MITIGATION OF IMPACT OF NATIONAL HIGHWAY- 58 ON INDIAN PRIMATE, HANUMAN LANGUR *(PRESBYTIS ENTELLUS)* IN UTTARAKHAND HIMALAYAS

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Abstract:

Roads are amongst the most ubiquitous human infrastructure and their interaction with the natural habitat of wild animals is all pervasive. The environmental impacts of road are numerous and include direct effects on wild animal population, whose home ranges are split by road and where individuals suffer mortality and death due to collision with vehicles. Vehicle collisions with wild animals are serious problem that justifies the widespread application of mitigation measures. National Highway-58 (538 km) traverses 373 km in Uttarakhand and caters the need of high volume of pilgrims to the world famous Indian shrines – Badrinath, Kedarnath and Hemkund Saheb. The study area has a length of 70 km of NH-58 from Rishikesh to Devprayag along the river Ganga. The highway is constructed and maintained by Indian Army from Rishikesh to Mana. Large scale road widening activities are in progress for the last five years on NH-58 in Uttarakhand. This highway has also a strategic importance, as it connects with Tibet and China. Indian primate, Hanuman Langur (*Presbytis entellus)* is a large, black faced, grey bodied with long limbs and tail longer than head and body which is very common in the study area. This Indian primate is a sacred animal and treated as Hanuman God in India. The entire study area with six sampling sites (S_1-S_6) was thoroughly surveyed for the period October 2009 to September 2011. Specific feeding and mating grounds, crossing zones were visited frequently. Ecological responses including the mating behaviour, close watch during morning and evening, cause of conflicts, spots of accidental deaths in vehicle accidents of Hanuman Langur were thoroughly investigated. A total population of Hanuman Langur was recorded 546 in the study area in different groups of 10-12 individuals. Impact of NH-58 and its widening on Hanuman Langur was resulted in the form of habitat fragmentation and modifications, restriction of movement, injury and mortality, soil erosion and hydrological alterations and environmental contamination. NH-58 has turned a natural habitat area into isolated small patches of habitats. Gaps between habitats prevented dispersal and recruitment of Hanuman Langur. Mean frequency of heavy vehicles (truck, bus, car, sumo, jeep, and troller) was recorded 414 vehicles per day on NH-58 during the two - year period of study. Maximum movement was recorded between 0600-0900 hours in the morning. Mean road kill of Hanuman Langur were recorded 3 individuals per month. Killing was common at the sharp turns, slopes, near the water holes and small tracks which crossed the NH-58. A total of 72 animals (40-killed, 22-seriously injured, 10-sustained minor injuries) were met with vehicular accidents during the period of study. Male Hanuman Langur killed were significantly more than females. Maximum killings (15%) was recorded in May and minimum (2.1%) in January. It was 85% during pilgrim season (May-October) in each year. Road kills were disappeared within few hours as a result of scavengers operating in the area. Appropriate mitigation measure for reducing number of accidents and maintaining habitat connectivity has been suggested. These are animal detection warning system, speed limit reduction (within 30 $km.hr^{-1}$), automated speed detectors (interceptors), use of lightening reflectors during night for reducing collisions. Public education and awareness, fencing of numerous types, lengths and heights, placing culverts at frequent intervals, road bridges, under passes, dry drainage use and designing of innovative vegetative

overpasses connecting vegetation of both sides of the road at frequent intervals are very effective in mitigation.

INTRODUCTION

Roads and National highways are very important for mobility in the inaccessible areas of Himalayas. A network of roads has been expanded in the entire area of Himalayas including the Uttarakhand Himalayas during the last two decades. The interaction of these roads with the natural ecosystems is all pervasive. The environmental impacts of roads are numerous and include both direct effects on the habitats destroyed for their construction and changes in the dynamics of the ecosystems they run through (Forman and Alexander 1998; Spellerberg 1998). The latter primarily include effects on mammal populations whose home ranges are spilt by roads and where individuals afterwards suffer mortality due to collision with vehicles (Case 1978; Groot and Hazebroek 1996; Slater 2002; Malo *et. al.* 2004). There were lots of studies regarding the impact of road construction on wildlife in Europe, North America and Australia in terms of road killing (Patten *et.al.* 2008; Grilo *et.al.* 2009; Baskaran and Boominathan 2010), avoiding effect (Forman and Deblinger 2000), crossing behaviour (Hoeven *et.al.* 2009), migration barriers (Shepard *et. al*. 2008), habitat degradation (Ortega *et.al*. 1999) and habitat fragment (Thiel *et.al*. 1985). However, a very little work on the impact of road construction on wildlife has been done so far in India including the Himalayan region. An initial attempt has been made on the conflict between linear developments and Asian elephants in Sub-Himalayan zones of Uttarakhand (India) by Singh and Sharma (2001). Suggestions for designing railroads, highways and canals in protected areas to reduce man-elephant conflicts have been recommended (Singh and Satheesan 2002).

