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Research Article

Wildlife road-kills on the Tikauli section of East-West Highway in Barandabhar Corridor Forest, Chitwan, Nepal

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Abstract

Roads are one of the linear infrastructures that play important role in nation development. Roads create barrier for the movement of wildlife, however, their impacts on wildlife are not sufficiently studied in Nepal. Thus, current study attempted to explore the impacts of Tikauli section of East-West Highway of Nepal on the wildlife of Barandabhar Corridor Forest. Wildlife vehicle collisions (WVCs) were recorded from December 2019 to September 2020 by dividing a day into morning, day, and late evening periods. Primary data were collected through direct road survey and key informant interview (n = 22) whereas secondary data were collected from the annals of Chitwan National Park, National Trust for Nature Conservation-Biodiversity Conservation Center and Division Forest Office, Chitwan, Nepal. Arc GIS 10.5 was used to produce relevant illustration and WVC hotspot identification based on Kernel Density Function. Out of thirty-three dead animals observed during the study period, spotted deer (*Axis axis*) were killed most frequently (n = 11) from WVCs followed by Oriental garden lizard (*Calotes versicolor*). The highest number of deaths were recorded in winter and in late evening. Besides keeping track of WVC records properly, further research is recommended.

Keywords: Biological corridor; Kernel density estimation; Vulnerable species; Wildlife vehicle collisions

1 | Introduction

Linear infrastructure is important for society because it provides connectivity for people. However, it also exerts significant negative impacts on adjacent habitats, wildlife population, communities, and ecosystem (Rodney et al. 2011). Basically, ecosystem fragmentation, and specially the loss of connectivity between different habitat areas is considered to be one of the main impacts of linear transport infrastructure (i.e. highways/road) to the biodiversity that is often known as the barrier effect to wildlife dispersal (Manuel et al. 2015).

Most of the protected areas of Nepal are connected by corridors and bisected by highways. Its impact to wildlife could be underestimated because of lack of systematic monitoring of roadkill incidents. It leads to fundamental changes in landscape structure that can have both direct and indirect impacts on the conservation of species and biodiversity (Bennett 2017). Mortality of animals is the most significant direct effect of road on wildlife (Kassar 2005). The indirect effects of roads and associated networks can have major ecological impacts on landscape processes and biodiversity because roads disrupt natural processes, for example, animal movement and ecosystem functions. The significant physical barrier to movement for many species and a major source of mortality has been the

presence of road and of vehicular traffic and its continuousness (Carr et al. 2001). Wherever the highways/road have bisected protected areas and corridors, the mortality of wildlife due to roadkill is in increasing trend (Hariyo Ban Program 2019).

The purpose of this study was to examine the situation of wildlife deaths and to identify the species most at risk from vehicle collisions. Roadkill studies can give significant information for assessing the impact of road traffic on animal populations, but they are difficult to conduct on a large scale (Canal et al. 2018). It is one of the least studied subjects in Nepal, so that the one cannot be sure about the idea of kind of effect linear structures have in wildlife. This study can serve as an important baseline information in impact of infrastructure to wildlife and ecology for managers and policy makers.

