

Impact of Gujjar Rehabilitation Programme on the group size of Asian elephants (*Elephas maximus*) in Rajaji National Park, North-West India

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Abstract. Joshi R. 2015. *Impact of Gujjar Rehabilitation Programme on the group size of Asian elephants (Elephas maximus) in Rajaji National Park, North-West India. Biodiversitas 16: 188-195.* A comparative study has been done to assess the impact of the Gujjar Rehabilitation Programme on the group's size of Asian elephants (*Elephas maximus*) in Rajaji National Park, north-west India. Field surveys were carried out before the Gujjar's rehabilitation during 1999-2001 and after the Gujjar's rehabilitation during 2006-2008 in Chilla and Haridwar forest ranges of the park. A total of 833 groups of elephants were sighted, varying from 2-5 (mean value \pm SD=28.5 \pm 24.7) to 21-25 animals (mean value \pm SD=8.2 \pm 4.6). The number of groups sighted in Haridwar forest after the Gujjars' rehabilitation were significantly low in summer and winter as compared before the Gujjars' rehabilitation. However, the number of groups sighted in Chilla forest before and after the Gujjars' rehabilitation in both the seasons was found to be same. Results indicated that elephant's group's size and movement was shrinking/reducing in Haridwar forest, however, in Chilla forest it was found to be slightly expanding/increasing. The impact of Gujjar Rehabilitation Programme has not brought any drastic change in restoring the larger population of elephants and in increasing their group's size, however, this has increased the frequent movement and activities of elephants within their home range. Restoration of large fragmented forest stretches/corridors for elephant's migration and habitat management are of paramount importance in providing elephants a wider way to move across entire landscape in large herds. As increase in human population in the nearby areas and developmental activities, with increase in vehicle traffic pressure on national highways and railway track existing across the park were found to be creating negative impacts on the overall movement of large groups of the elephants.

Keywords: Asian elephant, group size, Gujjar Rehabilitation Programme, Rajaji National Park, Shivalik Elephant Reserve

INTRODUCTION

Group formation is a widespread phenomenon throughout the social mammals, and the problem of animal grouping is one of the most fundamental ones in biology (Durand et al. 2007). Most of the vertebrates, including humans, are gregarious to a certain degree and tend to form groups of conspecific individuals, which build up a major component of their environment thereby influencing major aspects of their lives, such as predation pressure, pathogen pressure, aggression, foraging success, metabolism and sexual selection (Reiczigel et al. 2008). The size and composition of social groups have diverse effects on morphology and behavior, ranging from the extent of sexual dimorphism to brain size, and the structure of social relationships (Silk 2007). Elephants are known to live in large herds, which generally depend upon the availability of feeding grounds and suitable habitats. Besides, availability of adequate water sources (rivers, reservoirs, etc.) is another important factor, which influences grouping in elephants. Elephant's group sizes are probably determined by factors such as forage abundance, seasonality, animal density and numbers, human disturbance, natural predation pressure, genetic relatedness; and among all these factors, food resource availability probably plays important role in determining family or group size (Sukumar 2008).

A larger group of elephants is generally called herd, which is a large family unit. In elephants, single groups generally consists an adult cow and few individuals, however large herds consists several small groups making it a larger clan, especially during migrations or adverse environmental condition. Sukumar (1994) proposed that the term 'family' should be restricted to a single adult female plus off springs, and the term 'joint family' is used in the Asian tradition to describe groups with more than one adult female, even if these are reasonably stable. Elephant populations are composed of several clans, which represent large extended families; different clans or members of different clans do not associate with each other, however, members of a clan can mingle and form associations with others in the clan (Desai 1997).