The Hanuman Langur (*Presbytes entellus*, Dufrense 1797) is one of the common primates (Cercopithecidae, Colobinae) being found in a wide range of habitats from plains to 3,660 m above m.s.l. in the Himalayas and from relatively dry tropical forests, scrub jungles and arid rocky areas (Roonwal and Mahnot 1977). Hanuman langur is a large, black-faced, grey-bodied with long limbs and tail longer than head and body. Eyebrows are well developed. Sex skin well developed in adult males but does not exhibits cyclic changes. The Hanuman Langur is very common in the study area. This Indian primate is a sacred animal and treated as Hanuman God in India. Nowhere has the ancient relationship between human and non-human primates has been more intimate and complex than on the Indian Sub- continent. Protected for centuries by the Hindus belief that all creatures carry a spark of divinity and must not be killed (De Vore 1977).

Roadside primate mortality is relatively new environmental dimension in developing countries including India, with the recent abrupt increase in the number of high speed of vehicles and the simultaneous improvement of roads. Road kills dealing with transportation impact on wildlife have still not become a major issue that attract the attention of wildlife managers and infrastructure engineers. Therefore, keeping in view the importance of addressing the serious problem of vehicle collisions with wild animals, the present contribution on mitigation of impact of National Highway-58 on Indian primate, Hanuman Langur (*Presbytes entellus*) in Uttarakhand Himalayas has been made.

MARERIALS AND METHODS

The Study Area

The study area is located in Garhwal Himalayas. It is an important part of the state Uttarakhand of India (Latitude: 29 degree 26 minute-31 degree 28 minute N; Longitude: 77

degree 49 minute-80 degree 6 minute E). The Garhwal Himalayas encompasse seven districts and covers an area of 30,029 km^2. The entire region is bestowed with rich biodiversity including wildlife. The area is famous for the world famous Indian shrines- Badrinath, Kedarnath, Gangotri, Yamnotri and Hemkund Saheb. It is also famous for many snow clad Himalayan peaks including the second highest peak, Nanda Devi of the world. The area is also famous for the presence of a world famous 'Valley of Flowers', a world heritage site, famous for its rich diversity of the naturally growing flowering plants.

During the last two decades, Govt of India has taken initiatives for constructing and widening a network of roads and National highways including the National Highway-58 in this region for providing efficient mobility. This area is also important for the strategic points of views, as is it is bordering with Tibet, China, and Nepal.

Salient Features of National Highway-58

The National Highway-58 (538km) links Ghaziabad near Delhi, the capital of the country with the world famous Indian shrine Badrinath in Uttarakhand Himalayas. The National Highway traverses 373 km in Uttarakhand and caters the need of high volume of pilgrims to the world famous Indian shrines- Badrinath, Kedarnath and Hemkund Saheb. The study area has a length of 70 km of NH-58 from Rishikesh to Devprayag along the National River Ganga (Figure 1). The highway is constructed and maintained by Indian army from Rishikesh to Mana, the last village of the border area near Badrinath. This highway has also a strategic importance, as it connects with Tibet and China.

