and around buffer zone in the CTR.

The distribution of livestock kills differed significantly viz-a-viz different topography types (χ^2 = 119.4, d.f. = 2, P<0.001) and distance to water (χ^2 = 259.1, d.f. = 3, P< 0.05). There were higher number of livestock kills on flat topography (70.5%) than expected by chance as compared to hilly (11.5%) and dissected topography (17.8%, Figure 3e). Majority (75.2%) of livestock kills were located within a distance of 500 to 1000 m from water sources (Figure 3f).

The distribution of kills differed significantly (χ^2 = 126.6, d.f.= 2, P<0.001) in relation to distance to human settlements. Majority (68.4%) of cattle kills were located within a distance of 2 km from human habitation. The tigers dragged their kills from the place of attack. Majority of the kills (90.5%) were also found to have been dragged to a maximum distance of 200 m. The remaining kills were dragged beyond 200 m but to a maximum of 1000 m.

Food Habits

A total of 39 tiger scats were analyzed. Out of 39 scats, one scat contained tiger hairs. The analysis is based on 38 scats only. 76% of scats examined contained hairs of only one prey species, 21% of scats had hairs of two prey species while the remaining 3% had hairs of three prey species. Table 3 provides frequency and percentage occurrence of different species in the scats of tigers. While chital (47.9%) and sambar (14.6%) were found to be major prey species for tiger in and around buffer

Table 4. Details of natural prey killed by tigers in the buffer zone of Corbett Tiger Reserve.

Species	Sex	Place	Habitat	Topography
Chital	F	Phooltal	Sal forest	Hilly
Nilgai	F	Shikarikual	Mixed forest	Plain
Chital	F	Near Ringora	Mixed forest	Hilly
Barking deer	F	Dhikuli	Mixed forest	Hilly
Sambar	?	Near Bijrani FRH	Riverine	Dissected
Chital	F	Near Bijrani FRH	Riverine	Dissected
Chital	M	Near Teenpani	Bankali mixed	Hilly
Sambar	M	Near Tera	Teak plantation	Plain
Chital	M	Dhikuli	Sal forest	Hilly
Chital	M	Above Ladua	Mixed forest	Hilly
Nilgai	M	Hathiyasot	Scrub	Plain
Sambar	M	Above Dhikuli	Bankali mixed	Hilly
Chital	F	Near Amgadhi sot	Mixed forest	Hilly
Sambar	F	Near Teenpani	Mixed forest	Hilly

zone of CTR, livestock contributed 12.6% to the tiger's diet. One of the scats had leopard hair indicating tiger predation on the leopard.

Table 3. Frequency and percent occurrence of different prey species in tiger diet in the buffer zone of Corbett Tiger Reserve.

Species	Frequency of occurrence	Percent occurrence
Chital	60.5	47.9
Sambar	18.4	14.6
Langur	2.6	2.1
Cow	7.9	6.3
Buffalo	7.9	6.3
Unidentified	26.3	20.8
Leopard	2.6	2.1

During the study period, 14 kills of natural prey were located in the buffer zone. Table 4 provides the details of wild prey species killed in the study area. There were 7 chital, 4 sambar, 2 nilgai and 1 barking deer kill. Thus chital (50%) and sambar (28.6%) contributed major portion of the tiger's diet in the buffer zone of Corbett Tiger Reserve.

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