

## WILDLIFE MORTALITY ON NATIONAL HIGHWAY 72 AND 74 ACROSS THE RAJAJI NATIONAL PARK AND THE HARIDWAR CONSERVATION AREA, NORTH INDIA

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### Abstract

*Evaluating the road impact on resident wildlife is one of the important aspects of future conservation planning and of management related actions. Expanding a motor road network in and around protected habitats is considered to be a major threat that can cause the extinction of endangered species. We assessed vertebrate fauna mortality on two inter-state national highways: No. 72 (Haridwar–Dehradun) and 74 (Haridwar–Bijnor) and an ancillary road running across the Rajaji National Park and Haridwar Conservation area, North India. Field data on wildlife mortality was collected from June 2009 to May 2011. A total of 352 individuals of 39 species (3 amphibians, 9 reptiles, 18 mammals and 9 avian species) were found dead on the national highways 72 & 74 and Haridwar–Chilla–Rishikesh motor road, which is running in between Rajaji National Park. Among all the mortalities, avian species were the most affected accounting for 38%, followed by mammals (27%). During Maha–Kumbh 2010, road accidents increased. It was an event that caused tremendous disturbance in animal migratory corridors and in drinking sites. The evaluation of vehicle traffic pressure on national highways revealed that  $\pm 14100$  and  $\pm 9900$  vehicles had been moving across these highways every day. In addition to that, expanding the motor roads network and increasing vehicle traffic pressure is disrupting ecological connectivity and impeding the movement of wild animals. In addition, wildlife mortality rate was observed to be increasing. Further studies are needed to understand the ecological impacts of increasing vehicle traffic on various national highways and roads and on animal behavioral responses, in order to take proper conservation actions.*

**Keywords:** Wildlife mortality; National highway; Rajaji National Park; Maha-Kumbh 2010; Ecological impact; Conservation.

### Introduction

The impacts of roads on wildlife species are well documented; aside from the fact that roads may prove beneficial to some wildlife, as habitats for plants and corridors for travel, they can also create barriers to movement paths, eliminate and alienate habitats and be a source of mortality. Road-related mortality is the most visible and direct effect roads have on wildlife [1]. Nothing is worse for the sensitive wildlife than a road; over the last few decades, studies in a variety of terrestrial and aquatic ecosystems have demonstrated that many of the most pervasive threats to biological diversity—habitat destruction and fragmentation, edge effects, exotic species invasions, pollution, and over-hunting are aggravated by roads [2]. Road and highway construction works affect wildlife through the direct loss and fragmentation of habitats, by

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introducing an additional source of mortality for wildlife populations and by disrupting animal movement and dispersal [3].

The naturally continuous forest ranges of India have been broken up into many parts due to the rapid expansion of agricultural land, urbanization, increasing road traffic and development related activities, as well as other anthropogenic activities. All those activities created problems for wild animals, especially for those living in fragmented habitats. Genetic isolation, limitation of dispersal, migration and the decline of populations of animals requiring large territories are the most common problems connected with the fragmentation of forests and other components of the environment. A serious threat to Shivalik wildlife was observed, resulting from the drastic expansion of the transportation infrastructure network. That transportation network disrupts migration corridors of wild animals residing there, especially for large terrestrial mammals. Our paper focuses on the wildlife mortality on the national highways 72 and 74 and on an ancillary road running across the Rajaji National Park and the Haridwar forest division.

The results of this study could be considered as more important because we found no other published data on the status of road kills in the Rajaji National Park. Moreover, it revealed that the traffic amount on various roads and highways is increasing rapidly, which will have an adverse effect on the fragmented populations of wildlife in the near future. Our study also focuses on the status of those roads and their ecological impact on wild animal seasonal movements. Such reports are required in order to know the current situation and to test our competence in illustrating successes and failures of wildlife habitat management and also in the conservation of endangered species.

## Experiment

### Study Area

The Rajaji National Park (RNP, Fig. 1; 29°15' to 30°31' N, 77°52' to 78°22' E, altitude 250–1100 m) in north India was created in 1983 to protect the habitat of the Asian elephant. At present, it is known as the Shivalik Elephant Reserve No. 11.



