VEHICLE COLLISIONS WITH WILD FAUNA ON THE TWO ROADS THAT PASS THROUGH THE MONTES DE MARÍA, SUCRE, COLOMBIA

ATROPELLAMIENTO DE FAUNA SILVESTRE EN LAS DOS VÍAS QUE CIRCUNDAN LOS MONTES DE MARÍA, SUCRE, COLOMBIA

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ABSTRACT

The present study aimed to identify and quantify the wild fauna that is struck by vehicles on the two principal roads that run through the Montes de María in the department of Sucre, Colombia. This study addressed some of the environmental problems that are affecting the dry tropical forest area that is still found in this Caribbean zone of Colombia. Between October of 2011 and March of 2012, encompassing the dry and the rainy seasons, on the roads between Sincelejo – San Onofre and between Sincelejo – Ovejas, 608 vehicle-struck or "road-kill" specimens were collected, which were identified to the extent possible (order, family, genus, species). A Fisher test and analysis of variance were used to analyze the data. The vehicle-struck fauna were found on the principal roads that run through the Montes de María in the department of Sucre in this study and had notable representation from the following: amphibians (*Rhinella marina, Leptodactylus bolivianus, Scinax* sp.); reptiles (*Leptodeira septentrionalis, Pseudoboa neuwiedii*, *Epicrates cenchria, Oxyrhopus petola, iguana iguana, Kinosternon scorpioides, Trachemys callisrostris*); and mammals (*Didelphis marsupialis, Tamandua mexicana, Cerdocyon thous*), with a total of 253, 219 and 111 specimens, respectively. The dry season had more vehicle-struck specimens, with a high percentage seen on both roads, which may have been related to the scarcity of food in this season, forcing the animals to travel longer distances and cross the roads.

Key words: Collisions, native fauna, dry forest, Caribbean, Sucre.

RESUMEN

El objetivo del presente trabajo fue identificar y cuantificar la fauna silvestre atropellada en las dos principales vías que rodean los Montes de María, en el departamento de Sucre, Colombia. Este estudio aborda parte de la problemática ambiental que afecta la zona circundante del bosque seco tropical, que aún persiste en esta zona del Caribe colombiano. Entre octubre de 2011 y marzo de 2012, época de lluvia y de sequía en las vías: Sincelejo–San Onofre y Sincelejo–Ovejas, se recolectaron 608 especímenes atropellados; a los especímenes colectados, se les realizó la identificación, hasta donde fue posible (orden, familia, genero, especie). Para el análisis de datos, se aplicó el test de Fisher y análisis de varianza. Entre la fauna silvestre atropellada, que mayormente prevaleció en las principales vías que rodean los Montes de María, en el departamento de Sucre, durante las épocas de lluvias y sequía, se destacan: anfibios (*Rhinella marina, Leptodactylus bolivianus, Scinax* sp.); reptiles (*Leptodeira septentrionalis, Pseudoboa neuwiedii*, *Epicrates cenchria, Oxyrhopus petola, iguana iguana, Kinosternon scorpioides, Trachemys callisrostris*) y mamíferos (*Didelphis marsupialis, Tamandua mexicana, Cerdocyon thous*), con un total de 253, 219 y 111 especímenes, respectivamente. La época, que tuvo mayor prevalencia de atropellamientos, fue la de sequía. El alto porcentaje de atropellamientos evidenciado en la época de seca –para ambas vías-, se puede relacionar con la escasez de alimento, ya que los animales se ven obligados a recorrer mayores distancias exponiéndose a la carretera.

Palabras clave: Colisión, fauna nativa, bosque seco, Caribe, Sucre.

