

SEÇÃO — BIODIVERSIDADE, ESPÉCIES AMEAÇADAS E SUSTENTABILIDADE
NO ESTADO DO PARANÁ (EM DEBATE)

Road kills impact
over the herpetofauna of Atlantic Forest
(PR-340, Antonina, Paraná)
Impacto dos atropelamentos
sobre a herpetofauna da Floresta Atlântica
(PR-340, Antonina, Paraná)

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The damage caused by vehicles on wild animals is a reason for the concern of the researchers. Most of the studies on this matter evaluated the road kills rate on wild vertebrates, mainly seeking for mammal movements (REED *et al.*, 1982; MCLELLAN & SHACKLETON, 1988; SWIHART & SLADE, 1984; BELLIS & GRAVES, 1971; VIEIRA, 1996).

Studies aiming on herpetofauna are rare, but there are studies about amphibians and reptiles, mainly carried through in North America (BERNARDINO & DALRYMPLE, 1992; DODD *et al.*, 1989), Europe (LIZANA, 1991; CARRETERO & ROSELL, 2000) and Australia (KOENIG *et al.*, 2002). Researches over this subject were also carried through in Venezuela (RODDA, 1990; PINOWSKI, 2005) and in a few points of the Brazilian highways (CÂNDIDO-JR *et al.*, 2002; RODRIGUES *et al.*, 2002).

Among the problems caused to fauna due to road placements, the amphibian population decrease (FAHRIG *et al.*, 1995, HELS & BUCHWALD, 2001) and the isolation of the population of small mammals (OXLEY *et al.*, 1974; GARLAND & BRADLEY, 1984, RICHARDSON *et al.*, 1997) have been documented. The conservation and protection areas are used as shelter by several species and, because of that, placing roads nearby these areas would bring disastrous consequences.

The motivation of this study was the amphibians and reptiles deaths caused by vehicles, mainly in Reserva Natural Morro da Mina Conservation Area (Paraná, south of Brazil). The study was carried through aiming to discover the affected species, the daily periods, part of the road where most road kills occurs, and suggest measures to decrease the prejudice caused to the local herpetofauna, encouraging similar actions throughout the country.

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MATERIAL AND METHODS

STUDY AREA

From the third to the eleventh kilometer of PR-340, paved road located in Antonina, north littoral of Paraná, in the limit region of the APA of Guaraqueçaba, southern Brazil (Fig. 1). The road covers twenty eight kilometers from Trevo do Quatro until Cachoeira de Cima, and, from this point on, the road is called PR-405 and is unpaved for eighty kilometers all the way to the city of Guaraqueçaba. Along PR-340 there are Conservation Areas, such as, Reserva Natural Morro da Mina ($25^{\circ}22' S$; $48^{\circ}46' W$), between the seventh and the ninth kilometer.

This road is about five meters wide and has no side path. The first six and a half kilometers are winding, but the rest of the road is straight up to the crossing with PR-405, allowing speeding. Tourism causes heavy traffic in this road, which is the only access to Guaraqueçaba. However, a large number of government and non-government vehicles that patrolling APA or heading to Guaraqueçaba, also run along this road. Houses, small holds and bathers can be found along this road that also heads to Governador Parigot de Souza Hydroelectric Power Plant in Bairro Alto. According to Cacatu Forestry police station, located one kilometer from Reserva Natural Morro da Mina, the average car/day on PR-340 is 70 cars/day, during the high season and 50 cars/day on the rest of the year. This number generally increases during weekends and include night rides.

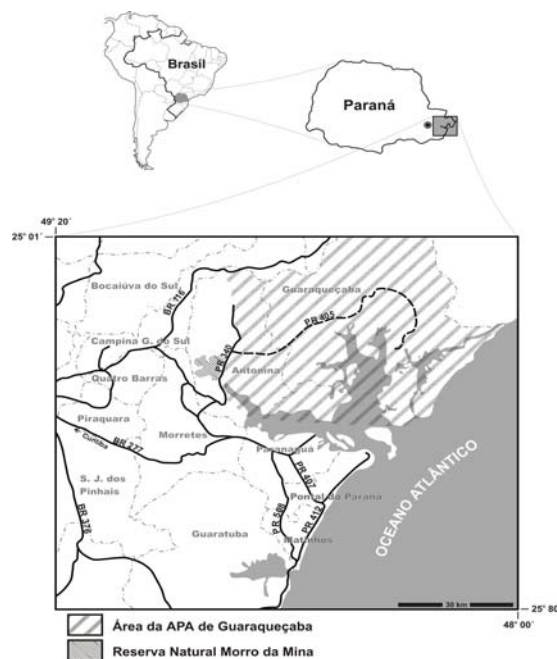


Fig. 1. Geographic location of PR-340 and Reserva Natural Morro da Mina conservation area, Antonina municipality, Paraná State, Atlantic Forest (southern Brazil).