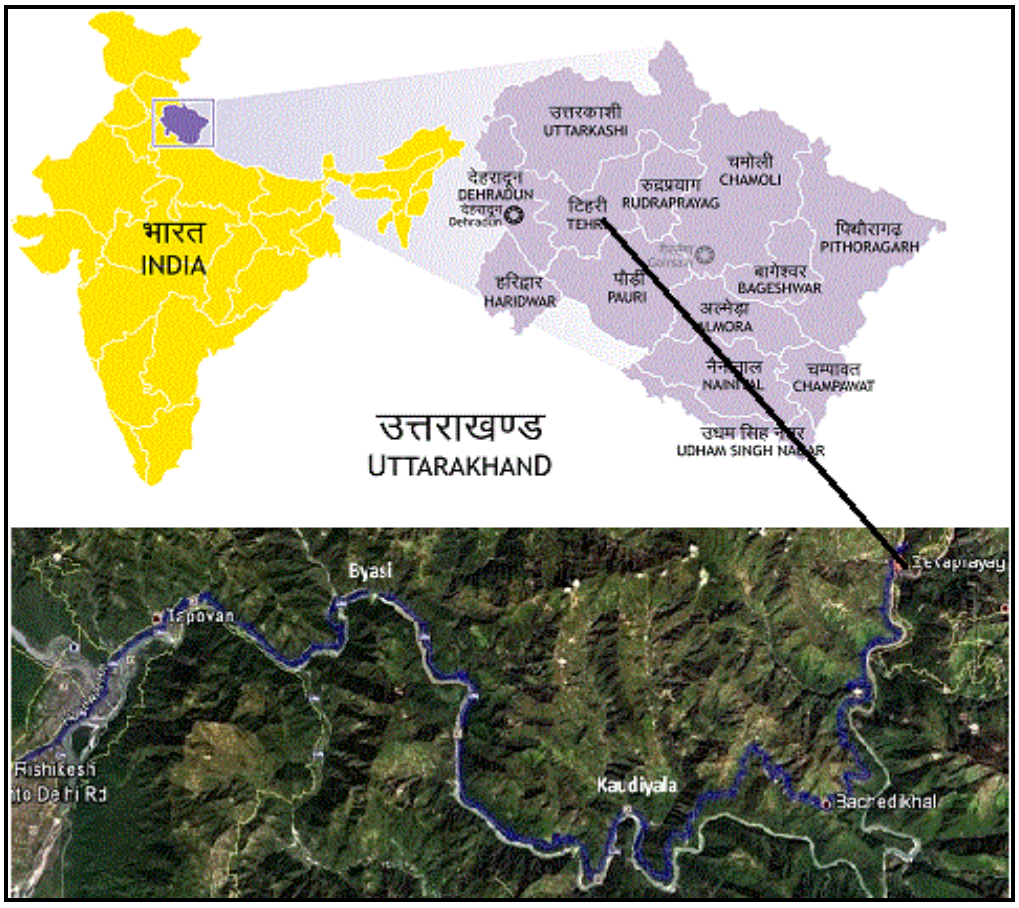

FIGURE 1 Location map of the study area in Uttarakhand Himalayas

Vegetation on Both Sides of NH-58

The vegetation in the study area on both sides of the National Highway-58 is predominantly of forest communities with frequent interruption of scrub jungles, grassy patches and crop fields. The covered area of forest as per visual understanding is about 75%. However, satellite imagery interpretation indicates 57.89% of forest covers in the study area. The vegetation in the study area (from Devprayag to Rishikesh) is of two types- sub montane vegetation and intermixed vegetation. The sub-montane vegetation is represented by the tree species of Sal (*Shorea robusta*), Khair (*Acacia catechu*), Sheesham (*Dalbergia sissoo*), Tun (*Toona serrata*), and Bhimal (*Grewia optiva*). Intermixed vegetation is of common deciduous components and is represented by Kail (*Pinus walichiana*), *Ficus* spp, *Lantana camara*, Bel (*Aegle mermelos*) and Kaphal (*Myrica esculenta*).

Faunal Component in the Study Area

The study area has a considerable number of wild fauna including mammals- Leopard (*Panthera pardus*), Tiger (*Panthera tigris*), Hanuman langur (*Presbytes entellus*), Jackal (*Canis aureus*), Monkey (*Macaca muleta*) and Jungle cat (*Felis claus*), reptiles- Python (*Python molurus*), King Cobra (*Ophiophagus hannah*) and Krait (*Bungarus caeruleus*) and several bird species.

Methodology

The entire study area (70 km stretch of NH-58) was divided into six transects/sampling sites (S_1-S_6). These sites were located at different altitudes (350 m to 620 m above m.s.l.) covering specific feeding and mating grounds, crossing zones, near the water holes, grasslands, and rock structures. These were-S_1 (Devprayag), S_2 (Kaudiyala), S_3 (Totaghati), S_4 (Byasi), S_5 (Shivpuri), S_6 (Muni-Ki-Reti). The entire study area covering 25m on both sides of the NH-58 was thoroughly surveyed for the period October 2009 to September 2011. Specific feeding and mating grounds, crossing zones were visited frequently. Ecological responses including the mating behaviour, close watch during morning (0600:900hrs) and evening (1600-1900hrs), cause of conflicts, spots of accidental death in vehicle accidents of Hanuman langur were thoroughly investigated.

