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Impact of Transportation on Mammalian Fauna of Rajaji Tiger Reserve, India

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ABSTRACT

Assessment and evaluation of road impact on wildlife is important for its conservation, planning and management. Various protected areas of India have been broken into many fragments due to the rapid expansion of road infrastructure. A serious threat to mammalian fauna in and around Rajaji Tiger Reserve (RTR) was observed in recent years, resulting from the drastic expansion of the transportation infrastructure network. We assessed mammalian fauna mortality on National Highway 72 which exists across Rajaji Tiger Reserve. The study was conducted from January to June 2016. A total of 16 road kills of wild animals by motor-vehicle collision were reported which includes *Felis chaus*, *Viverricula indica, Semnopithecus entellus,*etc. During the onset of summer, vehicular density tends to increase due to influx of tourists which causes disturbance in movement of animal across their traditional migratory corridors. Further, this repeated disturbance may have caused a shift in local density of fauna. This unique habitat holds one of the healthy populations of elephants and leopard in North India. The outcome of this study will advance our understanding of the considerations that must be taken into account during wildlife habitat management and conservation.

Key words: Rajaji tiger reserve, motor-vehicle collision, Uttarakhand, Mammalian fauna, Linear infrastructure.

Road infrastructure is increasingly becoming an essential part of India's development, providing vital needs of transport, communication and connectivity for the people. However, the creation, expansion and maintenance of such infrastructures have significant environmental effects which have been well documented (Forman & Alexander, 1998). Road-induced injury or mortality is one of the most visible and direct impact on animals (Sunder, 2004). Further, the construction of roads causes habitat loss and fragmentation (Burnett, 1992).The indirect effects include barriers to movement, leading to fragmentation of populations and isolation from resources, mates and other biological requirements (Richardson *et al*., 1997; Clevenger & Kociolek, 2006). Avoidance of habitat close to highway increase with traffic volume, which may vary seasonally, weekly, and with time of day (Rowland et al., 2000; Gagnon *et al*., 2007).

Various protected areas of India have been broken into many parts due to the rapid expansion of linear infrastructure like roads, railways and transmission lines, as well as other anthropogenic activities. Animal living in fragmented habitats suffer from problems like genetic isolation, limitation of dispersal, and decline in populations, especially those having wide-ranged habitat. A serious threat to mammalian fauna of Rajaji National Park (RNP) was observed in recent years, resulting from the drastic expansion of the road infrastructure network (Singh & Sharma, 2001;Joshi *et al*., 2010; Joshi & Dixit, 2012). RNP constitutes an important repository of the mammalian fauna of Uttarakhand state and perhaps is the last refuge for a number of threatened mammal species in the lesser Himalayan zone and upper Gangetic tract. Therefore, the present study investigates the impact of National Highway-72 (Haridwar-Dehradun) on mammalian fauna of RNP in Shivalik foothills.

The RNP is located in northwest India at 29° 51′ N to 30°15′ N, 077°52′ E to 078°22′ E, and is at elevations from 250–1,100 m and is 820 sq.km. The Park was established to enhance the long-term survival of the Asian elephant in North-west landscape of India. It falls within the Gangetic Plains biogeographic zone and upper Gangetic Plains province (Rodgers *et al*., 2002). The park lies between the junction of Shiwalik ranges and Indo-Gangetic plains, protecting a biodiversity-rich landscape. The vegetation type of the adjacent forest habitat is broadly classified as Tropical Moist deciduous Forest type (Champion & Seth, 1968). The dominant vegetation of area comprises of *Shorea robusta* (Sal), *Mallotus phillipinensis* (Kamala), *Haldina cordifolia* (Yellow Teak), *Terminalia bellirica* (Beleric), *Ficus bengalensis* (Banyan), *Dalbergia sissoo* (North indian rosewood), *Acacia catechu* (Kutch). The park is a natural home for diverse wildlife including the flagship species *Elephas maximus* (Asian elephant), *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). The study area comprises of NH-72 which exist across RNP and Dehradun Forest Division (DFD). In total, a stretch of 35 km between Rishikesh (Nepali Farm) to