INTRODUCTION

Road networks are vital to the socioeconomic development of regions because they allow for improvements in the quality of life of local inhabitants, facilitate the transport of people, and are used to carry products to market (Arroyave *et al.* 2006). However, roads also impact the ecology of the areas they pass through; for example, they alter the hydric cycle, increase the production of particulate material and noise, decrease the population of flora and fauna, create microclimate changes, and contaminate the soil and water (Arroyave *et al.* 2006; Messmer *et al.* 2008). Furthermore, roads can isolate and fragment the habitat of diverse populations of plants and animals, the latter of which must cross these roads, which increases the probability that they will be struck by a vehicle (Messmer *et al.* 2008).

Several studies that have been conducted in South America, Europe, and the United States have revealed disturbing data for the number of vehicle-struck animals and the threat that this situation represents for some species that are in danger of extinction (Aresco, 2005; Rosa & Mahus, 2005; Gumier & Sperber, 2009). Studies carried out by Pinowski (2005) indicated that there are patterns for vehicle-struck animals that are related to the type of vegetation, climatic conditions, and the behavior of these species, with a high incidence of vehicle strikes in opossums (*Didelphis marsupialis)*, foxes (*Cerdocyon thous)* and various snake species, among others.

It has been documented that vehicle strikes with wild fauna occur in relation to climatic periods because they coincide with reproduction periods and the low availability of food, which increase the probability that animals will cross roads, thereby generating higher probabilities for vehicle strikes, a grave situation for species that are endangered or that have a restricted distribution (Erritzoe *et al.* 2004; Langley *et al.* 2006; Ramp *et al.* 2006; Glista *et al.* 2009). The rapid development of cities and increases in human populations have increased road networks, giving rise to a new cause of animal mortality that has become an increasingly greater threat for the affected species (Arroyave *et al.* 2006).

All roads, in addition to facilitating transport, commerce, and development, affect terrestrial and aquatic ecosystems in the following ways: a) they increase the mortality of organisms when constructed and the mortality of animals that are commonly struck on the roads; b) alter animal behavior; c) change the chemical makeup of the environment and d) serve as a corridor for the dispersion of foreign species and increase the alteration or use of natural habitats by humans (Trombulak & Frissell, 2000). Cupul (2002) described certain patterns of seasonal behavior, such as courtship, migration, reproduction, mating, abundance of animals, and the search for food, among others, that make it possible for there to be a higher or lower quantity of dead animals on roads in determined periods of the year.

In Colombia, there have been few studies that have measured the frequency of vehicle strikes on roads (Arroyave *et al*. 2006; Delgado, 2007; Vargas-Salinas *et al*. 2011), usually there are only journalistic reports. It is clear that vehicle strikes decrease the population of wild fauna, interfere with the flow of genetics and trophics, and debilitate the natural system, factors that lead to local extinction over time (Gumier & Sperber, 2009). The present study allowed for the comparative identification and quantification of the mortality of wild fauna that results from vehicle strikes on the two principal roads that pass through the Montes de María, Sucre, Colombia: between Sincelejo–San Onofre and between Sincelejo–Ovejas.

MATERIALS AND METHODS

Study area: Two roads in the department of Sucre, Colombia were studied. One of the roads is a principal western artery between the points: 9°15´36´´ N and 75°24´12´´W - 9°31´55´´N and 75°13´14´´W and connects the populations of Sincelejo and Ovejas, and the other road is a branch from the western artery between the points: 9°15´36´´N and 75°24´12´´W - 9°52´19´´N and 75°23´08´´W and connects the city of Sincelejo to the village of San Onofre. Neither road has illumination on the majority of their routes. They have an average width of 8m and are relatively flat. Both of the studied sections are paved and lack signs or infrastructure for the protection of the wild fauna (Figure 1).

Method: Between October of 2011 and March of 2012, which included a dry season and a rainy season, simultaneous and continuous samples of vehicle-struck fauna were taken. The paved roads included 62.71km between Sincelejo and San Onofre and 36.59km between Sincelejo and Ovejas. The protocol established by Hawbaker & Radeloff (2004), Arroyave *et al.* (2006), Coffin (2007), and Gumier & Sperber (2009), was followed.

