Does escalating conflict and conservation challenges allow the Asian elephants to co-exist with humans in north India?

Ritesh Joshi

Conservation and Survey Division,
Ministry of Environment and Forests, Government of India,
Paryavaran Bhawan, CGO Complex, New Delhi – 110 003, India
E-mail: ritesh_joshi2325@yahoo.com

Abstract: The Shivalik Elephant Reserve (c 5405 Km^2) appears to be one of India's most important biological areas, which holds a healthy population of Asian elephants (±1,346) and sex ratio. But during the recent past, man-elephant conflict has escalated drastically in this region primarily due to the increasing movement of elephants in agricultural fields, and attacks. For the last six years, cultivators were found to be hostile towards elephants, protected areas and managers, thereby having a negative impact on conservation-based community participation. The objective of this study was to evaluate the technical reasons behind this conflict. Field data was collected from June 2008 to May 2010, to assess people's perceptions and attitudes in connection to elephant conservation. Drastic changes in the pattern of land use, elephant's attempts to enter their traditional ground, communication gaps, human causalities, an increase in the rate of crop raiding, and anthropogenic activities inside the forest areas were found to be issues behind this conflict.

Keywords: Asian elephant; Shivalik Elephant Reserve; man-elephant conflict; environmental conservation; sustainable development; north India.

Reference to this paper should be made as follows: Joshi, R. (2013) 'Does escalating conflict and conservation challenges allow the Asian elephants to co-exist with humans in north India?', *Int. J. Environment and Sustainable Development*, Vol. 12, No. 3, pp.205–221.

Biographical notes: Ritesh Joshi is a Scientist and presently working as Scientist at the Ministry of Environment and Forests, Government of India. He had conducted research on the behaviour and ecology of Asian elephant for more than a decade at the Rajaji National Park and adjoining protected habitats. He had worked with G.B. Pant Institute of Himalayan Environment and Development and with Doon Institute of Engineering and Technology as a Scientist/Assistant Professor. He had been awarded DST-Young Scientist Fast Track Scheme by Department of Science and Technology, Government of India in 2004 and 2008. His main research interests include research on Asian elephant's ecology, animal behaviour and conservation biology. He has published two books on wildlife and more than 60 research papers in various reputed national and international scientific journals/magazines.

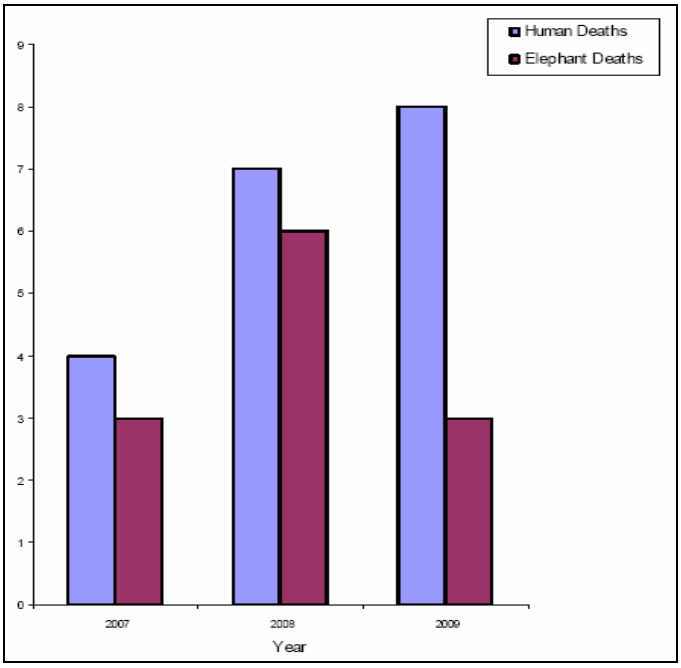
1 Introduction

India has more than 26,000 Asian elephants (*Elephas maximus*) in the wild (Rangarajan et al., 2010) and of these Uttarakhand state harbours 1,346 elephants distributed within 14 protected areas. India currently has the largest surviving population of the Asian elephant, approximately 50% of the total world population of the species (Daniel, 1996). The male – female sex ratio in Rajaji and Corbett National Parks had one of the least skewed sex ratios, 1 : 1.8 male : females in Rajaji National Park and 1 : 1.5 – 2.1 male : females in Corbett National Park (Williams, 2002). However, a study carried out in Chilla, Motichur and Haridwar forests of the Rajaji National Park found that the sex-ratio of the elephants was 100 females : 22.4 males, which shows a good elephant population along with ratio, i.e. on an average it comes to male : female is about 1 : 4.4 (Joshi et al., 2007).

In the villages, which are situated in the outskirts of Rajaji National Park, conflict between elephants and local people is increasing rapidly and a very critical situation was observed, while examining cultivated fields and on the other side protected habitats. This conflict involves crop raiding and human killing by elephants. Many initiatives have been taken out but no proper solution has been derived to date and notably in some areas, the problem is chronic, predictable and causing fear among locals living near to forests. Political influence has also brought this issue to the priority for conservation of elephants and to ensure the safe livelihood of locals. News related to this aspect could be seen at least thrice in a week in the newspapers and it was observed that whenever any causality happens, local people express their frustration by vehicle traffic jams on nearby roads and making complaints against forest staff. Wildlife personnel, who have the authority to manage elephants, are generally impeded by lack of funds, trained personnel and equipment. Human-elephant conflict poses the single greatest threat to the survival of wild Asian elephants (Doyle et al., 2010). From a study carried out in Bhalalogpur village, situated within the Rajaji-Corbett National Park corridor area, it was revealed that across categories of gender, landholding size and household size, human-wildlife conflict is perceived to be a severe problem resulting in decreased food security, changes to work load, decreased physical and psychological well-being, economic hardship, and at times an increase in illegal or dangerous activities (Ogra, 2008).