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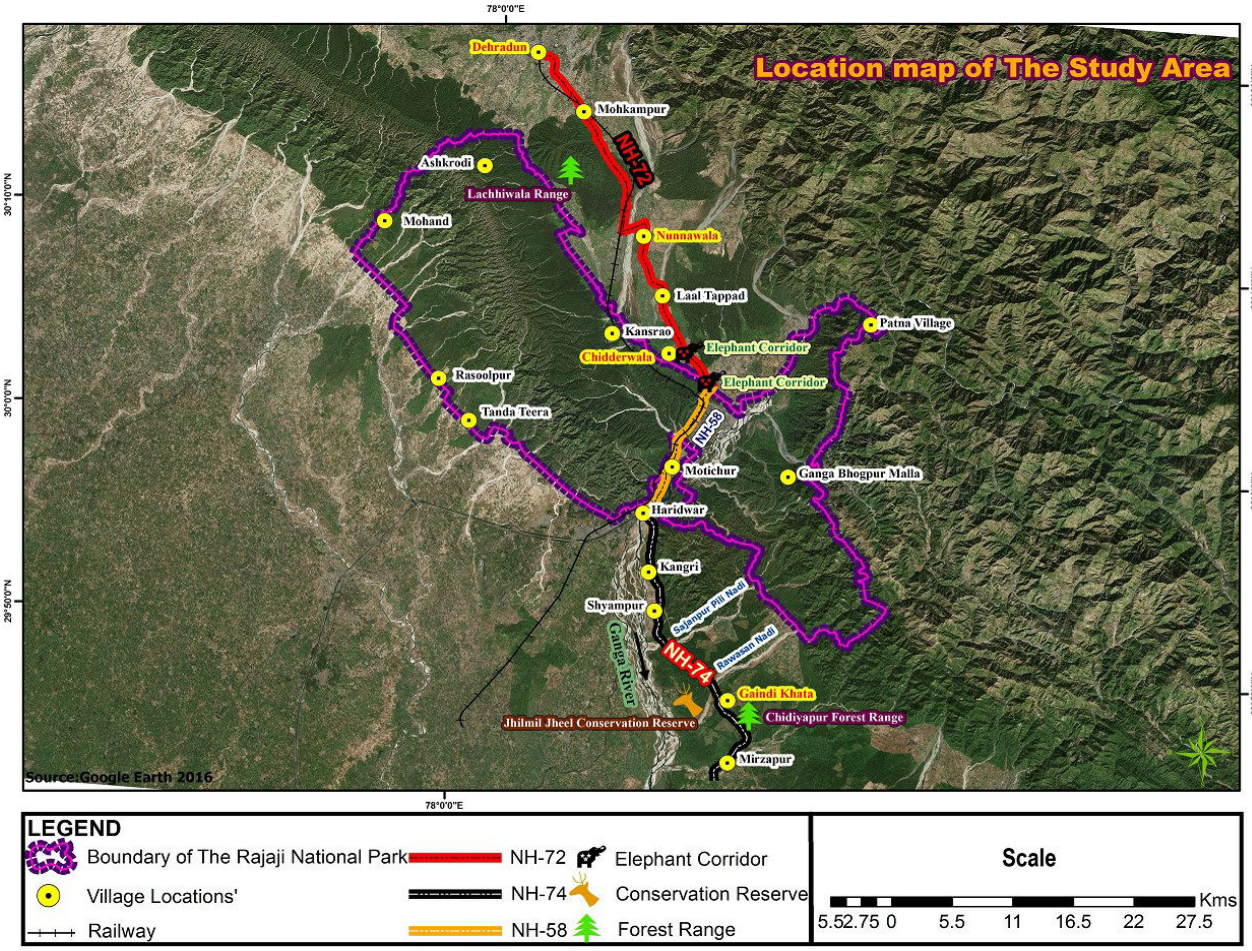