Fig. 1. Location map of the Rajaji National Park (29°5'-30°31' N, 77°52'-78°22' E)

RNP spreads over an area of 820.42 Km<sup>2</sup> in and around the Shivalik foothills, which lies in the lower Himalayas and the upper Gangetic plains and it was designated as a reserved area for the "Project Elephant" by the Ministry of Environment and Forests of the Government of India with the sole purpose of maintaining a viable population of Asian elephants. Haridwar Forest Division (HFD; 29°54'60" N, 78°11'98" E, altitude 271.2 m) is well connected with the RNP and the Lansdowne forest division (LFD) and it holds a healthy population of wild flora and fauna. Our study was conducted on two inter-state highways, namely the Haridwar–Dehradun National Highway No. 72 (HDNH, from Haridwar to Satyanarayan area, Motichur forest range of RNP) and the Haridwar–Bijnor National Highway No. 74 (HBNH, from Haridwar to the Chiriapur forest range of HFD), which are 15 and 24 kilometers long and one ancillary Haridwar–Chilla–Rishikesh motor road (HCRMR, *c.*, 28 kilometers long, up to the Pashulok dam, in the Gohri forest range of RNP), running across the RNP and the Shyampur and Chiriapur forest of the HFD.

### **Methods**

We collected data on wildlife mortality on National Highways (NHs) running across RNP and HFD between June 2009 and May 2011. Two inter-state highways, namely HDNH and HBNH and one ancillary road HCRMR, running across the RNP and HFD were investigated. Three days per week were spent on the respective sites especially early in the morning at 6 and in the afternoon, between 3 and 6; all the road kills that occurred on those three roads were counted. The data we recorded represents the number of road kills observed on both the NHs and on ancillary road. However, some carcasses are taken by scavengers and carrion feeders and sometimes carcasses are hidden in nearby vegetation. We restricted our study only to amphibians, reptiles, mammals and birds. Occasionally, road kills were also reported by forest officials and locals. We confirmed and cross-checked those reports before including them in our study. Sometimes we based our records on photographic evidence. At every sighting of road kills we recorded information on the place, species and cause of death and we took digital pictures of each dead specimen, for further examination. After recording the details, the carcass was always moved from the road to the nearby forest. Our study focused especially on the dry period, considered being a peak in wildlife road mortality and for the reptilian fauna we focused on the monsoon period, as during that season, snake mortality was observed to be quite high.

### **Results**

Motor roads are the prime destructive element of the habitat fragmentation process. In north India, they became a major problem in the management of wildlife and they disrupt the migratory corridors for several wild animals, including the flagship species – the elephant. The RNP and its adjoining protected habitats (HFD, LFD and Dehradun Forest Division) is an important biological area and it has great potential for the conservation of endangered species. During the last decade, the increased vehicle traffic on various national highways, the train traffic on the Haridwar–Dehradun railway track, the rapid construction of motor roads and the high expansion rate of high tension electric lines had a negative impact on the behavior of wildlife. At present, a railway track and four national highways are running across this protected habitat, which holds one of the healthiest populations of elephants and leopards in northern India. Wild animals were found to use the network of motor roads to cross the forest, in order to meet their water requirement, especially during the dry period, when most of the natural water bodies dry inside the forest (Fig. 2 a-f).

A total of 352 individuals of 39 species (3 amphibians, 9 reptiles, 18 mammals and 9 avian) were found dead on the NH 72 & 74 and HCR motor road (Table 1, Fig. 3 a-f, 4 a-l and 5). Among the 352 mortalities, the avian species were the most affected, accounting for 38%, followed by mammals (27%). Noticeably, amphibians and reptiles accounted for almost the same (18% and 17% respectively), the only difference being that amphibians consist of only

three species, whereas the reptilian fauna comprises nine species. Road kills occurred in all months of the year. However, the seasonal patterns in the kill rates were obvious.

**Table 1.** Species with their IUCN status and the number of road kills and their frequency recorded on the National Highway NH 72 Haridwar–Dehradun (from Haridwar to Satyanarayan area, 15 kms. towards Dehradun), NH 74 Haridwar–Bijnor (from Haridwar to Chiripur area, 24 kms. towards Bijnor) and Haridwar–Chilla–Rishikesh motor road H–C–R (from Chandi Ghat area/Haridwar to Pashulok Barrage, 24 kms. towards Rishikesh) running across Rajaji National Park and the Haridwar conservation area, from June 2009 to May 2011.

