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# Wildlife-vehicle collisions in Hurungwe Safari Area, northern Zimbabwe

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A B S T R A C T

This study is the first to assess wildlife-vehicle collisions (WVC) in Zimbabwe. The study analysed the impact and factors that influence vehicle collisions with large wild mammals along the Harare-Chirundu road section in the protected Hurungwe Safari Area, northern Zimbabwe. Data were retrieved from the Hurungwe Safari Area records and covered the period between 2006 and 2013. Descriptive statistics were used to analyse the recorded variables across the sampled area and to show trends of the prevalence of large wild mammals roadkill over time. Using STATISTICA version 10 for Windows, a two-tailed Mann-Whitney *U* test was used to determine differences between the number of wild mammal animal roadkills and seasons. A total of 47 large wild mammal animals were killed between 2006 and 2013. The large wild mammal animals that died as a result of vehicle collisions constituted a total of 11 species, with the African buffalo and spotted hyena being the most hit and killed animal species. Most WVC involved heavy haulage trucks and passenger buses. There was no significance difference ($P = 0.936$) between number of large wild mammal animals killed from WVC between dry and wet seasons. The large wild mammal animals were mostly killed in areas near water sources. We recommend for the inclusion of wildlife protection safeguards in road infrastructure network design and development, particularly on roads that traverse across protected areas in Zimbabwe and beyond.



## Introduction

Wildlife mortality due to roadkills is a global conservation problem [1]. Linear infrastructure that includes roads, rail, power lines, pipelines, whilst a necessary part of socio-economic development for the transport of goods and people [2], all can impact wildlife and biodiversity negatively, specifically roads. However, the negative impact of road network systems

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to wildlife in both protected and non-protected areas are rarely considered in southern Africa with little research attempts made to find appropriate interventions to reduce the negative impacts on biodiversity [3,4].

Road networks can negatively influence wildlife populations in several pathways, for example, directly, roadkill and high traffic flows generally limit large wild mammals' movement in wildlife protected areas and the associated road infrastructure modify the natural animal movements [5,6]. In addition, vehicular noise, vibrations, and lights also have a negative bearing on wildlife movements and behaviors [7] that may result in altered gene flow [8]. Road networks can also alter the feeding behaviour of large wild mammals, especially for those species that are attracted to roads [9]. For instance, browsing large wild animal species may be attracted to the normally green vegetation matter along the road edges, other ectothermic wild animals habitually bask on asphalt, while other herbivores tend to consume spilt grain from roadsides [10]. Indirectly, the road networks can negatively affect wildlife through promoting fragmented habitats as roads cut across habitats that lead to limitations in movement of wildlife species and hence isolate populations (e.g., [9,10]). Furthermore, the cumulative effect of all such impacts may likely result in reduced wild animal species diversity and animal densities in conservation area [11–13].

Various wild species have been reported to be attracted and negatively influenced by roads and these include, amphibians, birds, insects, mammals, and reptiles [14–17]. This wild animals' attraction to the existing road network highways in wildlife protected areas mostly leads to increased wildlife-vehicle collisions (WVC) resulting in direct wild animal mortality [18] with a further impact on scavenging wild animals that eat carcasses that would have been accidentally killed [4,19–21].

Zimbabwe has a record of high prevalence of road traffic accidents involving WVC. However, there is dearth of knowledge on the impact of roadkills on wildlife and biodiversity [22,23], as reported by the Zimbabwe Parks and Wildlife Management Authority (ZPWMA), [24]. This study was conducted to investigate the impact and factors that influence vehicle collisions with large wild mammals along the Harare-Chirundu road section in the Hurungwe Safari Area, northern Zimbabwe. The findings of this study may inform the wildlife and traffic authorities to expand WVC mitigating measures and enhance public awareness programmes to inform motorists on WVC in Zimbabwe and related habitats in the region of southern Africa.