SAMPLING

From October 2003 to April 2004 four field sampling trips were accomplished each week. The road was covered partly on foot, and partly by bike or by car, preferentially at 06:00 a.m., at noon and at 06:00 p.m., completing three hour of sampling each day. Anuran amphibians and reptiles found dead were collected. Dates, times and the place were also considered. The average number of amphibians and reptiles road kills was measured within the period of study. Based on that study a total number of deaths for 30 days have been estimated.

Individuals with minor damages were measured with a ruler, sexed, prepared with 10% formalin, conserved in alcohol 70% and identified at the lowest taxonomic category possible. When facing an advanced damaged level the samples were counted and discharged. The digestive content of snakes were analyzed, and reference species were deposited on Herpetological Collection of Museu de Ciências Naturais da Universidade Federal do Paraná in Curitiba (amphibians MCN UFPR 268, 270-276, 367-372 and reptiles MCN UFPR 174, 185, 190-196, 199-202).

In certain situations mammals and birds were seen while catching and feeding themselves with dead amphibians and reptiles on the road. Binoculars were used to determine necrophagous and carcasses. Although night collecting was not done, we registered vocal activity and breeding of anurans at the edges of the road to determine the species that were more exposed to road kills. Help from park rangers, forestry technicians from Reserva Natural Morro da Mina and local residents was essential on the results.

RESULTS AND DISCUSSION

FREQUENCY OF ROAD KILLS PER TAXON

Among anurans, the most representative families were Leptodactylidae (49%), Hylidae (37%) and Bufonidae (14%). From the recorded species, 23 young *Leptodactylus cf. ocellatus* (Linnaeus, 1758) were found dead, during January 2004 (Tabela 1).

These species breed between September and February in some Atlantic areas (e.g. BERTOLUCI, 2001). In the littoral of Paraná these species breed between September and March and individuals newly metamorphosed are usually found looking for shelter or food. Within the area of study the majority of anurans road kills showed full stomach, what implies on foraging activity. This means that road impact is more intense during reproduction period, and mainly on young individuals.

Among the reptiles, the highest road kills rate refers to snakes of the Colubridae family (79%). The rest was represented by lizards from Teiidae (13%), Polychrotidae (4%) and Anguidae (4%). The mentioned species seemed to be common in the region, except for the malacophagous snake *Dipsas indica petersi* (Hoge & Romano, 1975). However, besides being hardly sighted along their distribution area, many specimens of this snake species were found by ALVES e ARGÔLO (1998) in the south of Bahia. These species have nocturnal activity and can be found active on the ground or in the vegetation (SAZIMA, 1989; MARQUES *et al.*, 2001). Two individuals were collected on the road during the morning in December 2003 and supposedly were killed in the road during night activity.

FREQUENCY OF ROAD KILLS PER TIME

All the dead anuran amphibians were found between 06:00 a.m. and 07:00 a.m., considering their nocturnal activity the most likely dead time occurred between 06:00 p.m. and 07:00 a.m. Although night traffic was not rated, the traffic is more intensive between the first hours of the day and the late afternoon.

Tabela 1. Amphibians and reptiles road kills between the third and the eleventh kilometer on PR-340, Antonina municipality, Paraná State, Atlantic Forest, South of Brazil.