North-western Shivalik landscape is one of the most crucial elephant's habitats, which holds nearly 1346 elephants, distributed within 14 protected areas (records of the 2007s elephant census, Uttarakhand Forest Department). During the last 3-4 decades, rapid rate of developmental activities, especially after the establishment of Uttarakhand state in 2000, had disconnected a long chain of elephant's habitat, which earlier was known to spread across river Yamuna in the west to Sharda in the east, as a result of which elephants were pocketed in smaller forest patches, and thus their larger herds were converted into smaller groups. Rajaji National Park (RNP), one of the

crucial elephant's habitat in Shivalik Elephant Reserve serves as the north-western limit to the distribution range of the Asian elephants. It holds a healthy population and sex ratio of elephants as well. A total of 416 elephants were recorded in RNP during the elephant's census carried out in 2007. In a study carried out in Shivalik Elephant Reserve, the male-female sex ratio of the elephants in Rajaji and Corbett National Parks was recorded as 1:1.8 male:females in RNP and 1:1.5-2.1 male:females in Corbett National Park (Williams 2002). However, in a study carried out in Chilla, Motichur and Haridwar forests of the RNP, the elephant's sex-ratio was recorded as 100 females:22.4 males (male:female ratio=1:4.4), which revealed on a healthy elephant's sex ratio (Joshi et al. 2007).

Gujjars are a nomadic pastoral community, arrived in the Shivalik hills from Jammu and Kashmir State nearly 200 years ago, as part of the dowry of a princess of Nahan (at present, a part of the Himachal Pradesh State). In Shivaliks, they raised domestic buffalos and practiced pastoralism, spending winter and beginning months of summer (from October to April) in the Shivalik foothills and peak summer and monsoon (from May to September) in the Himalayan alpine pastures. These traditional migrations generally take 20 days to complete one side journey from lower to higher altitude areas or from higher to lower altitude areas. Gujjar's livelihood is primarily based on rearing buffalo and cattle, and selling milk in local markets. In view of achieving the objectives of the provisions of the Wildlife (Protection) Act 1972, Gujjar Rehabilitation Programme (GRP) commenced effectively in 1980s, especially after the establishment of Uttarakhand State in November 2000. Initial attempts were made in 1984 to resettle Gujjars (by the then Uttar Pradesh State Government) but the program could not succeed, because of non-participation of Gujjars in the program. Besides, the fear of divesting of their traditional rights was another reason, which encouraged them not to leave the forest. With the passage of time, program was made more effective because of sincere and dedicated efforts of Government and Gujjars' understanding about the benefits of urban life and in this way, nearly 93.3% Gujjars were resettled to two different rehabilitation sites, namely Pathri and Gaidikhatta.

As a result of effective implementation of the Wildlife (Protection) Act, out of total nine forest ranges, seven ranges are completely free from Gujjars so far, which has reduced anthropogenic pressure from the park. GRP has motivated Gujjars to live urban life, which considerably enhanced their livelihood and socio-economic status. Now-a-days, maximum of their children are gaining education from schools, established by the State Government at rehabilitation sites. Besides, they are cultivating few of the cash crops and vegetables in the land provided to each family at rehabilitation sites. GRP in RNP can be considered as a model demonstration to showcase effective conservation programs of the country, which has facilitated in achieving the objectives of the provisions of the Act on one hand, and has provided better livelihood options to the pastoral Gujjars on the other hand. Program has also ensured our priorities of wildlife conservation and is a

milestone to showcase the successful rehabilitation and ecological restoration model and to share conservation lessons with other range countries (Joshi and Pande 2007; Joshi 2012). Overall, substantial increases in the encounter rates of several species were apparent from 2002 onwards. This study illustrates the impact of GRP on the group's size of elephants in Chilla and Haridwar forest ranges of the RNP.

MATERIALS AND METHODS

Rajaji National Park (RNP) is located in Uttarakhand, north-west India at 29°15'-30°31' N 77°52'-78°22' E, and falls under the Gangetic plains biogeographic zone and upper Gangetic plains province (Figure 1). Maximum portion of the park lies under Shivalik's bio-geographic sub-division. RNP was established in 1983 with the aim of maintaining a viable Asian elephant's population in the Shivalik landscape and is designated a reserved area for 'Project Elephant' by the Ministry of Environment, Forest and Climate Change. The total geographical area of the park is 820.21 km². The dominant vegetation of the area comprises Sal (*Shorea robusta*), Kamala (*Mallotus philippensis*), Cutch (*Acacia catechu*), Kadam (*Adina cordifolia*), Bahera (*Terminalia bellirica*), Indian Banyan (*Ficus benghalensis*) and Indian Rosewood (*Dalbergia sissoo*). However, dominant fauna of the park consists of Tiger (*Panthera tigris*), Leopard (*Panthera pardus*), Himalayan Black Bear (*Ursus thibetanus*), Sloth Bear (*Melursus ursinus*), Hyaena (*Hyaena hyaena*), Barking Deer (*Muntiacus muntjak*), Goral (*Naemorhedus goral*), Spotted Deer (*Axis axis*), Sambar (*Rusa unicolor*) and Wild Boar (*Sus scrofa*) and among reptilian fauna the Mugger Crocodile (*Crocodylus palustris*) and King Cobra (*Ophiophagus hannah*) represents Rajaji's faunal diverseness.