## Materials and methods

### *Study area*

The study was conducted on a 74 km road stretch section of the Harare-Chirundu Highway which passes through Hurungwe Safari Area (2894 $km^2$) in northern Zimbabwe (Fig. 1). This Highway is a paved-tarred road which is a two-way highway with a minimum width of 12.5 m. However, there were neither game fences in either side of the road nor

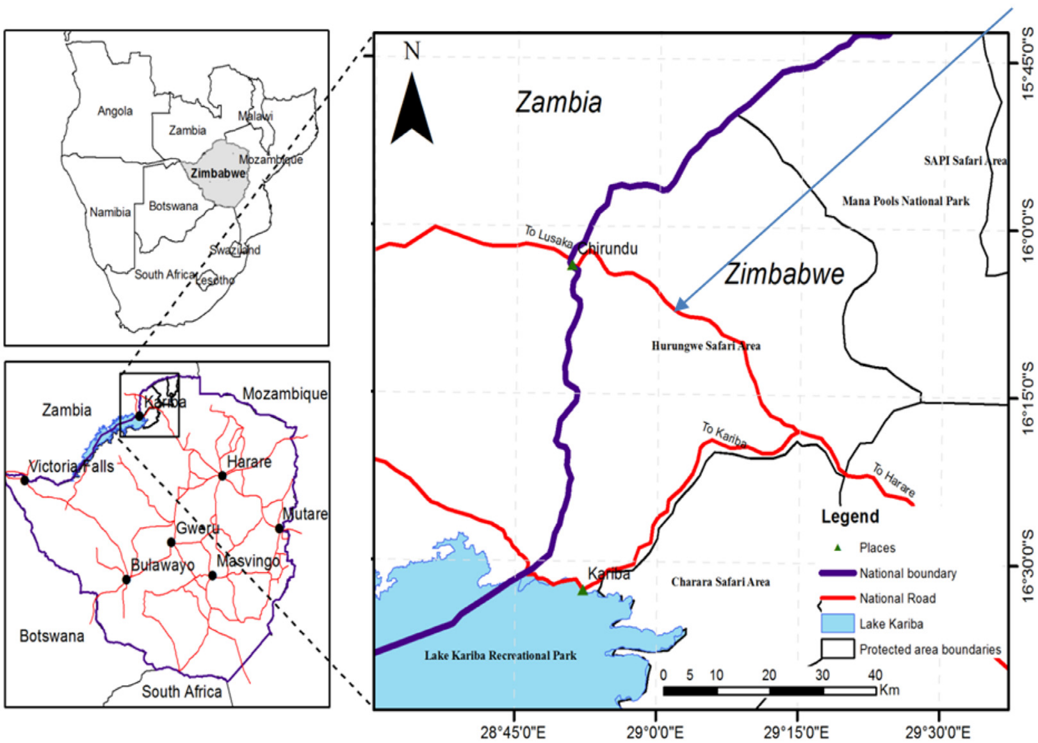


**Fig. 1.** Location of the Harare-Chirundu highway in Hurungwe Safari Area, northern Zimbabwe (a pointing arrow show the Harare-Chirundu road).

presence of some type of tunnels or bridges to help fauna to cross the road. The traffic speed limitation on the highway range from 80 to 120 km/hr depending on the class of vehicle. This Highway is classified as a traffic-busy international road, connecting Harare, the capital of Zimbabwe, and Lusaka, the capital of Zambia [23]. It also provides a link between the Beitbridge (Zimbabwe-South Africa) and Chirundu (Zimbabwe-Zambia) border posts that are some of the busiest inland ports in southern Africa. Thus, the Harare-Chirundu Highway is important and ever-busy with large volume of traffic flows at high speed for both imports-exports of goods and movement of people [23] as the road link main economic centres of southern Africa to Zimbabwe. Hurungwe Safari Area (HSA) borders both the Charara Safari Area and Mana Pools National Park. In the HSA, the highway runs adjacent and near Mhenzva Pan and Kaminga Dam that are utilized by wild animals. The road also passes through Chirundu town which has a human population of about 4000 people and is a small farming and border community [25].

HSA is a state-protected area with diverse vertebrate fauna that consists of over 100 species of mammals, 400 species of birds, 75 species of reptiles, 26 species of amphibians and 50 species of fish [24]. This high diversity of wildlife species includes African buffalo (*Syncerus caffer*), African elephant (*Loxodonta africana*), African wild dog (*Lycaon pictus*), sable (*Hippotragus niger*), impala (*Aepyceros melampus*), greater kudu (*Tragelaphus strepsiceros*), nyala (*Tragelaphus angasii*), spotted hyena (*Crocuta crocuta*), waterbuck (*Kobus ellipsiprymnus*) and zebra (*Equus quagga*) [24]. Notable bird species in the park include the Rock Pratincole (*Glareola nuchalis*), the African Skimmer (*Rynchops flavirostris*), the Meves's Glossy-starling (*Lamprotornis mevesii*), the White-breasted Sunbird (*Nectarinia talatala*) and raptors such as Fish Eagles (*Haliaeetus vocifer*) [24].

