DOI: 10.4025/actascibiolsci.v32i3.4752

Roadkill of wild vertebrates along the GO-060 road between Goiânia and Iporá, Goiás State, Brazil

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ABSTRACT. Roadkill of wild vertebrates along GO-060, Brazil. Roads represent an old and constant cause of accidental death of wildlife. From May 2004 to November 2005, we recorded the roadkills of vertebrates in the GO-060 road between Goiânia and Iporá. For each road-killed animal we wrote down the species and location along the road. We found 308 animals road-killed from at least 25 vertebrate species: 86% mammals, 11% birds and 3% reptiles. *Tamandua tetradactyla*, *Cerdocyon thous* and *Myrmecophaga tridactyla* were, in decreasing order, the species with the largest number of road-killed individuals. Among mammals, the number of road-killed individuals was not related to species weight. The number of species and road-killed animals was constant throughout the 17 months of the research. The average frequency of animal roadkills in the dry season (April to September) is slightly higher than the frequency in the rainy season (October to March). The average frequency of species victim to accidents, however, is constant throughout the dry and rainy seasons. The incidence of species and individuals of road-killed animals per 10 km was not influenced by the number of forest fragments along the sides of the road. We suggest that speed reducers could decrease the number of animals killed on the road.

Key words: road mortality, forest fragmentation, Cerrado.

RESUMO. Atropelamento de vertebrados silvestres na rodovia GO-060 entre Goiânia e Iporá Estado de Goiás, Brasil. As rodovias representam uma antiga e constante causa de mortalidade acidental da fauna silvestre. Entre maio/2004 e novembro/2005, registramos os vertebrados atropelados às margens da rodovia GO-060, entre Goiânia e Iporá. Para cada animal atropelado anotamos a espécie e a localização ao longo da estrada. Foram registrados 308 animais atropelados de pelo menos 25 espécies de vertebrados: 86% de mamíferos, 11% de aves e 3% de répteis. *Tamandua tetradactyla*, *Cerdocyon thous* e *Myrmecophaga tridactyla* foram em ordem decrescente as espécies com maior número de indivíduos atropelados. Entre os mamíferos, o número de animais atropelados não esteve relacionado a massa corporal das espécies. A frequência de espécies e de animais atropelados foi constante ao longo dos 17 meses entre 2004 e 2005. A frequência média de animais atropelados na estação seca (abril a setembro) é ligeiramente superior à freqüência da estação chuvosa (outubro a março). Já a freqüência média de espécies atropeladas é constante ao longo das estações seca e chuvosa. A incidência de espécies e de animais atropelados por faixa de 10 km não foi influenciado pelo número de fragmentos de matas nas margens da estrada. Nós sugerimos que redutores de velocidade em trechos críticos poderiam reduzir as mortes por atropelamento na rodovia.

Palavras-chave: mortalidade em estradas, fragmentação de matas, Cerrado.

Introduction

In Brazil, economic development is traditionally linked to the expansion of the frontiers of agriculture, cattle-breeding and industry, and to the expansion of the road network. This type of strategy has been responsible for the change of landscapes in the country. Deforestation of native Cerrado and Caatinga vegetation, for instance, is closely related to the construction of roads (PRADO et al., 2006; SANTOS; TABARELLI, 2002).

Roads can function as ecological barriers dividing populations of wild animals, in addition to provoking water and soil pollution and leading to mortality by road kills (SILVA et al., 2007; VIEIRA, 1996). Thus, roads should permit the flux of animals, and the development of mechanisms that can avoid road kills and facilitate the crossing of animals should be part of road planning, construction and expansion (BISSONETTE, 2002).