The factors that contribute to the killing of humans by elephants are primarily the presence of people in forests to collect firewood and fodder, conflict over water and cultivation of palatable crops near the forest boundary. Noticeably, elephants and human beings in the Shivalik landscape are increasingly entering into conflict with each other mainly because of the conversion of protected habitats into farm, urban and industrial lands. In between November 2000 to March 2012, elephants have killed 101 persons and injured 64 persons in Uttarakhand state, out of which more than 65 persons were killed in Rajaji-Corbett National Parks and its adjoining habitats, since 2006 (Figure 1). On the other hand, in between November 2000–2011, 212 elephants died due to various reasons in Uttarakhand State. The human population around Rajaji alone has doubled during the last decade and rapid urbanisation and industrialisation has resulting in the loss of many forestlands to townships and to various developmental activities (Joshi and Singh, 2007a).

Figure 1 Number of deaths of human and elephants during 2007–2009 in Rajaji-Corbett wildlife corridor (see online version for colours)



Movements in large mammals are considered to be one of the most important ecological factors, which influences the distribution of other small herbivores. Elephants, especially bulls, travel long distance as part of their migration and at the same time they stay within different habitats, which are enriched with water and fodder species. Slowly large natural feeding grounds are denied to them and due to tremendous human encroachment in the forest, elephants are encountering humans everywhere, even in the core areas. Once elephants of this track were known to perform extensive migration from river Yamuna to Sharda. In the last three decades, elephants were found to be pocketed in small areas due to escalated rate of developmental activities and fragmentation of large habitats into smaller ones. This has affected high in-breeding rate among different populations of elephants and constrained them to live within smaller habitats.

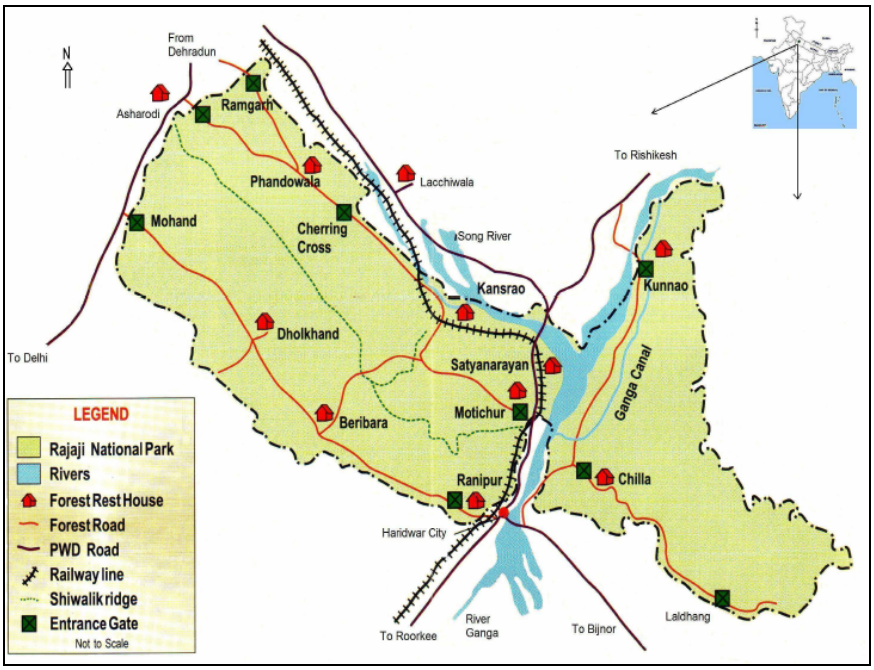
In the past decade, some strong stone walls have been constructed, and in several places electric fencings were also installed but all of these failed to resolve this conflict. The lack of detailed scientific study on the causes behind this confrontation has hidden this important issue. This study addressed the status of acute man-elephant conflict and conservation issues around Rajaji National Park, north India. Such reports are largely absent from the literature despite their importance in illustrating success and failures of our wildlife management and conservation efforts.

2 Study area

Rajaji National Park (RNP; Figure 2; 29º5′–30º31′N, 77º52′–78º22′E, elevation 250–1,100 m asl) was established in 1983 to protect the Asian elephant's habitat,

which comes under 'Shivalik Elephant Reserve No. 11'. The park is spread over an area of 820.42 km^2 across the Shivalik foothills, which lies in the lesser Himalayas and the upper Gangetic plains. RNP has been designated as a reserved area for the 'Project Elephant' by the Ministry of Environment and Forests, Government of India with the sole aim of maintaining the viable population of Asian elephants. Haridwar Forest Division (HFD, 29º 54.602′ N, 78º 11.982′ E, elevation 271.2 m asl) is well connected with RNP and Lansdowne Forest Division (LFD) and holds a rich biological diversity, which the Rajaji carries.

Figure 2 Location map of the Rajaji National Park (see online version for colours)



The study was carried out in villages namely Rawli-Mehdood, Roshnabad, Aaneki, Aurangabad, Teera-Tongia, Bandarjoor and Daluwala (first site) situated adjoining the southwest boundary of RNP and in Kangri, Gaziwali, Shyampur, Tatwala-Rasiabad, Pili, Missarpur, Jagjeetpur, Ajeetpur, Jiapota and Panjanheri (second site) villages situated on the western edge of HFD across the Ganges. Villages namely Gaindikhatta, Chiriapur, Vasuchandpur, Naurangabad, Rasulpur, Laldhang, Sigaddi, Nalgaddi, Papidanda and Chillarkhal (third site) situated in between the LFD, HFD and Bijnor forest division (BFD, Uttar Pradesh State) were also incorporated in this study as this belt is one of the severely affected areas and falls under the Rajaji-Corbett wildlife corridor.

