

Wildlife corridors and Asian Elephants (*Elephas maximus*): Lessons from Rajaji National Park, North-West India

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Abstract: Presently, most of the mega herbivores are under great threat mainly due to the loss and degradation of their natural habitat and loss of corridors. During the past 50 years most of the forest areas have undergone to drastic changes mainly due to huge amount of anthropogenic and developmental activities like agricultural expansion, human settlements, construction of canals, railway and road network. All these developmental activities lead to degradation of natural corridors for animal's movement and loss of natural connectivity between the different forest ranges of the same protected area. Corridors are valuable conservation tools, which provide connectivity to different landscapes. We reviewed some of the major reasons those are responsible for declining the population viability of Asian elephants (*Elephas maximus*) within their natural habitat. Rajaji National Park and its adjoining forest comprises of many valuable corridors through which elephants performs their long-term migration. During the recent past developmental work along with biotic pressure has affected the elephant's movements in these corridors. Presently elephant's movement in Chilla – Motichur corridor area is quite rare but elephants are currently utilizing Khara – Anjani corridor and this corridor offer urgent need for conservation. Elephants of this area were subjected to move only in few of the forests as anthropogenic barriers are currently restricting their long movements from Rajaji to Corbett National parks. The long-term effects will include genetic isolation, habitat fragmentation within the same forest and enhancement in the human-elephant conflict in adjoining areas. Genetic isolation of elephant populations may also increase the chances of replacement of interbreeding to intra-breeding, and thereby reduce the population persistence even for wide ranging wildlife species. Major threat to most of the wild animals and elephants has been the railway track and national highways, which are passing exactly in between the forests. [Journal of American Science 2009;5(5):31-40]. (ISSN: 1545-1003).

Key words: Asian elephant, conservation, corridors, Rajaji National Park, north-west India

1. Introduction

India has between 21,000 and 25,000 Asian elephants (*Elephas maximus*) in the wild and among them Uttarakhand state harbours 1346 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). Presently a number of wildlife habitats have undergone or are being threatened with the fragmentation due to various anthropogenic factors and this has adversely affected the large mammal populations residing in them (Johnsingh et al., 1990). Recently, developmental activities and habitat destruction have caused a major decline in the abundance of the terrestrial mega-fauna. As most of the wild animals are presently categorized under threatened

category therefore, there is an increasing concern that the area-wise decline of the elephant will have unexpected and grave consequences for the long-term viability of the terrestrial ecosystems.

The Rajaji National Park was established to enhance the long-term survival of the Asian elephant in a sub tropical moist deciduous forest in India. But during the recent past natural continuous forest ranges of India has been broken up into many parts due to agriculture, urbanization, increasing road traffic and development related activities as well as some other anthropogenic activities. This situation creates many problems for various organisms living in forests especially for large size mammals like elephant. Genetic isolation, limitation of dispersal, migration and the decline of populations of animals requiring large

territories are the most common problems connected with fragmentation of forests and other components of the environment. Shivalik landscape (lesser Himalayan zone) is one of the last few places in the world where elephants exist and offers urgent need for conservation. From conservation point of view Rajaji National Park appears to be India's one of the most successful national park and its development has helped to boost the population of Asian elephant in their natural habitat. Before the Gujjar rehabilitation programme elephants must scarify the feeding grounds in order to feed on the short grasses due to domestic buffaloes being grazed (Joshi and Pande, 2007).

Besides, human settlements in and around the park area have created the shrinking of elephant's natural paths. The human population around the Rajaji National Park alone has doubled during past one decade and with rapid urbanisation and industrialisation has resulted in the loss of many forestlands to townships and to various developmental activities (Joshi and Singh, 2007; Joshi and Singh, 2008a). The factors that contribute to the killing of humans by elephants are the presence of people into elephant's habitat to collect firewood and fodder, conflict over water and cultivation of palatable crops near the forest boundary. In between years 1986 to 2004, elephants have killed 47 persons and injured 43 persons in and around the Rajaji National Park area whereas during the last three years more than 30 people were died due to encounter with elephants in the Rajaji Park and its adjoining protected habitats. On the other hand from 1987 to 2004, more than 134 elephants succumbed in the wild to various reasons (train accident, poaching, electrocution, fallen through hillock, disease, bull fight and natural).