Roadside Counts

Roadside counts of Hanuman langur were made at all the six sampling sites covering all major micro habitats assuming a sighting distance of 25m on each side of the NH-58. An open jeep with driver and two observers standing in the back, who concentrate on spotting and counting of Hanuman langur on their side of the vehicle was used for roadside counting. A recorder who takes down information on the roadside count was also involved in the counting team. All counts were carried at a standard time of day (0600-0900 hrs) with a slow speed (20 km per hour). These counts were made fortnightly in different months for the entire period of study. Road kill data were also collected during a two-year period of study.

Traffic Flow

Figures on traffic intensity (number of vehicles per 24 hour) of different vehicles with their velocity were also recorded. For velocity, the data taken by the interceptor was used. Traffic intensity was recorded as the mean number of vehicles on the road in each one-hour interval round the 24 hrs from October to September 2011.

RESULTS AND DISCUSSION

Roads and other linear infrastructure exert a myriad of negative effects on adjacent landscapes, populations and individuals. Fauna are particularly impacted, with increased rates of mortality, reduced or modified movement patterns, changes to amount, quality and management of habitat (Soanes and Van der Ree 2009).

Ecology of Hanuman Langur

Hanuman langur (*Presbytes entellus*) inhabits a diverse variety of habitats including deciduous forests to open forests, scrub jungles and arid rocky areas along the NH-58 in Uttarakhand Himalayas. Hanuman Langur feels at home among trees, jumping from branch to branch and tree to tree, but also spends a good deal of time on the ground during the mornings and evenings (Figure 2). *Presbytes entellus* is entirely vegetarian, eating mainly leaves, shoots, buds, flowers, bark, fruits and seeds of a large number of plants, only rarely do eat insects. Cultivated crops and vegetables are also taken whenever available. *Presbytes entellus* also regularly licks stones and hard rocks. This is done to obtain its requirements of salts and minerals, such as Calcium and Magnesium and trace elements. *Presbytes entellus* starts feeding shortly after waking up at dawn and continues during the morning (0630-0830 hours). There was an intense bout of feeding in the afternoon and some feeding at the roosting time in the evening (1630-1830 hours). Hanuman langur drinks clean water regularly from the springs and small pools close to the NH-58.

FIGURE 2 Hanuman langur spending good deal of time on the railing of NH-58

Population of Hanuman Langur

The Hanuman langur (*Presbytes entellus*) lives in social groups of various sizes and composition in the study area. *Presbytes entellus* has variable social organization. Two basic types of social groups are bisexual troops and the all-male bands. Bisexual troops are generally composed of adult , sub adult females , and juveniles with one adult male (uni-male bisexual group) or more than one adult male (multi- male troop).The percentage of uni-male *verses* multi-male troops and the corresponding number of extra troops band males vary from site to site (S_1-S_6) on the 70 km stretch of NH-58. Social change is a natural process in Hanuman langurs and resident male replacement is an important and regular phenomenon of

social change in the population of Hanuman Langur in the study area. The process of replacement and tenure of resident male Langur is very fast growing in the area. It is likely that males are only able to conquer and defend a troop during a rather restricted period of life, when they have maximum skill and physical power. Under the present study, a resident male simultaneously hold a neighbouring troop where the establishment of new resident could not take place. Thus, it has been observed that the male have intention to hold more and more female to maximise the reproductive success.

Although each group of Himalayan langur has its home range, territories are not defined. Home ranges, which offer overlap to some extent, may be quite extensive. A total population of 546 Hanuman langurs recorded in the study area in different groups of 10-12 individuals (Table 1). Maximum density of population of hanuman langur was found at S_2 (Totaghati) followed by S_3 (Kaudiyala). Minimum population was recorded at S_6 (Muni-ki-Reti).

