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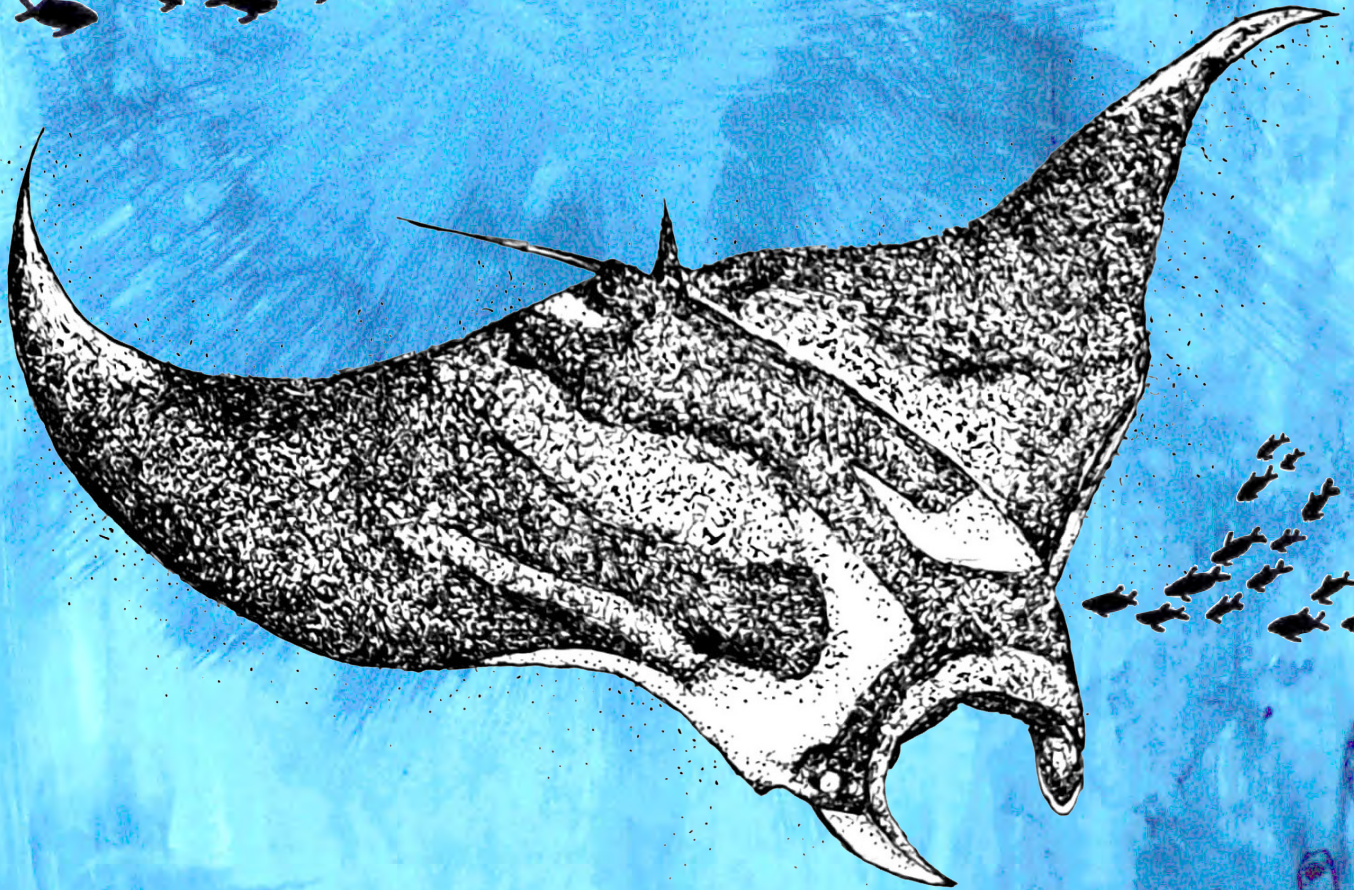
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Cover: Giant Oceanic Manta Ray *Mobula birostris* in ink on acrylic wash by Elakshi Mahika Molur adapted from scientific illustration by Roger Hall.