3 Methods

To evaluate the conflicting attitudes of local people and other reasons behind severe man-elephant conflict, I conducted 125 surveys in different villages situated across the RNP from June 2008 to May 2010. Maximum surveys included interactions with locals

and cultivators and examination of agriculture fields along with elephants' movement tracks. The selection of villages was based on economic loss through crop raiding and where elephant movement was higher. I interviewed a total of 217 people (138 men and 79 women) and emphasis was given to the families, which were cultivators and used to move in the forest to collect fodder and fuelwood to meet out their household requirements. The data was collected with the help of a field assistant. Several meetings were also organised, where we are required to collect the data on crop depredation and to document local's indigenous knowledge based favourable suggestions. All the affected villages were surveyed thoroughly and information was collected on every aspect of arising conflict. As I had worked on the elephant's ecology in RNP area, it was comfortable for me to trace the movement routes of the elephants.

It is not easy to sight elephants during the night as there are chances of casualties. Thus, this study incorporated both direct as well as indirect methods. As the elephants are always used to enter the agriculture fields predominantly during evenings and their tracks are fixed, all sightings of elephants were made between 15:00 hours and 19:00 hours when their movement was common on the outskirt of forests and in the motor roads, which are running adjoining to villages. In addition, observations were also made during early morning hours (06:00 hours to 07:00 hours), when elephants were known to return back to the forest. The data collected was part of the animal monitoring activities and the daily record was based on direct sighting of animals, indirect evidences like feeding sign, footprints impression time and fresh dung piles. The direct sighting was documented in field register; recording the group composition, age and sex, if observed in groups and the time and location. In addition, villagers of adjoining areas, Gujjars (where available) and staff of forest department were also interviewed. Field binoculars were also used from an adequate and safe distance for observing the individual features (tusk size and shape, group composition etc.) without disturbing the animal. Field binoculars (Nikon Action series, 10X50 CF) and Nikon Coolpix 8700 Camera were used for field observations and to document photographic evidences. Garmin-made GPS was also used to denote geographical coordinates.

4 Results: technical reasons behind increasing conflict

4.1 Seasonal migration of elephants and affected villages

The eastern part of the RNP, HFD and LFD has the same biological area and elephants use this entire stretch year round. It also lies under Rajaji-Corbett wildlife corridor incorporating Kalagarh Tiger Reserve (Sonanadi Wildlife Sanctuary) and some part of the BFD. Elephants start moving towards lower slopes in plains of Ganges (Chilla forest of the RNP and Shyampur and Chiriapur forest of the HFD) especially at the onset of summer as part of their seasonal traditional migration and due to scarcity of natural water inside the forests especially in the hillocks. Within this duration, their movements become common in riparian corridors, as these consists of some grass species like *Saccharum spontaneum* and *Saccharum munja*, which are the favourite food of elephants.

At the onset of monsoon, when all the forest compartments are fulfilled with natural water and new vegetation starts growing rapidly, elephants starts moving upward in the foothills dominant areas and some groups prefer to move within their traditional tracks towards Corbett Tiger Reserve (Dogadda forest of the LFD). One important reason

behind this movement is the swampy nature of lowlands during monsoon and presence of a big blood sucking mosquito in the lower part. During these journeys, when elephants move across the Laldhang-Dogadda forest track encounter several hamlets situated in between forests. In addition, they also come across the anthropogenic activities ongoing there. Elephants were observed to stay in forests adjoining to different villages while moving across agriculture areas to feed upon available palatable crops. This can be attributed to increasing rate of conflict (Figure 3). The affected villages were Kaudia, Rasulpur, Laldhang, Sigaddi, Nalgaddi, Papidanda, Kham, Chillarkhal and Mandevpur.

Figure 3 Bull elephant is feeding on paddy Oriza spp. at Ghaziwali village adjoining to HFD and Ganges (see online version for colours)

In the western edge of HFD elephants use intensively the agriculture fields before 2002 but later the elephants' movements, especially groups' movements, were restricted in this part primarily due to tremendous increase in vehicle traffic in Haridwar-Bijnor National Highway No. 74. However, bulls use this stretch year round as all these villages are well connected to the forest and historically were traditional feeding grounds of elephants. One important feature that attracts the elephants is the presence of river Ganges in between this landscape. Affected villages were Kangri, Gaziwali, Shyampur, Tatwala, Sajanpura, Pili, Rasiabad, Jagjeetpur, Missarpur, Ajeetpur, Jiapota, Panjanheri, Rani-Majra, Gaindikhata, Lahadpur, Chiriapur, Vasuchandpur and Naurangabad.

The situation is the same with south-western boundary of RNP, where alarming situation has been observed and notably during 2010. Two bull elephants (a makhna and a tusker) were shot dead while moving in cultivated lands adjoining to forest. The bulls' movement was found more frequent here as they move alternatively in all the forest compartments, whereas groups, if performing movement to other zones (Kansrao, Motichur and Dholkhand) especially in core areas reported to use this track for few weeks. The affected villages were Aaneki, Aurangabad, Teera-Tongia, Bandarjurh and Daluwala whereas agriculture lands of Rawli-Mehdood and Roshnabad villages have been replaced by human settlements and industrial area. On the other hand, Bharat Heavy Electricals Limited (BHEL) campus and industrial area are connected with RNP and therefore, cases of conflict arise from time to time.