There are various works about the mortality of wild animals on roads abroad. In general, the

number of species of individuals killed on roads is high (CLEVENGER et al., 2003; GLISTA et al., 2008; ORŁOWSKI; NOWAK, 2006; PINOWSKI, 2005; SAEKI; MCDONALD, 2004) and frequently related to traffic conditions and to characteristics of the topography and vegetation of the environment (BISSONETTE; KASSAR, 2008; CLEVENGER et al., 2003; KANDA et al., 2006; ORŁOWSKI; NOWAK, 2006; SAEKI; MACDONALD, 2004). Measures that keep animals from crossing the road, according to Aresco (2005), generally reduce the mortality rate. However, this method is relatively expensive and there are no further studies that conclusively confirm its efficiency. Bager (2003) states that barriers and measures that facilitate crossing produce species-specific results, and that speed reduction is the best mitigating measure.

In Brazil, the number of research studies on this topic has grown in recent years, and these works have shown that the number of animal roadkills is high: 869 vertebrates on roads of the southeastern region of the Atlantic Forest (COELHO et al., 2008); 259 vertebrates on a part of the RO-383 highway (TURCI; BERNARDE, 2009); 257 mammals on roads in Santa Catarina (BR-116, BR-282 and BR-470 roads) (CHEREM et al., 2007); 211 vertebrates in a stretch of BR-070 in Mato Grosso State (MELO; SANTOS-FILHO, 2007); 90 vertebrates on RS-040 (ROSA; MAUHS, 2004); 58 mammals on parts of BR-472 and BR-290 in Uruguaiana-Rio Grande do Sul State (TUMELEIRO et al., 2006); 51 anurans and 23 reptiles on PR-340 (SILVA et al., 2007); 44 mammals on PA-458 (PEREIRA et al., 2006); 31 vertebrates around Altamiro de Moura Pacheco State Park-Goiás State (PRADO et al., 2006).

Some data indicate that the number of roadkills is associated to vehicle traffic (COELHO et al., 2008) and the presence of more well-preserved areas (COELHO et al., 2008; SILVA et al., 2007; TURCI; BERNARDE, 2009).

In this research, we identify the species and quantify the number of roadkills of wild vertebrates on a part of the GO-060 highway between Iporá and Goiânia, Goiás State, with the aim of verifying whether the rate of roadkills varies between seasons, whether it is related to the presence of fragments of native vegetation along the road, and whether it is influenced by the species weight. With this information, we suggest mitigating measures to reduce mortality and contribute to the conservation of the respective species.

Material and methods

Study Area

The study was conducted on a 216 km stretch of GO-060 between Goiânia and Iporá, in the state of Goiás, interrupted by a few towns and villages: Trindade (km 18), Santa Bárbara de Goiás (km 42), Claudinápolis (a district of Nazário), Nazário (km 73), Turvânia (km 92), Firminópolis (km 113), São Luís de Montes Belos (km 123) and Israelândia (km 188) (Figure 1).