TABLE 1 Average population of Hanuman Langur (*Presbytes entellus*) on the roadside of NH-58 at all the sampling sites (S_1-S_6)

Site	Place	Geographical location		No. of individual (Population)
		Latitude	Longitude	
S_1	Devprayag	30°14'N	78°59'É	95
S_2	Totaghati	30°11'N	79°01'É	108
S_3	Kaudiyala	30°07'N	79°02'É	104
S_4	Byasi	30°06'N	79°07'É	97
S_5	Shivpuri	29°97'N	79°09'É	86
S_6	Muni-ki-Reti	29°07'N	79°12'É	56
			Total	**546**

Traffic Flow

The traffic flow at the NH-58 is very high round the year. However, it is very high during pilgrim season (May-October). Traffic flow recorded during the period from October 2009 to September 2011 revealed that the mean frequency of vehicles (truck, bus, car, sumo, jeep and troller) was 414 vehicles per day (24 hrs). Maximum movement was recorded between 0600-0900 hrs in the morning. Maximum mean traffic flow (521 vehicles per day) was recorded in the month of May and minimum (320 vehicles per day) in the month of January (Table 2). Maximum contribution to the total traffic flow was made by cars (39.63%) followed by trucks (21.40%) and sumo and jeeps (20.17%). Minimum contribution (1.11%) was made by a huge vehicles troller (Figure 3). It was also recorded that road kill was also positively correlated with the volume of traffic flow. Maximum vehicle – Hanuman langur collision were made by the speedy vehicles of sumo and jeeps followed by trucks.

TABLE 2 Traffic flow (number of vehicles per day) on NH-58 during the period October 2009 to September 2011 in Uttarakhand Himalayas

Months	Mean number of vehicles per day					
	Bus	Truck	Car	Sumo and Jeep	Trolley	Total
October	78	102	148	73	04	405
November	71	98	141	72	03	385
December	65	85	138	69	02	359
January	67	76	122	53	02	320
February	68	78	129	66	04	331
March	61	82	140	73	06	362
April	78	89	171	97	07	442
May	92	110	195	116	08	521
June	89	103	197	114	07	510
July	83	86	207	99	05	480
August	78	83	190	88	04	443
September	63	71	191	82	03	410
Annual Total	**893**	**1,063**	**1,969**	**1,002**	**55**	**4,968**

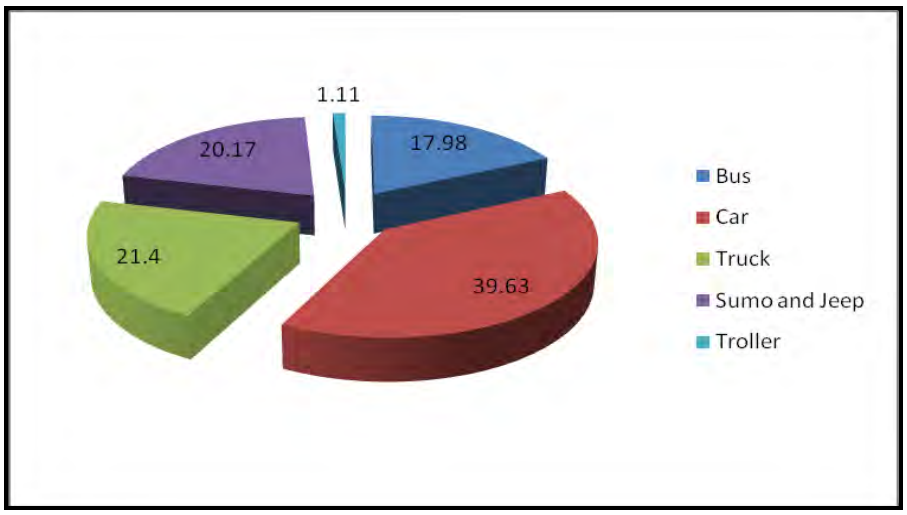

FIGURE 3 Percentage composition of traffic flow on NH-58

Habitat Fragmentation and Modifications

Impacts of NH-58 and its widening were observed in the form of wildlife habitat fragmentation and modifications. Fragmentation of large wildlife habitat at both sides of NH-58 into smaller patches in the study area was observed. Several small patches of habitat of Hanuman langur even if collectively equivalents in the study area to the original larger patch are not its functional equivalent.

Gaps between habitats prevent dispersal and recruitment of Hanuman langur. The nature of the habitats is itself changed by the creation of new ecotone along new patch borders. NH-58 is acting as barriers to the movement of Hanuman langur. Widening of NH-58 has contributed a lot into large scale modifications of natural habitat of Hanuman langur.