Species	IUCN status	Number of road kills			Frequency	% of road kills
		NH 72	NH 74	H–C–R		
Amphibians						
<i>Bufo melanostictus</i> - Common Toad	LC	13	12	3	28	7.9
<i>Bufo stomaticus</i> - Marbled Toad	LC	-	2	-	2	0.5
<i>Rana tigerina</i> - Indian Bull Frog	LC	10	17	5	32	9.0
Reptiles						
<i>Ophiophagus hannah</i> - King Cobra	VU	-	1	-	1	0.2
<i>Naja naja</i> - Cobra	LC	1	2	2	5	1.4
<i>Daboia russelii</i> - Russell’s Viper	-	-	1	-	1	0.2
<i>Bungarus caeruleus</i> - Common Krait	-	2	1	1	4	1.1
<i>Amphiesma stolatum</i> - Buff-striped Keelback	-	-	1	1	2	0.5
<i>Varanus bengalensis</i> - Monitor Lizard	LC	1	2	3	6	1.7
<i>Chamaeleo zeylanicus</i> - Chameleon	-	13	18	7	38	10.7
<i>Atretium schistosum</i> - Olive Keelback water snake	LC	1	1	1	3	0.8
<i>Python molurus</i> - Indian Rock Python	LR:nt	1	-	-	1	0.2
Mammals						
<i>Panthera pardus</i> - Leopard	LR:nt	4	3	-	7	1.9
<i>Felis bengalensis</i> - Leopard Cat	LC-	1	-	1	2	0.5
<i>Hyaena hyaena</i> - Striped Hyaena	LR:nt	-	-	1	1	0.2
<i>Cervous unicolor</i> - Sambhar	LC	1	2	3	6	1.7
<i>Axis axis</i> - Spotted Deer/Chital	LC	2	6	4	12	3.4
<i>Muntiacus muntjak</i> - Barking Deer	LC	-	1	1	2	0.5
<i>Lepus nigricollis</i> - Indian Hare	LC	-	1	1	2	0.5
<i>Viverricula indica</i> - Small Indian Civet	LC	1	2	3	6	1.7
<i>Paradoxurus hermophroditus</i> - Common palm Civet	LC	-	1	-	1	0.2
<i>Macaca mulatta</i> - Rhesus Macaque/monkey	LC	3	10	4	17	4.8
<i>Presbytis entellus</i> - Common Langur	LC	-	2	1	3	0.8
<i>Canis aureus</i> - Jackal	LC	1	6	2	9	2.5
<i>Herpestes edwardsii</i> - Common Mongoose	LC	3	4	2	9	2.5
<i>Hystrix indica</i> - Indian crested Porcupine	LC	1	-	-	1	0.2
<i>Manis crassicaudata</i> - Indian Pangolin	LR:nt	1	-	-	1	0.2
<i>Boselaphus tragocamelus</i> - Blue bull/Nilgai	LC	-	2	-	2	0.5
<i>Funambulus pennanti</i> - Northern palm Squirrel	LC	1	7	2	10	2.8
<i>Pteropus giganteus</i> - Indian flying Fox	LC	1	2	-	3	0.8
Birds						
<i>Pavo cristatus</i> - Indian Peafowl	LC	-	2	1	3	0.8
<i>Pycnonotus cafer</i> - Red-vented Bulbul	LC	3	19	12	34	9.6
<i>Merops philippinus</i> - Blue-tailed Bee-eater	LC	-	27	14	41	11.6
<i>Merops orientalis</i> - Little Green Bee-eater	LC	-	17	9	26	7.3
<i>Hirundo smithii</i> - Wire-tailed Swallow	LC	-	9	7	16	4.5
<i>Apus pacificus</i> - Fork-tailed Swift	LC	-	4	2	6	1.7
<i>Glaucidium radiatum</i> - Jungle Owlet	LC	1	2	1	4	1.1
<i>Psittacula eupatria</i> - Alexandrine Parakeet	LC	-	1	-	1	0.2
<i>Nectarinia asiatica</i> - Purple Sunbird	LC	-	1	3	4	1.1
39 species		66	189	97	352	