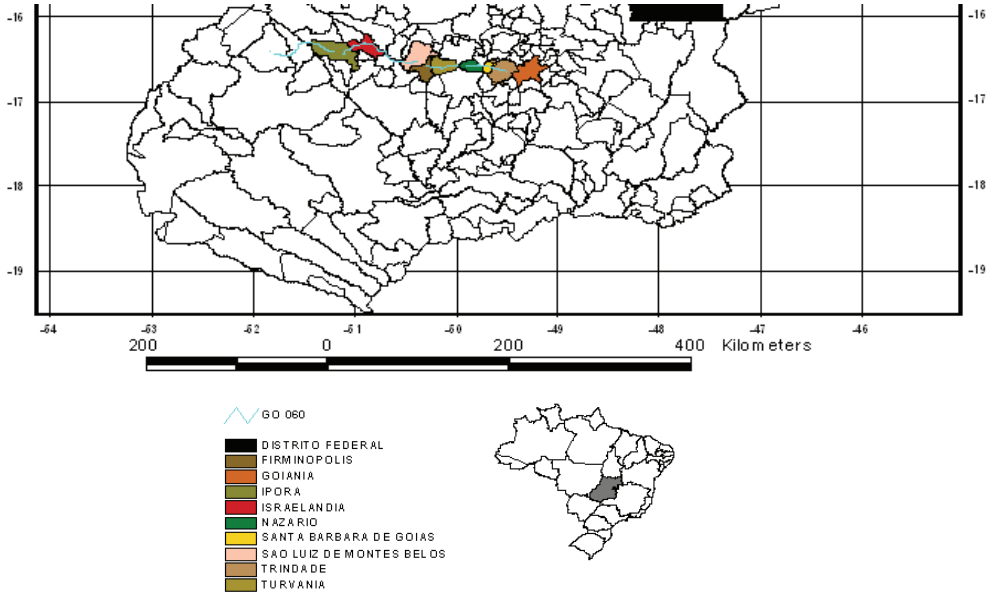

Figure 1. The stretch of the GO-060 road that crosses some municipalities in the state of Goiás, Brazil.

The road is a two-lane highway and is not in a good state of conservation, although during the study period some of parts were restored. The shoulder has no vegetation, allowing the sighting of carcasses. There are police stations near Goiânia, Santa Bárbara de Goiás and between Firminópolis and São Luis de Montes Belos, but there are no data on the daily vehicle traffic. Usually, daytime traffic is intense, as in addition to car traffic, the road is also used by trucks to transport soybeans, sugarcane and granite. The part with the highest vehicle traffic is between Goiânia and São Luis de Montes Belos, with a concentration of urbanization (six towns), quarries, brickyards, gelatin factories and tanneries. In the stretch between São Luis de Montes Belos and Iporá, with an extension of 93 km, vehicle traffic decreases and there are no urbanized areas.

On the sides of the road, there are small forest fragments (Seasonal Semidecidual Forest), pastures and seasonal plantations. Although the region is located in Cerrado Domain, we did not observe remnants of Cerrado *in loco* or in satellite images, as the farmers in the region usually transform the Cerrado areas into pastures and plantations, and the forest areas are kept as legal reserves. Out of the area of these nine municipalities crossed by GO-060, about 81% are farm land – plantations and pastures (IBGE, 2006).

Data collection

The road was monitored by car weekly, on Friday mornings in the direction Goiânia-Iporá and Saturday mornings in the direction Iporá-Goiânia, from May 15th, 2004 to November 4th, 2005, resulting in 50 round trips, 100 days of data collection and 21,600 km covered. There was no data collection on holidays and school vacations. Four trips prior to the study were used for training in sighting the carcasses, familiarization with the road and adaptation to travel routine. We tried to maintain a speed of 100 km h^{-1} and two observers, the same observer being responsible for sighting and identifying the carcasses. Every time a carcass was sighting, the speed of the car was reduced. Only large animals, recently killed and in good state of conservation were counted, in order to avoid pseudo-replication. During the first two months of data collection, thirty cases of roadkill were georeferenced with GPS ("Global Position System" – Garmin eTrex). These places were taken as reference to mark the road on the satellite image. A range of 5 km from the road, totaling 216,000 ha between Goiânia and Iporá, was used to analyze the forest fragments.

Data analysis

The frequency of roadkill was calculated dividing the number of animals and species killed by the number of kilometers covered. The average frequencies of animals and species killed were compared between the dry season (April to September) and the rainy season (October to March). A paired t-test was used to evaluate the difference between the dry and rainy seasons.

As the studied part of the road was covered completely on all the trips, there was no difference in data collection between different parts of the road. Thus, the number of animals and species killed were expressed per 10 km range to analyze the spatial variation along the studied stretch.

Simple regression analysis was used to verify whether the number of animals and species killed per 10 km range is influenced by the number of forest fragments present. The record of forest fragments along the road was done based on images using the maps SE22XB, SE22XA and SE22VB of Landsat satellite 7TM–2001 (GOIÁS, 2001).

