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Notes on Mexican Herpetofauna 12: Are Roads in Nuevo León, Mexico, Taking Their Toll on Snake Populations?

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Abstract

Mortality caused by road traffic could contribute to a decreased gene pool in amphibian and reptile populations. There have been no previous studies done on road kills of these vertebrate groups in the northeast of Mexico. In order to document this anthropogenic phenomenon, the catalogue of the preserved herpetological collection of UANL/FCB was examined to locate specimens that were observed or collected on federal and state roads in Nuevo León. During the period (1993–2007) a total of 825 specimens were collected from the state of Nuevo León. Of these, 710 were found on a road within the state (Alive on Road [AOR] = 468 and Dead on Road [DOR] = 242). Of these we could only pinpoint on the state road map 176 AOR and 126 DOR; the rest were not used in this study.

Resumen

La mortalidad causada por el tráfico en las carreteras puede contribuir a disminución del pool genético local y regional de las poblaciones de anfibios y reptiles. No hay estudios sobre la mortalidad en carreteras del noreste de México sobre este grupo de vertebrados. Como una manera de contribuir a la documentación de este fenómeno antropogénico, se analizo la colección herpetologica preservada de la UANL/FCB en búsqueda de ejemplares que fueron encontrados en carreteras estatales o federales en Nuevo León desde (1993-2007), con un total de 825 ejemplares colectados para el estado; de estas un total de 710 ejemplares fueron encontrados en las carreteras, categorizandose de la siguiente manera (AOR = 468 and DOR = 242) por siglas en Ingles, después de esta solamente 176 AOR (Alive on Road) y 126 DOR (Dead on Road), pudieron ser correctamente localizadas en la carreteras del estado, los ejemplares restantes fueron descartados y no examinados.

Introduction

There is a substantial amount of literature on the effect that roads have upon vertebrate population groups, and the high mortality rates occurring with amphibians and reptiles that transit roads during their terrestrial movement while carrying out their physiological needs on a daily or seasonal basis (Langton, 1989; Ashley and Robinson, 1996; Smith and Dodd, 2003; Aresco, 2005). Also, 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 (e.g., 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, for example, 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 pose what many conservation ecologists consider the greatest obstruction to maintaining species diversity and ecological integrity (Wilcox and Murphy, 1985; Saunders and Hobbs, 1991; Forman and Alexander, 1998). In general, mortality increases with traffic volume (e.g., Rosen and Lowe, 1994; Fahring et al., 1995). Also, that reptile and amphibian species, and even sex and age classes within a species, differ in the cause of movements that result in road crossing has also been documented (Gibbs, 1998; Semlitsch, 2000; Carr and Fahrig, 2001; Andrews and Gibbons, 2005; Steen and Smith, 2006).

This anthropogenic phenomenon has not been documented in the northeast of Mexico. With increasing traffic volume and road construction (federal, state, municipal and dirt roads) throughout Nuevo León, it is without doubt a growing problem for reptiles and amphibians, especially for those federal or state roads that for kilometers may have a mid-road taffic barrier. Such roads make it even more difficult for animals to cross; here we find not just herpetofauna, but also mammals such as field rodents, coyotes, deer, opossums, ring-tails, armadillos, etc., trapped and killed. Mortality is also frequently observed in roads close to cities, where many domestic animals are found as DORs, including many terrible traffic accidents within city limits when horses are allowed to roam without any restraint.