The datasets for this article have been extracted from the field studies, which were carried out from 1999 to 2011 on the ecology and behavior of elephants in RNP and adjoining protected areas. Haridwar and Chilla forests were selected for this study, because Haridwar forest was the site where anthropogenic activities were higher, whereas Chilla forest was the site where anthropogenic activities were quite lesser, except of the Gujjars' activities during their stay in the park area up to 2004. A comparative study on elephant's group composition, before the GRP (from June 1999 to May 2001) and after the program (from June 2006 to May 2008) was attempted to address the impact of Gujjar's rehabilitation on the grouping pattern of elephants in RNP. Chi-square test was used to determine differences in the group's size of elephants. In addition, information on the elephant's group's size was also collected from the forest officials, Gujjars residing in HFD and local people to cross check the datasets. Field binocular (Nikon Action Series, 10x50 CF) was used to observe the elephants in forests and Nikon Coolpix 8700 Camera was used to produce photographic evidence. Geographical coordinates of each observation were taken (Garmin GPS 72).

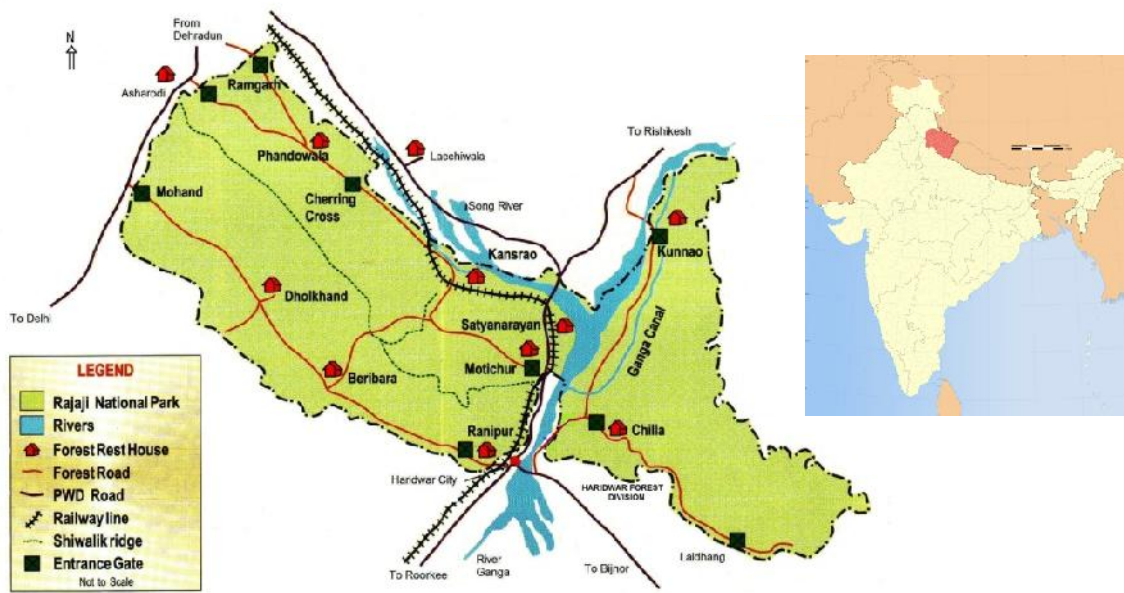


Figure 1. Location map of the Rajaji National Park, Uttarakhand, north-west India