During the recent past natural continuous forest ranges of India has been broken up into many parts due to agriculture, urbanization, increasing road traffic and development related activities as well as other anthropogenic activities. This situation creates many problems for various organisms living in forests. Genetic isolation, limitation of dispersal and migration and the decline of populations of animals requiring large territories are the most common problems connected with fragmentation of forests and other components of the environment. A serious threat was also recorded to European wildlife resulting from the dynamic development of a

transportation infrastructure network within the Trans-European Transportation Network (TEN-T) programme. This transportation network disrupts migration corridors of large terrestrial mammals and causes a fragmentation of their environment on a scale not previously recorded (Nowak and Myslajek, 2005).

2. Methods

2.1 Study Area

Rajaji National Park [29° 15' to 30° 31' North Latitude, 77° 52' to 78° 22' East Longitude] is spread over an area of 820.42 Km² in and around the Shivalik foothills, which lies in the lesser Himalayas and the upper Gangetic plains. Rajaji National Park (RNP) was notified in 1983 by amalgamating three erstwhile wildlife sanctuaries namely, Rajaji, Chilla and Motichur. Spread across Hardwar, Dehradun and Pauri districts of Uttarakhand state, 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 in their natural habitat. The Shivalik foothills offer the most prominent geomorphic features of this tract. The river Ganges has cut across these hills at Hardwar. The Chilla forest area of the RNP lies in the east of the river Ganges and is attached by the Garhwal Forest Division. The study was conducted in Chilla forest of the RNP and Shyampur forest of the Hardwar forest division (HFD). The altitude lies between 302 and 1000 meter above sea level.

2.2 Flora and Fauna

This protected habitat in India's lesser Himalayan region falls under sub tropical moist deciduous forest type with extensive stands of *Shorea robusta* (Sal), *Mallotus philippinensis* (Rohini), *Acacia catechu* (Khair), *Adina cordifolia* (Haldu), *Terminalia bellirica* (Bahera), *Ficus bengalensis* (Bar) and *Dalbergia sissoo* (Shisham) in its premise besides many other important fodder plant species. This entire belt is natural home of Asian elephants (*Elephas maximus*) besides many other wild animals like *Panthera tigris* (tiger), *Panthera pardus* (leopard), *Melursus ursinus* (Sloth bear), *Hyaena hyaena* (Hyaena), *Muntiacus muntjak* (Barking deer), *Axis axis* (Spotted deer), *Cervous unicolor* (Sambhar), *Sus scrofa* (Wild boar) and *Ophiophagus hannah* (King cobra).

2.3 Data Collection

For analyzing the movement of elephants and assessing the impact of developmental activities on riparian wildlife corridors, two forest ranges (Chilla of the RNP and Shyampur of the HFD) were selected and in-depthly surveyed during 2000 to 2008. The study area was visited at weekly intervals during which observations on elephants were made along the motorable forest track, present in between different forest habitats. Few other connected rough routes, which connect the grassland habitat with motorable road, were also used during the course of study. Besides, all the potential habitats (water dominant areas, cool shaded areas, fodder enriched areas and rough forest routes) were also investigated on foot during early morning, mid-day and evening hours. Cool shaded trees like *Ficus bengalensis*, *Adina cordifolia* and *Ficus glomerata* and dense forest of *Mallotus philippinensis* and other favourite fodder species were examined mostly during mid day (March-June) hours as elephants generally take rest under these cover. Whereas all the water sources (perennial/seasonal) were investigated alternatively during evening hours.

As the elephants in RNP have been known to emerge from the forest predominantly during evenings, all sightings of elephants were made between 1500 hours and 1900 hours. Besides, observations were also done during early morning hours (0600 hours to 10 hours). The data collected was as 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 were noted in duly prepared proforma, recording the group composition, age and sex, if observed in groups and also the place of sighting, time and vegetation type. Besides, villagers of adjoining areas, Gujjars (where available), staff of the forest department, the researchers from various scientific institutions and non-government organizations and other individuals working on this problem, were also interviewed. Field binocular was also used for observing their movement behaviour without disturbing the animal from an adequate and safe distance.