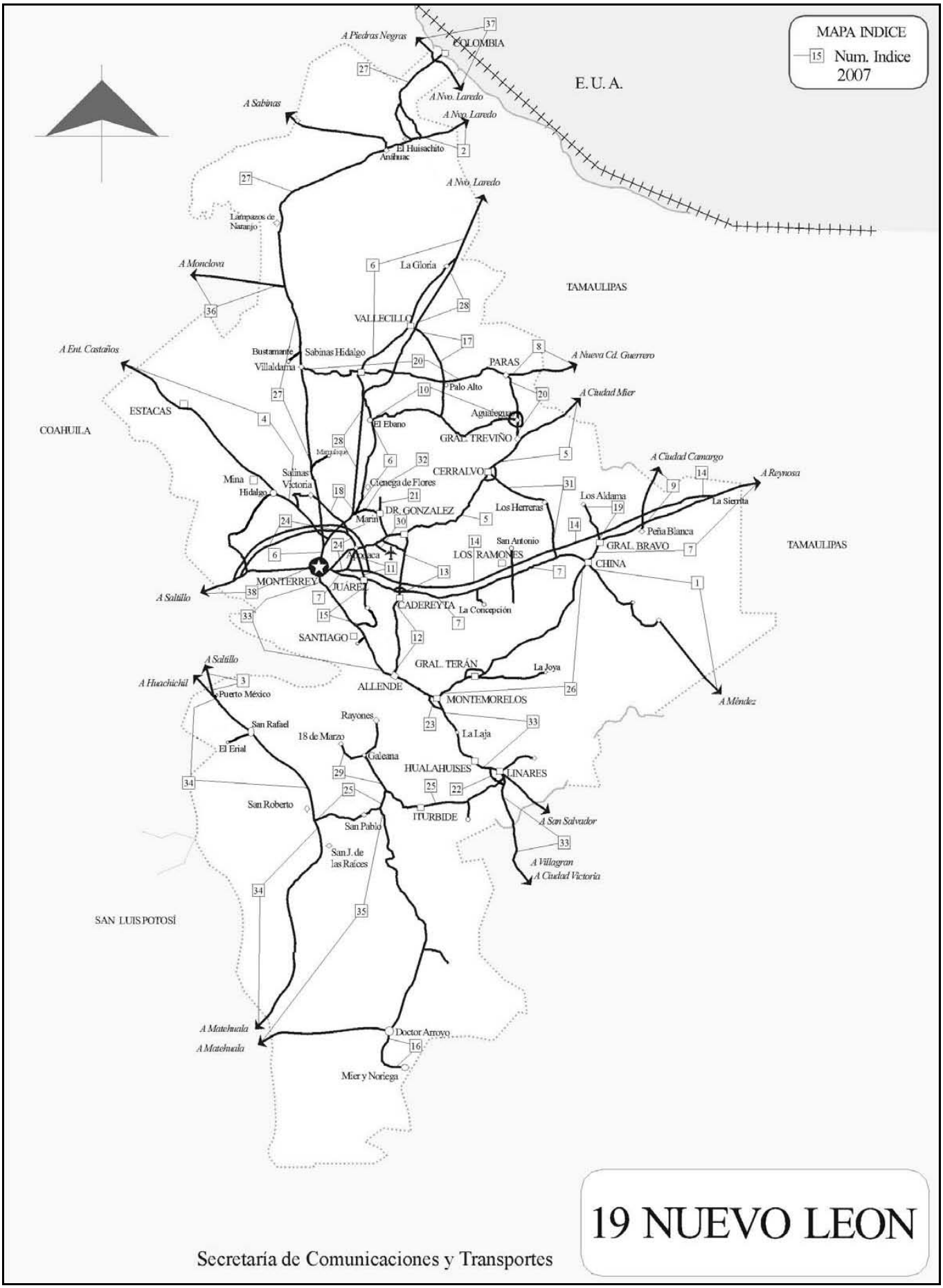

Figure 1. Map of Nuevo León (2007) showing federal and state roads (numbered squares correspond with the road numbers in Table 1).

Study Area

The state of Nuevo León lies between longitudes 98°17′W and 101°07′W, and between latitudes 23°06′N and 27°50′N. It has as neighbors the U.S. state of Texas to the northeast and the Mexican states of Tamaulipas to the east, Coahuila to the northwest and west, and Zacatecas and San Luis Potosí to the southwest. The state is shaped like an irregular rhombus with a surface area of 64,081.94 km^2. Its maximum north-south axis exceeds 500 km. The majority of the state is found within the northern temperate zone, but a small portion of its southern area lies south of the Tropic of Cancer (Contreras-Balderas et al., 1995). Figure 1 shows the various federal and state roads throughout the state of Nuevo León and Table 1 gives a corresponding list of the roads.

Table 1. Road numbers and corresponding Highway Nº in Guía Roji for the state of Nuevo León, Mexico. The figures in the column headed Traffic represent the average number of vehicles per day traveling each road during the year 2007.