4.2 Drastic changes in land-use pattern

Since the last decade, after the establishment of Uttarakhand state in 2000, drastic changes have been observed in land use pattern especially on the southern boundary of the RNP from Ranipur to Daluwala. In several places agriculture lands were converted into industrial area, government offices and human habitation. The situation is the same in the western edge of HFD, where various stakeholders had constructed shopping complexes, check posts and shrines and all of these spots have restricted the elephants' movements.

During 2000–2002, six flyovers were constructed over various annual rivers flowing across the HFD and developmental activities within the buffer forest regime have affected about 18 kilometres of forest stretch. Expansion of agriculture land, construction of industrial area near to river Malan, enhancing rate of vehicle traffic in forest road and expanding rate of high tension electric lines has also caused drastic changes in various habitats of the LFD. During the commencement of Gujjar rehabilitation programme, 755 hectares of forest land (at Gandikhatta site, falls under HFD) was provided to Gujjars in view of their re-settlement outside of the RNP area. Noticeably, with the increasing demand of arable land for habitation purposes, several long patches of agriculture fields were converted into concrete land. Drastic changes in some annual river beds have been also observed, several pockets of land adjoining to annual rivers, namely Ranipur, Rawli, Bagro, Motichur, Song, Siddh, Rawasan, Malan, etc., were also replaced by human hamlets, which sometimes cause threat to local's living within, especially during monsoon when all these torrential rivers have tremendous water (Figure 4). A four-lane national highway project is also being implemented in Haridwar-Dehradun national highway, which would further disrupt the migratory corridors of wild animals especially of large-ranged elephants. As this highway is running across the Motichur forest of the RNP, the Motichur-Chilla and Motichur-Barkot-Gohri wildlife corridor would be affected, which further could impede the movement of tuskers in between Rajaji-Corbett national parks.

Figure 4 Construction work is being carried out in the boundary of the Rajaji National Park on an annual river during 2007 (see online version for colours)

4.3 Human casualties

Noticeably, the maximum number of human casualties occurred inside the forest while villagers were moving in the forests to collect fuelwood and fodder. Some casualties also occurred inside the villages. In between September 2006 to August 2012, a total of 65 human deaths occurred due to elephant attack both inside and outside the forest, i.e., within agricultural land and on roads. Noticeably, 65.4% (36) of deaths occurred inside the forest consisted of rural women and Gujjar (men), which were collecting fodder or fuel-wood and grazing cattle or lopping the trees (Figure 5). However, if villages are taken into account, women casualties accounted higher compared to men, besides the fact that rural women always used to move extensively inside the forest area to collect the fodder and fuelwood. This entire stretch lies under tropical moist deciduous forest type, which could be considered as one of the important facts behind these casualties as elephants' movements is highest. The elephants change forests on seasonal basis and during these journeys; elephants use different recognised grounds most likely for two to three months and thereafter move to another adjoining forest where their frequent movements were not observed until their arrival. On the other hand, cultivators/locals are unaware of the elephants' presence and arrival, and they frequently utilise various forest compartments to meet their requirements. Similarly, during the course of migration elephants moves across intensively cultivated areas, which are adjoined to forests, and elephants were found to stay there for four to five days to feed upon palatable crops. Suring those times chances of casualties become frequent.

Figure 5 Signs of conflict: author is collecting information from an influenced Gujjar family about elephant attack (see online version for colours)

Note: In 2007, a tusker has attacked a Gujjar dera (shelter) during the night and killed two children on the spot in Kotawali forest, Haridwar forest division.

Figure 6 An adult male elephant (makhna) found dead near to the boundary of Rajaji National Park with gunshot injuries (see online version for colours)

4.4 Tusker's death

A serious threat observed in this area was the increasing rate of tuskers' deaths. A study carried out in Rajaji and its adjoining areas revealed that during 2009–2010, 12 male elephants died in Rajaji-Corbett National Parks and its adjoining protected habitats and the mortality rate for males were significantly higher than for females and calves (Joshi and Singh, 2010). Noticeably, greater than 35 male elephants died in this area since March 2007, among which about 25% deaths are due to man-elephant conflict (Figure 6). Crop raiding males had longer annual home ranges than other groups living within the forest area, however; tuskers take huge risks in performing long distances round the year. Four male elephants died naturally in the Rajaji National Park area during 1992–1999. In addition, four males also died during the same period due to human-related reasons (Williams, 2002).

4.5 Traditional journeys and tracks

Elephants have a strong strategy to enter the agriculture field and escaping from there, but sometimes they are trapped in the villages especially when they remained there up to dawn and sometimes when they crossed a long distance during the night and were not able to escape from there. Most of the elephants' rampage cases were found in the situation when elephants were trying to escape out from villages and want to return back to the forest track and a huge crowd was standing and shouting in front of them. As all this generally happened in daylight, locals were always found chasing the elephants to deter them off back into the forest by making noise, lighting fires and bursting crackers. Since the last three decades, ongoing developmental activities have restricted the frequent movements of elephants within their home range. Some tracks, which were once the

feeding grounds of elephants, are currently denied to them and are replaced by agriculture lands. Notably, some bulls were found making attempts to follow these tracks/grounds. Here a question arises that, if some bulls are doing this, does this phenomenon continue? The answer is absolutely yes, because the juvenile bulls are learning these journeys while moving with older bulls. Encounter between locals and elephants were also found in the islands (part of HFD) situated in between Ganges. Assessment of the said situation primarily indicates that the increasing rate of crop raiding is a symptom of traditional utilisation of home range by elephants.