RESULTS AND DISCUSSION

Considering the records of direct sightings of elephants in between 1999-2001 in Chilla forest, maximum sightings occurred were of 11-15 animals (24.54%, sighted 54 times in summer), followed by 2-5 animals (22.27%, sighted 49 times in summer). However, maximum sightings occurred in between 2006-2008 were of 11-15 animals (26.16%, sighted 62 times in summer), followed by 6-10 animals (24.05%, sighted 57 times in summer). On the other hand, maximum sightings of elephant's group recorded in Haridwar forest in between 1999-2001 were of 2-5 animals (27.46%, sighted 78 times in summer), followed by 6-10 and 16-20 animals, respectively (15.84%, sighted 45 times in summer). However, maximum sightings occurred in between 2006-2008 were of 11-15 animals (21.81%, sighted 24 times in summer), followed by 6-10 animals (17.27%, sighted 19 times in summer) (Figure 2A-D).

In contrast, minimum sightings occurred in Chilla forest in between 1999-2001 and 2006-2008 were of 21-25 animals (0.90%, sighted twice in winter), followed by 16-20 animals (1.26%, sighted thrice in winter). Similarly, minimum sightings occurred in Haridwar forest in between 1999-2001 and 2006-2008 were of >25 animals (0.35%, sighted once in summer), followed by 16-20 animals (2.72%, sighted thrice in winter) (Table 1). The largest group of elephants, comprising of 37 individuals was sighted in May 2007 in Luni river in Chilla forest, however, another group comprising of 28 elephants was sighted in June 2006 in Ghasiram water stream, while moving across Ganges. In respect of Haridwar forest only a large group, comprising of 26 elephants was sighted in June 2000 in Kharkhari forest.

A total of 833 groups were sighted in between 1999-2001 and 2006-2008 in Chilla and Haridwar forests respectively, which varied from 2-5 (mean value \pm SD=28.5 \pm 24.7) to 21-25 animals (mean value \pm SD=8.2 \pm 4.6). Significant changes were not observed in the number of groups sighted in Chilla forest during summer before the Gujjars' rehabilitation outside from the park area (mean value \pm SD=30.4 \pm 20.5) as compared after the Gujjars' rehabilitation (mean value \pm SD=32.2 \pm 23.4; One-sample goodness-of-fit test $\chi^2=7.4$; df=5; $p=0.19521$). Similarly, during the winter significant changes were not observed in the number of groups sighted before the Gujjars' rehabilitation (mean value \pm SD=6.4 \pm 5.05) as compared after the Gujjars' rehabilitation (mean value \pm SD=7.4 \pm 5.2; One-sample goodness-of-fit test $\chi^2=14.1$; df=4; $p=0.00724$).

Significant changes were observed in the number of groups sighted in Haridwar forest during summer, before the Gujjars' rehabilitation (mean value \pm SD=35.0 \pm 27.7) as compared after the Gujjars' rehabilitation (mean value \pm SD=13.2 \pm 9.0; One-sample goodness-of-fit test $\chi^2=13.2$; df=4; $p=0.01053$). Similarly, during the winter significant changes were observed before the Gujjars' rehabilitation (mean value \pm SD=12.7 \pm 8.4) as compared after the Gujjars' rehabilitation (mean value \pm SD=5.2 \pm 4.9; One-sample goodness-of-fit test $\chi^2=4.9$; df=4; $p=0.30432$). Noticeably, the number of groups sighted in Haridwar forest after the Gujjars' rehabilitation were significantly low in summer and winter as compared before to the Gujjars' rehabilitation. However, the number of groups sighted in Chilla forest before and after the Gujjars' rehabilitation in both the seasons was almost same (Figure 3A-D).

Population dynamics

Social factors such as territoriality, average group size, seasonality of breeding etc. have a profound influence on the population dynamics of many large mammals and are important in their management (Caughley and Walker 1983). Population dynamics has been widely studied in African elephants (*Loxodonta africana*), which has given a higher insight on their social life, however, only few studies have been conducted on this aspect in Asian elephant range countries and more information on their families' bond and group's interaction is still needed to be studied. GRP has strengthened the frequent movements and activities of elephants in RNP, however, has not placed any drastic impact on their grouping pattern. In between 1999-2001 and 2006-2008, maximum sightings of elephant's groups occurred in Chilla forest was of 11-15 individuals. In contrast, maximum sightings of elephant's groups occurred in Haridwar forest was of 2-5 and 6-10 individuals respectively. It is evident from the data sets that elephant's group's sizes were slightly shrunked and their movements were reduced in Haridwar forest. However, elephant's group's sizes were slightly expanded and their movements were slightly increased in Chilla forest.