The study area lies in the Miombo eco-region comprising of *Colophospermum mopane* woodland, *Faidherbia albida* woodland, *Brachystegia-Julbernardia* woodland and *Commiphora-Combretum* thicket [26]. The understorey consists of species such as *Combretum mossambicense, Combretum obovatum, Diospyros senensis, Gardenia spatulifolia, Grewia flavescens* and *Cardiogyne africana* [26]. Annual average rainfall of the study area was estimated to be 708 mm [26]. Temperatures in HSA are high with monthly means approaching 41 °C prior to the rains and mean monthly minimum temperatures are usually above 10 °C [24].

*Data collection*

The Park staff, assisted by a driver, once on a monthly basis collected data for all the wildlife roadkill trip survey along the 74 km road stretch of Harare-Chirundu Highway. Large wild mammal animal roadkill historical data were obtained from the HSA management records kept at the station head office, i.e., Marongora Field Station, and covered the period between 2006 and 2013 [24]. For each roadkill, we retrieved data on large wild mammal species name, Geographical Positioning System (GPS) locations and month of collision. The types of vehicle involved in a collision with an animal were also recorded. Every first Monday of the month, a road survey was conducted as part of road patrol law enforcement with each drive being at a speed of 40 km/hr with all roadkills of large wild animals along the defined road stretch being recorded over the study period. Once recorded, a roadkill was removed to avoid recounts. Some of the roadkill collisions were reported by drivers who informed Park rangers to go and record the animal collision incident on an ad-hoc basis.

*Data analysis*

Descriptive statistics and graphical analyses were used to summarise the recorded variables across the sampled area and to show trends of the prevalence of large wild mammals roadkill over time. A two-tailed Mann-Whitney *U* test was used to determine differences between the number of wild mammal animal roadkills and seasons, i.e., dry season (May–October) and wet season (November-April) in STATISTICA version 10 for Windows [27]. Further, an analysis of the type of vehicles in relation to spatial locations of roadkill incidents and the sites "hot spots" was conducted in a Geographical Information System (GIS) environment [28].

## Results

Out of the 96 road trip surveys and ad-hoc reports, a total of 47 killed large wild mammal animals were recorded comprising 11 species between 2006 and 2013, i.e., the highest being the African buffalo ($n = 23$; 50%) and the least comprising of aardvark (*Orycteropus afer*) ($n = 1$; 2%), African elephant ($n = 1$; 2%), impala ($n = 1$; 2%), leopard (*Panthera pardus*) ($n = 1$; 2%), lion (*Panthera leo*) ($n = 1$; 2%) and zebra ($n = 1$; 2%) (Fig. 2).

A frequency of large wild mammal mortality rate of 1.60 roadkill km$^{-1}$ was recorded over the 8-year study period, i.e., between 2006 and 2013 in HSA. The year 2010 had the highest roadkill of large wild mammals ($n = 12$; 26%) followed by the year 2009 ($n = 10$; 21%) whereas the least roadkill of large wild mammal animals was recorded in 2012 ($n = 1$; 2%, Fig. 3). The African buffalo (0.31 roadkill km$^{-1}$) was the most killed animal species followed by the spotted hyena (0.12 roadkill km$^{-1}$). Other recorded densities of roadkill were as follows, African wild dog (0.07 roadkill km$^{-1}$), kudu and waterbuck recorded the same density (0.03 roadkill km$^{-1}$), with least recorded roadkill density of 0.01 roadkill km$^{-1}$ for aardvark, elephant, impala, leopard, lion and zebra.