4.6 Communication gap

Another point observed behind this conflict is increasing communication gap among cultivators and forest officials. In some places, villagers blamed that forest officials only arrive when any meeting is scheduled and when there are causalities. I had attended several meetings with locals especially cultivators and observed that in some places local people were very annoyed towards forest staff because of wildlife movement in the outskirts of villages. Crop raiding (economic loss) and human deaths by elephants were found to be the sharp reasons, which are increasing the quarrel among forest managers and locals. Imprisoning and beating the forest officers, making road jam and killing the animals were some conservation-associated problems observed.

4.7 Biotic pressure inside the core zone

Gujjars are still residing in HFD and two forest ranges (Chillawali and Gohri) of the RNP. In addition, collection of fuelwood and fodder by the locals especially from core zone areas and cattle grazing are other challenges, which are creating dilemma for herbivores especially for mega-herbivores.

4.8 Illusion among locals

Many cultivators believed that the increasing frequency of raids is evidence of increase in elephants' population in the area but this is not supposed to be the confirmed data because elephants' movement in nearby villages is quite dependent on the availability of cultivated crops. Few farmers also believed that there is a scarcity of fodder and water resources inside the park area and to fulfil their routine requirements, therefore elephants enter the village premise. Noticeably, elephants are also performing traditional migration toward Corbett National Park; therefore, elephant's population could not be considered as isolated. Similarly, south-western elephants' population of RNP used to move up to Mohand forest (Uttar Pradesh State) and Asharodi forest of the DFD and utilise different habitats on a seasonal basis.

At several places, villager's thoughts revealed that they are in delusion as far as enhanced movement of elephants is concerned. During 2000, once I asked a question from a villager 'What is the reason of crop raiding by elephants and what the forest department has done for controlling this problem?'. The villager replied "I am not sure but approximately two decades back, perhaps elephant population was not as much as it is today. At that time, the tree cover was more; a decade back elephants were dropped by helicopter to the park area and forest officials allowed them to raid our fields". This type of answer, I received from some of the villagers. Sometimes, when I tell them about

myself, they badly respond until they are fully satisfied and confirmed that I am only a research scholar and not the forest official. In few villages, I observed the awful image of forest department, on account of various reasons. This type of hostility between forest officials and villagers is one of the most important factors leading to serious man-elephant conflict in this region. Open discussions with various communities revealed that they are demanding for quick compensation in case of any human casualty and severe crop raid by elephants; this shows that there has been a communication gap or some sort of fear psychology among the villagers towards the forest staff.

4.9 Presence of national highways

Motor roads are prime destructive element of the habitat fragmentation process. In north-west India, it becomes a major problem in management of wildlife and disrupts the migratory corridors for several wild animals including the flagship species-elephant. Since the last decade, enhancement of vehicle traffic in various national highways, train traffic in Haridwar-Dehradun railway track, rapid construction of motor roads and expanding rate of high tension electric lines has caused negative impact on the behaviour of wildlife. At present, a railway track and four national highways are running across this protected habitat, which holds one of the healthy populations of elephants and leopards in north India. Wild animals were found to use the web of the motor roads to to meet out their water requirement especially during dry period when maximum natural water bodies become dried inside the forest (Figure 7). However rapidly increasing vehicle traffic pressure on motor roads has hindered the frequent movement of elephants, especially of groups. On average, 14,100 vehicles were found to run across Haridwar-Dehradun national highway No. 72, whereas 9,900 vehicles have been observed to sprint daily across the Haridwar-Bijnor national highway No. 74 and due to this Motichur-Chilla wildlife corridor has been affected severely, which links Rajaji and Corbett National Parks.

Figure 7 Bull elephant about to charge the vehicle in Haridwar-Dehradun national highway running across the Chilla-Motichur wildlife corridor (see online version for colours)

5 Composition of crop raiding elephants

During the study period, the elephants' composition, which was recognisably performing movements in agriculture fields and classified as sharp crop raiders was also documented. Of the 51 observations made, 23 (45%) represent those of solitary bulls – adult males and sub-adult males, 7 (14%) represent those of bull groups, 2 (4%) represent those of cow groups and 19 (37%) represent those animals, which constitute groups including males, females and juveniles (Figure 8). The highest number was observed for the adult and sub-adult males. In a study of 113 elephants, the proportions of adults, sub-adults and juveniles as determined from direct and indirect observations around RNP were 89 (79%), 10 (9%) and 14 (12%) respectively (Figure 9). Calves were not observed during this period; therefore, do not represent the proportions of these age-groups. The adults were observed in maximum proportions as compared to other age groups.