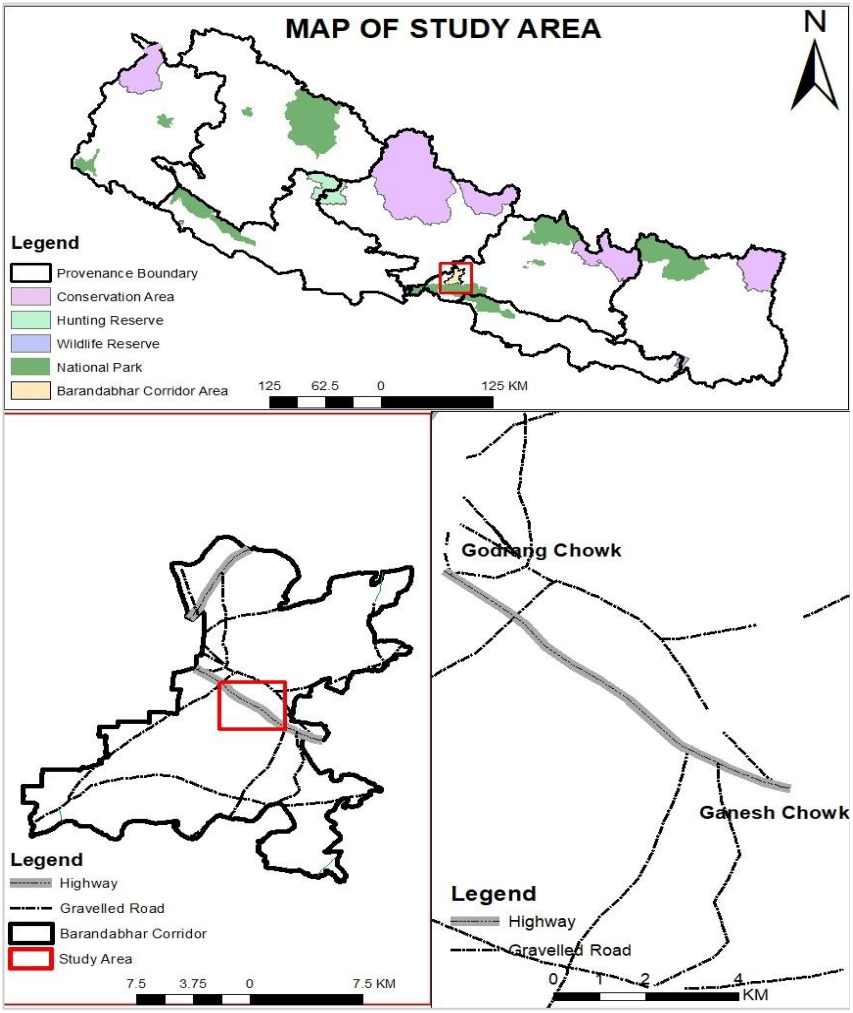

Figure 1. Map of the study area showing the Tikauli section of the East-West Highway

2 | Materials and methods

2.1 | Study area

The study was conducted in the Tikauli, the East-West Highway section, Barandabhar Corridor Forest (BCF) in Chitwan, Nepal. BBC is a bio-corridor that joins the two unlike ecosystems with significant altitudinal variations, especially the lowland Chitwan National Park (CNP) and the highland Mahabharat range in Nepal. It is located between 27°33'30" to 27°44'30" North and 84°22'30" to 84°34'00" East in central part of Chitwan District in Bagmati Province, Nepal.

East-West Highway divides the BBC into two executive jurisdictions. The buffer zone forest in the south of the East-West Highway is managed under the patronage of the CNP, while the northern side of the highway is patronized by the Division Forest Office, Chitwan. This study was focused in Tikauli section of the East-West Highway that lies between Ganesh Chowk on the east and Godrang Chowk on the west extending about 4.9 km.

BBC is rich in faunal and floral diversities. Around 75% of this area was previously forested, supporting a rich diversity of flora and fauna (Aryal et al. 2012). Majority of the flora of Barandabhar Forest is dominated mainly by Sal forests and partly by riverine forests, tall grassland and short grassland.

The CNP and Chure Siwalik range and the Mahabharat range are connected by the BBC, which is the only remaining natural forest (Aryal et al. 2012). BBC is frequently utilized by mega-species like rhinoceros (*Rhinoceros unicornis*), tigers (*Panthera tigris tigris*), and leopards (*Panthera pardus*); reptiles like mugger crocodiles (*Crocodylus palustris*), waterfowls, and wintering birds. It also serves as a refuge during the monsoon floods (Kandel 2012). Since 2005, the CNP, and BBC has been declared as an Important Bird and Biodiversity Area (IBA) (CNP 2019). Additionally, the region is home to a huge variety of bird species (Aryal et al. 2012).