TAXA	NUMBER SAMPLES
AMPHIBIA	51
BUFONIDAE	
Bufonidae undetermined	2
<i>Chaunus</i> sp.	5
HYLIDAE	
Hylidae undetermined	4
<i>Hypsiboas albomarginatus</i>	2
<i>Hypsiboas faber</i>	1
<i>Hypsiboas semilineatus</i>	2
<i>Scinax alter</i>	6
<i>Scinax perereca</i>	1
<i>Scinax</i> sp.	3
LEPTODACTYLIDAE	
Leptodactylidae indeterminado	1
<i>Leptodactylus ocellatus</i>	23
<i>Leptodactylus notoaktites</i>	1
REPTILIA	23
COLUBRIDAE	
<i>Chironius exoletus</i>	2
<i>Chironius laevicollis</i>	2
<i>Chironius</i> sp.	1
<i>Dipsas indica petersi</i>	2
<i>Erythrolamprus aesculapii</i>	4
<i>Liophis miliaris</i>	3
<i>Sibynomorphus neuwiedii</i>	3
<i>Spilotes pullatus</i>	1
ANGUIDAE	
<i>Ophiodes fragilis</i>	1
POLYCHROTIDAE	
<i>Enyalius iheringii</i>	1
TEIIDAE	
<i>Tupinambis merianae</i>	3

Out of 23 reptiles collected, the highest rate (78%) corresponds to species that are active at day time and that were found during the day. Such as *Chironius exoletus* snake (Linnaeus, 1758), with diurnal activity and a diet based on anuran amphibians (SAZIMA & HADDAD, 1992). Two individuals of this species were found dead and had fragments of an unidentified anuran amphibian in their stomach; one also had a *Dendropsophus elegans* (Wied-Neuwied, 1824). This

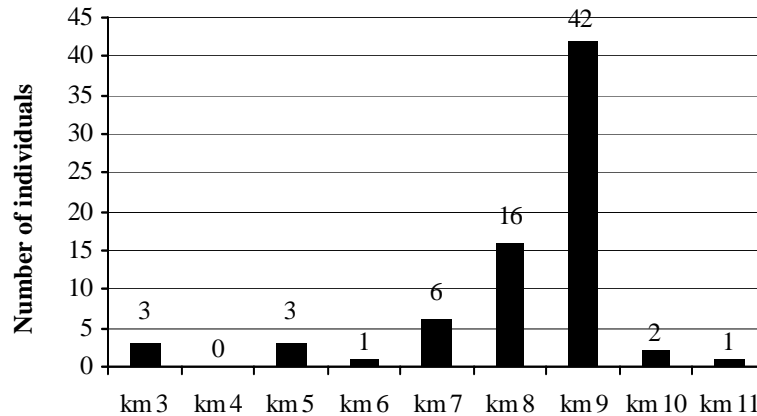


Fig. 2. Anuran amphibians and reptiles road kills between the third and the eleventh kilometer on PR-340 (n=74). Seventh to ninth kilometer correspond to Reserva Natural Morro da Mina Conservation Area.

specie of hylid frog occupies open environment at the edges of the road and also establishes some resting sites over the bushes. Probably the road kills of *Chironius exoletus* had occurred during foraging movements among these microhabitats.

The 22% left refer to nocturnal activity species – *Dipsas indica petersi* and *Sibynomorphus newwiedii* (Ihering, 1810) – that were collected from the road in the early morning hours (06:00 a.m.). Besides these, *Liophis miliaris* (Linnaeus, 1758) was collected by morning and have been killed probably in the beginning of the active period or at night, because this species can also be active at night (SAZIMA & HADDAD, 1992).

Among the lizards we verified that *Tupinambis merianae* (Duméril & Bibron, 1839) frequently settles on PR-340 edges for foraging, and uses bushes as shelter at the hottest period of the day. On the unpaved PR-405 road extension, young and adults from the same species are easily sighted in the middle of the road warming themselves and consequently, more vulnerable to vehicles.

In general, anuran amphibians and small reptiles were road killed or eaten by necrophagous animals, early in the morning. In two situations we observed a *Milvago chimachima* (Vieillot, 1816), collecting carcasses of snakes *Liophis miliaris* and *Chironius* spp. from the road, and a crab-eating fox *Cerdocyon thous* (Linnaeus, 1776), feeding of an amphibian on the road, possibly a *Leptodactylus ocellatus*. We emphasize that birds and mainly mammals with necrophagous habit, can also become vulnerable when searching for food on

the road. This fact was already mentioned by OXLEY *et al.* (1974) in a study involving small and medium sized mammals.