Figure 8 Composition of elephants outside the park area (51 observations) (see online version for colours)

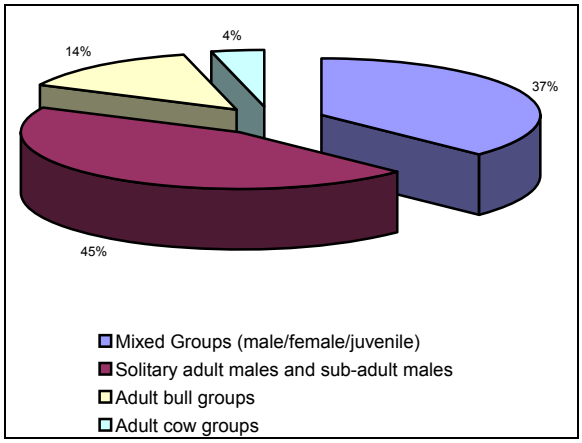
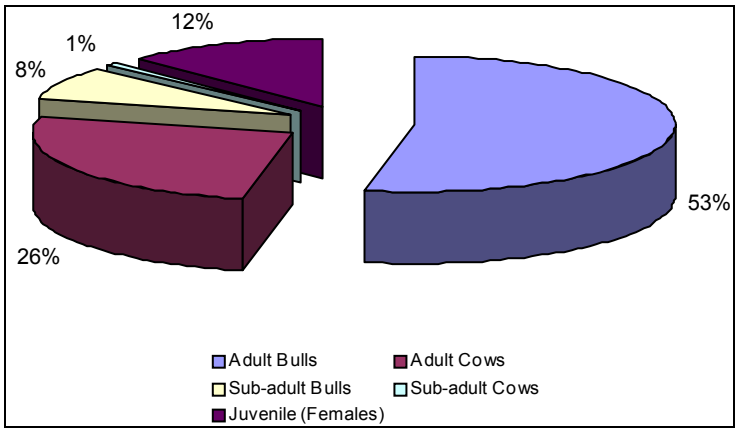


Figure 9 Composition of elephants outside the park area during night / day period (n = 113) (see online version for colours)



6 Discussion

There have been several studies documenting the man-elephant conflict in Asia (Singh, 1969; McKay, 1973; Santiapillai and Suprahman, 1986; Sukumar, 1989; Johnsingh and Williams, 1999; Williams et al., 2001; Joshi et al., 2001; Singh and Sharma, 2001; Joshi and Singh, 2007b; Ogra, 2008; Perera, 2009; Roy et al., 2009) and some studies have explored viable options for managing crop raiding by elephants and to resolve man-elephant conflict. During the recent past elephants were observed moving through many intensively cultivated and populated areas, which include national highways, railway track, villages and populated areas. Rapid urbanisation and industrialisation (after the separation of Uttarakhand state from Uttar Pradesh state) around 'Shivalik Elephant Reserve' have been major factors that have caused disturbance in elephants' movement.

A number of villages are situated around a long chain of elephants' habitat, and grow many potential cash crops. The major cash crops are *Saccharum officinarum* (sugarcane), *Oryza sativa* (paddy), *Triticum spp.* (wheat) and *Zea mays* (maize) and a few farmers also grow fruit yielding species in their fields like *Musa paradisiaca* (banana) and *Mangifera indica* (mango). Even though elephants raid crops traditionally their outside movement in agriculture areas was more common since 2001. In addition, crop raiding reports also arise more frequently because of increasing human population (Joshi et al., 2001). Since the last six years, the raids have become more frequent and the number of complaints by cultivators has increased. Several hamlets were also covered with electric fencing by state forest department but due to lack of proper checking/maintenance several fences have been damaged. Notably, it was revealed while exploring the implications of these fences that at several places locals used to obliterate these lines because fences also restricted locals' movement to forest areas; and at places where these fences were placed parallel to Ganges and agriculture lands, has been shattered because of mining activities.

Historical records and available literature indicated that elephants have been ranging over large areas and their habitats are also dynamic in food resources. The question arises as to why elephants go into cultivated lands by crossing a large stretch with populated area and with imminent risk to their lives. Generally, it is said that elephants' habitat becomes exhausted and their large home ranges were converted into smaller ones. But my review suggested that there is no shortage of food in RNP and HFD as both forests comprise of fodder species, which elephants like and are being used by them on seasonal basis. Earlier a total of 52 fodder species were recorded from RNP area, which has been utilised by the elephants and notably the bulk of their diet in a number of species and quantities eaten came from twigs, barks, fruits and leaves (Joshi and Singh, 2008). Surveys of different villages revealed that once some of these villages were better known for sugarcane cultivation and production but since 2005 few of them have totally bunged the cultivation of sugarcane mainly due to fear of loss by elephants.

Since the last decade, man-elephant conflict in this region has drastically increased and coexistence among cultivators and elephants has been a difficult task. On one hand it has created severe problem for cultivators and on the other hand placed the future of more than 450 elephants at risk, which includes populations of RNP and HFD. Drastic changes were also observed in elephants' behavioural responses during the recent past, which was primarily the result of human encroachment into the traditional wildlife corridors and human-elephant encounter inside the forest (Joshi and Singh, 2010).

7 Is providing compensation the right method for mitigating conflict?

Compensation has some negative impacts as far as conflict is concerned. Several times it has been noticed that the members of the sufferer family were not able to receive compensation easily from the department. Issuing of the allotted compensation to the family member is a long process and it sometimes takes six months or more than a year. Further, it again depends upon political approach and recommendation from a local representative. Generally, when any human casualty occurs outside the reserve forest, the department immediately provide some small grant as compensation but providing full compensation is still observed to be a long process, which is escalating conflict among locals. However, within the protected habitat, there is no provision for any such compensation except for Gujjars, where they are still residing inside the forest. The compensation still has value within an overall conflict mitigation strategy provided that potential claimants are made aware of the objectives and extent of the scheme; an effective approach to compensation will encourage broad-based participation in rural development and natural resources management by institutionally enabling the participation of disadvantaged groups and by building local level capacity to do so (Ogra and Badola, 2008).