LR:nt-Lower Risk: near threatened; VU-Vulnerable; LC-Least Concern

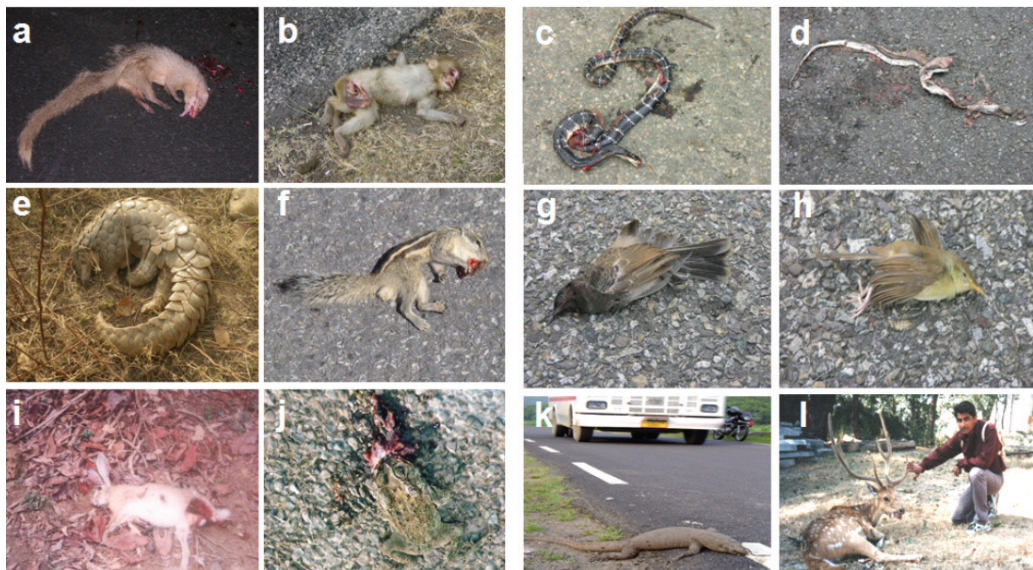




**Fig. 2.** a - Bull elephant about to charge the vehicle on Haridwar–Dehradun national highway, b - A group of wild boars is crossing the Haridwar–Chilla–Rishikesh road during day hours, c - King cobra is crossing the Haridwar–Chilla–Rishikesh road near to Soni shroath, d - Common mongoose is crossing the Haridwar–Bijnor national highway, e - Jackal before crossing the Haridwar–Bijnor highway, f - A group of monkeys on Haridwar–Dehradun highway



**Fig. 3.** a - Leopard dead on Haridwar–Bijnor highway in Shyampur forest of the HFD, b - Sambhar died due to collision with vehicle on Haridwar–Chilla–Rishikesh road, c & d - Blue-bull and jackal died on Haridwar–Bijnor highway in Chiriapur forest, e & f - Carcass of Indian palm civet and hyena on Haridwar–Chilla–Rishikesh motor road



**Fig. 4.** a, b, e & f - Mongoose, monkey, Pangolin and common squirrel died on Haridwar–Dehradun national highway running across Chilla–Motichur wildlife corridor, which is also a connection link between Rajaji–Corbett National Parks, i & j - Indian hare and common toad crushed by speeding vehicle on Haridwar–Chilla–Rishikesh road; c & d - Common krait and olive keelback water snake badly crushed on Haridwar–Bijnor highway, g & h - Red-vented bulbul and little green bee-eater died on Haridwar–Chilla–Rishikesh road, k - Badly injured monitor lizard on Haridwar–Chilla–Rishikesh road, j - First author with injured spotted deer, this deer was injured through a speeding vehicle while crossing the Ranipur – Haridwar by - pass road

The maximum frequency of amphibian and reptile road kills was observed during the monsoon (June–September), whereas that of mammals was during the dry period (March–June) and that of birds was observed during the winter and summer (December–January and March–June respectively). Among amphibian road kills, the Indian bull frog (*Rana tigerina*) and the common toad (*Bufo melanostictus*) were the most affected species, which accounted for 17% of the total of road kills, whereas the chameleon (*Chamaeleo zeylanicus*) accounted highest (10.7%) followed by cobra (*Naja naja*) (1.4%) and the common krait (*Bungarus caeruleus*) (1.1%). Notably, large mammals, such as the leopard (*Panthera pardus*), the striped hyaena (*Hyaena hyaena*), the spotted deer (*Axis axis*) and the sambhar (*Cervous unicolor*) were also severely affected on those motor roads. Among mammals, the Rhhesus monkey (*Macaca mulatta*) was the most affected species, accounting for 4.8% of the total road kills, followed by *Axis axis* (3.4%). Nevertheless, both the jakal (*Canis aureus*) and the common mongoose (*Herpestes edwardsii*) accounted for an equal mortality rate (2.5%). The population of *Panthera pardus* was also severely affected by those inter-state highways, as seven road kills were found during the study period, which accounted for 1.9% of the total road kills.

During the two years survey, nine different avian species were found affected, many being killed during collisions with speeding vehicles. The blue-tailed bee-eater (*Merops philippinus*) and the red-vented bulbul (*Pycnonotus cafer*) were severely affected species, accounting for the highest death rate, 11.6% and 9.6 % respectively. The little green bee-eater (*Merops orientalis*) and the wire-tailed swallow (*Hirundo smithii*) were also affected by the road network, accounting for 7.3% and 4.5% of the road kills. As all of those roads are running in between forests and the river Ganges is flowing across that area, large flocks of different birds, including several migratory species, use to soar over to this forest, especially during the early morning and evening hours, which further enhances mortality risks.

