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Notes on Mexican Herpetofauna 31: Are Roads in Nuevo León, Mexico, Taking Their Toll on Snake Populations? (Part II)

David Lazcano [1], Daryne B. Esquivel Arévalo [1], Arturo I. Heredia Villarreal [1], Juan Antonio García Salas [2], Bryan Navarro-Velázquez [1] and Manuel Nevárez-de los Reyes [1]

Abstract

Mortality caused by vehicular road traffic is among the principal contributors to decreased gene pools in amphibian and reptile populations. This phenomenon has been documented to some extent for other areas of Mexico by recent authors, but for the northeast of the country our herpetological group at the Universidad Autónoma de Nuevo Leon has been documenting the finding of snake road kills. This has become a topic of interest at many universities in Mexico. To document this anthropogenic phenomenon, we examined the herpetological collection catalogue of UANL/FCB for DOR (Dead on Road) specimens found on various state roads during the period 2008–2016. Seventy-nine specimens, representing five families, 20 genera and 31 species, were recorded from 10 classified roads.

Keywords: Road kills (DOR); snakes; Nuevo León, Mexico

Resumen

Mortalidad causada por el tráfico vehicular esta entre la causa o contribuir en la disminución del patrimonio genético en las poblaciones de anfibios y reptiles cercanas a estas. Este fenómeno se ha documentado escasamente en algunas zonas de México por cierto autores, pero para el noreste del país nuestro grupo herpetológico aquí en el Universidad Autónoma de Nuevo León ha estado documentando el hallazgo de serpientes en carreteras federales, estatales o municipales (área urbana). Sin embargo recientemente este fenómeno a despertados un gran interés en muchas universidades en México, en buen ahora. Para documentar este fenómeno antropogénico, examinamos el catálogo de la colección herpetológica preservada de UANL/FCB para documenta las muestras de animales atropellados en los diferentes caminos del estado durante el período (2008–2016), resultaron un total de 79 ejemplares con la representación de 5 familias, 20 géneros y 31 especies, que fueron localizadas en 10 caminos que clasificados.

Palabras Claves: Atropelladas; serpientes; Nuevo León, México

Introduction

It would be impossible to cite all the many articles out there dealing with the effects that roads have on vertebrate populations, and this literature continues to grow. Amphibians and reptiles that transit roads during their terrestrial movements while carrying out their physiological needs on a daily or seasonal basis are especially vulnerable, and sustain high mortality rate (Langton, 1989; Ashley and Robinson, 1996; Smith and Dodd, 2003; Aresco, 2005; Hamer et al., 2015; Andrews et al., 2015). Death as a result of road traffic plays an important role in the mortality rates of reptiles (Sullivan, 2012; Sullivan et al., 2016). Trombulak and Frissell (1999) reviewed the ecological effects of roads on animal populations. Factors that may affect mortality in various organisms include the speed with which they cross roads, body length (Hels and Buchwald, 2001; Gibbs and Shriver, 2002), movement patterns (Jaeger et al., 2005), traffic intensity and speed (Forman et al., 2003), and changes in habitat associated with road construction (Rudolf et al., 1999; Kjoss and Litvaitis, 2001).

A very particular factor attracting ectotherms to roads is the need to thermoregulate (Forman et al., 2003; Andrews et al., 2015). It has been hypothesized that reptiles and amphibians are attracted to roads to elevate their body temperature on cool nights following sunny days because the road surface remains warmer than the air and surrounding landscape (Dodd et al., 1989; Rosen and Lowe, 1994). The heat stored on the road surface is released into the atmosphere at night, creating “heat islands.” Animals respond to these heat islands: snakes, for example, preferentially aggregate on or near warm roads, increasing their risk of being hit by cars (Trombulak and Frissell, 1999). In the northeastern United States and southeastern Canada, road mortality is associated with population declines and altered population structure of amphibians and reptiles (Fahrig et al., 1995; Marchand and Litvaitis, 2004; Steen and Gibbs, 2004; Gibbs and Shriver, 2005). Habitat fragmentation and physical barriers imposed by roads pose what many conservation ecologists consider the greatest obstruction to maintaining species diversity and ecological integrity in areas that are being urbanized or altered for human transportation activities (Wilcox

1. Universidad Autónoma de Nuevo León, Facultad de Ciencias Biológicas, Laboratorio de Herpetología, Apartado Postal # 513, San Nicolás de los Garza, Nuevo León, C.P. 66450 México.