Restriction of Animal Movements

Hanuman langur moves from one place to another or from one side to another side of NH -58 for foraging, finding mates, seeking shelter, reaching breeding sites and participation in social interactions. These movements of Hanuman langur occur on a variety of scales ranging from few meters to hundreds or thousands of meters. Three major characteristics of NH-58 act as the barriers to the movement of Hanuman langur. These characteristics which are acting as barriers to the movement are bare and rough surfaces, altered roadside habitats including deep roadside ditches and drainages and the broadband of emissions, and disturbances such as noise, dust, light illumination and airborne pollutants.

Wildlife barriers imposed by NH-58 inhibit movements, change ranges, and isolate populations which may lead to altered population dynamics of Hanuman langur.

Injury and Mortality

NH-58 has a high volume of traffic during pilgrim season (May-October) in the study area. A significant number of animals are injured or killed by passing vehicles. Improvements and widening of NH-58 permit higher average speed (60-70 km per hour), which contributes increasing chances of fatal wildlife – vehicle collision. Hanuman langurs are attracted to road to exploit food resources and sun warming. Langurs also utilize roads for walking, juveniles playing, running and foraging on vegetation available along the roadsides. This is also an added advantage to langurs to avoid predators.NH-58 is very busy and the predators like panther and jackal usually avoid coming towards roads in the day time.

The comparatively higher mortality of Hanuman langurs due to road accidents is because of their diurnal habits. The NH-58 is used by a large number of pilgrims for visiting world famous temples of Badrinath and Kedarnath. These pilgrims offer food to langurs seen around on the NH-58 due to religious sentiments. Thus, the Hanuman langurs have developed habit of keeping them close to the road and also expect food from every vehicle and do not bother much to speedy vehicles passing through. These vehicles often hit langurs and kill or injure them. Many times during fights and interaction between bisexual troops and all male bands, langurs suddenly and unknowingly come in front of the vehicles while running behind and chasing at a speed of 60-70 km/hr and are thus hit by the vehicles. In such cases langurs often die instantaneously (Figure 4).

FIGURE 4 Killing of Hanuman langur by speedy vehicles on NH-58

An in-depth survey for two annual cycles (October 2009 to September 2011) for road kills, and sustained major and minor injury to Hanuman langur on NH-58 revealed that the killing

was common at the sharp turns, slopes near the water holes and small tracks which crossed the NH-58. A total of 72 animals (40 killed, 22 seriously injured, and 10 sustained minor injuries) were met with vehicular accidents during the period of study (Table 4 and Figure5). Male Hanuman langur killed were significantly more than females. Maximum mean killing (15%) was recorded in May and minimum (2.1%) in January during the period of study. It was 85% during the pilgrim season (May- October) in each year. Road kills were disappeared with in few hours as a result of scavengers operating in the area.

TABLE 4 Details of Hanuman langur (*Presbytes entellus*) met with vehicular accidents on NH-58 during October 2009 to September 2011.

Sex	Killed	Seriously injured	Minor injury	Total
Male	24	15	06	45
Female	16	07	04	27
Total	**40**	**22**	**10**	**72**