Roadkill records of two civet species on National Highway 715 passing through Kaziranga-Karbi Anglong landscape complex, Assam, India

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Abstract: This study was conducted on a continuous 64-km stretch of National Highway (NH) 715, which bifurcates the Kaziranga-Karbi Anglong landscape complex, with Kaziranga National Park on its southern side and North Karbi Anglong Wildlife Sanctuary on the northern side. The survey was carried out from October 2017 to September 2018 via two-way journeys three days a week, with two observers using a motor vehicle at a steady speed of 25–35 km/hour. Roadkill reports of one Large Indian Civet *Viverra zibetha* and six Small Indian Civets *Viverricula indica* were collected. Both the species are solitary and nocturnal, and prefer to inhabit secondary landscapes intermingled with human habitation. This stretch of NH 715 forms a crucial passage for wildlife foraging and breeding, and this study reflects the impacts of roads causing wildlife-vehicle collision for two civet species.

Keywords: Large Indian Civet, mortality, Small Indian Civet, *Viverra zibetha*, *Viverricula indica*, wildlife-vehicle collision.

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Author contributions: SS—conceptualization, methodology, validation, investigation, resources, data curation, writing - original draft, review & editing. PKS—supervision, conceptualization, validation, writing, review & editing. MKS—supervision, resources, writing, review & editing.

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INTRODUCTION

Roadways can pose substantial threats to the movement of local wildlife when they pass through protected areas (Gokula 1997; Selvan 2011). Roads are often concrete and permanent features of any landscape, and a road in the wrong place can have devastating consequences for the environment (Laurance et al. 2001). Also, roads in pristine areas like forest covers or patches are environmentally challenging (Laurance et al. 2001). The effect of roads and highways on animals and their environment ranges from habitat alteration and modification (Carr & Fahrig 2001) to disruption of animal distribution and movement (Desai & Baskaran 1998). This can affect breeding density (Reijnen et al. 1995), heterozygosity, genetic polymorphism (Reh & Seitz 1990), and survival due to mortality from vehicular collisions (Shwiff et al. 2007). Thus, with the demandingly growing road network, animals get forced to cross roads to meet with their routine necessities and hence are killed by vehicular collisions (Hourdequin 2000). The ecological effects of roads and traffic have been reported in various studies that date back to the beginning of the 20th century with a rapid increase in studies since the 1980s when road ecology became recognised as a scientific discipline (Linsdale 1929; Laursen 1981; Raman 2011; Samson et al. 2016; Jegannathan et al. 2018; Miranda et al. 2020).

With an estimated total population of 1.3 billion people and 2.4% of an annual rate of change (The World Factbook 2020), India has the second largest road system in the world as per the National Highway Authority of India. The network covers approximately 5.89 million km of road stretch, which in length is after the USA. Enormous growth in road network is expected and predicted in the upcoming years (Indian Road Industry Report 2020). Considering this vast network of roads in concoction with the incessant anthropogenic factors like habitat alteration, alien species invasions, and climatic change, the impact of roads on wildlife cannot be overlooked (Erritzoe et al. 2003; Glista et al. 2008).