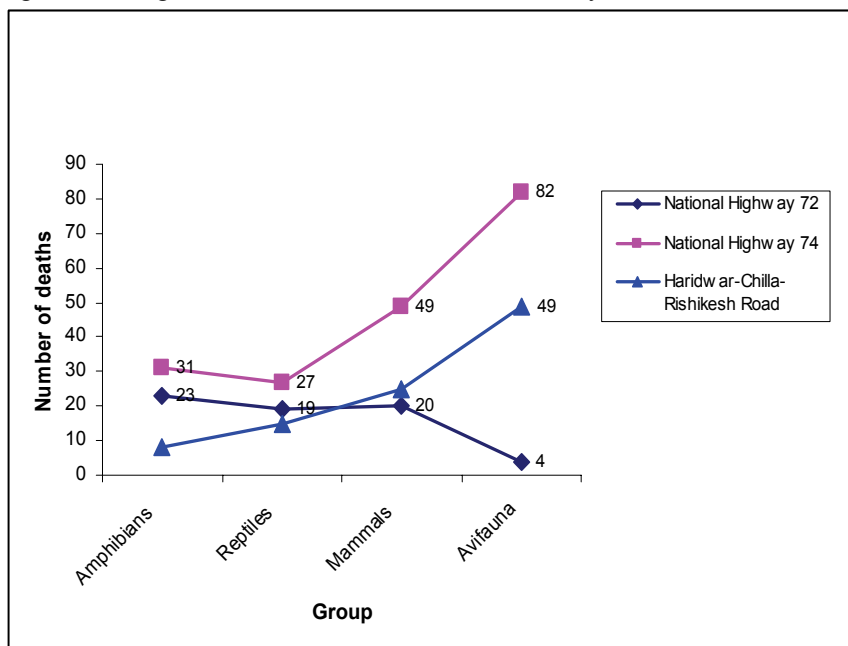
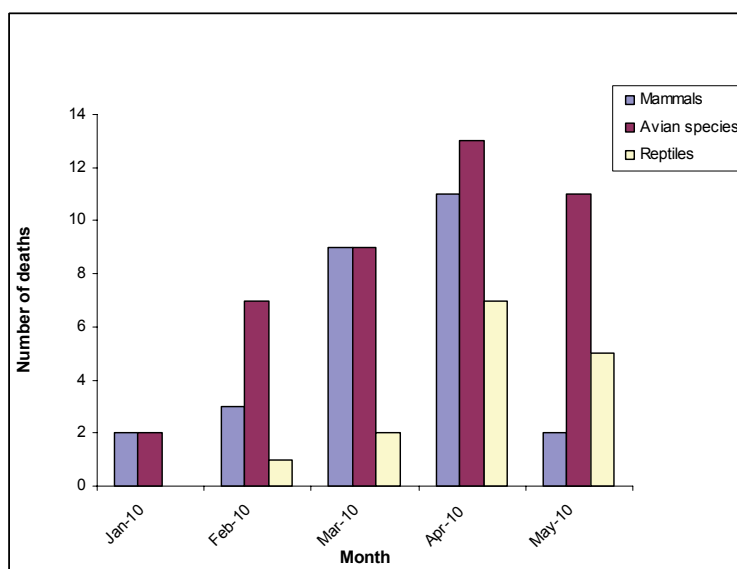


Fig. 5. Mortality of different groups, with number of deaths on the national highways 72 & 74 and the Haridwar-Chilla-Rishikesh road, during June 2009 to May 2011

### *The Impact of Maha-Kumbh 2010*

Maha-Kumbh 2010 was held in Haridwar city (Uttarakhand state) and it was the first Kumbh fair of this century. Spanning across 130 Km<sup>2</sup>, the fair area covered the districts of Haridwar, Pauri, Tehri and Dehradun. The fair was the biggest of Kumbh organized to date. Maha-Kumbh has a religious significance in Hindu Mythology, being held every twelve years, while Ardh-Kumbh (the shorter version of Maha-Kumbh) is held every six years. Four cities organize this fair alternately and Haridwar Kumbh lasted the longest. This year it lasted for four months (January 1<sup>st</sup> to April 28, 2010). Allahabad (Uttar Pradesh), Ujjain (Madhya Pradesh) and Nasik (Maharashtra) also host this fair. The magnitude of the Maha-Kumbh fair can be gauged by the fact that on April 13<sup>th</sup> and 14<sup>th</sup> – the day of ‘Shahi Snan’ (Baisakhi, royal bath) approximately 1.63 crore people were in the Haridwar Kumbh fair area, as per satellite images data and administrative records. That created a world record of the largest number of human beings at one single place at once.

As Maha-Kumbh 2010 also happened during our study period, we also collected data on wildlife mortalities during the fair (Fig. 6). This event caused tremendous disturbance in animal migratory corridors and in their drinking sites. On January 13<sup>th</sup>, a small Indian civet was found dead near to Kunao forest (RNP), due to a collision with a vehicle. Again, on January 30<sup>th</sup>, a common palm civet was found dead in the same forest. Moreover, a sambhar and two jackals died in the Chilla forest of the RNP and in Shyampur and Chiriapur forest of the HFD, respectively, during February 11–12 & 16, 2010. Tremendous crowd pressure was observed during 14<sup>th</sup>–15<sup>th</sup> March and on that day, four monkeys were found dead in HCRM, which is running across the RNP. In addition, one spotted deer, two common mongooses and one barking deer also died at different locations due to collisions with speeding vehicles. On March 27<sup>th</sup>, a female leopard was found dead on the HBNH running across the Shyampur and Chiriapur forest of the HFD (Fig. 6). Additionally, during March–April several avian species (red-vented bulbul, blue-tailed bee-eater, green bee-eater, wire-tailed swallow, fork-tailed swift, jungle owlet and alexandrine parakeet) died due to speeding vehicle traffic.