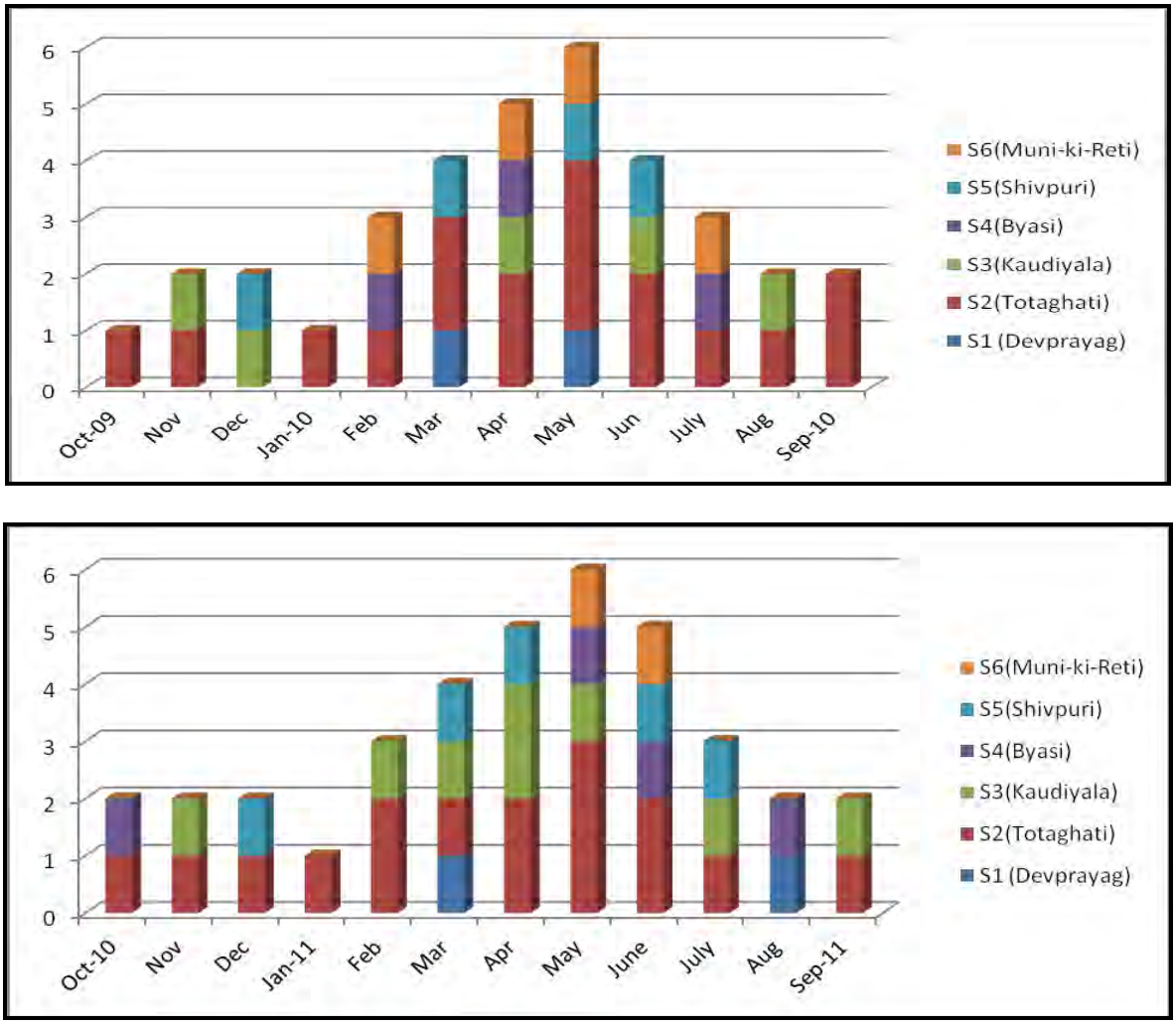

FIGURE 5 Injury and mortality of Hanuman langur in different transects of NH-58

Soil Erosion and Sedimentation

Construction and widening of National Highway -58 has caused adverse impacts on soil and land stability. Instability of slopes tends to be most pronounced in hilly areas, where geological features exacerbate construction related destabilization. Creation of steep cuts in rapidly weathering rock removal of basal support of slopes, loading of unstable surfaces, inadequate drainage provisions, removal of vegetation and vibration from blasting and heavy traffic may lead to slope failure and erosion.

Construction of drains, embankments, cuts and fills can affect local hydrology both within and beyond the boundaries of the NH-58. The water sources of springs, streams and the Ganga are adversely affected (Sharma 2007, 2009). The poor construction practices, improper disposal of debris and massive landslides on NH-58 along the river Ganga have caused large scale soil erosion and sedimentation in the Ganga and into small streams.

Environmental Contamination

Run-off from road surfaces typically contains a range of contaminants of which depends on traffic volume, organic wastes, lubricants, petrol, phenols and road materials. During monsoon seasons (July-August), these contaminants contribute environmental contamination of water and soil.

In addition to it, road dust produced during construction and operation often settles on vegetation as well as dwellings and reducing photosynthesis. These environmental contaminations of water, soil, and vegetation have direct impact on the life of Hanuman langur (*Presbytes entellus*) in terms of their drinking water and vegetative food of plant materials.

MITIGATION MEASURES

Preventing all animal vehicle collisions on the NH-58 in the study area is not practically possible. However, by implementing appropriate mitigation measures, it is possible to reduce the number of number of accidents, increase animal health safety and maintain habitat connectivity. For minimising mortality of Hanuman langur and for sustainable transportation in the Himalayan state of Uttarakhand, following viable mitigation measures have been recommended.

Animal- Detection Warning System

Several designs for animal detection warning system have been developed using motion sensors or detectors wired to signs that flash when large animals are detected on the road. It will alert the driver for avoiding any vehicle- animal collision.