Figure 1. Location map of the study area

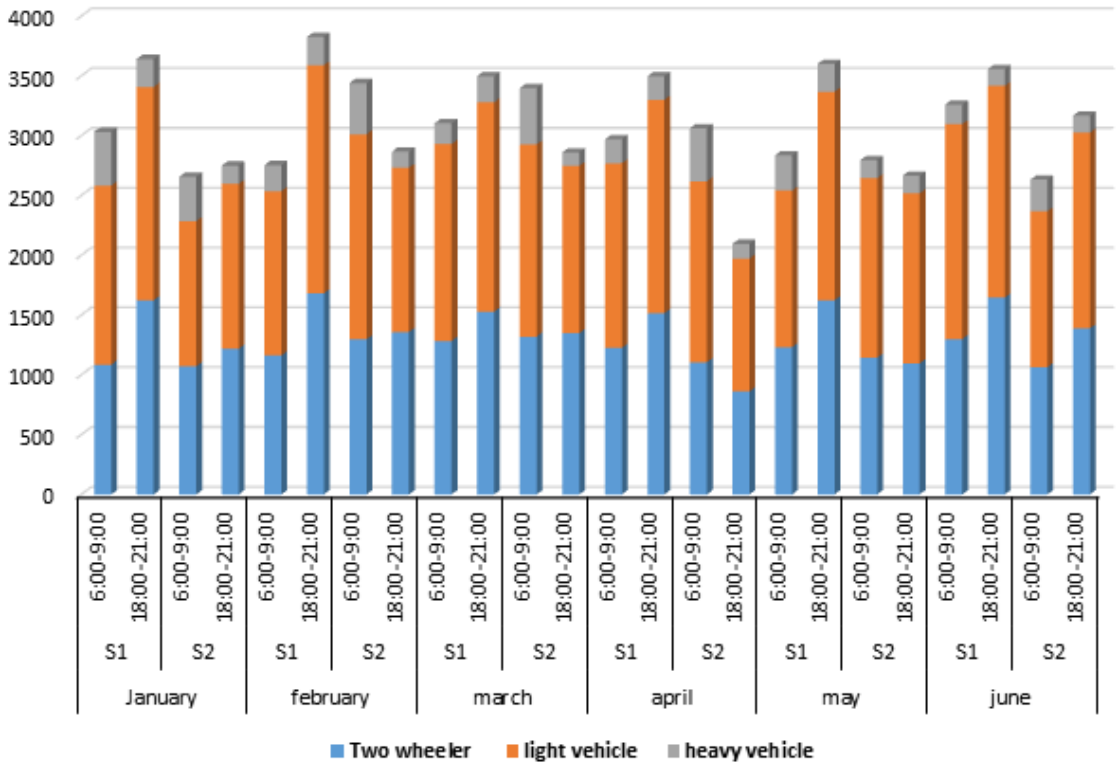

Figure 2. Vehicular pressure along NH-72

Dehradun was selected to quantify the road kills (Figure 1). The Highway passes through ~5.2 km across Lachiwala forest range of DFD and 10 km passes through the important wildlife corridors of RNP.

To quantify the direct impacts of road on mammals, the number of road kills were recorded on National Highway-72 (Haridwar - Dehradun) existing across RNP and DFD during January-June 2016. The highway was traversed three days per week, especially during morning and evening. In addition, using opportunistic sampling method, data on road kills was collected from Forest Department staff, check posts and locals. At every sighting of a road kill, information such as the location, state of the road kill, roadside habitat features and possible reason to cross the road was recorded. The dead animals were identified up to species level (Menon, 2014), wherever possible, and removed from the road to avoid recounting. In addition, waterholes, hoofmarks, pugmarks, dung, scat etc. were also observed to identify the presence of mammals near the highway edges. To estimate vehicular density, the number of vehicle passing through the selected sites viz., Lachiwala (S1) and Chidderwala (S2) were monitored. The traffic flux was systematically recorded for six hours during morning and evening (6:00 -9:00 hr. and 18:00-21:00 hr.) over six months (Figure 2).The vehicles were also divided into various categories such as two wheelers and four-wheelers (light and heavy).

A total of 16 road kills belonging to three orders and five families of mammals were recorded during the study period (Table 1 & Figure 3). It was observed that small-sized and nocturnal mammals were the prime victims. Rhesus macaque was the most affected (37.5%, N=6) by motor-vehicle collisions, followed by common mongoose (25%, N=4). The carcasses of some other nocturnal animals like jungle cat, small Indian civet and porcupine were also found. Two wheelers and light four-wheelers like car, jeeps etc. were observed to be higher during morning and early evening hours. However, high movement of heavy four-wheelers (trucks and buses) were recorded during early morning and late night.