Noticeably, in some places some recognised bull elephants are habitual of human activities like drum beating, air fire, loud noise and presence of vehicle-traffic on highways and due to this, human casualties are happening around the year. Still we do not have any practical strategy for repelling elephants other than deputising the staff for some days just after the causality. In such a situation a need is felt to employ some scientific protocols to control such outside movements of elephants, which should include radio-collaring of problem elephants and electric fencing at sharp crossings. In addition, some changes are required in providing compensation, which includes on the spot facilitation of help and regular contact with the sufferer household. This would be effective to minimise the casualties and conflict and to revive our compensation policy.

Land use conflicts have intensified especially in those areas where wildlife movements are more common outside the protected areas. Presence of human habitation and expanding agricultural activities across Rajaji-Corbett wildlife corridor has already increased the number of incidents of conflicts between local communities and elephants. Uncontrolled fishing, collection of fuel wood, grazing by cattle and encroachment along the forest edge and river Ganges would ultimately prevent the movement of elephants and other wild animals in this part. The long-term effects will include genetic isolation, habitat degradation within different reserves and intensify the conflicts between villagers and wild animals.

Elephants and human beings in the Shivalik Elephant Reserve are increasingly entering into conflict with each other mainly because of habitat fragmentation, disconnectivity of large migratory corridors, human encroachment into the deeper forest regime and conversion of elephants' habitat into agricultural areas especially around the Rajaji-Corbett wildlife corridor and other parts of the landscape. The lesser Himalayan zone and upper Gangetic plain of India is important and is a sensitive area as this belt comprises both the Rajaji National Park and Corbett Tiger Reserve and connecting corridors. It is therefore appropriate to develop a scientific-based protocol for conducting in-depth analysis of these traditional corridors and human-elephant conflict.

8 Conclusions and recommendations

Since the last decade, rapid increase in the human population, demand of land, expansion of national highways, human encroachment into the forest and fragmentation of a long chain of natural habitats has resulted in the confrontation of man and elephants in Shivalik Elephant Reserve. Although, conservation efforts are being made by the state government on a regular basis, our movement towards development has been dominating over conservation goals. The reasons for elephants movements near to the town, causes human fatalities, impact of highways and motor roads running across the elephants' habitat, changes in land use pattern and some aspects, which are related to crop raiding were illustrated. Overall, this study highlighted some technical reasons behind increasing man-elephant conflict. As most of the villages were found expanding, increasing demand of resources and dependency on forests has increased. Besides, unawareness of local people about the seasonal elephant's movement was one of the causes behind human casualties inside the forest. Notably, in addition to human beings, tuskers were also found to suffer; as they are known to use wide ranges and perform long journeys. Their unnatural deaths (through electrocution, poisoning, shot, etc.) have been observed at several occasions while moving through cultivated fields. Increasing vehicle traffic pressure on the highways running across this habitat has hindered the elephants' frequent movement and also disrupted some important corridors for elephant movement in between Rajaji and Corbett National Parks. All these have caused serious man-elephant conflict and to minimise this requires greater understanding about working with local communities in designing programmes to realise joint benefits. It also requires effective community empowerment to allow the communities to plan for wildlife management and conservation.

1 To minimise man-elephant conflict, a need is felt to initiate a community-based elephant monitoring programme, which ensures the community participation and inclusion of their perceptions to resolve this conflict.

2 Construction of strong wall is always considered to be the solution, but regular monitoring of annual/torrential rivers should be ensured.

3 Landscape planning is another important issue; to ensure the objectives of Project Elephant. We should focus on this aspect as it is especially near to elephants' habitat.

4 Research related to elephants' movement and home range could be helpful in minimising this conflict. For that, ground-based surveys are required on a regular basis and some bulls, which are recognised as crop raiders or problem animals could be radio-collared.

5 As the movement of elephants is certainly seasonal, therefore a detailed monitoring programme/research study can be initiated, which can be helpful in knowing the seasonal movement of elephants.

6 Villages which are situated on the very outskirts of the corridor area should be relocated.

7 Haridwar industrial area is attached with the Haridwar forest range of the RNP and it was observed that during night periods animals were facing intricacy due to

shimmering light, while performing their movements nearer to boundary wall of the park, which needed to be addressed.

8 *Tectona grandis* (Sagaun) and *Holophramitis spp.* (Kut Sagaun) were observed to be favourite food items for elephants and elephants' movement was observed near to these plantations around the year. On the other hand, these species are mostly abundant in the buffer zones of the elephants' habitat, where most of the villages are situated across the forest boundary. Therefore, it is recommended that villagers should be informed about this aspect as most of the people are not aware of these technical issues.

9 At some places, electric fencing was installed along the village premise especially at the elephant's entering areas by the forest department, but unfortunately these were damaged by some locals, as this caused hindrance to enter islands to collect fuelwood and other resources from river Ganges. Such issues should be monitored and could be controlled through community-based conservation programmes. Electric fencing would be a successful measure if managed, but noticeably it was observed that some bull elephants (recognised by us) are very habitual for these fences. They dropped up the twig on to the fence and then the current in the fence got tripped. Then they bent the iron pillars with the help of their foot and enter the crop fields.

10 Firecrackers, beating drums are not helpful as most of the bulls are habitual of these repelling techniques. If we made a deep and wide trench along the villages especially at sharp elephant entering sites, then it could be helpful to control the elephants' movement in crop fields; but it needs proper checking and maintenance on a regular basis.