This study found (Sur et al. 2022) roadkill of various species of amphibia, reptiles, birds, and other small mammals, but here we primarily focus on the roadkill of two civet species. The Large Indian Civet *Viverrazibetha* of the Viverridae family is a solitary and terrestrial nocturnal animal, categorized as 'Least Concern' by the IUCN Red List (Timmins et al. 2016). The Indian population is listed on CITES Appendix III, as there is an increasing decline in its population. The Small Indian Civet *Viverricula indica* is

also categorized as 'Least Concern' by the IUCN Red List (Choudhury et al. 2015), with a stable population trend, widespread geographical distribution, and habitat use, it is commonly found in India, Sri Lanka, and Bangladesh (Choudhury 2013; Mudappa 2013). *V. zibetha* is known to prefer forests, grasslands, & scrubs intermingled with human habitats and is a good climber. *V. indica* is nocturnal and terrestrial, known to occur in healthy populations in agricultural & secondary landscapes and is highly adaptable in degraded & open habitats (Su 2005). As only a single study of reptilian roadkill has been reported from this area (Das et al. 2007), this is the first documentation of civet roadkill in this stretch of the highway and thereby depicts the need and urgency of similar research work in relation to roads and their effects on wildlife in NH 715.

METHODS

This study was conducted on a continuous 64 km stretch of the paved NH 715 (26.5669–26.7669 N & 93.1336–93.6002 E), which was earlier known as the NH 37, and runs parallel to the southern boundary of Kaziranga National Park (KNP) dividing the landscape into south and north (Figure 1). The Kaziranga-Karbi Anglong landscape is located in the northeastern state of Assam spreading over an 25,000 km² south of the Brahmaputra River in Assam, touching the neighbouring states of Meghalaya and Nagaland. The landscape includes KNP, North Karbi Anglong Wildlife Sanctuary (NKAWS), East Karbi Anglong Wildlife Sanctuary (EKAWS), river Brahmaputra, and NH-715. River Brahmaputra divides the state into northern and southern halves, and the NH 715 runs between KNP and NKAWS. The landscape covers the districts of Golaghat, Nagaon, Sonitpur, and Karbi Anglong. This stretch of the road bisects two protected areas, with KNP to the north and NKAWS to the south, thus making it a crucial passage for wildlife.

Wildlife movement across the NH 715 is vital, since during the wet season, when there are floods the animals migrate from the low-lying floodplains of KNP to the elevated Karbi Anglong hills. Movement also takes place during the dry season when the animals cross move to meet their breeding and feeding necessities. This paved road passes through various habitats including tea gardens, human habitations, paddy fields, teak plantations, wetlands, swamps, and marshy areas besides forest habitats of KNP at Panbari, Haldibari, Kanchanjuri, and Gorakati. All these habitats are potential sites and corridors for animal movement,