For fourteen species of mammals identified, we obtained the weight (kg) from literature (Table 1). In order to analyze whether the weight influences the frequency the animals are killed, we regressed the number of individuals killed from those fourteen species with the maximum weight of the species.

Results and discussion

On the 50 trips, 308 killed animals from at least 25 species were recorded: 86% mammals, 11% birds, and 3% reptiles (Table 1). At times, some animals were seen crossing the road, such as seriemas, preás and perdizes.

It is difficult to compare the mortality rate by roadkill among different studies made on Brazilian roads, due to the different methods applied and the different characteristics of the road, such as surrounding vegetation, distance to Conservation Units, vehicle traffic, number of lanes, climatic data, etc. Furthermore, some authors do not provide these data. The mortality rate of wild vertebrates found in the present work (0.014 animals per km covered) was higher than that found by Pereira et al. (2006) (0.003 animals km^{-1}), Vieira (1996) and Cherem et al. (2007) (0.008 animals km^{-1}), but lower than those of other works: 0.078 (TURCI; BERNARDE, 2009) and 0.082 (ROSA; MAUHS, 2004).

Table 1. Number of individuals (N), percentage of the total (%), weight (kg) and status of threat of extinction according to IUCN (NT, near threatened; LC, least concern; DD, deficient data; LR (lc), lower risk; NE, not evaluated) of the vertebrate species found killed on GO-060 between Goiânia and Iporá.

Scientific Name	Vulgar Name	N	%	Weight (kg)	IUCN
Reptiles					
Iguana iguana (Linnaeus 1758)	Green-iguana	1	0.3	5	NE
Spilotes pullatus (Linnaeus 1758)	Tiger-ratsnake	1	0.3	2	NE
Boa constrictor (Linnaeus 1758)	Common-boa	4	1.3	8	NE
Eunectes murinus (Linnaeus 1758)	Anaconda	1	0.3	150	NE
Unidentified	Snake	3	1.0		
Birds					
Guira guira (Gmelin 1788)	Guira-cuckoo	4	1.3	0.15	LC 2004
Athene cunicularia (Molina 1782)	Burrowing-owl	1	0.3	0.17	NE
Rhea americana (Linnaeus 1758)	Greater-rhea	4	1.3	36	NT 2004
Polyborus plancus (Miller 1777)	Crested-caracara	1	0.3	1	NE
Falco sparverius (Linnaeus 1758)	Sparrow-hawk	2	0.6	0.165	LC 2004
Gnorimopsar chopi (Vieillot 1819)	Blackbird	4	1.3	0.70	LC 2004
Caryama cristata (Linnaeus 1766)	Seriema	15	4.9	2	NE
Unidentified	Bird	2	0.6		
Unidentified	Vulture	1	0.3		
Mammals					
Cerdocyon thous (Linnaeus 1766)	Crab-eating-fox	59	19.2	8	LC 2004
Galictis vittata (Schreber 1776)	Grison	2	0.6	3	LR(lc) 1996
Didelphis marsupialis (Linnaeus 1758)	Opossum	19	6.2	1	LR(lc) 1996
Puma yaguarondi (Lacépède 1809)	Jaguarundi	4	1.3	7	LC 2002
Chrysocyon brachyurus (Illiger 1815)	Manned-wolf	4	1.3	25	NT 2004
Cebus apella (Linnaeus 1758)	Brown-capuchin-monkey	1	0.3	3.5	LC 2003
Procyon cancrivorus (G.[Baron] Cuvier 1798)	Crab-eating-raccoon	7	2.3	12	LR(lc) 1996
Coendou prehensilis (Linnaeus 1758)	Porcupine	16	5.2	5	LR(lc) 1996
Nasua nasua (Linnaeus 1766)	Coati	12	3.9	6	LR(lc) 1996
Lycalopex vetulus (Lund 1842)	Brazilian-field-fox	4	1.3	4	DD 2004
Myrmecophaga tridactyla (Linnaeus 1758)	Giant-anteater	30	9.7	25	NT 2006
Tamandua tetradactyla (Linnaeus 1758)	Collared-anteater	74	24.0	8	LC 2006
Dasypus novemcinctus (Linnaeus 1758)	Common-armadillo	4	1.3	7	LC 2006
Euphractus sexcintus (Linnaeus 1758)	Yellow-armadillo	12	3.9	7	LC 2006
Unidentified	Cats	2	0.6		
Unidentified	Preá	3	1.0		
Unidentified	Armadillo	11	3.6		