The tasks included: placing six observers along the roads, three per section, who visually searched for animals found on the road and the shoulder during the hours of Monday to Saturday from 5 am to 9am, traveling at an average speed of 15km/h on motorcycles; the collected specimens were photographed and geo-referenced for location; subsequently, they were taken to the wild fauna office, Fauna Silvestre de CARSUCRE, where they were identified taxonomically; the following toll booths were used to count the vehicles and quantify the traffic volumes: la Esperanza, located in the municipality of Toluviejo (road between Sincelejo - San Onofre); and Las Flores, located in the municipality of Corozal (road between Sincelejo - Ovejas).

Figure 1. Study zone. 1= Sincelejo-Ovejas, 2= Sincelejo-San Onofre (Google Earth, free version).

For each collection, when the conditions allowed it, the sex and maturity stage were identified. Depending on the state they were found in, the samples were systematically identified as much as possible. For the analysis of the data, a Fisher test and analysis of variance with confidence intervals of 95% were applied (Zar, 1999).

RESULTS AND DISCUSSION

Table 1 contains a list of the vehicle-struck species by road. The majority of the vehicle-struck species was found on the Sincelejo – Ovejas road, rather than the Sincelejo - San Onofre road. Table 2 shows the percentages of vehicle-struck animals by taxon during the two seasons of the year, independent of the sampled road, and table 3 presents the percentage of vehicle-struck fauna by taxon for each of the studied roads.

For the herpetofauna, on both roads, the dry season months (February and March) presented the higher number of vehicle-struck specimens; however, in the dry season, the Sincelejo – Ovejas road had the highest number in November and the Sincelejo – San Onofre road had the highest number in October. For birds, especially on the Sincelejo – Ovejas road, the collisions increased in November, at the end of the rainy season, and, between January and February, during the dry season. For mammals, on both roads, the vehicle strikes increased in the rainy season and decreased on both roads in the dry season; the vehicle strikes increased as the rainy season progressed and the decrease in the measurements was more intense in the dry season.

In general, the herpetofauna was the taxonomic group that suffered the most vehicle strikes, which agreed with the results of Ramo & Busto (1986), Grosselet *et al*. (2008) and Seijas *et al*. (2013). Among the herpetofauna, when analyzing the list of vehicle-struck species, the amphibians presented a numeric value that contrasted with the low relative diversity that this group possesses in this region (Acosta-Galvis *et al*. 1999), with 18 species in the department of Sucre (Lynch *et al*. 1997; Lynch & Suarez, 2001).

In the present study, although the amphibians were the group with the highest volume of vehicle strikes, only three species were identified: *Rhinella marina, Leptodactylus bolivianus and Scinax* sp, which may have been related to feeding patterns. For example, *Rhinella marina* has a diet with a high content of terrestrial insects, which are abundant in open areas with deposits of organic plant material and land depressions that form small ponds, as seen on the shoulders of the roads and as seen with other vertebrates (Waide, 1991). Likewise, mobility was a factor; the amphibian species with

Table 1. List of all of the species of the vehicle-struck wild fauna on the Sincelejo – Ovejas and Sincelejo –San Onofre roads. The IUCN category status is included (International Union for the Conservation of Nature) (2010): NE= Not evaluated; LC= Low concern; NT= Threatened; VU= Vulnerable.