Road number and description	Guía Roji Highway Nº	Traffic
1. China – Méndez	State Nº 4	2056
2. Ent. Huisachito – Nuevo Laredo	State Nº 1	9220
3. Aut. Puerto México – Ojo Caliente	Fed. Nº 57	63513
4. Monterrey – Castaños	Fed. Nº 53	69931
5. Monterrey – Mier	Fed. Nº 54	121997
6. Monterrey – Nuevo Laredo (free)	Fed. Nº 85	238603
7. Monterrey – Reynosa (free)	Fed. Nº 40	105584
8. Paras – Nueva Ciudad Guerrero	Fed. Nº 30	1398
9. Peña Blanca – Ciudad Camargo	—	7552
10. Agualeguas – El Ébano	State Nº 23	2393
11. Apodaca – Villa Juárez	—	28281
12. Cadereyta – Allende	Fed. Nº 9	2507
13. Cadereyta – Doctor González	—	2024
14. Cadereyta – La Sierrita	Fed. Nº 40	No data
15. Cd. Benito Juárez – Villa de Santiago	—	13451
16. Doctor Arroyo – Mier y Noriega	State Nº 88	1174
17. Palo Alto – Vallecillos	—	2381
18. Santa Rosa – Salinas Victoria	—	18260
19. Gral. Bravo – Los Aldama	—	1781
20. Gral. Treviño – Villa Aldama	State Nº 3	10608
21. Hacienda Guadalupe – Higueras	State Nº 6	3709
22. Libramiento de Linares	Fed. Nº 85	18370
23. Libramiento de Montemorelos	Fed. Nº 85	7593
24. Libramiento Noroeste de Monterrey	Fed. Nº 40	45083
25. Linares – Ent. San Roberto	Fed. Nº 57	8127
26. Montemorelos – China	Fed. Nº 35	9456
27. Monterrey – Colombia	State Nº 1	48232
28. Monterrey – Nuevo Laredo (tollway)	Fed. Nº 85	7438
29. Ramal a 18 de Marzo	State Nº 32	2124
30. Ramal a Aeroporto Mariano Escobedo	Fed. Nº 54	20894
31. Ramal – Cerralvo	State Nº 13	2404
32. Ramal – Marín	Fed. Nº 54	3560
33. Ciudad Victoria – Monterrey	Fed. Nº 85	204859
34. Matehuala – Ent. Puerto México	Fed. Nº 57	71531
35. Matehuala – La Poza	State Nº 61	6068
36. Monclova – Estación Candela	State Nº 30	3923
37. Piedras Negras – Nuevo Laredo	Fed. Nº 2	25741
38. Saltillo – Monterrey	Fed. Nº 40	234311
39. Dirt roads within the state	—	No data

The state of Nuevo León connects directly to all important destinations of Mexico via federal roads, and to all its 51 municipalities via state roads. The most important roads are shown in Figure 1.

The geographic location of the state is a transition zone between Nearctic and Neotropical biogeographic divisions, giving the state a variety of ecosystems that have an enormous influences on distributional patterns of vertebrate groups (Anonymous, 2000). In the state of Nuevo León we can find some of the following vegetation types: *matorral desértico rosetófilo* [desert scrubland with succulents], *matorral submontano* [submontane scrub], pine and oak forests (Anonymous, 1994).

Federally protected areas account for 4.3% of the state's territory. These would be the following national parks: Cumbres in Allende, Monterrey, Santa Catarina, San Pedro Garza García, and Santiago (177,395 ha); El Sabinal in Cerralvo (8 ha); and Monumento Natural Cerro de la Silla in Guadalupe, Juarez and Monterrey (6,039 ha) (Arriaga et al., 2000). There are also 23 state protected areas with 57,387 ha (Anonymous, 2000), and a few in review. We presume that these protected ares 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, 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.

Materials and Methods

Specimens used here have been deposited in the preserved collection of the FCB/UANL. They were identified and electronically catalogued. We included the following information in the database: scientific classification (family, genus, species and subspecies), catalogue number, locality, municipality, state, coordinates, date collected, field number, collector(s), and specimen characteristics such as weight, length, sex and physical condition of the animal such as AOR or DOR. The electronic catalogue is an invaluable tool when it comes to detailing information on all specimens observed or collected. From here we proceeded to analyze our database looking for specimens that had been found on roads in conditions that we categorized as AOR or DOR.

Many of the road-collected specimens from throughout the state are due to the fact that since 1993 we have been involved in herpetological studies in various areas within the state, mainly mountainous areas. This has given us access to a good number of specimens as we commuted back and forth from these study sites. Unfortunately we have not had the opportunity to focus our attention on a particular federal or state road at a given time of year to determine the intensity of this phenomenon.