Tikauli section of East-West Highway bisects the BBC into two parts, buffer zone of the CNP in south and community forests in north, consequently wildlife movement between the forests has been hindered. Traffic pressure on this section of the highway is very high, about a total of 62,396 vehicles pass weekly through this section. In an average, daily vehicle flow is 8990 (Lamichhane 2019). The study may contribute to the development of efficient mitigating methods to address the difficulties associated with wildlife vehicle collisions (WVC) on this portion of the East-West Highway, which is subject to very high vehicular pressure.

2.2 | Data collection

Both primary and secondary data were collected and analyzed during this study. Primary data were collected from the Tikauli section of the highway while secondary data were collected from published and unpublished documents regarding wildlife vehicle collision. Primary data collection involved key informants' interview (KII) and direct field observations. KII was done with the Chief Conservation Officer, Divisional Forest Officials, National Trust for Nature Conservation-Biodiversity Conservation Center Officials, Terai Arc Landscape Officials, Armed Forest Guard Training Center Officer and Chairperson of the associated community forests to determine how many incidents occur and, in particular, which species are the most vulnerable, direct observation of frequently accident occurring at sites and animal crossing sign, etc.

Direct field observation was carried out daily in 4.9 km stretch of the highway passing through the corridor in different time frame: morning- 6:00 AM–10:00 AM, day- 11:00 AM–3:00 PM, late evening- 4:00 PM–7:00 PM. The study was conducted over a nine-month period, from December 2019 to early September 2020. Data were collected from all seasons that is summer, spring and winter except fall or autumn which could be covered partially. We can assume that different incidents may occur according to the season. Therefore, the major point for the longer time spent in the field was that the data would reflect the entire season but could not cover the entire season owing to time restrictions. Throughout the study period, the road was systematically surveyed in the early morning hours starting at 6:00 AM, primarily by bicycle and occasionally by motorbike, auto, and public bus. Whether or not there had been incidents or traffic fatalities during the study time period, the road was continuously observed daily in different time frame. If dead or injured wildlife was observed following WVCs, environmental variables such as location, elevation, topography, road type, distance from the point of incidence to different land use (such as water, settlement, forest, agricultural field, etc.) were noted. In 2016, 10 Closed Circuit Television (CCTV) cameras were installed along the highway in BBC in various locations in the northern roadside with the support of electric poles in collaboration with CNP, National Trust for Nature Conservation (NTNC), and Division Forest Office (DFO), Chitwan. But after few years, it stopped functioning. We were able to receive data from them as well and assumed as primary data.

The study area was divided into five sections of each one kilometer length: section-1: (from Ganesh chowk at east to Tikauli Buffer Zone Community Forest (BZCF) gate at west), section-2: (from Tikauli BZCF gate at east to Sasastra Talim Centre at west), section-3: (from Sasastra Talim Centre at east to Joint venture Camp/last point of Ratnanagar boundary at west), section-4: from Joint venture Camp (check point) at east- near to Sambar board at west and section-5: from Sambar board at east to Godrang post at west. Daily the accident occurring sites and wildlife crossing routes were observed directly. All information of dead and injured animal while seen on the road and roadside in the observation period were recorded. Binoculars, digital cameras, GPS were used to capture the ground points and movements of wildlife.

Secondary data were collected from the CNP, National Trust for Nature Conservation-Biodiversity Conservation Center (NTNC-BCC), Division Forest Office (DFO), websites of Department of National Parks and Wildlife Conservation (DNPWC). In order to determine the trend of the wildlife mortality rate, past recorded data on vehicle wildlife accidents were gathered from Division Forest Office (DFO), Chitwan National Park (CNP), Terai Arc Landscape (TAL), and also investigated the CCTV camera picture or recorded video footage from Armed Forest Guard Training Center (AFGTC).

2.3 | Data analysis

For the analysis and detection of hotspots, Kernel Density Estimation has been widely used (Danks & Porter 2010). The collision frequency per kilometer of roadways for all relevant species is expressed as kernel density. Mapping kernel density allows identifying hotspot zones where mitigation measures should be set up (Morelle et al. 2013). The given equation was used to calculate it.

$$f(x) = \left[\frac{1}{nh^2}\right]\sum_{i=1}^{n} k\left(\frac{x - x_i}{h}\right)$$

Where, n is the number of analyzed points, h is the band width, K is the kernel function, x is the vector of x, y coordinates of the location where the function is estimated, X_i is the vector series of the coordinates. where all the analyzed points are defined in above equation (Özcan & Ozkazanc 2017).