Taxon	Species	Common name	Status	Roads		Total
				Sincelejo-Ovejas	Sincelejo-San Onofre	
Amphibians	*Rhinella marina*	Sapo Común	LC	133	76	**209**
	Scinax sp.	Rana		1	0	**1**
	Leptodactylus bolivianus	Saltona	LC	5	2	**7**
	Non identified Amphibians.			11	25	**36**
	Total Amphibians			**150**	**103**	**253**
Reptiles	*Boa constrictor*	Boa	NE	2	2	**4**
	Bothrox asper	Mapaná	NE	1	1	**2**
	Chironius carinatus	Cazadora	NE	3	2	**5**
	Clelia clelia	Bibora	NE	0	1	**1**
	Epicrates cenchria	Candelilla	NE	2	14	**16**
	Helicops danieli	Mapaná de Agua	NE	2	7	**9**
	Imantodes cenchoa	Bejuquillo	NE	7	9	**16**
	Leptodeira ahaetulla	Bejuquillo	NE	0	0	**0**
	Leptodeira annulata	Coral	NE	3	2	**5**
	Leptodeira septentrionalis	Ojo de gato	NE	22	32	**54**
	Leptodeira sp.	Bejuquillo	NE	1	0	**1**
	Liophis lineatus	Guarda Camino	NE	1	8	**9**
	Liophis melanotus	Guarda Camino	NE	1	1	**2**
	Liophis sp.	Coral		1	0	**1**
	Mastigodrias pleei	Cazadora	NE	1	0	**1**
	Micrurus sp.	Coral	NE	0	2	**2**
	Oxyrhopus petola	Gargantilla	NE	2	8	**10**
	Phimophis guianensis	Culebrita	NE	7	1	**8**
	Pseudoboa neuwiedii	Coralito	NE	10	6	**16**
	Spilotes pullatus	Cazadora	NE	1	0	**1**
	Caiman crocodilus	Babilla	LC	0	1	**1**
	Iguana iguana	Iguana	LC	7	7	**14**
	Kinosternon escorpioides	Tapa Culo	LC	4	11	**15**
	Trachemys callirostris	Hicotea	VU	1	1	**2**
	Non identified snakes			10	14	**24**
	Total Reptiles			**89**	**130**	**219**
Birds	*Buteo magnirostris*	Gavilán	LC	4	2	**6**
	Buteo nitidus	Gavilán	LC	1	0	**1**
	Buteo sp.	Gavilán		0	1	**1**
	Campilorhynchus griseus	Chupa huevo	LC	3	0	**3**

Continuation Table 1.

	Cathartes aura	Laura	LC	1	0	**1**
	Columba domestica	Paloma		0	1	**1**
	Coragyps atratus	Golero	LC	1	0	**1**
	Milvago chimachima	Pigua	LC	1	2	**3**
	Pitangus sulphuratus	Chicha Fria	LC	1	0	**1**
	Thraupis episcopus	Azulejo	LC	3	1	**4**
	Tyrannus melancholicus	Garrochero	LC	1	0	**1**
	Non identified Birds			2	0	**2**
	Total birds			**18**	**7**	**25**
Mammals	*Cerdocyon thous*	Zorra Perro	LC	5	*43*	**48**
	Conepatus semistriatus	Zorrillo	LC	1	0	**1**
	Didelphis marsupialis	Zorra Chucha	LC	41	3	**44**
	Puma yagoarundi	Gato pardo	LC	1	0	**1**
	Rattus sp.	Rata		2	2	**4**
	Speothos venaticus	Perro de Monte	NT	0	1	**1**
	Sylvilagus floridanus	Conejo	LC	0	1	**1**
	Tamandua mexicana	Oso Hormiguero	LC	3	1	**4**
	Non identified mammals			4	3	**7**
	Total Mammals			**57**	**54**	**111**
	Total specimens			**314**	**294**	**608**

Table 2. Vehicle-struck wild fauna by taxon, according to the season and independent of the road.

Season	**Amphibians**		**Reptiles**		**Birds**		**Mammals**		**Total**	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Rainy	82	13,5	101	16,6	10	1,6	46	7,6	239	39,3
Dry	171	28,1	118	19,4	15	2,5	65	10,7	369	60,7
Total	253	41,6	219	36,0	25	4,1	111	18,3	608	100

Table 3. Vehicle-struck wild fauna by taxon on the two roads that pass through the Montes de María in the department of Sucre, Colombia.