3. Results

The population of wild Asian elephants has a discontinuous distribution in the northern, eastern and southern forest ranges in India. In the past the elephant

population of the north used to migrate freely from one end to the other from the river Yamuna to the river Brahmaputra, traveling a maximum distance of approximately 1,300 kilometers as per their requirements in the foothills of Himalayas (Singh and Sharma, 2001). All the major habitats of elephants are very close to perennial rivers that fulfill their water requirements. This entire belt has comprised of all those fodder plant species that elephants like. Generally elephants do not have a fixed territory, but they show various territorial behaviours according to the season and availability of natural food and water. RNP and its adjoining forests are playing an important role in the conservation of elephants especially after the rehabilitation of Gujjar community from few of the forest pockets.

Chilla forest range of the RNP and Shyampur forest range of the Hardwar forest division is well connected forest zone therefore; elephant utilizes both of these forest ranges round the year. These forests also provide connectivity to the Lansdowne forest division for elephant movement towards Corbett National Park. But during the recent past number of construction work along with huge amount of anthropogenic activities has restricted the frequent movement of elephants within their home range. It was observed during the present investigation that most of the elephants in these forest pockets do not represent their long-term migration mainly because of barriers present in between the forest areas. In the course of this study we have encountered many elephant groups and solitary bulls and on the basis of their physical identity it was revealed that they are only restricted to move to some extent in this forest stretch. In this area we have reported two major corridors, which are currently in use by the elephants.

The motor roads, which are adjacent to the forests like Hardwar-Dehradun National Highway, Hardwar – Bijnor National Highway, Rishikesh – Hardwar road (via Chilla) and BHEL road network have heavy traffic pressure. As per a preliminary study, the average number of vehicles passing on Dehradun-Hardwar road per day is 7,929 and all the wild animals, including elephants, are not in a position to cross this track at any time due to the presence of heavy traffic (Singh and Sharma, 2001). Same situation is with other corridors present adjacent to the RNP area. Kotdwar – Lansdowne road runs parallel to the river Kho and crosses the Rajaji-Corbett corridor, the major movement track of northwestern elephant population between the Yamuna

and river Sharda. This road serves as the major transport link between Pauri town and Kotdwar area. The presence of traffic on the road, construction of steep retaining walls and the presence of human population along the entire corridor area have almost restricted the migration of elephants (Johnsingh and Williams, 1999).

Chilla – Motichur corridor

This corridor is about 7 kilometers long beginning at the tail end of Mundal valley and links the Chilla forest range on the eastern portion to the Motichur forest range on the west. Elephants used this corridor traditionally but currently elephants are not utilizing this corridor regularly. Sometimes solo bulls are reported to follow this route and very occasionally group movements was also observed but only up to the island area, which is situated in between river Ganges. This corridor area comprises of many fodder plant species like *Mallotus philippinensis* (Rohini), *Acacia catechu* (Khair), *Dalbergia sissoo* (Shisham), *Tectona grandis* (Teak), *Zizyphus mauritiana* (Ber), *Aegle marmelos* (Bel), *Ficus bengalensis* (Bar), *Ficus glomerata* (Gular), *Grewia oppositifolia* (Bhimal), *Bombax ceiba* (Semal), *Lannea grandis* (Jhingan), *Bauhinia variegata* (Kachnar), *Lagerstroemia parviflora* (Dhauri), *Kydia calycina* (Pula), *Syzygium cumini* (Jamun) and *Ehretia laevis* (Chamror). Besides, elephants also use various grasses and shrubs as their food resources, which includes *Dendrocalamus strictus* (Bamboo), *Helicteres isora* (Kapasi), *Saccharum munja* (Pula), *Saccharum spontaneum* (Kans), *Cynodon dactylon* (Doob Grass), *Eulaliopsis binata* (Bhabhar Grass) etc. Presently Gujjars are completely relocated from Chilla and Motichur forest ranges of the RNP but the programme for resettling them to rehabilitation site from Gohri forest range is still ongoing.