FREQUENCY OF ROAD KILLS PER KILOMETER

The highest frequency of amphibians and reptiles dead by road kills were found between the seventh and ninth kilometer, which correspond to a part of the road that pass through the Reserva Natural Morro da Mina (Fig. 2).

The average of dead animals per kilometer was 8.2 individuals on the appointed road during the study period of seven months. The carcasses of amphibians were small fragments (total size from 19.5 mm to 81.4 mm) and due to their size they remained on the road for a maximum period of 24 hours, being destroyed by vehicles or ingested by necrophagous. The carcasses of reptiles were represented by medium and big frames (total size from 22 cm to 135 cm) remained on the road for a maximum period of two days. This way, the expected result of road killed animals for a period of thirty days would be 382.2 amphibians and 86.1 reptiles.

With this information in hands, we can consider the shock caused to the herpetofauna on PR-340 highly intense. Methodological differences and the fact that only two vertebrate groups were covered in our study, do not allowed comparisons with another studies. The number of individuals obtained mainly amphibians, is associated to the use of a bike, an unusual but very useful method that allowed us to locate and quantify the small carcasses.

Moreover, losses also occurred in other roads in the coast of Paraná. On November 25th 2004, after intense rain, a high number of road killed amphibians were found on PR-412 (Praia de Leste - Matinhos) and PR-508 (Alexandra - Matinhos). The explosive breeder hyloid frog *Trachycephalus mesophaeus* (Hensel, 1867) was observed in large groups moving on these roads searching for breeding sites. Twenty eight road killed individuals of this species, one *Hypsiboas faber* (Wied-Neuwied, 1821), one *Scinax littoralis* (POMBAL & GORDO, 1991), two *Leptodactylus ocellatus* and one *Rhinella margaritifera* (Laurenti, 1768) were collected along 25 kilometers.

FINAL CONSIDERATIONS

On PR-340 the frequency of road kills was considered too high. In this period of study, 51 amphibians and 23 reptiles were found in 9 km extension. Animals totally destroyed, without possible recognition or use, and carcasses eaten by necrophagous in early morning hours, led us to assume a higher number of death animals on PR-340. Data indicated that the high death rate is related to daily activity and reproductive period of the recorded species, and the use of the edges of the road, mainly in the Reserva Natural Morro da Mina Conservation Area. Negative impacts lay differently on the sample groups, being higher on the anuran species, which are active at night, and on reptiles, with diurnal activity.

For the amphibians, the adult displacement to reach their breeding sites and the dispersion of the younger individuals after metamorphosis can be a crucial impact factor over local species. About the reptiles, the exploration of microhabitats in the edge of the road areas for foraging and as a shelter can intensify the number of deaths by vehicle collision.

The results suggest that the roads are not barriers for the herpetofauna, as observed in small mammals (RICHARDSON *et al.*, 1997). Further information about barrier length and traffic intensity, is a need in order to analyze the isolating effect over amphibians and reptiles.

The settlement of Conservation Areas is of great importance to maintain and protect the wild fauna; on the other hand if placed nearby roads is necessary to prevent road kills, with actions to minimize these impact. Due to the frequency of death of anurans and reptiles, we suggest the installment of speed reducers and better signaling the protection area. Because of the lack of side path on PR-340, it is necessary to clean road surroundings, so that drivers can better visualize the site. A program of tracking amphibian and reptile along PR-340 is also an important action, in order to find the species that have decreasing population.

We emphasize the important role of PR-405 road on the wild fauna conservation. This road links Cacatu to Guaraqueçaba, and the eighty kilometer of unpaved extension has promoted lower vehicle speed, more care at driving and, therefore, less impact over the local herpetofauna. This way, it is desirable a comparative long term study to show about other vertebrates and to determine the intensity of road kills on the paved PR-340 and on the unpaved PR-405.

The data from this study can help to recover environmental management and conservation programs on the local fauna.

ACKNOWLEDGEMENTS — We express our gratefulness to Emygdio L. A. Monteiro-Filho, André A. R. de Meijer, Júlio C. de Moura-Leite and Paulo S. Bernarde, for critical review of manuscript and suggestions. Tânia Zaleski and Mirco Solé for literature. Rafael C. da Silva for the map version and Alexandre Morais and Solene Lepoutre for the Résumé. To SPVS for technical support and photos of road killed animals. Fernando B. Matos for helping us in the field works. Especially to Eros Amaral Ferreira and park rangers and forestry technicians of Reserva Natural Morro da Mina conservation area, whose help was crucial to the results of the research. Ozéas Gonçalves of IAP for personal and logistical support to scientific research. CNPq, for financial support. The Centro de Conservação e Manejo de Répteis e Anfíbios (RAN) of IBAMA, provided collecting permit (02017.004773/02-11; 002/04-RAN).