After locating the specimens that fell into the AOR and DOR categories, we extracted the locality information from the data base and used a map which is a combination of maps issued by

Table 2. Numbers of DOR specimens from various states of Mexico and the U.S. deposited in the FCB/UANL collection.

State	# of DORs
Chiapas	10
Chihuahua	2
Coahuila	21
Durango	4
Edo. de México	2
Guerrero	2
Jalisco	6
Louisiana	2
Morelos	2
Nuevo León	242
Oaxaca	7
San Luís Potosí	2
Sinaloa	3
Sonora	27
Tabasco	1
Tamaulipas	609
Texas	1
Veracruz	4
Yucatán	2
Zacatecas	2

the Secretaria de Comunicación y Transportes de México [SCT] (2007) and Guía Roji (2002 and 2007–2008) (see Figure 1 and Table 1). We emphasize that the SCT map used here is constantly changing its nomenclature from year to year: roads may change location or length, and may join with or be replaced by other roads. So pinpointing which road a specimen corresponded to, if it was a federal or state highway, was with the use of the 2007 map (Anonymous, 2007). From this we constructed a group of tables with number of the road, observed/collected species, numbers or frequency and whether AOR or DOR..

Results

The Universidad Autónoma de Nuevo León, Facultad de Ciencias Biológicas under its [UANL/FCB] has in its preserved collection a total of 7990 specimens corresponding to Caudata, Anura, Testudines and Serpentes. The collection was established in 1966, and continued growing with specimens mainly from Nuevo León, Tamaulipas and Coahuila. It stopped growth sometime in 1979. After 1993, with a reorganization, it initiated a new phase of continued growth, with help from faculty, students and projects.

Of the 7990 preserved specimens in the collection, 1794 corresponded to snakes,with 825 being from Nuevo León. Of the 825, a total of 710 were found on a road within the state (AOR = 468 and DOR = 242). And of these we could only pinpoint on the state road map 176 AOR and 126 DOR; the others were not used in this analysis.

Table 2 indicates the species and number of DORs collected per federal state (and two U.S. states as well) between 1993 and 2007. Tables 3 and 4 show the species and numbers of DORs and AORs observed/collected in the state of Nuevo León during this period.

Discussion

The most DORs were found on the Matehuala–La Poza road (State Road # 61), a total of 20, accounting for 15.9% of the total. Roads with similar frequencies were Ent. Huisachito–Nuevo Laredo (State Road # 1) with 11.1%, Monterrey–-Colombia (also part of State Road # 1) with 11.1% and dirt roads with 9.5%. The roads with the highest frequencies of live specimens were: Ciudad Victoria–Monterrey (Federal Road # 85) with 21.6%, Matehuala–La Poza (State Road # 61) with 10.2%, Monterrey–Colombia (State Road # 1) with 9.1%, Ent. Huisachito–Nuevo Laredo (also part of State Road # 1) with 8.5% and dirt roads with 6.8%.

Our roads present a gray–dark coloration; their exposure to the intense sun allows them to become excellent surfaces for snakes that are looking for a warm spot. But this has a negative effect on snake populations putting them in risk of being hit by cars more frequently as documented by Trombulak and Frissell (1999). Immobilization is often coupled with the snake flattening its body against the asphalt, which lends to an appearance of basking. Thermoregulation likely does occur in some situations (e.g., Bernardino and Dalrymple, 1992) but probably under low-traffic conditions or in desert locations where animals are accustomed to open landscapes.

Another factor known to affect herpetological activities is ambient temperature, but this changes with the seasons. In our region the months with the hottest temperatures and lowest relative humidities are May, June, July and August. Of these, May is sometimes considered the hottest; temperatures cool down only as the rainy season appears. Even though we didn't graph AORs and DORs by monthly frequency, in the hottest months herpetological activities seem to come to a halt. But moving across roads will increase as the rains appear and the temperature decreases (Lazcano et al., 2007).

In our data the species found most often was *Crotalus atrox* with 26 specimens (20.6%) of the total of DORs. Other species with high frequencies of DORs were *Rhinocheilus lecontei tessellatus* with 12 specimens (9.5%) and *Lampropeltis triangulum annulata* with 11 specimens (8.7%). The species most seen alive was *Crotalus atrox* with 27 specimens (15.3%) of the total of the AORs observed. This species in particular is distributed throughout the state from the northernmost municipality of Anahuac to the southernmost municipality Mier y Noriega. Other species frequently seen alive were *Lampropeltis triangulum annulata*, also with 27 specimens (15.3%), *Rhinocheilus lecontei tessellatus* with 14 specimens (8.0%), and *Elaphe* (=*Pantherophis*) *emoryi* with 13 individuals (7.4%).