In between 2007-2009, tremendous wildfires destroyed the natural forest in Haridwar and Chilla ranges and adjoining habitats. The Kharkhari and Chilla forests were affected severely by the wildfires and thus disrupted elephant's seasonal movement. Wildfires occurred in between 2006-2009 in Chilla and Haridwar forests and shrinkage of natural water sources has affected the frequent movement of free-ranging elephants within the RNP (Joshi and Singh 2010). Since last 15 years, vehicle's traffic pressure on two national highways (Haridwar-Bijnor and Haridwar-Dehradun) has increased almost two folds and elephants were observed not in the situation to cross the road easily, especially during evening hours. It was exposed in a study that nearly 9,900 and 14,100 vehicles moves across the Haridwar-Bijnor and Haridwar-Dehradun national highways per day, except only 3 hours, from 12 am to 3 am (Joshi et al. 2010). Besides, train's traffic has also increased in the Haridwar-Dehradun railway track. In 2000, establishment of State Industrial Development Corporation of Uttarakhand in nearly 10 kilometers long stretch, spread along the Haridwar forest range had severely affected the movement of elephants, especially in

the buffer zone of the park. Anthropogenic activities were also observed enhanced mainly because of increased human population along the periphery of the park.

In eastern part of the park, bigger groups of elephants were observed maximum at the onset of summer (March-April), when elephants were observed arriving to RNP from Lansdowne forest division and when elephant's movements were found confined towards the riparian corridors of Ganges. At the onset of monsoon, elephants were observed migrating towards Lansdowne forest division and in some higher ridges of the park in closed family groups. However, in the south-western part of the park, bigger groups were observed maximum during summer and monsoon, when elephant's movements were found confined nearer to the natural water sources. Occasional splitting of herds was also recorded; especially when elephants reached in the lower patches of the park, however, composition of most of the herds were observed remained same. Generally, large herds used to split into smaller groups, after reaching to the new feeding grounds and stay there nearly for 3-4 months. Environmental factors affect elephant's population dynamics, home range, migration patterns, diet, group size and composition, all of which can vary tremendously, in turn influences the dynamics of elephants and their habitats (Poole 1996). The dynamics of a population may be affected through changes in group's size or other social disruptions such as the removal of age classes, which are important to the group's social structure and functioning (Dublin and Taylor 1996).

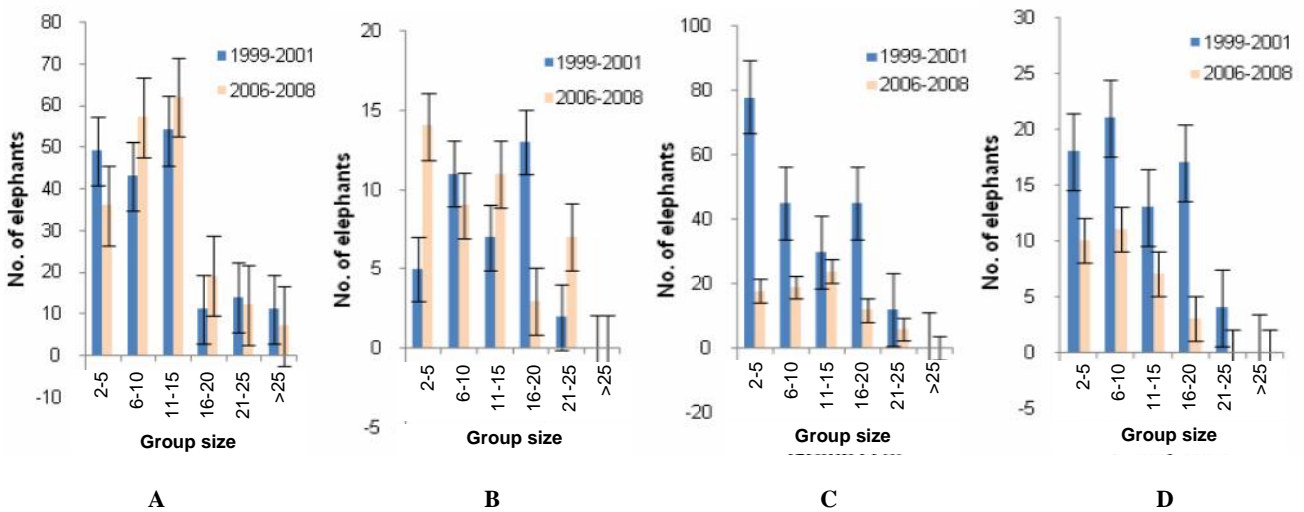
In African elephant's ranges, larger elephant's groups were reported during wet season when resources are abundant (Western and Lindsay 1984; Poole and Moss 1989), however, in Asian elephant ranges, larger groups were reported during dry season, when elephants congregate around scarce water sources and chances of their social contact and association are high (Sukumar 1989). Studies in East Africa revealed that elephants used to enter forests in large groups, but leave in small groups, thereby implying that the large groups break up into smaller units within the forests (Laws et al. 1975). In RNP, pronounced elephant's mating season was recorded as warm period, therefore one of the important reasons behind such gathering particularly in summer might also be for mating needs (Joshi et al. 2009).