SUMMARY

During the months of October 2003 to April 2004 we verified the road kills rate of anuran amphibians and reptiles, on paved road PR-340 extension, between the third and the ninth kilometer, in Antonina municipality, Paraná State, Atlantic Forest in Southern Brazil. Among anurans, the most representative families were Leptodactylidae (49%), Hylidae (37%) and Bufonidae (14%); and among reptiles were Colubridae (79%), Teiidae (13%), Polychrotidae (4%) and Anguidae (4%). The anurans deaths only happened between sunset and sunrise and were related to nocturnal activity standard of the different species; while in the reptiles, road kills occur mainly on snakes with diurnal activity. The high death rate of amphibians and reptiles in the PR-340 road (8.2 animals per km) is related to the species displacement during reproduction and the exploration of microhabitats in the edges of the road for foraging. Road edge places were used for reproduction and foraging mainly between the seventh and the ninth kilometer, where most road kills happened. This corresponds to Reserva Natural Morro da Mina Conservation Area.

KEY WORDS: anurans; reptiles; road-kills; Atlantic-Forest; Paraná.

RESUMO

Durante os meses de outubro de 2003 a abril de 2004, verificamos a incidência de mortes por atropelamento de anfíbios anuros e répteis, no trecho asfaltado entre os quilômetros três e nove da rodovia PR-340, Município de Antonina, Floresta Atlântica paranaense, Sul do Brasil. Dentre os anuros, as famílias de anuros representadas foram Leptodactylidae (49%), Hylidae (37%) e Bufonidae (14%), e para os répteis Colubridae (79%), Teiidae (13%), Polychrotidae (4%) e Anguidae (4%). As mortes de anuros ocorrem exclusivamente entre o ocaso e a aurora e relacionam-se a espécies com padrão noturno de atividade, enquanto que para os répteis, a mortalidade incide principalmente sobre serpentes diurnas. A elevada incidência de mortes de anfíbios e répteis na PR-340 (8,2 indivíduos por quilômetro) relaciona-se a os movimentos das espécies durante a época de reprodução e utilização de ambientes marginais da rodovia para forrageamento ou assoalhamento. O trecho entre os quilômetros sete e nove tem a maior incidência de atropelamentos, pois corresponde a área de abrangência da Reserva Natural Morro da Mina.

PALAVRAS CHAVE: anuros; répteis; atropelamentos; rodovias; Paraná.

RÉSUMÉ

Pendant les mois d'octobre de 2003 au avril de 2004, on a vérifié l'incidence de meurtres d'amphibiens anures et reptiles par heurt de véhicules, dans l'espace récapé entre les kilomètres trois et neuf de la route PR 340, ville d'Antonina, Forêt Atlantique du Paraná, sud du Brésil. Les familles d'anures plus représentés sont Leptodactylidae (49%), Hylidae (37%) e Bufonidae (14%) et pour les reptiles Colubridae (79%), Teiidae (13%), Polychrotidae (4%) e Anguidae (4%). Les meurtres d'anures arrivent exclusivement entre le couché du soleil et l'aube et se rapportent aux espèces d'activité nocturne. D'autre part, pour ce qui est des reptiles, les mortalités plus répandus sont principalement celles des serpents diurnes. La grande occurrence de meurtres d'amphibiens et reptiles sur la PR 340 (8,2 individus par kilomètres) sont dus aux mouvements d'espèces pendant l'époque de reproduction et l'utilisation des bords de routes qui servent à fourrager. Ceux ci sont aussi utilisés comme emplacement pour la thermo-regulation de ces espèces. L'espace entre les kilomètres sept et neuf, est celui qui presente le plus grand nombre de heurts, c'est aussi celui qui correspond à la Résèrve Naturelle Morro da Mina.

MOTS CLÈS: anures; reptiles; meurtres; routes; Paraná.

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Recebido em 10 janeiro de 2006.