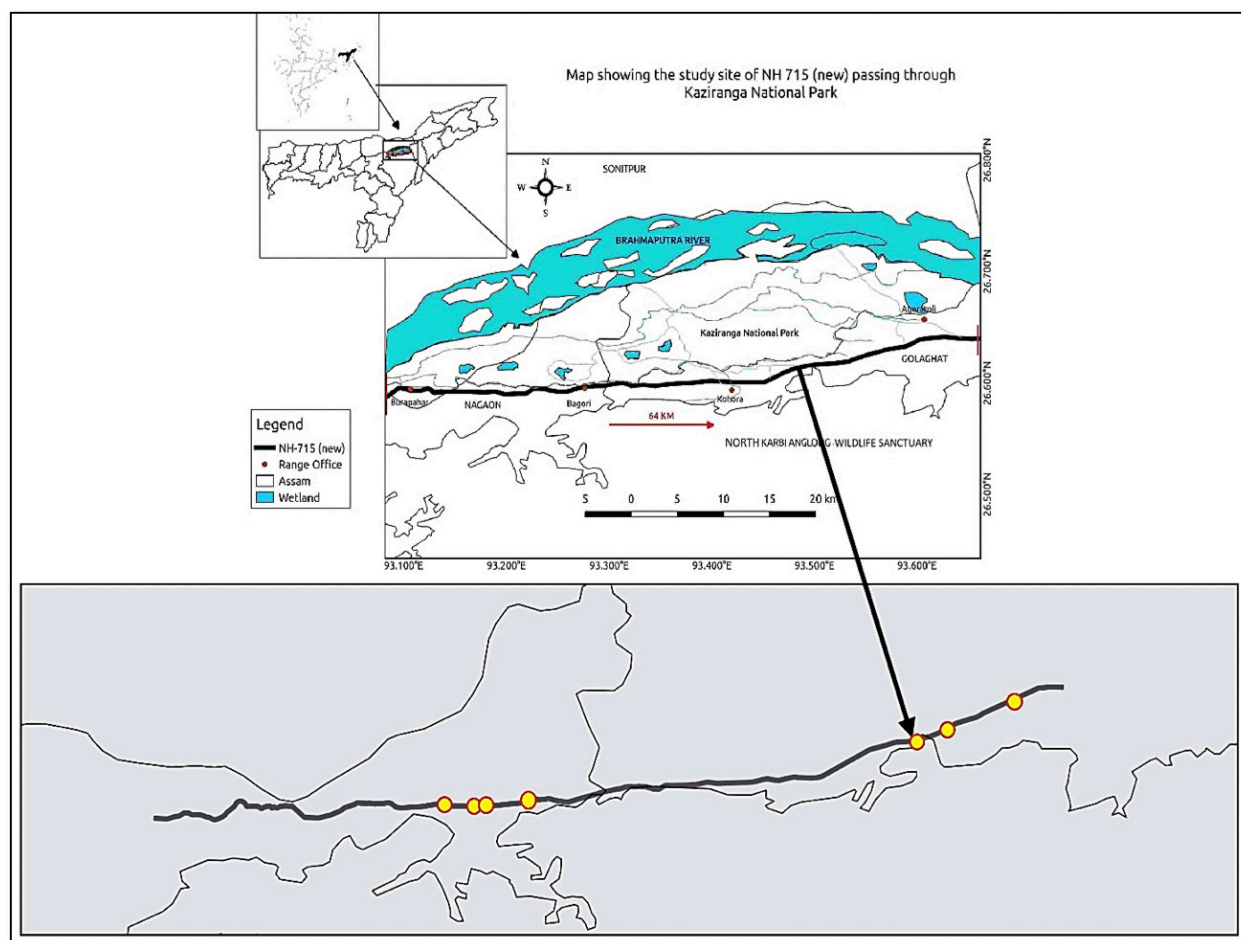


Figure 1. Map showing study area (upper map) along with the location of civet roadkill (dots in lower map).

typically between KNP and Karbi Anglong Hills, and therefore more susceptible to collisions due to moving traffic and vehicles when the animal crosses the 7.5m paved width of the road.

The survey was conducted for a period of one year from October 2017 to September 2018. Data were collected by two observers at 0700 h during the winter and at 0500 h in the summer, depending upon visibility, in both directions from Bokakhat to Amguri, using a motor vehicle at a steady speed of 25–35 kmph, for three days a week. Thereby, a total of 144 systematic surveys were conducted from starting to end point, for the entire study period, approximating to 128 km for every instance. On encountering a civet roadkill, the number of individual roadkill, their status, and nearby habitat characteristics were recorded along with geo-location (Figure 1). The animal carcasses encountered were photographed for identification and were removed from the road to avoid double counting (Glista et al. 2008). The animals were identified by their distinguishing tail

pattern, spots, body colour, and size (Images 2, 3) using a field guide (Menon 2014).

RESULTS

Here we report the roadkill of one *V. zibetha* near Gauri Shankar Shantidevi School, Diphloo, on NH 715 and six *V. indica* at different locations (Table 1). The roadkills were found in a dry and deformed condition (Image 1,2).

V. zibetha roadkill was observed in March which is the pre-monsoon season, and the *V. indica* roadkill were observed in March ($n = 2$), June ($n = 1$), August ($n = 1$), and December ($n = 2$) which falls under pre-monsoon, monsoon and winter seasons respectively. Immediate habitat of the incident sites were tea plantations, scattered human settlements, agricultural fields, open lands, scrublands, and waterbodies (Table 1).