Because, few of the forest pockets of the Gohri forest range also falls under this corridor area, therefore, it will be needed to resettle the Gujjars from this forest range. Elephant's movement was restricted in this area mainly due to biotic pressure and cattle grazing inside the forest area. Before 2002, we have observed large herds of elephants (maximum 38 elephants) in Kunao forest beat and in Binj river but presently their large groups have been subjected to dispersed in small ones.

There are four islands within the river in this region, which form part of the park. However, in the 1950's and 60's a number of developments, having drastic effect of land use came up on the western bank. The BHEL set up a major plant to the west of Ganges in the southern

part of this trans-Ganga corridor for wildlife. Later the IDPL set up a large factory in the northern part of the corridor, also to the west of Ganga. The Army for a large ammunition dump has utilized the area in between and subsequently some remaining land was given away for the rehabilitation of Tehri Dam oustees. Thus, on the west bank most of the corridor stands diverted and rendered unusable.

On the east bank yet another major development activity has all, but destroyed the ecological corridor. A hydro-electric power project was set up in the 1970's. A barrage was constructed across the Ganga at Kunao just outside the park in the middle of the northern boundary. From here a deep power channel runs parallel to the east of Ganga for about 14 kilometers up to Chilla where the powerhouse is located. Although there are a couple of narrow bridges over the channel, these are not generally used by the animals. There have been cases of deer and even elephant mortalities, in attempts to cross these bridges.

Rarely elephant bulls and the group are known to cross, but otherwise there is complete isolation between western and eastern components of an internal ecological unit. The presence of army camp in the elephant corridor has also adversely affected the movement of wild animals. Besides, Khand village (48.5 hectares) is also located in the elephant migration corridor and is an obstacle to their movement. Ganga Bhogpur and Kaudia villages are also situated in eastern side of river Ganges and peripheral to Ganga canal. This area also lies under corridor area and elephants sometimes used to move in these villages in search of cultivated crops. Dudhia forest beat (island) due to its proximity to the Haripur Kala village is one of the most sensitive area as far as elephant casualties are concerned. During the study period occasionally, the movement of only solo bulls was observed in this part of the park. Group movement is almost restricted in this forest pocket mainly due to anthropogenic activities. Despite the fact that Dudhia area is rich in *Dalbergia sissoo* (Shisham) and *Acacia catechu* (Khair) forest, the preferred food item of the elephants. Besides, few of the fodder grass species like *Saccharum munja* and *Desmostachya bipinnata* are also grow in profusion in this area.

A major developmental project, which has divided the Rajaji – Corbett elephant habitat into two regimes is the 14 kilometers long Kunao – Chilla power channel, which was constructed on the east bank of river Ganges.

In the early 1970s, this canal is 22 meter wide, nine meter deep and with full flow of water. The side of the canal is at an angle of 45° and cemented except for 500 meter; therefore, do not offer foot-hold to the elephants (Kumar, 1995). There are three places at which bull elephants and groups cross the power channel and go to Ganges.

- 1) Binj / Been rau – in Gohri forest range.
- 2) 60 meters long aqueduct connecting Dogadda with Ganges – in the edge of Gohri and Chilla forest ranges.
- 3) Bridge across the power channel, 2 kilometers from Chilla – in Chilla forest range (Soni Shroth).

In summer, bulls were observed more to use these tracks for their movements towards river Ganges but occasionally groups also follow this route, when their movement is towards western direction. Elephants generally use the Ghasiram water streams and Soni shroth bridge for interchanging these forest zones.

3.1 Khara – Anjani corridor

This corridor is about 5 kilometers long and connects the Khara forest beat of the RNP with Chandi, Siddh and Anjani forest beat (Shyampur forest range) of the Hardwar forest division. Presently this is one of the major corridor for elephant movement towards river Ganges. The corridor area consists of the fodder species that Chilla forest comprises. The Anjani forest beat is attached with river Ganges and the forest comprises of *Acacia catechu*, *Dalbergia sissoo*, *Bombax ceiba*, *Helictres isora*, *Tectona grandis* and *Ficus bengalensis* trees. Besides, few of the important grass species are also present in the island area. During the last two years, state Government has constructed about four flyovers in Hardwar – Bijnor National Highway and due to this about 18 kilometers forest stretch along both the sides of the highway has got destructed mainly due to huge amount of anthropogenic activities. Besides, agricultural expansion adjoining to river Ganges has lead to the loss of forest wealth, which is also hindering the traditional movement of elephants.