2. Universidad Autónoma de Nuevo León, Facultad de Ciencias Biológicas, Laboratorio de Ornitología, Apartado Postal # 513, San Nicolás de los Garza, Nuevo León, C.P. 66450 México.

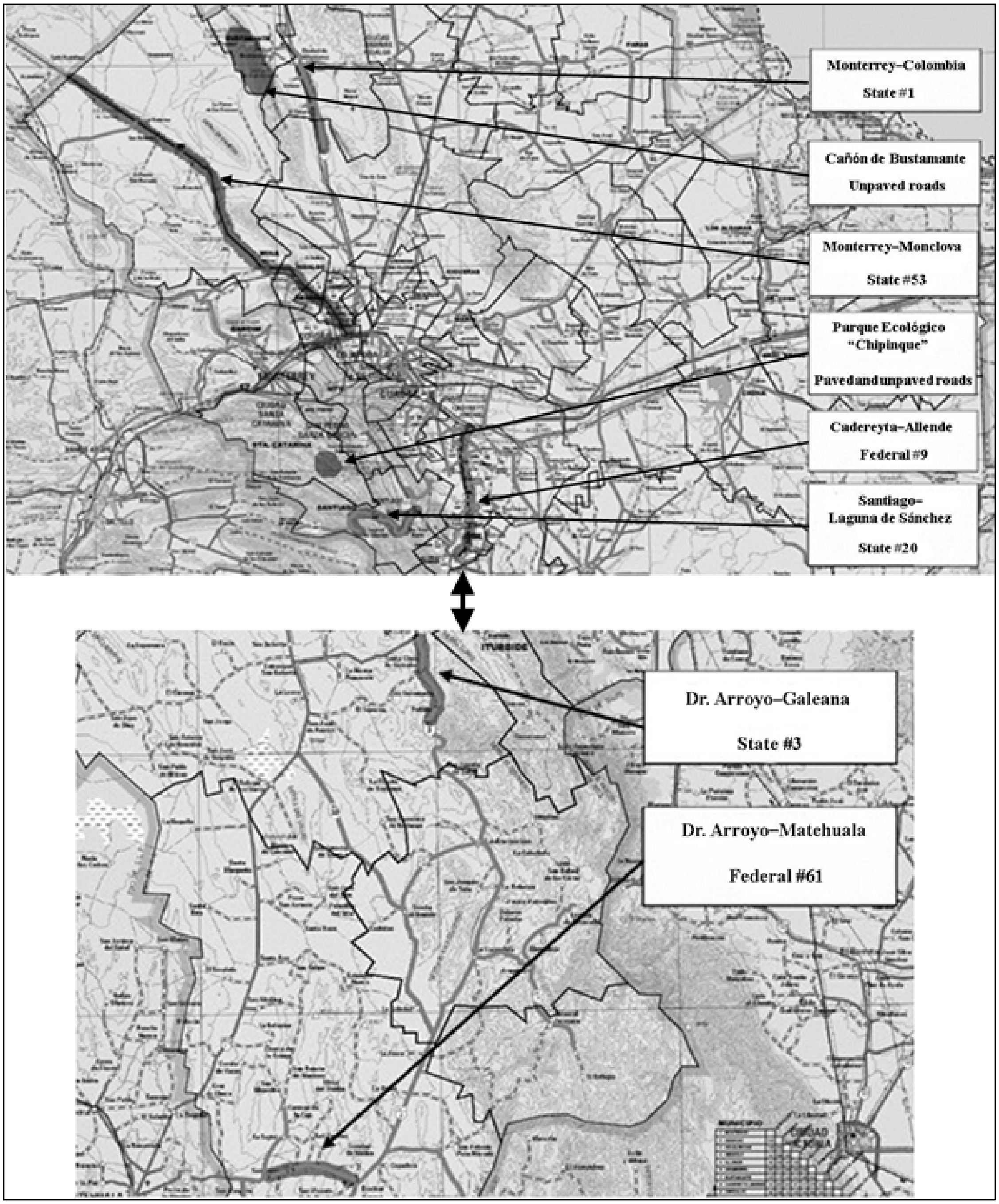


Figure 1. Locations of roads in the Mexican state of Nuevo León from which road-killed snakes were taken for this study.

and Murphy, 1985; Saunders and Hobbs, 1991; Forman and Alexander, 1998). In general, mortality increases with traffic volume (Rosen and Lowe, 1994; Fahrig et al., 1995).