Road length was broken down into different sections, each having one-kilometer length, and counted the number of collisions. Based on the frequency of events hotspot was identified.

3 | Results

3.1 | Species-wise number of killed wildlife

During the study period, 33 dead animals were recorded that were killed as a result of WVCs. These included 11 spotted deer (*Axis axis*), 5 Oriental garden lizards (*Calotes versicolor*), 4 Indian rock pythons (*Python molurus*), 4 Asian bull frogs (*Hoplobatrachus tigerinus*), 2 Asian palm civets (*Paradoxurus hermaphroditus*), 1 sloth beer (*Melursus ursinus*), and 6 other species (Fig. 2). Higher number of *Axis axis* were commonly killed by WVCs, followed by *Melursus ursinus*, according to 95% of respondents to the overall KII.

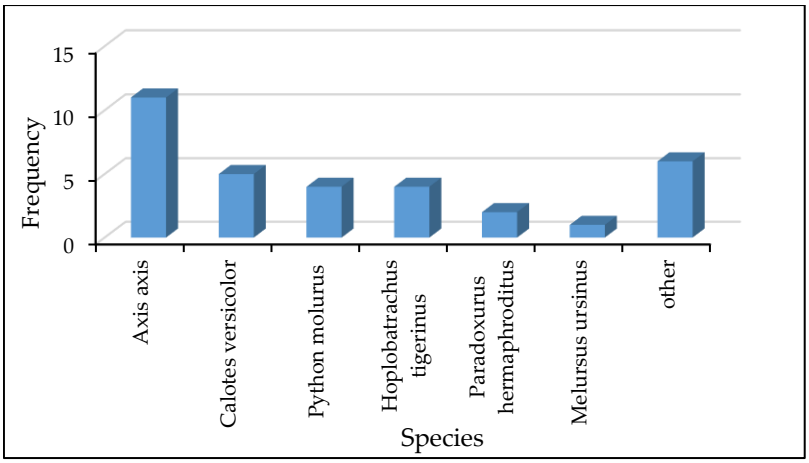

Figure 2. Number of killed wildlife from WVCs in study area

3.2 | Pattern of roadkill due to WVC

The study revealed that the highest number of mammals (8) species were killed in the winter, however highest number of reptiles (7) were killed in summer and higher number of amphibians (4) were killed between summer and autumn (Fig. 3).

Temporal patterns were studied based on incidence in the morning (6:00–10:00 AM), day (11:00–3:00 PM) and late evening (4:00–7:00 PM). Most of the road kills happened during late evening and least happened during daytime. Out of the total 33 events 12 were recorded from section-1 followed by 4 in section-2, 10 in section-3, 2 in section-4 and 5 in section-5 (Fig. 4).