It was observed during the present study that mostly adult bull elephants are utilizing this route. Sometimes few of the male elephants through associating, follow this route to enter the Anjani forest, which is peripheral to river Ganges. Elephants cross the national highway (Figure 1) and river Ganges during evening hours and re-enters to forest area in early morning hours. During this long journey elephants sometimes spent more time to feed on the plant species

those are present in the island situated in between river Ganges. Besides, elephants also utilize Gaziwali bridge (Figure 2), Shyampur bridge and Pili bridge those are situated over east Ganga canal for their outside movement and to feed on the cultivated crops in nearby villages. It was also observed during the study period that elephants also use the Ganga canal for fulfilling their water requirements (Figure 3).

Jagjeetpur, Mishrpur, Panjneri, Ajeetpur and Jaipota village are situated in the western direction of Ganges and village Kangri, Ghaziwali, Shyampur, Sajanpura and Pili are located towards eastern direction of river Ganges and adjoining to forest area and national highway. Once, all of these villages were better known for sugarcane cultivation and production but from last four years few of them have totally bunged the cultivation of sugarcane mainly due to fear of loss by elephants. These crop raids are the indications of attempts by some of the elephants to use their traditional routes leading to their feeding grounds, which are now denied to them and are replaced by human settlements (Figure 4).

Gujjars are still living in Hardwar forest division and it was observed that most of their deras (shelters) are present in this corridor area. Elephants generally follow Siddh shroth river stretch for interchanging the forest areas and most of the Gujjar deras were situated in this part. Gujjars are currently utilizing all the fodder resources frequently as the result of which few forest patches are rapidly replaced by toxicious weeds like *Parthenium hysterophorous* and *Lantana camera*. Whereas in the adjoining forest of RNP Gujjar rehabilitation programme has provided the better opportunity for livelihood to pastoral Gujjars and on the other hand it has promoted the regeneration of forest wealth along with movement related activities of wildlife (Joshi and Pande, 2007). Besides, one temple was also located in this forest stretch and the pressure of workers and visiting devotees sometimes caused hindrance in animal movement.

In the adjoining areas of Hardwar – Bijnor National highway various stakeholders has constructed shopping complexes, check posts, shrines, etc. and all of these spots are working as a barriers as far elephant's movement is concerned. Elephant's movement was quite frequent near to east Ganga canal and irrigation road especially during night period because this area comprises of bushes of *Dendrocalamus strictus* (Bamboo), which is a favourite food item of elephants.

Whereas during the day hour biotic pressure is quite more in this route and cattle grazing is also a very common phenomenon observed in this part.



Figure 1. Bull elephants on the Hardwar - Bijnor National Highway at Shyampur forest.



Figure 2. A bull elephant over to Ganga canal bridge at Shyampur forest.



Figure 3. Elephants drinking water from Ganga canal near to Chilla forest range.



Figure 4. Bull elephant feeding on paddy yield at a village adjoining to forest.

4. Discussion

Since Independence, forest were cleared and felled and bought under the plough on a large scale. Construction work along with developmental activities like establishment of hydro-electric power plants, irrigation canals and national highways entailed deforestation of large tracts and colonization brought in its wake have resulted in a significant shrinkage in the habitat of wild animals (Singh, 1969). Presently most of the elephant habitats are destructed by various developmental activities or for human need purposes. There has been rise in competition among the same species for the food, shelter and other basic requirements. The status of the elephant in the adjoining

countries is equally poor. Nepal, which has the lowest country population, has lost over 80% of its elephant habitat on account of human settlement. Bangladesh, Myanmar, Cambodia, Vietnam, Laos and Sri Lanka are also losing rapidly the natural forest cover, specially the elephant habitats. In Thailand in spite of the elephant having been a protected species since the 18th century, over exploitation of the habitat and the pressure of human population has made the species highly vulnerable (Daniel, 1996).