It has been documented that reptile and amphibian species, and even sex and age classes within species, differ as to the cause of movements that result in road crossing (Gibbs, 1998; Semlitsch, 2000; Carr and Fahrig, 2001; Andrews and Gibbons, 2005; Steen and Smith, 2006).

Roads have been shown to result in the sudden population decrease of several species (Beaudry et al., 2008, 2010; Corlatti et al., 2009). They form physical barriers, limiting or preventing regular movements in now isolated populations and potentially increase the probability of local extinction (Benítez-López et al., 2010; van der Ree et al., 2015). Such barriers may alter the genetic diversity of the separated populations (Steen and Gibbs, 2004; Clark et al., 2010).

Environmental scientists have studied how to minimize these effects by constructing fences or elevated sections of the road or underground passages (Yanes et al., 1995). Also signs can be used to reduce the velocity of vehicles in areas where animals frequently cross (Arroyave et al., 2006; Barrí, 2010). The effectiveness of such methods varies greatly between taxa (Bissonette and Adair, 2008; Glista et al., 2009; van der Ree et al., 2015).

There has been an increasing interest in documenting the effect of roads on mortality of vertebrate fauna in Mexico (Grosselet et al., 2009; Herrera-Robledo, 2011; Martínez-

Hernández, 2011). Even a magnificent animals like tapirs (*Tapirus bairdi*), a threatened species with restricted distribution in the Peninsula of Yucatan and south of Veracruz, have been found road-killed (Puc-Sánchez et al., 2013). But the effects of road-kill have been documented in the northeast of Mexico only by Lazcano et al. (2009). With increasing traffic volume and road construction (federal, state, municipal and dirt roads) throughout Nuevo León, it is without doubt a rising problem for reptiles and amphibians, especially for those federal or state roads that for kilometers may have a mid-road traffic barrier. Such roads make it even more difficult for living creatures to cross; here we find not just herpetofauna, but also mammals such as field rodents, coyotes, deer, opossums, ring-tails, armadillos, and thousands of invertebrates, trapped and killed. Mortality is also frequently observed on roads close to cities, where many domestic animals are found DOR. Terrible traffic accidents occur when horses are allowed to roam without any restraint within city limits, a never-ending problem because horses are still used as draft animals throughout the Metropolitan Area of Monterrey.

Study Area

The state of Nuevo León lies between 98°17′ and 101°07′W, and between 23°06′ and 27°50′N. Neighboring states are Tamaulipas to the east, Texas on the northeastern border, Coahuila to the northwest and west, and Zacatecas and San Luis Potosí to the southwest. Shaped as an irregular rhombus exceeding 500 km at its longest (north/south) axis, its area is 64,081.94 km^2. Nuevo León is the 13th largest state in Mexico and the 14th most densely-populated, at 73 people per km^2 (wikipedia.org; accessed 16 September 2016). Most of the state falls within the Northern Temperate Zone. However, a small portion extends south of the Tropic of Cancer (Cantú-Ayala et al., 2013).

Table 1 lists the roads in Nuevo León where we found DORs. The state connects directly to all important destinations of Mexico via federal roads, and to all its 51 municipalities via state roads. Here we assigned a name and number only to the roads that had DORs registered.

Nuevo León encompasses a transition zone between the Nearctic and Neotropical biogeographic divisions, giving the state a variety of ecosystems that have an enormous influence on the distributional patterns of vertebrate groups (Cantú-Ayala et al., 2013). Some of the following vegetation types are present: gypsophyllous plants, piedmont, rosetophilous scrub, chaparral, and oak and pine-oak forests (Cantú-Ayala et al., 2013). These vegetation assemblages play an extremely important role in species distribution..