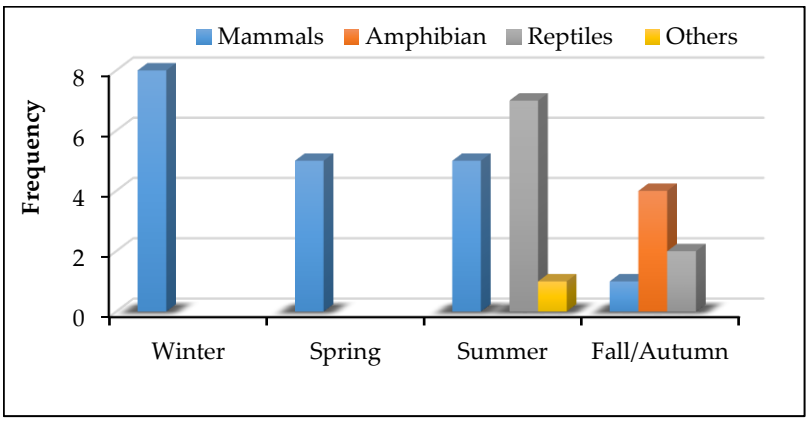

Figure 3. Seasonal patter of roadkill in the study area

3.3 | WVC hotspots

Kernel Density Estimation (KDE) was used and the risk zones of Tikauli section of East-West Highway were identified (Fig. 5). The area was characterized as very low, low, medium, high, and very high WVCs risk zone area, which was represented by different color as white, yellow, light green, sky blue and dark blue respectively (Table 1). The Kernel density estimation was based on the filed data collected from the study area.

According to the spatial analysis of WVCs data, distribution of events along the road was not uniform. Even though WVCs occurred all over the section of the highway. Overall, main risk zones were recognized specially at near to grassland, water availability area, namely around mid-section of Tikauli and around irrigation canal gate and AFGTC.

4 | Discussion

Roads can affect abundance and distribution of animals within habitats adjacent to it. A wide variety of birds,

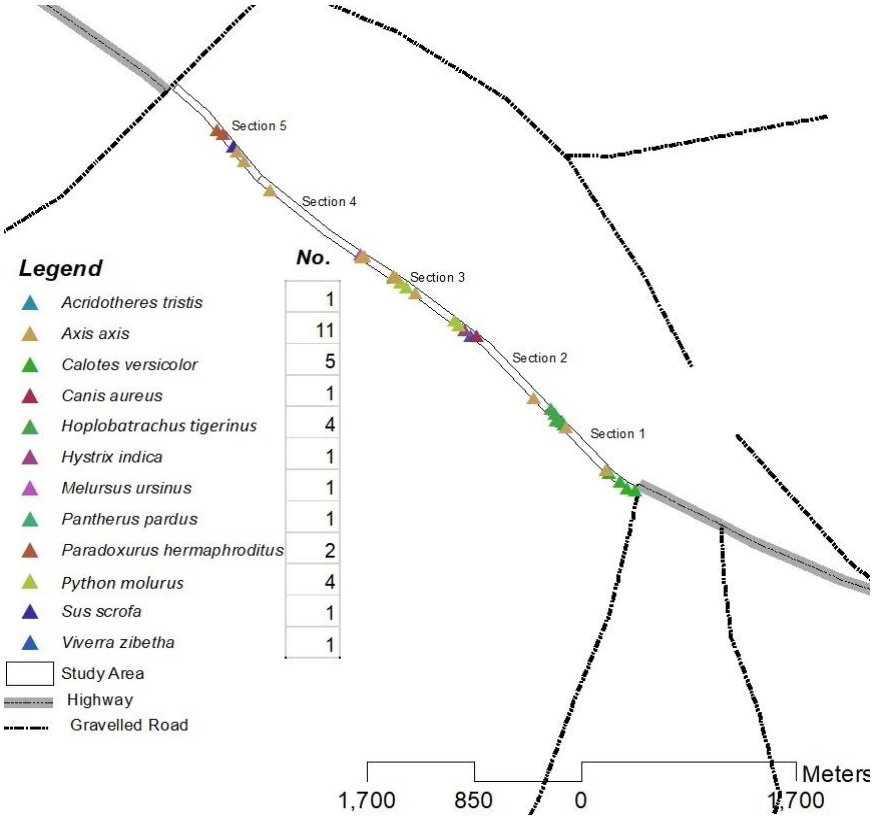

Figure 4. Spatial patterns of WVCs in Tikauli section of East-West Highway

mammals, reptiles, and invertebrates could be displaced from habitats in proximity to roads (Bennett 2017). In Nepal, there is a rising trend in the number of wildlife deaths from traffic accidents, especially in regions where highways cross through national parks and corridor forests. The BCF, one of the Nepal's corridors, provides a refuge for animals that depend on grassland habitats like deer and rhinoceros (Kandel 2012).