The Chilla – Motichur corridor and Khara – Anjani corridor linking the Chilla forest with Motichur forest and Shyampur forest are subjected to severe biotic pressures. Livestock grazing, fuel wood collection and movement of local people are the major activities observed in both corridors. These anthropogenic activities have substantially affected the movement of elephant within their home range and have led to the loss of forests connectivity. Grazing by cattle has altered the feeding grounds and has led to increase in exotic weeds. Few of the herbs and shrubs, which are replacing the forest vegetation rapidly are – *Parthenium hysterophorous*, *Lantana camara*, *Cassia tora*, *Cannabis sativa*, *Pogostemon benghalensis*, *Sida rhombifolia* and *Ageratum conyzoides*. These are never used by wild animals as their fodder, and on the other hand these are spreading very fast, reduces the other area in the forest. Weeds like *Parthenium hysterophorous* were more dominant in Motichur forest beat and distributed all over the site. In the month of October and November it shows flowering as well as fruiting stage, while in the month of December and January, it is in seed dispersal stage (Joshi et al., 2000).

Presence of railway track is another major problem, which impedes elephant migration and frequent movement within their home range. 19 elephants are killed due to train accidents since 1987 besides many other wild animals like leopard, spotted deer, python etc. This track is 16 kilometers long and comprises of sharp bends through which train drivers are unable to look the elephants from a safe distance and most of the accidents were occurred during night hours and in dry season (Joshi and Joshi, 2000). Various religious places were also situated inside the forest area and the visiting devotees and workers of the temples hinder elephant's movement. There are many instances when religious banquets on large scale are organized. During last decades the general economic condition of people has bettered, this has led to increase in the purchase

power, social interactions, tourists and religious activities of the people at all levels (Joshi and Joshi, 2006). Fishermen were also reported within these corridors in early morning and evening hours when elephants are more active. They used to cross the Ganges with the help of rubber tube and stay for whole of the day inside the island while moving inside the forest.

Corridors are important conservation tools and need to be preserved to ensure the genetic flow between the populations. If these corridors has got turned to shrink, interbreeding will be replaced by intrabreeding, which may led to loss of genetic material even for wide ranging wildlife species. Land use conflicts have intensified especially in those areas where wildlife movements are more common outside the protected areas. Human habitation and expanded agricultural activities between both of these corridor areas have already increased the number of incidents of conflicts between local communities and elephants. Similar phenomena are very likely to occur in few other internal corridors. Uncontrolled fishing, collection of fuelwood, grazing by cattle and encroachment along the forest edge and river Ganga will 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.

A large mammal like the elephant could be expected to move more considerable distances even with a short period and families of a clan seemed broadly coordinated in their seasonal movements (Sukumar, 1989). In the dry months i.e. from January to April, when no rainfalls occur, the groups seek the neighbourhood of streams and shady forests. From the month of July, after the first shower, they start roaming and feed on the fresh grass. This grass in hill tracts become long and coarse by July and August, the elephants then show their upward movements. The reason for the elephants and other animal's migration is the high lands, continuous and uninterrupted hilly terrain for grazing, assured food, ideal breeding ground and thick population (Sinha, 1981).

The long-term effects will include genetic isolation, habitat fragmentation within the same forest and enhancement in the human-elephant conflict in adjoining areas. Genetic isolation of elephant populations may also increase the chances of

replacement of interbreeding to intra-breeding, and thereby reduce the population persistence even for wide ranging wildlife species. The creation of corridors between two reserves has been proposed to minimize the genetic effects of isolation (Diamond, 1975). Large and medium sized herbivores and carnivores largely depend on corridors for exchange of genes between populations and to search for seasonal foraging grounds and water. Loss of forest cover due to agriculture expansion and construction related work is responsible for the loss of forest connectivity between forested areas in the Nilgiri Biosphere Reserve (Sukumar, 1990). Although the importance of corridors has been accepted widely for management of wide ranging species, only a few studies have been carried out on the impact of human interferences on habitat corridors in India (Johnsingh et al., 1990).