Roadkill incidents distribution of large wild mammals was not homogenous throughout the study years, showing a unimodal pattern with the highest rates of roadkill of large wild mammals in August followed by November (Fig. 4). In contrast, February had the least roadkill rate, i.e., zero. Overall, there was no significant difference in large wild mammal mortalities

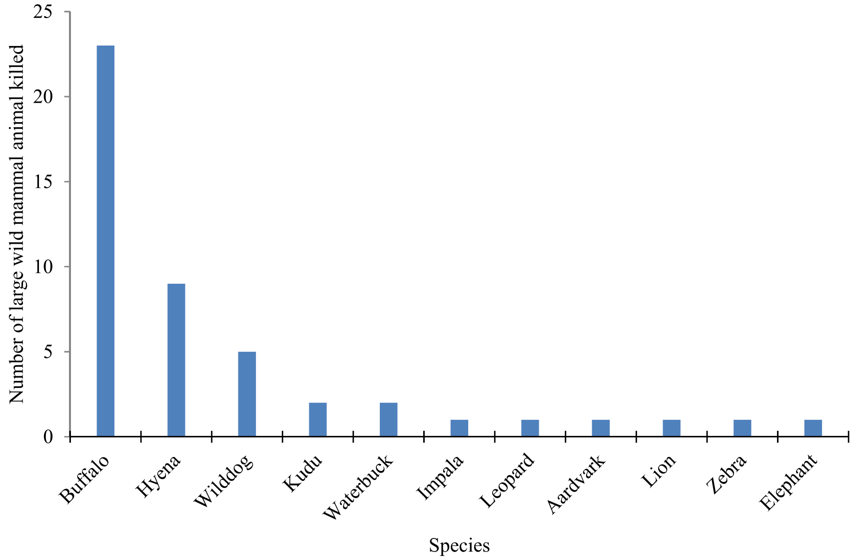


**Fig. 2.** Roadkill of large wild mammals by species in Hurungwe Safari Area, northern Zimbabwe, between 2006 and 2013.

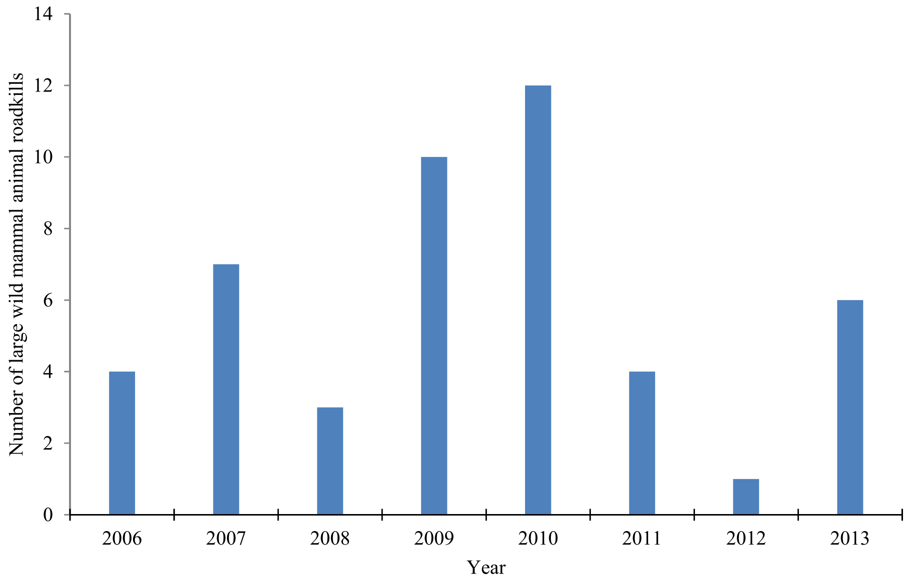


**Fig. 3.** Roadkill of large wild mammal animals by year in Hurungwe Safari Area, northern Zimbabwe, between 2006 and 2013.

between the dry (median = 2; range = 11) and wet (median = 3; range = 9) seasons in HSA (Mann-Whitney $U$ test, $U = 17$, $P = 0.936$; Fig. 4).

Most of the recorded WVC involved passenger buses ($n = 19$; 40.0%) and heavy haulage trucks ($n = 18$; 37.5%) with large wild mammal animals (Fig. 5a). Mostly large wild mammal animals collided with vehicles along the road near water sources, for instance Mhenzva Pan and Kaminga Dam in HSA (Fig. 5b). One notable aspect of the pattern was that most roadkill of large wild mammal animals occurred where there were curves along the road (Fig. 5b), with adjacent habitat of dense and thick vegetation cover. The curves occurred where the alignment of the roadway changed its direction due to some unavoidable range of hills and two dams.