Table 1. Sighting of elephant's groups during summer and winter seasons in Chilla and Haridwar forests of the Rajaji National Park in between 1999-2001 and 2006-2008

Number of individual in groups	Chilla						Haridwar					
	1999-2001			2006-2008			1999-2001			2006-2008		
	Summer	Winter	Total	Summer	Winter	Total	Summer	Winter	Total	Summer	Winter	Total
2-5	49	05	54	36	14	50	78	18	96	18	10	28
6-10	43	11	54	57	09	66	45	21	66	19	11	30
11-15	54	07	61	62	11	73	30	13	43	24	07	31
16-20	11	13	24	19	03	22	45	17	62	12	03	15
21-25	14	02	16	12	07	19	12	04	16	06	-	06
> 25	11	-	11	07	-	07	-	-	-	-	-	-
Total	182	38	220	193	44	237	210	73	283	79	31	110



Figure 2.A. An elephant’s herd during migration from Rajaji National Park to Lansdowne forest division, B. Elephant’s group at Chilla forest with a newly born infant, C. A small family of elephants, consisting of five members; mother elephants are taking their calves with care, D. Members of a group greeting each other by inter-twining their trunks in Haridwar forest.



Figures 3 A-B. Number of elephants observed in different group sizes (with standard error) during summer and winter seasons in Chilla forest in between 1999-2001 and 2006-2008 (before and after the Gujjars’ rehabilitation), C-D. Number of elephants observed in different group sizes (with standard error) during summer and winter seasons in Haridwar forest in between 1999-2001 and 2006-2008 (before and after the Gujjars’ rehabilitation).

Sukumar (1994) recorded elephant's aggregation ranging from 50 to 200 in southern India. In a study carried out in the same area, elephant's group size was recorded ranging from 1 to 26 individuals with mean group size 4.32 ± 3.2 ; it was also revealed from this study that elephants have skewed group size with smaller group sizes being more common than larger groups (Ashokkumar et al. 2010). However, in a similar study carried out in the same area, it has been exposed that elephant's group size varied from 1 to 22 individuals with mean group size 4.6 ± 0.16 and 6.8 respectively (Ramesh et al. 2012). Vance et al. (2008) have illustrated on the social networks in African elephants and pointed out that social groups tend to be less cohesive and smaller, families are often divided into small subgroups in dry season, and they rarely fuse with other families to form larger aggregations, which is mainly due to scarcity of fodder resources. Further, during wet season, families often travel in intact groups and whole families often fuse with other families, constituting a bigger continuous aggregation, which occurs mainly because of availability higher resources.

Scientific reasons behind conversion of large groups into smaller ones

Habitat fragmentation and disconnectivity of large migratory corridors were observed as prime cause, which had converted large elephant's herds into smaller ones. Four crucial wildlife corridors namely, Motichur-Chilla, Motichur-Gohri, Motichur-Kansrao-Barkot and Rawasan-Sonadi, which exists across RNP and connect this protected area with Corbett Tiger Reserve, were found almost blocked, mainly because of expansion of human settlements, national highways/motor roads and agriculture lands and increasing traffic in Haridwar-Dehradun railway track. The presence of traffic on the road, construction of steep retaining walls and the presence of human population along the entire Rajaji-Corbett wildlife corridor area have almost restricted the migration of elephants in between the Rajaji-Corbett National Parks (Johnsingh and Williams 1999).