Mammals and herpetofauna were the major killed animals by WVCs in the study area (Appendix 1). However, according to the study by Baskaran and Boominathan 2010 in Mudumalai Tiger Reserve, most affected were amphibians followed by reptiles. Animal behavior changes with seasons, and so does accident patterns in certain seasons. Most numbers of animals were killed in winter and summer seasons as per frequency of accidents in the study area. However, study of Shrestha (2019) found the higher record of wildlife vehicle accidents

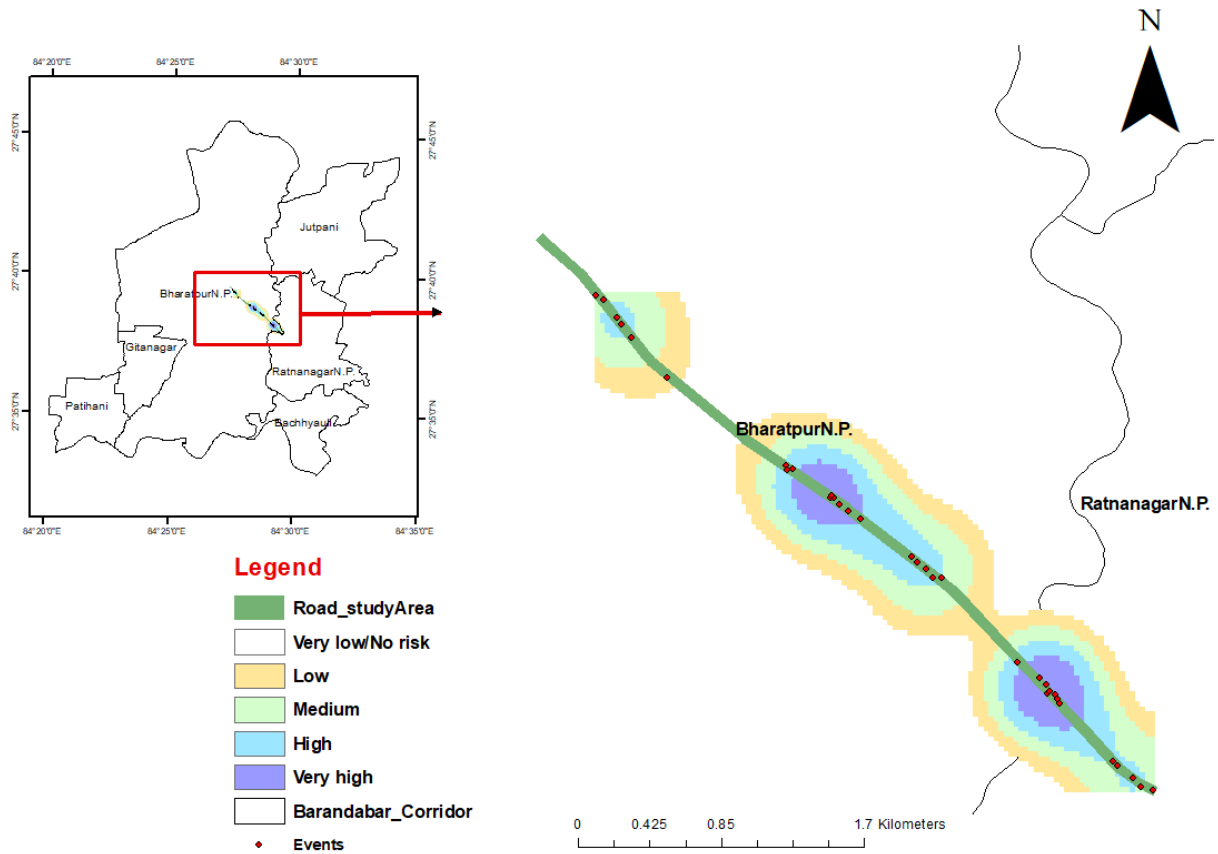

Figure 5. WVC hotspots in the Tikauli section of the East-West Highway

occurred in the spring and summer. The greatest number of mammals killed were nocturnal which is similar to what have been found in this study that most animals were killed during evening or in the late evening. This might be caused by threats from tigers which are active during late evening time. Next reason behind the WVCs, the visibility is impaired by the headlights of speeding vehicles while crossing the roads at late evening. As a result, there were highest number of wildlife road kills on highway at late evening.