Most of the animal roadkills were mammals, a result also found by Rosa and Mauhs (2004) and by Melo and Santos-Filho (2007); while Prado et al. (2006) found a majority of birds; and Turci and Bernarde (2009) recorded a majority of amphibians The species that most frequently fell victim – *T. tetradactyla* (24%), *C. thous* (19%) and *M. tridactyla* (10%) (Table 1) – were also the majority on other roads in Mato Grosso State (MELO; SANTOS-FILHO, 2007), Pará State (PEREIRA et al. 2006), Santa Catarina State (CHEREM et al, 2007) and Rondônia State (TURCI; BERNARDE, 2009).

The mortality of threatened species is commonly recorded in most studies on roads. Three species of this work are listed as near threatened (NT) according to IUCN (2006), including one of the most commonly recorded (*M. tridactyla*), a primate (*C. apella*) and a bird (*R. americana*) (Table 1). *Chrysocyon brachyurus* and *M. tridactyla*, categorized as near threatened (NT) by IUCN (2006), were also recorded prominently by Pinowski (2005). *Myrmecophaga tridactyla* is a rare species that occurs naturally in low densities throughout its distribution range, due to low reproductive potential (Braga, 2003). Silveira et al. (1999) believe that one of the reasons for their population decline is roadkill. *Tamandua tetradactyla* and *C. thous*, classified as not threatened (LC) by IUCN (2006), showed significant mortality in this study. Unfortunately, there were no conclusive results about population size and distribution range of these species, preventing an analysis of the impact of roadkills.

At least among mammals, the group most affected by roadkills, the number of animals killed per species was not influenced by weight (r^2 = 0.0071; p = 0.7734, Figure 2). Regardless of animal size, all species have the same risk of being road-killed. From 20 species found in Santa Catarina State, only two were large (CHEREM et al., 2007).

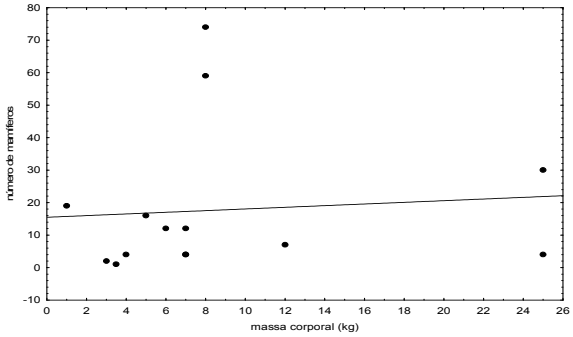

Figure 2. Relationship between the number of roadkills and weight for 14 mammal species recorded on GO-060 road between Iporá and Goiânia, Goiás State, Brazil.

In some regions the mortality of wild animals varies seasonally (MELO; SANTOS-FILHO, 2007; ROSA; MAUHS, 2004; TURCI;

BERNARDE, 2009). This study showed the same frequency of road kills over the different months of the year and the dry and rainy seasons, a result also obtained by Coelho et al. (2008) and by Pereira et al. (2006).

The frequency of road-killed species and individuals was almost constant over the months (Figure 3). This fact suggests that these animals use the fragments surrounding the road as a route of dispersal for their daily activities. Some species, such as, *P. plancus*, *E. sexcintus, D. novemcinctus, C. thous* and vultures on the GO-060 can be road-killed on roads when they are attracted to feed on carcasses (ROSA; MAUHS, 2004).