Nandy et al. (2007) carried out the assessment of Chilla-Motichur wildlife corridor using temporal satellite imagery from years 1972, 1990 and 2005, which exposed that an area of 17.56 Km² has been lost in between 1972-2005 mainly because of various developmental activities. Another study carried out in between June 2009 to May 2011 exposed that a total of 352 individuals of 39 species were killed on Haridwar-Bijnor and Haridwar-Dehradun national highways and on an ancillary road (Haridwar-Chilla-Rishikesh) existing across RNP (Joshi and Dixit 2012). Noticeably, 23 elephants were killed in collision with train on Haridwar-Dehradun railway track since 1987. Besides, few cases of collision of elephants with the speeding vehicles on national highways were also observed, during the study period.

In 1970s, the establishment of Chilla hydro-electric power plant/channel had almost divided RNP into two major parts, the eastern and western fringe. Further, after the establishment of Uttarakhand state in 2000, vehicle traffic pressure on Haridwar-Dehradun national highway

and railway track, which exists in between the park area has increased many folds, which restricted elephants to inter-change the forests frequently. In south-western part of the park, elephant's access to river Ganges, which is flowing in between the park area was found restricted, mainly because of presence of a national highway, railway track and human settlements. Some recognized bulls (~2-3) were observed visiting Ganges occasionally by crossing the populated area and national highway and railway track, however group's movement was found almost restricted in this part. In eastern part of the park, elephant's were found visiting Ganges, especially in summer when their movements were confined nearer to the riparian corridors. However, elephant's frequent movement towards Ganges was observed affected because of the presence of the Chilla power channel.

Non availability of large grasslands was recorded another reason, which compels the elephants to aggregate in smaller groups. In addition to some small patches of grasslands, Mundal grassland in Chilla forest is only a vast patch (tentatively 500 hectares), where large groups of elephants were recorded in summer. This grassland was developed across the Mundal river after the relocation of Gujjars in 2003-2004, consisting mainly Wild Sugarcane (*Saccharum spontaneum*) and Kans Grass (*Saccharum munja*) species.

Anthropogenic activities were observed affecting frequent movement of elephants within their home range and thus their group's size. More than 20 villages are situated along the south-western boundary of RNP, 20 villages along the eastern fringe and nearly 15 villages are situated along the northern axis of the park. Noticeably, most of the villagers were found dependent on forest resources for their livelihood, which primarily includes collection of fuelwood and fodder. Spreading of invasive species like Lantana Weed (*Lantana camara*) and Parthenium Weed (*Parthenium hysterophorus*), and native weeds like Malabar Nut (*Adhatoda vasica*), Indian Hemp (*Cannabis sativa*) and Wild Senna (*Cassia tora*) was also recorded affecting the regeneration of various species of grasses. Spreading of these invasive species was found occurring mainly because of cattle's grazing across the boundary of the park. Besides, annual/torrential rivers were also noted as cause of spreading of these species.

Few previous records

Evidences of sighting of large herds of elephants in the park were mostly noticed sporadic and specifically during dry period. In between 1999-2011, I had seen the largest herd of elephants in May 2000, consisting of 50 individuals in Gohri forest of the RNP, while moving across the Ganges, which embraces the peak of dry season. In between 2004-2008, largest herd of elephants, comprising of 47 individuals was sighted in 2005 in Chilla forest of the RNP in summer (Pande GS 2015, personal communication) months. Since last two decades, only a large herd of elephants was sighted in 1997 during summer in Rawasan river in Chilla forest, which consisted nearly 78 elephants and later on, such a large herd was never sighted (Negi MS 2015, personal communication).