**Fig. 6.** Mortality of mammals, avian species and reptiles on various NHs and roads during Maha-Kumbh 2010 (January-May 2010)

April was a very adverse month for wildlife. Eleven mammals, including one mongoose, one small Indian civet, one spotted deer, one jackal, one Indian hare and six Rhesus macaques were found dead at different locations in the area under study. As per our review, all of those road accidents occurred during late evening and early morning hours, which are known to be the peak hours for wild animal movements and vehicle traffic is also at its highest during this period. On May 11, a male leopard and a monkey were found dead at HDNH running across the Motichur forest of the RNP. In addition to that, four species of snakes, including the king cobra, the Indian cobra, the olive keelback water-snake, the common krait and the Indian rock python were also found crushed on different motor roads within that area.

### ***Vehicle traffic pressure***

#### *Haridwar–Dehradun national highway No. 72*

This highway is running parallel to the railway track up to the Satyanarayan forest and it divides the Chilla and Motichur forest, which is a crucial corridor for elephant movements in between the Rajaji and Corbett National Parks. Three kilometers of this road (from Motichur river to Raiwala area) are across a very vital corridor and animals used to cross this highway round the year to cross the forest to the Ganges. Wildlife movements across the roads in this area were observed to reach a maximum during the dry season and the late winter. On an average 14,100 vehicles were reported to move on this highway per day (except for only 3 hours, from 12 am to 3 am) (Fig. 7). Vehicle traffic also varies depending on the Char–Dhaam Yatra and the tourist season. This road has also divided the Motichur–Barkot wildlife corridor and only solo bull elephants were observed to cross the road after dusk, group movements being rare. On the other hand, all other wild animals were found to move across forests after dusk (during the dry period) by crossing this highway, even though their movements were not frequent.

#### *Haridwar–Bijnor national highway No. 74*

This highway is running across the Shyampur and Chiriapur forests and the Jhilmil Jheel conservation unit of the HFD. About 24 kilometers of this highway pass through wildlife habitat and during evening hours animals were observed to move on this highway between forests and to the river Ganges. During 2000–2002, six bypasses have been constructed over to various annual rivers and that affected 18 kilometers of forest area, primarily due to the tremendous anthropogenic and developmental activities conducted there. Besides, agriculture expansion adjoining to the river Ganges has lead to the loss of forest wealth, an aspect which is also hindering the traditional movement of wildlife. In the adjoining areas of this track, various stakeholders constructed shopping complexes, check posts and shrines and that restricted the frequent movement of animals, especially during day hours. Elephant movement was observed to be frequent on this highway during late summer and the monsoon. On an average, 9,900 vehicles (including motor bikes) were recorded circulating this highway per day (except for only 3 hours from 12 am to 3 am) (Fig. 7).

#### *Haridwar–Chilla–Rishikesh road*

The construction of the Ganga canal and a motor road in the eastern axis of the Ganges divided the Chilla and Motichur forests. Almost 17 kilometers of road, running across that forest stretch, consist of several internal paths (Ghasiram shroath, Soni shroath, Binj shroath and Hazara shroath) through which wild animals move towards the Ganges. Animal movement



was frequent on this road during the summer. On average, 200 vehicles circulate this road per day during the tourist season, whereas more than 75 vehicles exceed on routine basis (Fig. 7).

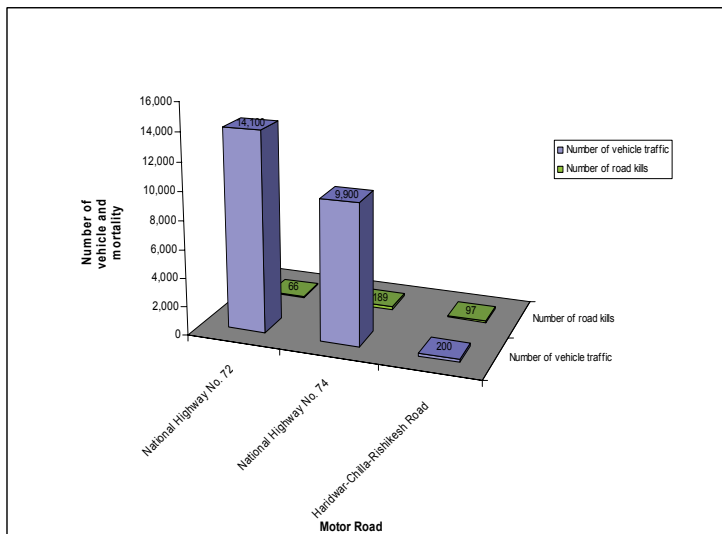


Fig. 7. Different motor roads, with the number of vehicle traffic running through and number of wildlife mortality, during June 2009 to May 2011