macaques were most affected by traffic collision (N=6), due to their close association to human settlements, tourist spots and temple near highways for food. It was observed that presence of Rhesus macaque was mostly around the highway. Our field observation revealed that they were attracted to eatables thrown by tourists on highway which was also a reason for their high mortality. Artificial feeding of their wild population by humans caused change in their feeding behavior and habit, gradually altering their natural habitat. Carcass of common mongoose (N=4) were recorded on the highway mostly at places near to water bodies. Nocturnal animals like wild cat, civet and porcupine were killed during late night or early morning, their small size could have made them less noticeable to drivers. Majority of the kills were freshly observed during early morning time and late evening hours. Mortality of any big mammal was not recorded, which might indicate avoidance of highway by the macro-fauna due to their behavioral changes and habitat fragmentation. Many scavenger birds were also observed killed due to collision, however, they were not taken into account. Flattened fauna was frequently seen dead on highway crushed under heavy vehicles like trucks and buses which were often driven in careless manner.

Table 1. Road kill of mammals on NH-72

Taxa	IUCN Red List Status[1]	WPA 1972 schedule/ status[2]	No. of road-kills
PRIMATES			
CERCOPITHECIDAE			
Macacamulatta(Zimmermann, 1780), Rhesus Macaque	LC	SCHEDULE II	6
Semnopithecus entellus (Dufresne, 1797), Common Langur/Northern Plains Gray Langur	LC	SCHEDULE II	1
CARNIVORA			
Viverridae			
Viverriculaindica(E. Geoffroy Saint-Hilaire, 1803), Small Indian Civet	LC	SCHEDULE II	1
Herpestesedwardsii(E. Geoffroy Saint-Hilaire, 1818), Common Mongoose/Indian Grey Mongoose	LC	SCHEDULE II	4
Felidae			
*Felischausaffinis (*grey, 1830), Jungle Cat	LC	SCHEDULE II	1
RODENTIA			
Sciuridae			
Funambulus pennant, (wroughton, 1905),Northern palm Squirrel,	LC	SCHEDULE IV	2
Hystricidae			
*Hystrixindica (*Kerr, 1792), Indian Crested Porcupine	LC	SCHEDULE IV	1
Total			**16**

[1]Based on IUCN (2013): EN: Endangered, NT: near threatened, VU: Vulnerable, LC: Least Concern, DD: Data Deficient.
[2]Based on the Indian Wildlife (Protection) Act, 1972; Amended 1991 and 2002 (Source: Ministry of Environment, Forest and Climate Change, Government of India, http://www.moef.nic.in/legis/wildlife).

Figure 3. Road kill of **(a)***Herpestes edwardsii* (Common mongoose), (**b)** *Felis chaus* (Jungle cat) (**c)** *Macaca mulata* (Rhesus monkey) *(***d)** *Viverricula indica* (Small Indian Civet).

The traffic flux on the highway was quantified during the morning and evening hours (Figure 3), and categorized into two-wheelers, four wheelers (light and heavy). The calculated traffic volume was an average of 1027 vehicles passing through the highway hourly, during the six-month study period which was quite high. The vehicular pressure further intensifies during Chaar-Dhaam yatra and onset of tourist season. Few instances of elephant crossing highway was observed around Lachiwala range of Dehradun forest division but elephants couldn't pass the highway due to intense traffic. However, Motichur-Kansrao-Barkot corridor was utilized by solo bull elephants during the summer season, apparently, no large groups were sighted. Four laning of the existing highway caused increase in traffic volume and velocity, which causes hindrance to the movement of wide-ranging mammalian fauna by inducing "barrier effect". The development of two flyovers at Laltapur and Teen pani has been set up for the movement of elephants and other terrestrial animals across the highway. However, the completion of these flyovers is still pending and doesn't provide any permeability for wildlife movement through the highway.

The composition of species found dead on the highway appears to be the remnant of mammalian diversity left in park, indicating a shift in local density of species. The study is short term and preliminary in nature as it had limitations like the actual rate of mortality per day and seasonal variability. A more detailed year-round study is needed to better understand the impacts of vehicular traffic on wildlife. Moreover, long-term viability of road-side populations and landscape level impacts should be studied further to assess broad effects of roads. Nevertheless, this study indicates that NH-72 has a significant impact on mammalian diversity in Uttarakhand.

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