Federally protected areas account for 4.3% of the state's territory. These are the following three national parks: Cumbres in the municipalities of Allende, Monterrey, Santa Catarina, San Pedro Garza García, and Santiago (177,395 ha); El Sabinal in the municipality of Cerralvo (8 ha); and Monumento Natural Cerro de la Silla in the municipalities of Guadalupe, Juarez and Monterrey (6,039 ha) (Arriaga et al., 2000; Nevárez-de los Reyes et al., 2016).

Nuevo León now has 29 state (191,926.1 ha) and three federal (183,449 ha) protected areas, a total of 375,375.1 ha (Nevárez-de los Reyes et al., 2016), with an additional five in review. We presume that these protected areas help lower the pressure on state wildlife populations, but we consider this to be insufficient, due to the fact that the state has an extremely large population (SEDESOL et al., 2007), growing both from within and because of people coming in from neighboring states. Plus, these protected areas have many dirt roads crossing through them, and here we can also occasionally find DORs. Without a doubt, the consistent, unplanned urban development represents a direct threat to the state's ecosystems.

Materials and Methods

Methods that can be used when working on DOR herpetofauna have been documented by Langen et al. (2007). We reviewed the UANL electronic catalogue from the years 2008–2016, looking for any DOR specimens registered. We extracted from these DOR specimens the following information: species identification, date collected, SVL, tail length, total length, sex, DOR condition, locality, municipality, and the road on which they were found. These are the only parameters taken; microhabitat was not recorded. We created two tables and a figure to summarize this information. To designate the roads where specimens where found during this study, we numbered them from 1 to 10 in Table 1 (see also Figure 1). We included in Table 1 the official road number from the state map and the number of specimens found. Traffic volumes were not included because the data were not available for the particular sections of roads where we found road kills. The road numbers from Table 1 were then used in Table 2, which summarizes the species that were found as DORs, giving the average SVL of each species found, the roads on which it was found and the conservation status (Mexican Nom. and IUCN). Figure 1 summarizes the number of specimens found by year and season. Unfortunately, no specific survey method was followed; our data accumulated as a result of specimens found during our trips to different areas of the state when we were conducting herpetological surveys or from occasional visits to the areas for landscape photography.

Table 1. Roads where specimens were found and number of specimens.

Assigned road number	Official road number	Number of specimens found
1. Streets in urban area	none	6
2. Chipinque Ecological Park (dirt roads / tracks)	none	6
3. Chipinque Ecological Park (paved road)	none	10
4. Dr. Arroyo–Galeana	State #3	23
5. Laguna de Sánchez	State #20	17
6. Cañón de Bustamante	State # 94	3
7. Monterrey–Colombia	State # 1	6
8. Cadereyta–Allende	Federal #9	5
9. Monterrey–Monclova	State #53	2
10. Dr. Arroyo–Matehuala	Federal #61	1

Table 2. Species found in the categorized roads. **NOM** = protection status under NOM-ECOL-059-2010 (SEMARNAT, 2010): Pr = Protección Especial (Special Protection); A = Amenazada (Threatened). **IUCN** = protection status according to the International Union for Conservation of Nature: LC = least concern; EN = endangered.