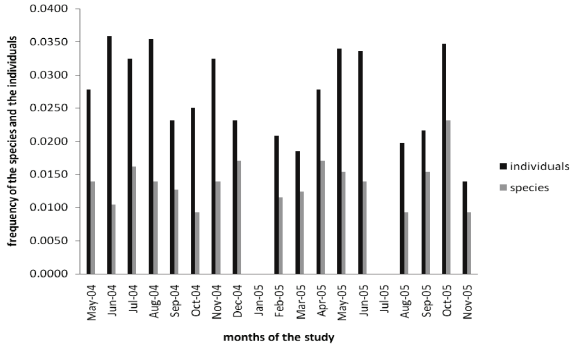

Figure 3. Frequency of individuals and species road-killed per kilometer covered over the months of this study, on GO-060 road between Iporá and Goiânia, Goiás State, Brazil.

The average frequency of roadkills in the dry season (0.0291 ± 0.0060) is slightly higher than the frequency in the rainy season (0.0241 ± 0.0074): t 6= 2.03; p = 0.09 (Figure 4). Probably, in the dry season there is a decrease in food supply, which should lead to increased activity of dispersal of animals in search of food. The average frequency of roadkills per species is constant throughout the dry season (0.0138 ± 0.0025) and rainy season (0.0138 ± 0.0049) (Figure 4), with 17 species in common for 2004 and 2005 (t 6= 0.28; p = 0.80). At the end of the rainy season, there were workers doing road maintenance, filling potholes and cleaning roadside vegetation. This period coincided with a decrease in records of roadkills, probably because these workers removed the animals from the road.

The critical points of wild animal roadkills on GO-060 are km 90, km 140-160 and km 180 (Figure 5), where there are more forest fragments. The 90 km range presents intense vehicle traffic between the districts of Turvânia and Nazário, 19 km from one another, with a gelatin factory and a tannery between them. The km 83 section reached a record of 12 roadkills. The km 140-160 section (3.85 roadkills per km) and the km 180 section (3.5 roadkills per km), are located in the less urbanized area of the road and with a greater number of larger vegetation fragments, between São Luis de Montes Belos and Israelândia , 65 km apart. These accidents can be reduced by decreasing the speed of vehicles through obstacles that require the driver to respect them, such as the installation of speed reducers (electronic barriers and/or speed humps) at the critical points mentioned above. Reducing the speed limit should be accompanied by supervision mechanisms. Clevenger et al. (2003) states that the decrease of the roadkills implies reducing the transit of animals on the road. One suggestion is to include the content about the wildlife roadkills in the training program to acquire driver's licenses.

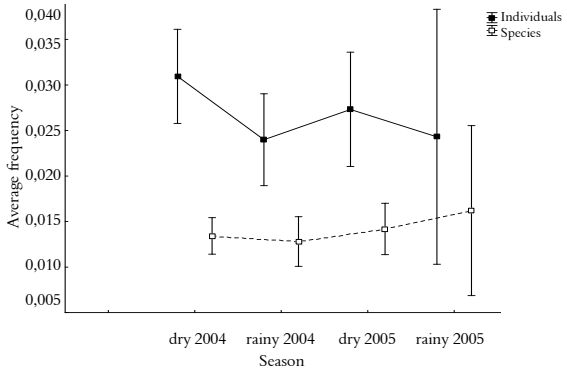

Figure 4. Variation in the frequency of the number of road-killed individuals and species reported per kilometer for the dry season (April to September) and rainy season (October to March) on GO-060 road between Goiânia and Iporá, Goiás State, Brazil.