Roads	**Amphibians**		**Reptiles**		**Birds**		**Mammals**		**Total**	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Sincelejo-Ovejas	150	24,7	89	14,6	18	3,0	57	9,4	314	51,6
Sincelejo-San Onofre	103	16,9	130	21,4	7	1,1	54	8,9	294	48,4
Total	253	41,6	219	36,0	25	4,1	111	18,3	608	100

the most vehicle strikes had a low range of movements and had terrestrial habits. The high percentage of strikes could be attributable to their vagility and opportunistic behavior and their use of the roads as a travel corridor (Vargas-Salinas *et al*. 2011).

When looking at the struck species by taxon, *Rhinella marina* had the highest position, both for its group and for all of the vehicle-struck fauna; this species has been reported as the most vehicle-struck species on Neotropical roads (Becerril-Morales, 2001; Vargas-Salinas *et al*. 2011; Omena-Junior *et al*. 2012). The vehicle strikes could be favored by the border effect (Kattan, 2002) because a species that colonizes borders is generally attracted to the favorability of barriers and changes in the trophic dynamic of a system, which increase the population of the species and, therefore, its exposure to the effects of roads.

For birds, it was observed that they were mostly opportunistic with scavenger characteristics, which made them more susceptible to vehicle strikes due to their foraging behavior (Arroyave *et al.* 2006). Of the birds, the scavengers Cathartidae and Falconidae suffered vehicle strikes because they were attracted to the roads in order to consume the dead animals found there (Noss, 2002); in addition, they were attracted by the organic waste left on the roads, which provided a opportunistic food source for them (Cupul, 2002).

For the insectivore mammal species, such as *Tamandua mexicana*, their presence among the vehicle-struck species was attributed to their formicivorous diets and to their possible increase in roadside foraging. In these open spaces, there is an increase in the accumulation of organic matter from weeds and litterfall, which results in an elevated presence of invertebrates, as indicated by Waide (1991).

Cerdocyon thous, in this study, had the highest number of vehicle strikes among the mammals and ranked third overall (Delgado, 2007). This species has a broad and opportunistic diet, making it a carnivorous scavenger (Vieira, 1996). Individuals of this species are frequently observed on the roads and it is one of the species with a higher number of vehicle-strike deaths in some low-lying areas of South America (Pinowski, 2005), as was seen in the present study.

Didelphis marsupialis, the mammal species with the second highest number of vehicle strikes, is an omnivore with opportunistic feeding habits. It has been recorded as a commonly vehicle-struck species on the roads of Antioquia, Colombia (Delgado, 2007); the high frequency of collisions could be related to its abundance (Delgado, 2007). This species has also been identified as the most vehicle-struck species for the fauna found on a road in the Amazon of Brazil (Omena-Junior *et al*. 2012). According to Pinowski (2005), *D. marsupialis* is also frequently struck in low-lying areas, as seen in the present study.

The results of this study, in which the herpetofauna was the fauna with the most vehicle strikes, differed from findings for Brazil in which: the Br-262 road in Mato Grosso do Sul and the BR-174 road in the Amazon, on which mammals had the highest representation, followed by birds, and amphibians and reptiles had low numbers (Lima, 2012; Omena-Junior *et al*. 2012). However, these results agreed with those of Grosselet *et al.* (2008) for Tehuantepec, México. The fact that the reptiles belonged to the group with the most vehicle strikes agreed with the studies conducted by Seijas*et al*. (2013) and Ramo & Busto (1986) for Venezuela and were similar to the results of studies conducted by Vargas-Salinas *et al*. (2011) in Colombia.

The adjacent habitats and the ecological formation of the roads influence the probability of vehicle strikes for determined zoological groups and also play an important role in the conservation of the existing plant matrix as well as the fundamental aspects of the distribution of the species and their population attributes. Furthermore, the collection schedule demonstrated that most of the samples came from nocturnal animals, which may suffer vehicle strikes due to the effect of headlight glare.