11 Scientific studies could also be incorporated in policy making and in proposing conservation actions.

Acknowledgements

Thanks are due to three anonymous referees, for providing valuable inputs and comments. The author would also like to thank the Science and Engineering Research Council, Department of Science and Technology (DST), Government of India for providing financial support for studies in Rajaji National Park during 2005–2008. The author would also like to thank Dr. Rambir Singh, Director, DST, Government of India and Mr. C.M. Dobhal, Director of the Doon Institute of Engineering and Technology for their inputs/suggestions and for providing infrastructural support. Dr. Srikant Chandola, Principal Chief Conservator of Forests, Government of Uttarakhand, Mr. G.S. Pande, Conservator of Forests and Mr. S.P. Subuddhi, Director, Rajaji National Park are acknowledged for giving permission to study elephants of this area during the course of study. Thanks are also due to Mr. M.S. Negi, Forest Range Officer, RNP, Mr. Alok Dixit, Research Assistant and to numerous villagers and forest officials, who provided valuable information and assistance during the field investigations.

References

Daniel, J.C. (1996) 'Conservation of Asian elephant', *Gajah*, Vol. 16, pp.9–16.

Doyle, S., Groo, M., Sampson, C., Songer, M., Jones, M. and Leimgruber, P. (2010) 'Human-elephant conflict – what can we learn from the news?', *Gajah*, Vol. 32, pp.14–20.

Johnsingh, A.J.T. and Williams, A.C. (1999) 'Elephant corridors in India: lessons for other elephant range countries', *Oryx*, Vol. 33, No. 3, pp.210–214.

Joshi, R. and Singh, R. (2007a) 'Asian elephants (*Elephas maximus*) are loosing their seasonal traditional movement tracks: a decade study in and around the Rajaji National Park, India', *Gajah*, Vol. 27, pp.15–26.

Joshi, R. and Singh, R. (2007b) 'Co-existence of Asian elephants (*Elephas maximus*) with human beings – a difficult dream to be realized: a case study from Rajaji National Park in northern India', *Annals of Forestry*, Vol. 15, No. 2, pp.369–384.

Joshi, R. and Singh, R. (2008) 'Feeding behaviour of wild Asian elephant (*Elephas maximus*) in the Rajaji National Park, India', *Journal of American Science*, Vol. 4, No. 2, pp.34–48.

Joshi, R. and Singh, R. (2010) 'Does wide ranging tuskers survive in north-west India?', *Nat. Acad. Sci. Lett.*, Vol. 33, Nos. 7 and 8, pp.205–215.

Joshi, R., Joshi, B.D. and Singh, R. (2007) 'Population composition of Asian elephant (*Elephas maximus*) in the Rajaji National Park, Uttarakhand, India', *Himalayan Journal of Environment & Zoology*, Vol. 21, No. 2, pp.189–202.

Joshi, R., Joshi, H. and Verma, J.K. (2001) 'Crop depredation around Haridwar range by elephants (*Elephas maximus*) in the Rajaji National Park area, India', *Nature and Biosphere*, Vol. 6, Nos. 1 and 2, pp.45–49.

Mckay, G.M. (1973) 'Behaviour and ecology of the Asiatic elephants in south-eastern Ceylon', *Smithson. Contrib. Zool.*, pp.1–112, Washington, DC.

Ogra, M. and Badola, R. (2008) 'Compensating human-wildlife conflict in protected area communities: ground-level perspectives from Uttarakhand, India', *Human Ecology*, Vol. 36, pp.717–729.

Ogra, M.V. (2008) 'Human-wildlife conflict and gender in protected area borderlands: a case study of costs, perceptions and vulnerabilities from Uttarakhand, India', *Geoforum*, Vol. 39, pp.1408–1422.

Perera, B.M.A.O. (2009) 'The human-elephant conflict: a review of current status and mitigation methods', *Gajah*, Vol. 30, pp.41–52.

Rangarajan, M., Desai, A., Sukumar, R., Easa, P.S., Menon, V., Vincent, S., Ganguly, S., Talukdar, B.K., Singh, B., Mudappa, D., Chowdhary, S. and Prasad, A.N. (2010) *Gajah: Securing the Future for Elephants in India*, The Report of the Elephant Task Force, Ministry of Environment and Forests, Government of India, New Delhi, India.

Roy, A.D., Ved, N. and Williams, A.C. (2009) 'Participatory elephant monitoring in south Garo hills: efficacy and utility in a human-animal conflict scenario', *Tropical Ecology*, Vol. 50, No. 1, pp.163–171.

Santiapillai, C. and Suprahman, H. (1986) *The Ecology of the Elephant (Elephas maximus Linn.) in the Way Kambas Game Reserve, Sumatra*, 96p, WW/IUCN-Report, Bogor.

Singh, A.P. and Sharma, R.C. (2001) 'Conflicts between linear developments and Asian elephants in sub-Himalayan zone of Uttaranchal', *Proceedings of the 2001 International Conference on Ecology and Transportation*, Centre for Transportation and the Environment, North Carolina State University, Raleigh, NC, pp.423–432.

Singh, V.B. (1969) 'The elephant (*Elephas maximus Linn.*) in Uttar Pradesh, India', *Journal of the Bombay Natural History Society*, Vol. 66, No. 2, pp.239–250.

Sukumar, R. (1989) *The Asian Elephant: Ecology and Management*, 251p, Cambridge University Press, Cambridge.

Williams, A.C. (2002) *Population Age-sex Ratios of Elephants in Rajaji-Corbett National Parks, Uttarakhand*, Technical report, Operation Eye of the Tiger, Dehradun, India.

Williams, A.C., Johnsingh, A.J.T. and Krausman, P.R. (2001) 'Elephant-humans conflicts in Rajaji National Park, north western India', *Wildlife Society Bulletin*, Vol. 29, No. 4, pp.1097–1104.