### *Ecological impact*

The direct ecological effects, such as flattened fauna are easy to see. In contrast, many indirect effects of those roads are cumulative and involve changes in community structure and ecological processes that are not well understood [2]. The fragmentation effects of those roads result when animals within populations are unable to approach or cross roads to connect habitats, access mates, or meet other biological requirements [1]. Developmental projects, mainly rail lines, roads, canals, industrial establishments and the encroachment by human habitation are basically responsible for the fragmentation of habitat and the blockade of migratory routes for elephants in RNP [4]. Roads were involved in causing animal casualties, ranging from snakes to wolves. They function as displacement factors affecting animal distribution and movement patterns [2]. Traditionally, the impact of highways on wildlife was viewed in terms of road mortality and threats to selected populations of animals. By viewing this issue from the perspective of landscape ecology, it became clear that highways have the potential to undermine ecological processes through the fragmentation of wildlife populations, restriction of wildlife movements, and the disruption of gene flow and meta-population dynamics [3].

During the last decade in the Shivalik landscape vehicle traffic on various highways and ancillary roads doubled. Moreover, several roads inter-linking different remote areas situated in buffer zones of the protected forests were redesigned. Expanding the road network in the buffer zones of the RNP area has disconnected a long chain of wildlife habitat from the river Yamuna to Sharda and, as a result, the population of wild fauna was isolated in fragmented habitats. This created a big problem, especially for elephants, which are known for their long migrations. Several paths of this region including Chilla–Motichur, Motichur–Gohri, Motichur–Kansrao–Barkot, Rawasan–Sonanadi were also affected severely, because of developmental activities, further restricting the gene flow among different populations and that may have a negative impact on their long-term survival. The fragmentation of wildlife habitats could restrict

individuals to move frequently within their traditional home range, it could separate different critical habitats and break up the animal population into smaller groups. In such conditions the demographic and genetic consequences could affect their long-term movements and persistence. During the last two decades, the elephant population in north-western India was isolated and found moving in small fragmented habitats. One example is that of the Rajaji–Corbett wildlife corridor. Only bull elephants used to move between those protected areas, whereas groups were not observed to cross this forest, primarily due to the intense traffic on the Kotdwar–Lansdowne motor road and the increasing rate of biotic pressure across the traditional wildlife corridor.

Traditionally, wild animals used to perform different unique movements to meet their physiological needs. That aspect remained neglected during the past and it is highly recommended we document it as it may be helpful in the management of any wild species. The fragmentation of a large area has an unenthusiastic impact the natural activities of animals. We should note that animals were finding water sources during the day inside the forests and those nearer to the roads were used mostly after dusk, mainly due to the traffic pressure and the unwanted noise. The presence of the Ganges in between the park area could be considered as an important reason behind this, as animals depend on the Ganges water during the dry period, when most of the natural water sources in the park area dry up.

Drastic changes in animal natural behavioral responses were also observed. One appropriate example is that of the spotted deer, which was found to use the edges of the roads after dusk to feed on edible items/garbage thrown by passengers. However, they were observed reaching the adjoining forests after mid-day. Similarly, elephants used to cross the roads between 04:00 and 08:00, even though their movement shifted to roadside forests after mid-day. Notably, elephants also made attempts to threaten people while crossing the road, sometimes they stop suddenly and spend more than 5 minutes standing on the road. Sometimes they slowly approach the people waiting for the way to clear and when people keep their distance the elephants move on and cross the road. Normally, wild elephants are not aggressive in nature, but the recent fragmentation of wildlife habitats placed some populations under threat and severe changes were observed in their behavioral patterns. Looking at the picture, we may say that animals are making a slow adaptation to using those roads on a daily basis. Road kills are also making a negative impact on the existing population of wild fauna. Several endangered vertebrate and invertebrate fauna are being killed daily by traffic on the roads that cross the landscape.