The analysis of variance confirmed that the factors of season and animal (taxon) had a statistically significant effect on the number of vehicle-struck animals and the road factor was statistically significant. On the other hand, the interactions: season x animal class, season x road, road x animal class, and season x road x animal class, were not statistically significant (Table 4).

For the vehicle-struck animals by taxon, the Fisher test demonstrated that there was a statistically significant difference between the means of vehicle-struck animals by taxon: birds, herpetofauna and mammals, with the herpetofauna being the animal class that suffered the most vehicle strikes (Table 5).

The season influenced the vehicle strikes; in this case, there were statistically significant differences, with more collisions in the dry season. Furthermore, the climatic factors influenced the availability of food and the reproductive period, which in turn influenced the number of vehicle strikes (Grosselet *et al.* 2008); similarly, foliage cover is related to the season, where the end of the rainy season and the start of the dry season see a higher production of wild fruits; the phenological periods also notably affect the composition, structure, and dynamic of ecosystems (Quigley & Platt, 2003). For Venezuela, Seijas *et al.* (2013) found that the transitional months between the dry season and the rainy season show a higher frequency

Table 4. Analysis of variance for the number of vehicle-struck animals, considering three fixed factors: season, road, animal class.

Factors	SS	DF	MS	F	p-level
Main effects					
A:Season	**513,778**	**1**	**513,778**	**5,74**	0,0247
B:Road	9,0	1	9,0	0,10	0,7539
C:Taxon	**9271,5**	**2**	**4635,75**	**51,81**	0,0000
Interactions					
AB	53,7778	1	53,7778	0,60	0,4457
AC	487,389	2	243,694	2,72	0,0859
BC	5,16667	2	2,58333	0,03	0,9716
ABC	19,0556	2	9,52778	0,11	0,8994
Residuals	2147,33	24	89,4722		
Total	12507,0	35			

Table 5. Means estimated with squared minimums for the number of vehicle-struck animals by animal class with confidence intervals of 95.0%.

Level	Cases	Media	Error Est.	Low limit	Upper limit
Global media	36	17,1667			
Animal class (Taxon)					
Birds	12	2,16667	2,73057	-3,46897	7,8023
Herpetofauna	12	39,4167	2,73057	33,781	45,0523
Mammals	12	9,91667	2,73057	4,28103	15,5523

of vehicle strikes, while Omena-Junior *et al*. (2012) did not find significant differences between rainfall and vehicle strikes throughout the year, which was attributable to the environmental characteristics of the studied zone, a tropical wet Amazon forest with abundant hydric resources year-round.

A traffic flow of 10,217 vehicles /day was seen on the Sincelejo - Ovejas road and 1,543 vehicles/day on the Sincelejo - San Onofre road; the number of vehicles that passed over the two roads had significant differences (p=0.049), but there were no significant differences between the two roads in terms of the number of vehicle strikes for the number of vehicles that passed over the road (p=0.7450).

Seiler (2003) proposed a model that has an indicator, Mean Daily Traffic (MDT), that points to a relatively low mortality when it is low, ≤ 2,500 per day, and to a high mortality when it is average, between 2,500 and 10,000. The results of the present study did not agree with those of Seiler (2003) because when using the Mean Daily Traffic to compare the two roads, the vehicle strikes did not have significant differences, although there was a significant difference in the number of vehicles that passed over each road/day.

It is important to mention that these results probably underestimated the dimension of the problem considering the fact that the scavenger birds, as well as the mammals, humans, and traffic flow may have displaced the carcasses (Grosselet *et al*. 2008). Not all of the vehicle-struck individuals were detected; some were not visible on the road because the collision may have knocked them from the road or injured them, after which they would have left the road; therefore, the actual mortality could be much higher (Bafaluy, 2000). The mortality of the fauna in the roads could be affecting the faunal species because the application of protection measures that would minimize the impact are difficult to implement, as is raising awareness in people of the damage that can be caused by their vehicles, especially when driven inappropriately (Bafaluy, 2000; Clevenger *et al*. 2003; Taylor & Goldingay, 2004).

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