Management guidelines

Three small bridges (± 3.5 meter wide) were constructed during 1970s over to the Chilla power channel during the establishment of Chilla hydro-electric power plant, one in Chilla forest, named Soni water source bridge, and two other in Gohri forest, one near to Kaudia village (Kaudia village bridge) and another at Kunao forest (Kunao water source bridge). Elephants were found utilizing only two bridges, one in Chilla and another in Gohri forest (Soni and Kunao water source bridges), however, not utilizing Kaudia bridge mainly because of presence of Kaudia and Ganga-Bhogpur villages across the bridge. Soni water source and Kaudia village bridges are connected with Chilla-Motichur and Motichur-Gohri corridor, whereas, Kunao water source bridge is connected to Motichur-Kansrao-Barkot corridor. All these corridors link RNP with Corbett Tiger Reserve area. It is needed to widen all these bridges to facilitate the movement of elephants in between RNP and Corbett Tiger Reserve. Besides, two more bridges could also be constructed over to the power channel, one at Ram water source, in between Chilla power house and Kaudia village and another at Kunao, in between Binj river and Kunao bridge, which would be feasible approaches to give elephants wider way to move across Ganges and corridors as well.

It is not easy to count elephants directly when moving in large herds or groups, especially in foothills and vegetation dominant landscapes. Further, there are chances of ground-based errors during estimating their numbers. Generally, elephant's large groups maintain a range while feeding or drinking, which ranges tentatively from 50-200 meter. Sometimes, some members of the group used to arrive in open areas or river beds from dense forest to drink, however some companions remain inside the forest, which can emerge out of the forest area after a while. Elephant is a giant animal and if some individual assembles at a place, it covers large space and looks like a large group. Similarly, pugmarks impressions of few individuals give an impression of movement of a big group. These are some examples which should be taken into account while estimating elephant's numbers in forests.

Some villages, which are situated across the crucial elephant's corridor, should be rehabilitated outside the protected area. In addition, Gujjars from Shyampur and Chiriapur forest ranges of the Haridwar forest division and Gohri forest of the RNP should also be rehabilitated outside from the protected area. In addition to the relevant provisions of the Wildlife Protection Act and Project Elephant, this could be achieved with the help of conservation actions, which were identified for development of site-specific management plans, securing identified corridors and connectivity areas for the integration of the protected areas, participatory wildlife monitoring for strengthening management and conducting targeted studies on protected areas valuation assessment as well as on climate change resilience and adaptation assessment in selected protected areas, under India's Action Plan for Convention on Biological Diversity's Programme of the Work on Protected Areas (Pande and Arora 2014).

Some important natural water reservoirs, which spread across the Bagro, Ranipur, Ravli, Chirak and Harnaul annual rivers in Haridwar forest and Ghasiram, Mitthawali, Mundal, Luni and Rawasan annual rivers in Chilla forest should be restored. Besides, water sources which are connected with the Chilla power channel should also be managed.

Riparian corridors of Ganges should be restored from anthropogenic activities, especially from mining activities.

Scientific studies on elephant's ecology and behaviour and its implementation would ensure the future survival of elephants in entire Shivalik Elephant Reserve.

In conclusion, the impact of GRP has not placed any drastic change in restoring elephant's population and increasing their group's size, however, has restored the wilderness of the park, which has increased the frequent movement and activities of elephants within their home range, and thus facilitated in ensuring the effective implementation of Wildlife (Protection) Act 1972. Catastrophic increase in human population, developmental activities, and increasing rate of vehicle traffic on national highways existing across the landscape were observed reinforcing negative impact on the movement of large groups and herds of the elephants. Since last 15 years vehicle-traffic pressure on the national highways and a railway track existing across RNP has increased drastically. Besides, developmental and anthropogenic activities have also increased across maximum of the forest edges and in some crucial corridors. Moreover, the establishment of State Industrial Development Corporation of Uttarakhand in 2000 has affected the frequent movement of elephants, especially in park's buffer zone. All these activities have reduced the connectivity between different protected areas, thus affected the elephant's movement across large undisrupted landscapes in large herds. Understanding how elephant populations acclimatize to such unwanted changes in their habitat, is essential for addressing future challenges in elephant's management and conservation. Since the extent to which elephant's aggregate in a particular area is relevant to their management, restoring the crucial wildlife corridors, facilitating the Ganges' access and ensuring community participation would strengthen the elephant's traditional migration across entire Shivalik Elephant Reserve.

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