Family	Species	Number found	Average SVL (mm)	Road numbers where found	NOM	IUCN
Colubridae	*Arizona elegans arenicola*	2	418	4, 7	–	LC
	Bogertophis subocularis	1	584	6	–	LC
	Coluber constrictor oaxaca	3	627	2, 5, 5	A	LC
	Coluber flagellum testaceus	3	934	1, 4, 4	A	LC
	Coluber schotti ruthveni	4	404	4, 3, 7, 7	–	LC
	Drymarchon melanurus erebennus	1	498	3	–	LC
	Gyalopion canum	1	223	4	–	LC
	Lampropeltis alterna	2	521.5	5, 6	A	LC
	Lampropeltis annulata	2	450	8, 8	–	–
	Lampropeltis mexicana	1	373	8	A	LC
	Lampropeltis splendida	2	519.5	4, 4	–	–
	Leptophis mexicanus	1	404	5	A	LC
	Pantherophis bairdi	4	765	2, 5, 2, 5	–	LC
	Pantherophis emoryi	3	840	9, 1, 3	–	LC
	Pituophis catenifer sayi	2	721	7, 7	–	LC
	Pituophis deppei jani	5	755.2	4, 4, 4, 4, 5	A	LC
	Rhinocheilus lecontei tessellatus	5	441	4, 4, 4, 9, 7	–	LC
Dipsadidae	*Diadophis punctatus*	1	338	5	–	LC
	Hypsiglena jani texana	5	280.5	4, 4, 4, 4, 1	–	–
	Leptodeira septentrionalis	5	551.7	5, 3, 1, 6, 1	–	–
	Rhadinaea montana	4	153	5, 4, 5, 2	Pr	EN
	Tropidodipsas sartorii	7	322.2	5, 3, 3, 3, 5, 3, 2	Pr	LC
Natricidae	*Storeria dekayi texana*	1	187	3	–	LC
	Thamnophis cyrtopsis cyrtopsis	2	271	4, 5	–	LC
	Thamnophis marcianus marcianus	1	219	8	A	LC
	Thamnophis proximus diabolicus	1	?	5	A	LC
Elapidae	*Micrurus tener*	3	376	8, 1, 3	–	LC
Viperidae	*Crotalus atrox*	2	537	4, 2	Pr	LC
	Crotalus molossus nigrescens	3	507.5	4, 5, 4	Pr	LC
	Crotalus scutulatus scutulatus	1	370	10	Pr	LC
	Crotalus totonacus	1	?	5	–	–
Anguidae	*Gerrhonotus infernalis*	50	125	3, 3	–	LC

Results

We found the largest number of snakes on Road 4 (Dr. Arroyo–Galeana), with 23 specimens representing 29.11% of the total specimens found in data analyzed. During this period of time (2008-2016), we obtained data from 79 specimens in five families, 20 genera, and 31 species (Table 2). Our largest snake specimen was *Coluber flagellum testaceus* with a SVL of 934 mm. and our smallest was *Rhadinaea montana* with a SVL of 153 mm. Road 3 is in the Parque Ecológico Chipinque. This is a very popular place for people of the Monterrey Metropolitan Area to visit, for outdoor sports or just for relaxation. There is a paved road that runs for about 7 km from the park entrance up to what is known as "La Meseta." Here we found eight of the 31 species of DORs listed in Table 2, including *Gerrhonotus infernalis* (Texas Alligator Lizard / *Falso Escorpión*). We decided to include this lizard in Table 2 because it represents the most common species found as DOR, more than 50 individuals in the last 10 years (Lazcano et al., 2006). We found seven specimens of *Tropidodipsas sartorii* (Sartori's Snail Sucker / *Caracolera de Sartori*) with 7 specimens, making this the most common snake found as a DOR over the course of this study. Figure 2 shows the distribution of the 79 specimens by year and season, with spring 2010 yielding the maximum of 10 DORs.

Discussion and Conclusion

Anthropogenic Development

Unfortunately, the expansion of any city proceeds at the cost of its surrounding natural ecosystems. The city of Monterrey was founded on 20 September 1596, but urban development was not a significant factor until after World War II, when industrial-

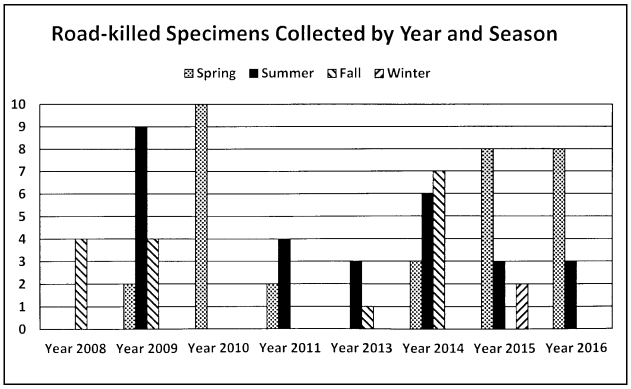


Figure 2.