Table 1. List of individual civet kills with their kill status surrounding landscape characters and geolocation.

	Date	Species	Status	Landscape Characteristics	Longitude (N)	Latitude (E)
1.	09.iii.2018	Large Indian Civet	Fresh	Tea Plantation/ Human Habitat	93.5504	26.6333
2.	01.xii.2017	Small Indian Civet	Fresh	Tea Plantation/ Human Habitat	93.5531	26.6344
3.	07.xii.2017	Small Indian Civet	Fresh	Open Area/ Open Area	93.4937	26.6116
4.	08.iii.2018	Small Indian Civet	Fresh	Tea Plantation/ Scrubland	93.5122	26.6172
5.	12.iii.2018	Small Indian Civet	Fresh	Agriculture field/ Agriculture field	93.2055	26.5754
6.	15.v.2018	Small Indian Civet	Fresh	Agriculture field/ Scrubland	93.2327	26.5747
7.	23.viii.2018	Small Indian Civet	Fresh	Agriculture field/ Waterbody	93.2247	26.5747

DISCUSSION

Most of the civet roadkills occurred in areas nearby or in close association with human settlements. The presence of these civets near human habitations could be attributed to the easy availability of food sources (Prater 1971). Since civets are nocturnal species, they were possibly killed during the night hours while crossing the road, as they get blinded by the vehicle headlights (Baskaran & Boominathan 2010).

The roadkill reports for these species might seem to be insignificant, and could be an underestimate of the actual road related mortality, but this loss is unlikely to be balanced by the equivalent birth rate in the current population of the species (Bennett 1991). Nonetheless such trivial loss is intolerable and raises concern, considering the animal's unique nature, uncertain distribution, population stability, and density (Bennett 1991).

V. zibetha face various anthropogenic threats, which is leading to its population decline. Hunting for bush meat and scent glands is the main threat to this species in southeastern Asia (Lynam et al. 2005). Furthermore, habitat modifications and alterations are also a major cause for declining population records of *V. zibetha*. Additionally, anthropogenic activities like clearing and burning of forest understory could also drive their presence (Bista et al. 2012). Another less recognized threat faced by them is the effect of linear intrusions like roads and rails, leading to direct mortality due to vehicular collisions. A large array of studies worldwide has reported the kill of civets due to vehicular collisions (Behera & Borah 2010; Seshadri & Ganesh 2011; Selvan 2011; Mahananda & Jelil 2017; Jeganathan et al. 2018; Jamhuri et al. 2020). However, this elusive species has been little studied in terms of its distribution, ecology, and threats, particularly in the state of Assam and northeastern India, hence needs more research, to

ascertain its actual status and position. *V. indica* are known to face various anthropogenic threats in terms of hunting for bush meat and medicines. They are subjected to little-controlled poaching and other forms of encroachment.

CONCLUSION

Linear infrastructures such as roads, railways, power lines, and pipelines may serve as barriers, conduits, habitats, sinks, or sources in the environment they bisect or traverse (Burel & Baudry 2003). Roads are one of the most crucial and critical components of human life since civilization and urbanization began (Demir 2007). Roads are considered to be the major man-made components that induces anthropogenic modifications in the natural environment (Keshkamat 2011). Therefore, these infrastructure constructions are degrading natural areas & environments and are eventually paving the way for quasi urbanization. Reduction of natural habitats is considered a global threat to biodiversity conservation (Geneletti 2003). Therefore, road designs and locations should be framed such that it should have low environmental cost and high socioeconomic costs.

It is thereby crucial to understand the interaction between roads and railways and wildlife, which have been intruded inside their habitat; it is certainly our responsibility to create and provide them with safe passage thus leading to peaceful coexistence and a long-term sustained effort to reduce such mortality of lesser-studied species.

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Image 1. Carcass of Large Indian Civet *Viverra zibetha* from vehicle collision.



Image 2. Carcasses of Small Indian Civet *Viverricula indica* from vehicle collisions.

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