Concerns over road passing have not become the priority of government or any non-government agencies working in conservation sectors till very recent. Even data about killings are not well recorded. The Tikauli area of the Chitwan District has high abundance of spotted deer and tiger, elephants inside the core regions of CNP or BBC. In the fiscal year (2017/2018), 30 wildlife were killed by vehicles in the jungle of Tikauli, Chitwan (Sauraha online 2018 as cited by Bhandari 2019). Between mid-July 2016 and mid-April 2017 in the Bardia National Park, there were 69 deaths, including the death of hyena, wild boar, spotted deer and porcupine (Mandal 2017). A total of 133 wildlife were killed out of 326 in road accidents among them 66 were in Bardia National Park, 58 killed in Banke National Park, 7 were killed in Parsa National Park, one animal was killed in Langtang National Park area (DNPWC 2017). Likewise, 82 wildlife casualties have been recorded in Chitwan due to road accident (CNP 2019).

One of the main problems that BBC and other protected areas are facing is the increasing frequency of WVCs. As a result, when traffic rises, animals become more prone to WVCs. The study found that spotted deer were the most sensitive wildlife species for roadkill incidents as a result of WVCs. Because of their higher abundance, mobility, and habits of crossing the highway, spotted deer were more vulnerable. The similar statements were made by the park officials, NTNC-BCC and divisional forests officials that spotted deer were comparatively higher in number than other species. Similarly, Bardia National Park had the highest number of spotted deer killed as a result of WVCs (Shrestha 2019). Similar to study of Rana (2018), indicating spotted deer in Banke National Park was susceptible. Mandal (2017) also reported the highest number of spotted deer hit by vehicles in the Tikauli section of the East-West Highway (Mandal 2017).

Trends of the WVCs are increasing over the years. The data from last four years (from 2072/73 to 2075/76) shows increasing trend of wildlife death from vehicular collision. According to the available data from CNP, Divisional Forest Office, NTNC-BCC, TAL and AFGTC, the spotted deer was killed in higher number by WVCs in the study area. Similarly, previous primary roadkill data also shows higher killing to spotted deer by WVC.

Roadways itself don't kill animals. It's the vehicle moving over the roads and species crossing the roads at the same time. Moreover, Tikauli section of East-West Highway acts as the corridor connecting two important and dissimilar habitat types. There is a high species density, hence, the wild animals suddenly cross the highway from north to south for searching the food and water. At the same time the high-speed vehicle may cause accidents of animals on the highway. KII with 22 key people of the concern representative person showed that 50% of the collision occurred due to carelessness or over speed of vehicle making it the key cause of WVCs.

5 | Conclusions

Major impact of road on wildlife is their death due to Wildlife Vehicle Collision (WVCs). The predominant species killed was spotted deer followed by herpetofauna. WVCs were more frequent in winter and summer season at late evening. Most of the WVCs were found in the section from Ganesh Chowk on east to Tikauli BZCF on the west and the section rom AFGTC gate on east to check point on the west of Tikauli section of East-West Highway.

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Authors' contributions

Rana Magar, P. conceptualized the study, collected and analyzed the data, prepared manuscript. Karki, J. B. supervised the study, revised and finalized the manuscript. Magar, L. K., Bolakhe, S. and Kunwar, N. improved the manuscript.

Conflicts of interest

Authors declare no conflict of interest.

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Appendix 1. Photographs showing WVC effects on wildlife from the Tikauli section of the East-West Highway

Photo 1- Spotted deer found dead on a Tikauli roadside due to WVC; **Photo 2**- Leopard found dead on Tikauli roadside due to WVC; **Photo 3**- Asian palm civet found dead on Tikauli road; **Photo 4**- Python found dead on Tikauli roadside; **Photo 5**- Asian bull frog found dead on Tikauli roadside; and **Photo 6**- Garden lizard found dead on Tikauli road