## Discussion

This study demonstrated a relatively high frequency of traffic collision induced mortality for large wild mammals (1.60 roadkill km$^{-1}$) in HSA, northern Zimbabwe over the 8-year study period, i.e., 2006 and 2013. The Harare-Chirundu highway is a busy road linking Zimbabwe and Zambia, hence high traffic volumes, also speed limitations may not be strictly followed, and hence the speeding may lead to these WVC [23]. Elsewhere, Bager and Rosa [29] reported 1.1 roadkill km$^{-1}$ of large wild

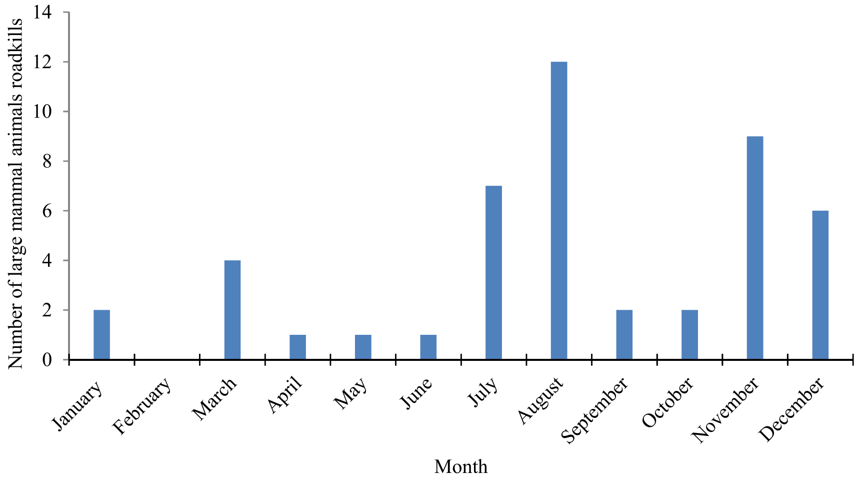


**Fig. 4.** Roadkill of large wild mammal animals by month, in Hurungwe Safari Area, northern Zimbabwe, between 2006 and 2013.

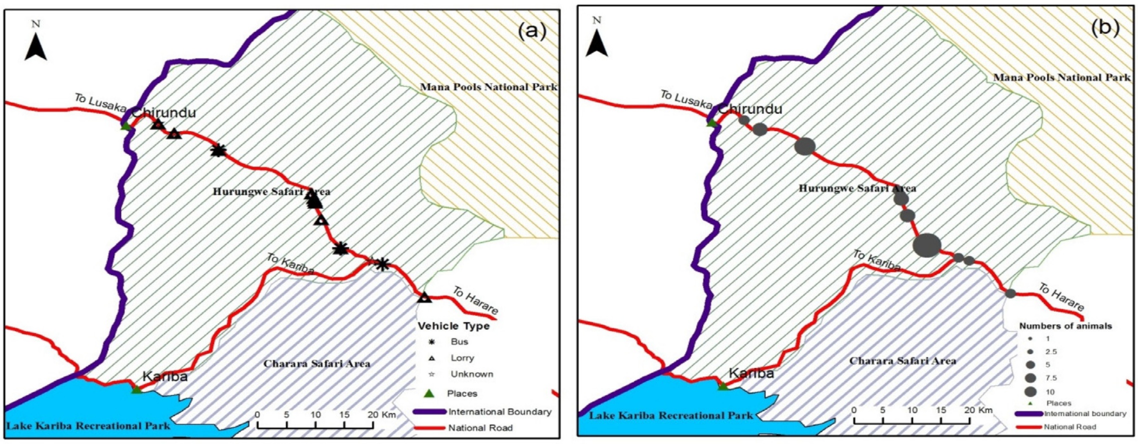


**Fig. 5.** (a) Type of vehicles in relation to spatial locations of roadkill incidents and (b) the sites “hot spots” in relation to the number of roadkill incidents of large wild mammal animal collisions, Hurungwe Safari Area, northern Zimbabwe.

mammal animals recorded in 91 days of roadkill monitoring trips done in a 4-year study period in southern Brazil. Whereas, Collinson [21] from a study with a record of 120 days of roadkill survey trips conducted over three years in Limpopo, South Africa, reported a roadkill rate of 0.90 $km^{-1}$. These relatively lower rates of roadkill of wild animals in Brazil and South Africa were attributed to preventative measures that include animal detection systems, speed bumps, reduced traffic volume measures and wildlife fences that prevent wildlife from accessing the road network [21,29].