Motorized traffic obviously had a negative effect on the behavior of the various deer species (white tailed deer, elk, moose, mule deer and bighorn sheep) studied in Mountain protected area. Our study revealed that deer were forced to use an alternative habitat when areas visible from the road were disturbed by high traffic and human activities, decreasing their probability of occurrence during weekends compared to weekdays [5]. Highway traffic was not the single contributor to collision rates. Besides, collision rates are also influenced by changes in wildlife behavior. Those changes vary, depending on species. However the migration to winter ranges adjacent to the transportation corridors has a significant influence on collision rates [6]. Collisions between wildlife and vehicles raise highway safety concerns for motorists too. Collisions have become common place in areas where high speed roads traverse high quality wildlife habitats [7].

## **Discussions**

Highways can negatively affect wildlife by creating barriers in their habitat that leading to fragmentation of populations. Small mammal populations separated by highways may be

partially or completely isolated from one another due to low dispersal capabilities, low probability of surviving highway crossing attempts and the avoidance of areas adjacent to highways [8]. Vehicles on high-speed highways pose the greatest threat to wildlife. The number of road kills usually increases with the increase in traffic [2]. Road kills of a wide array of wild animals are one of the major challenges in the current conservation scenario [9]. Roads cause habitat loss both directly through habitat destruction and indirectly by increasing disturbance through noise and traffic volume [10]. The deadly roads of Uttarakhand are taking a heavy toll on the wildlife, especially on leopards. Hundreds of animals have fallen prey to these roads [11]. NH 72 and 74 are acting as an unnatural death trap for several endangered wild animals residing within the Shivalik landscape. Besides some ancillary motor roads are also running across this range, which restricted the frequent movement of wild animals within their home range. NH 74 is the deadliest highway of Uttarakhand and it has killed more than 100 wild animals since the formation of state. A total of six leopards died on this road apart from several other animals like the sambhar, the wild boar, the blue bull and the jackal (Rajendra Agarwal, Project Coordinator, Wildlife Protection Society of India, *personal communication*). Currently, there is no other publication available on wildlife mortality, especially in the RNP and the adjoining areas, although this aspect is very important in order to test our competence in species conservation.

A total of 39 mammalian species, including the leopard, jackal, spotted deer, sambhar, common Indian civet, common palm civet, barking deer, common mongoose, Indian hare and Rhesus monkey died due to collision with vehicle traffic. It was revealed that all road accidents occurred during the night, especially after dusk and before dawn. However, animal movements nearer to motor roads were observed after mid-day, but it was found that they did not use to cross the motor road due to the tremendous traffic running there. In a study on road kills carried out in south India, it was found that most of the mammalian road kills were nocturnal species that had been killed while crossing the road, as they get blinded by the headlights [12].

During the last decade the Shivalik landscape has undergone a drastic change, primarily due to the rapid enhancement of human population and to industrialization. The results from this study provide a sketch of the wildlife mortality status on the NHs running across the Shivalik landscape in the lower Himalayan zone. Such reports are largely absent from publications, despite their importance in illustrating success and failures of our wildlife management and conservation efforts. In the future, we will face a worldwide increase in human population and therefore, the dependency of people on local forest resources will increase and anthropogenic disturbances will inevitably increase. More field oriented scientific studies addressing the impact of the expansion of motor roads and of anthropogenic activities on the behavior of wild animals are required. Various stakeholders, local people, Gujjars, tour operators, non governmental organizations, government organizations, media persons, researchers from various institutions and universities and protected area managers will have to work together to increase public awareness on the effects of human activities on animal disturbance and act to minimize those effects.

## Conclusions

The RNP and HFD are located in an important biological area with a huge potential for wildlife conservation. Vehicle traffic on these highways doubled compared to the previous decade back and wild animals are not able to cross the roads safely anymore. Some important wildlife corridors (Chilla–Motichur, Motichur–Gohri and Motichur–Kansrao–Barkot), which in this landscape were also affected due to this. The long-term effects will include genetic isolation, habitat fragmentation within the same forest and enhance the human–

wildlife conflict. At present, five national highways are running across this region, which holds one of the healthiest populations of elephants and leopards in north India.

Every year, lots of avian, reptilian and amphibian species die on NH 72 and 74, but we don't have any database on those unnatural deaths, which is also why we should keep a record as required proper management actions. Except for large carnivores as the tiger and the leopard, it is not possible to document all the mammalian road kills, especially when they happen during the night. Under the wildlife management programme, the state government is also placing some warning boards at potential accident sites, to make people aware, but there is a need to take some conservation actions so as to minimize wildlife mortality. A four lane national highway project is also being implemented on Haridwar–Dehradun NH 72, which would further disrupt the migratory corridors of wild animals, especially those of long ranged elephants. As this highway is running across the Motichur forest of the RNP, the Motichur–Chilla and Motichur–Barkot wildlife corridor will be affected severely. That could further impede the movement of wild animals in between the Rajaji–Corbett National Parks. Understanding how animal populations react to such vast land changes and their behavioral response thereto is essential for addressing future challenges of wildlife management and conservation.

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