Table 1 shows the average traffic volume per day for the year 2007 transiting various roads in Nuevo León. The roads with high traffic volume would be the most dangerous for any vertebrate or invertebrate to cross. These roads are where species must suffer high rates of mortality and are subject to fragmentation, and where insufficient numbers of individuals may successfully cross to maintain necessary population dynamics as documented by Andrews and Gibbons (2005). Furthermore; snakes are a maligned group of animals and are subject to the additional threat of intentional killing of individual snakes that

Table 3. List of taxa found DOR and the corresponding number of individuals found on each of 39 roads in the period (1993–2007). Scientific names based on Liner (2007).

	Road numbers (see Table 1)																																						
Taxon	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
Arizona elegans arenicola																				1																			
Crotalus atrox		4				2	1			2				1						1	2	2	1				4	2					2		1			1	
Crotalus lepidus (*lepidus* and *morulus*)																																			1				1
Crotalus molossus (*molossus* and *nigrescens*)																																							1
Crotalus pricei miquihuanus																																							1
Crotalus scutulatus scutulatus																																			3				
Drymarchon melanurus erebennus																																							
Drymobius margaritiferus margaritiferus																																							
Heterodon kennerlyi																																							
Hypsiglena torquata jani		4																									4								1				
Lampropeltis getula splendida							1							1										1														1	
Lampropeltis mexicana (*mexicana* and *thayeri*)																																			3				
Lampropeltis triangulum annulata		1				1	1							1								1	1	1			1	1					1					1	
Leptodeira septentrionalis septentrionalis	1																																						
Leptophis mexicanus																																							
Leptotyphlops myopicus myopicus		1																									1												
Coluberconstrictor oaxaca																																							
Coluber (=*Masticophis*) *flagellum testaceus*		1																									1								1				
Coluber (=*Masticophis*) *schotti ruthveni*																																			1				
Micrurus tener tener																																							
Nerodia rhombifer (*blanchardi* and *rhombifer*)						1																1	1					1					1						
Opheodrys aestivus																																							
Elaphe (=*Pantherophis*) *bairdi*																																							
Elaphe (=*Pantherophis*) *emoryi*						1	1							1						1		1	1	1				1					1		3			1	
Pituophis catenifer sayi						1				1												1	1					1					1						
Pituophis deppei (*jani* and *deppei*)																																			3				
Ramphotyphlops braminus																																							
Rhadinaea montana																																							2
Rhinocheilus lecontei tessellatus		3			1																						3			1		1			3				
Salvadora grahamiae lineata																																							1
Senticolis triaspis intermedia																																							
Sonora semiannulata semiannulata	1																																						
Storeria dekayi texana																																							3
Storeria hidalgoenesis																																							
Tantilla rubra																																							1
Thamnophis cyrtopsis cyrtopsis																																							1
Thamnophis exsul																																							1
Thamnophis marcianus marcianus										2										2																			
Thamnophis proximus diabolicus						1																1	1					1					1						
Trimorphodon tau tau																																							
Tropidodipsas sartorii sartorii																																							

attempt to cross roads. This has been documented by Langley et al. (1989), even to the extent where people feel happy about running over a snake.

We understand that DORs are catastrophic events to any vertebrate population, inflicting in many cases a loss to the genetic pool. Nevertheless, if collected and documented, DORs can be an excellent source of information such as distribution of the species, sizes, sex movements/activity and diet contents. This was the case with Lazcano et al. (2004), where they report on a DOR specimen of *Crotalus lepidus* found on a mountain road from Santiago to Laguna de Sanchez in the San Isidro Canyon. This snake was found completely flattened and matching the color of the road. Interestingly, it had in its mouth a *Sceloporus minor,* and this was the first time anyone reported this species of lizard as a food item for *C. lepidus.* This is just on example of what we can obtain from DOR specimens, which if not collected will just rot or consumed by scavengers.