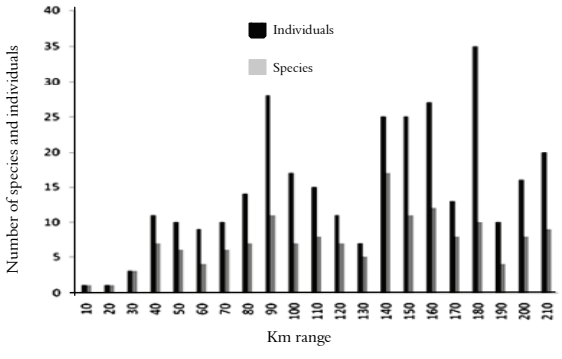

Figure 5. Number of road-killed individuals and species per 10 km range of GO-060 road between Goiânia and Iporá, Goiás State, Brazil.

The number of road-killed animals per 10 km range was not influenced by the number of forest fragments around the road (r^2 = 0.2762; p = 0.3003), as in the region of GO-060 there is a continuous pattern of forest fragmentation. Similarly, the number of road-killed species per

10 km range was not influenced by the number of forest fragments around the road (r^2 = 0.0913; p = 0.7367). The best solution would save the largest number of larger fragments, but this landscape type is not available today. The average size of forest fragments along the 216 km of the GO-060 range was 82 ha and the largest fragment was 653 ha (Figure 6). Even these larger fragments were not sufficient to keep the home range of individuals of the most victimized species in this study: 8018 ha for *C. brachyurus* (JACOMO et al., 2009), 1190 ha for *M. tridactyla* (MEDRI; MOURÃO, 2005) and 723 ha for *C. thous* (TROVATI et al., 2007).

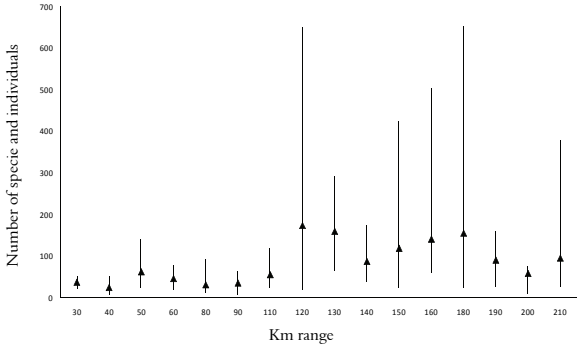

Figure 6. Forest fragments area (ha) (medium ▲; maximum and minimum ¦) per kilometer range along GO-060 road between Goiânia and Iporá, Goiás State, Brazil.

Conclusion

Despite the natural landscape surrounding GO-060 being quite fragmented, as confirmed by satellite images, the roadkills of different wild species in this road range revealed a great diversity and abundance of vertebrates occurring in the region. The high rate of roadkills of *T. tetradactyla* and *C. thous* in different research studies has not been sufficient to encourage their inclusion in the category of endangered species by the IUCN. Some of the roadkilled species, such as *C. thous*, are adapted to a variety of habitats and are common even in areas with anthropic disturbance. Roadkill is considered by IUCN as an extinction risk only for *C. brachyurus*, despite research showing that roads are a threat to the survival of other wildlife. The less urbanized road range presented a higher incidence of roadkills of wildlife, because it is a less fragmented area and there is more transit of animals. Educational campaigns for drivers, with the installation of signs about the incidence of roadkills of wildlife on the respective road, including the Brazilian legislation of punishment for such behavior, and reducing the speed limit, may assist in the conservation of species that normally are victims of vehicular traffic on Brazilian roads. As there are no studies that confirm the effectiveness of these mitigation measures, monitoring them becomes necessary.

Acknowledgements

We thank Diogo Andrade Costa for his help with the analysis of the satellite images and his assistance in Figure 1. We thank Viviane Bolba Cardoso, Paulo César Junior, Rugles César Barbosa and Geovane Campos for their help during the trips. We also thank the anonymous reviewers.

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Received on August 18, 2008.
Accepted on April 27, 2009.