ization brought about the substitution of imported products for locally created ones (Garza and Rivera, 1995; Garza, 2003; Nevárez-de los Reyes et al., 2016), at the expense of the natural surroundings. The Monterrey Metropolitan Area currently consists of 12 municipalities that contain 90% of the human population of the state. Its surface area encompasses 6,794 km^2 (10.6% of the total population of the state), with an average density of 109.1 people/km^2 (SEDESOL et al., 2007). Currently, an estimated two million vehicles are in the state, whereas 14 years ago that number was 900,000; the present estimate is equivalent to nearly 500 vehicles/1,000 people (www.elfinanciero.com.mx/monterrey/debe-frenar-expansion-urbana.html; accessed 9 September 2016.). This has increased traffic density in the Monterrey Metropolitan Area. Consistent and unplanned urban development undoubtedly represents a direct threat to the state's ecosystems. Sadly, this threat has caused some surrounding hills to become biological islands, as has occurred with Cerro del Topo Chico (Lazcano et al., 2012) and is about to happen with Cerro de las Mitras; both sites are designated as state protected areas. Another site facing a similar fate is the federally protected area of Cerro de la Silla, where the level of development on both east and west sides has disrupted some of its continuity with the Sierra Madre Oriental and the never-ending expansion of the urban stain. More and more so-called *colonias* or *fracionamientos* destroy surrounding natural habitat, with vertebrates of many species being displaced or killed. Due to economic recession, other cities in Nuevo León have not grown as exponentially as the Monterrey Metropolitan Area. We lack any information on the number of DORs in these areas. Urbanization is not just a problem in Nuevo León, it is the same in the entire country. The problem is growing at an exponential rate and putting at risk much of our biodiversity (Domínguez-Vega and Zurla, 2016; Garza, 2003).

Road Problems

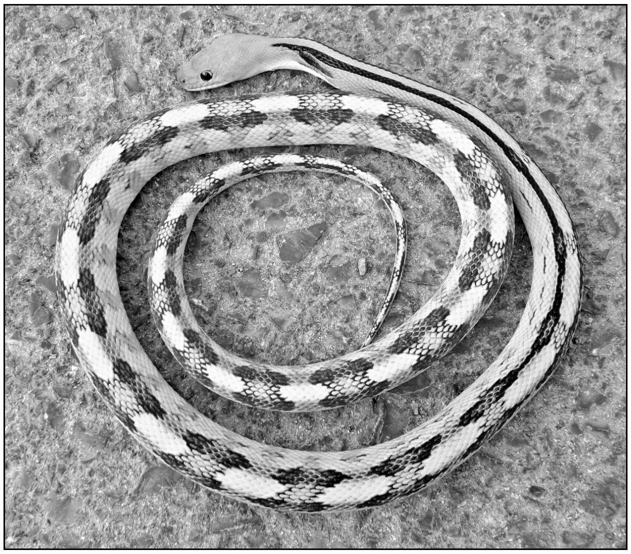
The loss of wildlife by road-kills worldwide is exorbitant. In the United States alone, one million vertebrates per day are lost (Forman and Alexander, 1998; Hels and Buchwald, 2001). In Spain the figure is 10 million per year (Cupul, 2002). In Australia the amount is 5 million per year (Forman and Alexander, 1998; Hels and Buchwald, 2001; Vargas-Salinas et al., 2011). Road-kills affect both fauna and people who are involved in accidents with large animals (Smathers, 2001), creating a large economic loss from these accidents and the loss of millions of faunal numbers (Spellerberg, 2002: pp. 225-248). Occasional human losses from such accidents are highly regrettable. These data are worrisome because in the case of the U.S. these economic figures involve only 1% of the country's surface, Perhaps, in many cases, animals that are killed on the road go unnoticed because they crawl away from the roads or are eaten by predators (Puc-Sánchez et al., 2013).

The worldwide loss of herpetofauna on roads has been widely documented (van de Ree et al., 2015; Puc-Sánchez et al., 2013); however, the impact of vehicular traffic on the Mexican herpetofauna, including that of Nuevo León, remains practically unevaluated. The principal roads in Nuevo León are federal highways 9 (Cadereyta–Allende), 40 and 40D (Saltillo–Monterrey–Reynosa), 53 (Monterrey–Miguel Alemán), 57 (San Roberto–Saltillo), 58 (Linares–San Roberto), 85 and 85D (Linares–Monterrey–Nuevo Laredo), and state highways 1 (Monterrey–Colombia), 3(Dr. Arroyo–Monclova), 20 (Santiago–Laguna de Sánchez), 54 (Monterrey-Monclova), and 61 (Dr. Arroyo–Galeana) (www.mapacarreteras.org/e2555-nuevo-leon.html; accessed 09 December 2016), and these roads are assumed to have a significant impact on local wildlife populations. Because the herpetofauna uses these roads for several reasons (Lazcano et al., 2009; Puc-Sánchez et al., 2013), conservation programs aiming to minimize the number of road-kills should be implemented.