In our analysis dirt roads are put together as a whole for the state. These are mainly those in mountainous areas. Our mountainous dirt roads, especially those in the area of Sierra Peña Nevada, have a very low volume of traffic. On occasion we wouldn't see another vehicle at all. But these roads still produced our rarest DORs: *Crotalus lepidus morulus* (1) and *Crotalus pricei miquihuanus* (1), very unfortunate creatures. Especially when their main activity here is restricted to the agave areas.

Conclusion

This article documents only an insignificant portion of what the DOR problem is for vertebrates in northeastern Mexico. We cannot halt human progress; roads constitute the basic backbone infrastructure for any nation that needs to move its goods within the country or export them. We have to look for more friendly transportation routes, that damage fauna and flora as little as possible, but it doesn't look like a solution is close. We're building wider roads, that will support a much more demanding transport system, making them impossible to cross. We think that fragmentation of populations by roads will continue and we

Table 4. List of taxa found AOR and the corresponding number of individuals found on each of 39 roads in the period (1993–2007). Scientific names based on Liner (2007).

	Road numbers (see Table 1)																																						
Taxon	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
Arizona elegans arenicola										1										1																			
Crotalus atrox		4				2	1			2				1						1		2	2	1		1	4	2					2		1			1	
Crotalus lepidus (*lepidus* and *morulus*)																																	3		1				1
Crotalus molossus (*molossus* and *nigrescens*)																1																							1
Crotalus pricei miquihuanus																																							1
Crotalus scutulatus scutulatus																																			3				
Drymarchon melanurus erebennus																																	1						
Drymobius margaritiferus margaritiferus																																							
Heterodon kennerlyi					1																																		
Hypsiglena torquata jani		4													1												4								1				
Lampropeltis getula splendida							1							1										1														1	
Lampropeltis mexicana																																			3				
Lampropeltis triangulum annulata		1				1	1					1		1								1	1	1			1	1					1					1	
Leptodeira septentrionalis septentrionalis	1																																5						
Leptophis mexicanus												2															1												
Leptotyphlops myopicus myopicus		1																									1												
Coluber constrictor oaxaca																																	2						
Coluber (=*Masticophis*) *flagellum testaceus*		1													1												1								1				
Coluber (=*Masticophis*) *schotti ruthveni*																1																			1				
Micrurus tener tener																																	1						
Nerodia rhombifer (*blanchardi* and *rhombifer*)		1																									1												
Opheodrys aestivus																																							
Elaphe (=*Pantherophis*) *bairdi*																																	8						
Elaphe (=*Pantherophis*) *emoryi*						1	1							1						1		2	1	1				1					1		2			1	
Pituophis catenifer sayi						1				1												1	1					1					1						
Pituophis deppei (*jani* and *deppei*)																																		1	2				
Ramphotyphlops braminus																																							
Rhadinaea montana													2																				4						2
Rhinocheilus lecontei tessellatus		3		2	1																						3			1		1			3				
Salvadora grahamiae lineata																																	1	3					1
Senticolis triaspis intermedia																																							
Sonora semiannulata semiannulata	1																																					1	
Storeria hidalgoensis																																	1						3
Tantilla rubra															1																		2						1
Thamnophis cyrtopsis cyrtopsis																																	1						1
Thamnophis exsul																																							1
Thamnophis marcianus marcianus										2										2																			
Thamnophis proximus diabolicus						1																1	1					1					1						
Trimorphodon tau tau																													1				1						
Tropidodipsas sartorii sartorii																																	2						

need to pay attention to the consequences of this. We hope that article will inspire more Mexican herpetologists to document this phenomenon throughout the country, perhaps in smaller sections.

Acknowledgments

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Literature Cited

Andrews, K. M., and J. W. Gibbons. 2005. How do highways influence snake movement? Behavioral responses to roads and vehicles. Copeia 2005(4):772-782.

Anonymous. 1994. Propuesta para la redelimitación del Parque Nacional Cumbres de Monterrey. UANL, SEDUOP, ITESM. p. 154.

Anonymous. 2000. Decretos de áreas naturales del estado de Nuevo León, México. Secretaria de Ecología y Recursos Naturales. Periódico Oficial 2000..

Anonymous. 2007. INEGI. http://dgst.sct.gob.mx/fileadmin/viales_2007/19_NL.pdf

Aresco, M. J. 2005. The effect of sex-specific terrestrial movements and roads on the sex ratio of freshwater turtles. Biological Conservation 123:37-44.