The study showed no significant difference between the dry and wet season in terms of roadkill of large wild mammals across the 8-year study record on the Harare-Chirundu highway in HSA, northern Zimbabwe. This could be attributed to the movement patterns of animals as they access the water resources and general availability of vegetation throughout the year. Further, animal corridors may traverse the highway hence increasing the risk for WVCs throughout the year. The other reason for the similarities across seasons could be unreported or non-recorded WVCs cases as animals hit by vehicles may fall and die in distances from the road that make it difficult to detect including hit and run cases. However, in some semi-arid savanna ecosystems, vehicular road accidents have been reported to be highly influenced by weather with most accidents occurring in the wet season in Zimbabwe [30]. Several other studies have also reported the influence of temporal weather patterns on WVC with additional influence of wildlife activity patterns, phenology, and activity patterns [1,31–34].

The study highlighted a higher roadkill rate amongst African buffaloes followed by spotted hyena and African wild dog. Some of the reported factors that may influence large wild mammal species to roadkill include the large home range and large body size with slow movement and gregarious social systems like that of the African buffaloes and the African elephant, poor eyesight, and the nocturnal nature of the spotted hyena [10]. The study recorded some carnivores that were also hit by vehicles, e.g., hyena and lion. It is unlikely that these carnivore species with large home ranges have higher chances of being involved in WVC [21,22]. Of concern is the impact of WVC on endangered and rare species of low reproductive rates e.g. the African wild dog [15] which may push such species to near local extinctions [35] if measures are not taken to minimise the impacts [36].

Passenger buses dominated the roadkill incidents, and this highlighted the risk to human life travelling across wildlife protected areas in northern Zimbabwe. Zimbabwe has a high record of victims of road traffic accidents killing and/or injuring people [23]. Hence, it is important to consider more aspects of improved road ecology in road network management and development. It is likely that when the Harare-Chirundu highway was built little focus was given on wildlife safeguards as the priority was on linkages and provision of safe and efficient transport. The present study is a first step in examining the impact of WVCs involving large mammals and associated influence of roads, especially those traversing across protected areas and this gives a good background for future studies to build on it in the study area and other wildlife-rich areas in Zimbabwe and beyond. Thus, future road development projects need to consider the wildlife resource in the planning phase to ensure that negative impacts are minimised given that roads play an important part for socio-economic development, especially in developing countries [4,37].

### *Implications for management*

Based on our study findings and related literature review, it is essential that road development strategies in Zimbabwe be ecologically sensitive in their design to ensure the country safeguard biodiversity through safe speeds, road signage, patrols along roads for speed adherence and allowing for clear marking of wildlife corridors across the road network [38]. Additional options for adaptation and mitigation measures against roadkill of wild animals in Zimbabwe could include; speed bumps to reduce traffic speed especially in hot spots, wildlife warning signs, and wildlife fences that prevent wildlife from accessing the road network [39]. Limitations of the present study were that we evaluated the temporal patterns of roadkill with inadequate record keeping and perhaps some animals killed were devoured by carnivores before detection. Future studies can consider higher frequency of data collection, e.g., environmental variables, traffic volume, speed, taxonomic groups and species, across study seasons. The study further recommend that a broader study is needed that looks at daily surveys of WVC in Zimbabwe beyond analysing historical records as is the case of the present study.

## Conclusion

This study is the first to highlight results in Zimbabwe about WVC. The study illustrated that the Harare-Chirundu highway is a stretch with hotspots for WVC that affect large wild mammal species populations in HSA. The species and geographical variation in roadkill patterns recorded in this study points to the importance of taking into consideration, type of wildlife species, types of vehicles likely to utilize the road, and volume of vehicle flow in the road planning, construction and monitoring phases. Overall, the study highlighted the need to find solutions related to the reduction of negative impact of road networks on wildlife in protected areas in Zimbabwe. It is, thus, important for Zimbabwe National Road Authority and the Zimbabwe Parks and Wildlife Management Authority to commission research to inform a national mitigation strategy to combat WVC and its impact to wildlife and biodiversity. The next step of our research will indeed be dedicated to consolidating the results of this research together with landscape and road factors to build a predictive model of WVC hotspots and to propose mitigation strategies that could enhance both human and wildlife safety in Zimbabwe.

## Declaration of Competing Interest

Authors declare no conflict of interest

## Acknowledgements

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