Two recent studies (Köhler et al., 2016a, b) dealt with biological information that can be derived from the examination of snakes killed on roads in the vicinity of Chetumal, Quintana Roo, including seasonal activity, abundance, reproduction, special distribution, external morphology, diet, among other topics. In particular their (Köhler et al., 2016a) research consisted in traveling at 15-day intervals from 2010 to 2016 along a 39-km transect, reporting 433 road killed snakes belonging to 31 species.

In addition to federal and state roads, our findings also document other cases of road-kills, for example in streets within suburban areas where new housing developments are being built. This is happening in seven of the municipalities that make up the Monterrey Metropolitan Area.. In the state of Nuevo León there are 65 species of snakes (Nevárez-de los Reyes et al., 2016): here we document 31 species, representing 47.69% of the total of species of the state. Since we didn't follow a regular method, the number of specimens documented during these years (2008–2016) is relatively small. One thing that we noticed is that federal or state roads with heavy traffic (Monterrey–Colombia, Cadereyta-–Allende and Monterrey–Monclova) result in fewer road-killed individuals. This is likely because the snake populations there for years have suffered continual road-killing to a point where their numbers have diminished.

The road network in the state is being developed intensively in order to accommodate the increasing demand of goods that need to be transported among municipalities and the bordering states; however, it is critical to recognize the potential threats to all groups of biodiversity. As road networks are increased and amplified, there is also a need to implement further research on the subject to measure the impact of this phenomenon, in order to promote better roads—both to satisfy human needs and to preserve the gene pools of species living and moving about in these areas.

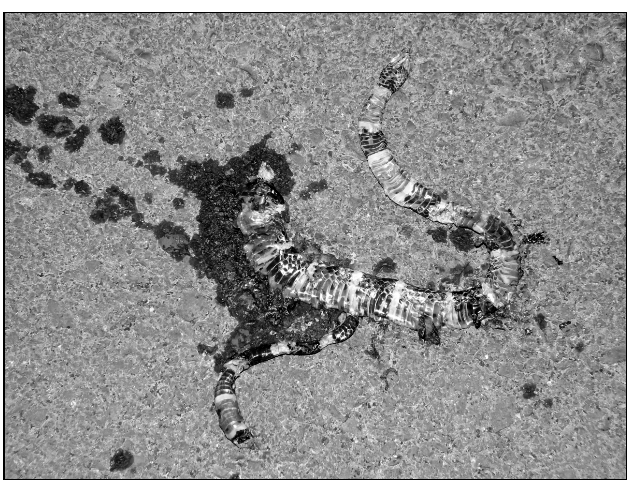


Trans-Pecos ratsnake, *Bogertophis subocularis*—a rare snake in Nuevo León—found DOR on Road 6.

Gray-banded kingsnake, *Lampropeltis alterna*, one of the most beautiful snakes of the state, found DOR on Road 6.

A large bullsnake, *Pituophis catenifer sayi*, found DOR on Road 6.

A beautiful mountain bullsnake, *Pituophis deppei jani*, found DOR on Road 5.



A Texas coralsnake, *Micrurus tener*, found DOR on Road 6.

Two adult turkey vultures, *Carthartes aura*, consuming a DOR western coachwhip, *Coluber flagellum testaceus*.

All photographs by Manuel Nevárez de los Reyes.

Reflection

As the human population grows, so will the necessity to transport more goods to towns and cities. There will be increasing requests for better infrastructure, which includes roads. This will no doubt increase road-kills. And as exploration opens new areas for minerals, petroleum, and wood, many more pristine areas will disappear in front of our eyes—we really can't do anything about this. Any animal that is road-killed is a very unfortunate incident and represents lost genetic potential. In Mexico we are waking up to document this phenomenon, but can we do anything to diminish the number of animals killed? Although our article deals with road-killed snakes, recently Loc-Barragan et al. (2016) documented the finding on the road in the municipality of Tecuala, Nayarit, of a road-killed *Heloderma horridum*, an incredible loss for this species and the Mexican herpetofauna. It is an animal not easily found.

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