Speed Limit Reduction

High traffic speed or rash driving is generally considered a primary cause of animal- vehicle collision. So speed limits can effectively reduce Hanuman langur-vehicle collision. A maximum of 30 km per hour is recommended on NH-54 due to several sharp turns and spiral nature of road.

Lighting

The wildlife-vehicle collisions are six times higher at night than the collisions during the day time. So, lighting reflectors are very important for mitigation the vehicle-wildlife collisions.

Automated Speed Detectors

The automated speed detecting devices have a proven effectiveness in getting people to abide by a speed limit at least temporarily thereby improving a driver's ability to avoid hitting on animal. This measure could be used periodically in combination with speed unit limit reductions and sign indicating why speed limits have been reduced.

Public Education and Awareness

Public service announcements, educational campaigns and poster-sized hot spot maps are believed to be effective in reducing animal-vehicle collisions. This mitigation measure should be implemented in conjunction with other measure to minimize its potential efficacy. For example, seasonal speed limit reduction could be combined with public service announcements of where, when and why the speed reductions are being implemented.

Culverts / Tunnels

To reduce mortality and facilitate movement of Hanuman langur across NH-58, culverts/tunnels have been recommended to install in areas with the highest incidence of road kills. These culverts should be placed at frequent intervals and vegetation cover should be developed in culvert approach area to provide security for passing the animals. The area under road bridges can also provide important crossing zones for wild animals including Hanuman langur.

Innovative Vegetative Overpasses

Keeping in the view the arboreal nature of Hanuman langur, an innovative vegetative overpasses connecting vegetation of both sides of the NH-58 at frequent intervals are very effective in mitigation of impacts of vehicles. The study area has many sites, where the canopy of trees of both the sites of the road is very close. These long branches of the trees at canopy level (6-10 m tall) can easily be connected for designing a vegetative suspended bridge of 1.0 m width and 25 m length with the additional tree branches. These suspended vegetative overpasses are used by Hanuman langur for crossing the roads in search of food, water and seeking shelter and finding mates.

Fences

Numerous types, lengths and heights of fences have been used to keep wildlife of roadways and reduce animal-vehicle collisions. Fencing of various types of structures will be useful for reducing langur-vehicle collisions.

CONCLUDING REMARKS

Sustainable transportation aims at promoting better and healthier ways of meeting individual and community needs while reducing the social impacts of current mobility practices. It attempts to achieve these through reducing resource inputs, whole outputs and minimizing transportation's often deleterious effects on the public realm (Schiller *et.al* 2010)

Thus, keeping in view the study made for two annual cycles, it has been concluded that one of the best ways of reducing the rate of collisions between vehicles and Hanuman langurs is to reduce the speed with in the area of natural habitat of Hanuman langur in the study area. Adequate signboards on possible turns spots of feeding and drinking at regular intervals will help the drivers reduce speed and presence of wild animals on the road. Another effective

way to reduce langur mortality, people should not throw and feed langurs on the road from their vehicles passing through the National Highway-58. Use and designing of innovative vegetative overpasses connecting vegetation of both sides of the road at frequent intervals are very effective in mitigation the impact of transportation on arboreal wildlife

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BIOGRAPHICAL SKETCH

Professor Ramesh C. Sharma has a distinguished academic career. He graduated with zoology Honors and obtained Master's degree in Zoology (Freshwater Fishery Biology). He obtained his doctorate (Ph.D) in Environmental Biology of Fish and his Doctor of Science (D.Sc.) in Environmental Biology. He has more than 37 years of teaching and research experience in various disciplines of Environmental Sciences. He has produced 32 doctoral students. Sixteen major research projects have been completed. He has published more than 132 research articles of high impact factor. He has received several National awards and gold medals (NATCON Environment Gold Medal 2001, Zoological Society of India Gold Medal 2001, Recognization Award Gold Medal 2004, Indira Gandhi National Environmental Award 2005, Indian Environmental Science Academy Gold Medal 2009, Smt. Amrita Bishnoi National Environmental Gold Medal 2009, and Dr M.C. Das Environmental Gold Medal 2012). He is fellow of many National and international societies (F.A.Sc, FZSI, FNESA, FSB, FAEB, and FIESA). Currently, he is the Professor and Chairman of the Department of Environmental Sciences, H.N.B. Garhwal University (A Central University), Srinagar Garhwal, Uttarakhand, India.

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