The results from this study provide a sketch of the extent and likely development of human-elephant conflict in Shivalik foothills and major threats. The RNP and its adjoining area is an important biological area and have great potential for wildlife and its conservation. People are also increasingly utilizing these old hamlets and as a result management of these traditional corridors is often uncoordinated and complicated. It is therefore appropriate to develop a scientific based protocol for conducting in depth analysis of these traditional corridors and serious human-elephant conflicts.

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References

- [1] Daniel, J.C. 1996. Conservation of Asian elephant. *Gajah*. 16: 9-16.
- [2] Diamond, J.M. 1975. The island dilemma: lessons of modern biogeographic studies for the design of nature reserves. *Biological Conservation*. 7: 129-146.
- [3] Johnsingh, A.J.T. and Williams, A. Christy 1999. Elephant corridors in India: lessons for other elephant range countries. *Oryx*. 33 (3): 210-214.
- [4] Johnsingh, A.J.T., Prasad, S.N. and Goyal, S.P. 1990. Conservation of the Chilla- Motichur corridor for elephant movement in Rajaji-Corbett National Park areas, India. *Biological Conservation*. 51: 125-138.
- [5] Joshi, P.C, Joshi, R. and Joshi, N. 2000. Analysis of vegetation of a protected forest. *Ecology, Env. & Cons.* 6 (3): 345-349.
- [6] Joshi, R. and Joshi, B.D. 2000. On the recurrence of rail accident death of an elephant (*Elephas maximus*) in Hardwar range of the Rajaji National Park. *Him. J. Env. Zool.* 14 (2): 123-128.
- [7] Joshi, R. and Joshi, B.D. 2006. Impact of anthropogenic activities on elephant (*Elephas maximus*) around few religious places: A case study from the Rajaji National Park, Uttaranchal. *Him. J. Env. Zool.* 20 (1): 87-90.
- [8] Joshi, Ritesh and Pande, G.S. 2007. Rehabilitation of Gujjar community from the Rajaji National Park: An approach for biological diversity conservation through restoration ecology. *Nat. Acad. Sci. Lett.* 30 (9&10): 263-267.
- [9] Joshi, R. and Singh, R. 2007. Asian Elephants are loosing their seasonal traditional movement tracks: A decade study in and around the Rajaji National Park, India. *Gajah*. 27: 15-26.

- [10] Joshi, R. and Singh, R. 2008a. Asian elephant (*Elephas maximus*) and riparian wildlife corridors: A case study from lesser-Himalayan zone of Uttarakhand. *J. Am. Sci.* 4 (1): 63-75.
- [11] Kumar, D. 1995. Management plan of Rajaji National Park. (1995-96 to 2005-06), UNDP/WII.
- [12] Nowak, S. and Myslajek, R.W. 2005. Problems affecting migration corridors for large terrestrial mammals caused by the network of fenced motorways and express roads within the TEN-T programme: the situation in Poland. Technical report; The Association for Nature (WOLF), Poland.
- [13] Singh, V.B. 1969. The elephant (*Elephas maximus* Linn.) in Uttar Pradesh. *J. Bom. Nat. Hist. Soc.* 66: 239-250.
- [14] Singh, A.P. and Sharma, R.C. 2001. Conflicts between linear developments and Asian elephants in sub-Himalayan zone of Uttaranchal. In: Ecology and transportation, eds. C.L. Irwin, P. Garrett and K.P. McDermott, PP. 423-432. Centre for Transportation and the Environment, North Carolina State University, Raleigh, NC.
- [15] Sinha, M.K. 1981. Elephant migration in Kaziranga. *Tiger Paper.* 8(1): 16-18.
- [16] Sukumar, R. 1989. The Asian elephant: Ecology and management. Cambridge University Press, Cambridge.
- [17] Sukumar, R. 1990. Ecology of the Asian elephants in southern India. II Feeding habits and crop raiding patterns. *Journal of Tropical Ecology.* 6: 33-53.

