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Roadkilled mammals in the northern Amazon region and comparisons with roadways in other regions of Brazil

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ABSTRACT. Roadways and road traffic modify landscapes, posing a threat to the conservation of species in different biomes. The aim of the present study was to analyze roadkill records of wild mammals and to compare the results to findings from 37 other studies conducted in Brazil, to evaluate the richness and diversity of threatened species in different eco-regions of the country. This study was conducted between June 2007 and June 2008, along 60 km of the inter-state highway BR-364, which connects the municipalities of Ouro Preto d'Oeste and Presidente Médici in the state of Rondônia (northern Brazil). Two hundred twenty roadkills were recorded involving 13 species of mammals. Cingualata, Pilosa and Carnivora were the most represented orders. The most represented were the generalist species *Dasypus novemcinctus* (56.7%), *Tamandua tetradactyla* (10.5%), and *Cerdocyon thous* (8.2%), reflecting the adaptability of these species to habitat changes and presence of humans. The number of roadkilled individuals and species indicated no significant differences between the dry and rainy seasons. The findings indicate a high index of roadkills (3.38 individuals/km/year) and moderate number of run over species (0.20 species/km/year) in the region in comparison to records from other roadways in Brazil, with 46% species having an endangered status. Roadways in the eco-regions of the Cerrado (Brazilian savanna) accounted a significantly larger proportion of endangered species (mean: 52%) in comparison to the *Pampa* (lowlands of southern Brazil; 24%), but the differences in comparison to roadways in Amazonia (37%) and the Atlantic Forest (31%) were non-significant. The present findings underscore the need for emergency measures to minimize the impact of roadkills on mammals. Moreover, priority should be given to more impacted roadways and more threaten eco-regions.

KEYWORDS. Environmental impact; habitat fragmentation; hotspots; threatened wildlife.

RESUMO. Mamíferos atropelados na região norte da Amazônia e comparações com rodovias de outras regiões do Brasil. As rodovias e o fluxo de veículos contribuem para os processos de fragmentação da paisagem e alteração do habitat natural, representando ameaça para conservação das espécies em diversos biomas. Este estudo avalia os registros de atropelamentos das espécies de mamíferos silvestres e compara este com outros 37 estudos realizados no Brasil, para avaliar a riqueza e diversidade de espécies ameaçadas em distintas ecorregiões. O estudo foi realizado entre junho de 2007 e junho de 2008, ao longo de 60 km da rota BR-364, entre os municípios de Ouro Preto d'Oeste e Presidente Médici, no estado de Rondônia. Foram registrados 220 atropelamentos pertencentes a 13 espécies de mamíferos. Cingualata, Pilosa e Carnivora foram as ordens mais representadas, sendo *Dasypus novemcinctus* a espécie mais significativa (56.7%), seguida por *Tamandua tetradactyla* (10.5%) e *Cerdocyon thous* (8.2%), refletindo a capacidade de adaptação das espécies às alterações do habitats e a presença humana. O número de atropelamentos de indivíduos e espécies não indicaram diferenças significativas entre estações climáticas. Este estudo indica altos índices de atropelamentos de indivíduos (3.38 indivíduos/km/ano) e moderado número de espécies atropeladas (0.20 espécies/km/ano) para a região em relação a outras localidades no Brasil, com 46% das espécies em status de ameaça. As rodovias nas ecorregiões do Cerrado apresentaram resultados significativamente maiores de espécies ameaçadas (média de 52%) em relação ao Pampa (24%), porém não houve diferença significativa se comparado às rodovias na Amazônia (37%) e Mata Atlântica (31%). Os dados reforçam a necessidade de medidas emergenciais para minimizar impactos por atropelamentos da mastofauna, recomendando prioridade em rodovias mais impactadas e ecorregiões mais ameaçadas.

PALAVRAS-CHAVE. Impacto ambiental; fragmentação de habitat; hotspots; fauna ameaçada.

Roadways through Amazon habitats are determinant factors of vast deforestation patterns and forest fragmentation related to the expansion of agriculture, lumber and pasture activities, and these aspects are more intensified by clandestine secondary roads (Fearnside, 2015). Roadways also alter the physical, chemical and biological patterns of terrestrial and aquatic environments, affecting drainage, infiltration and evaporation patterns, with direct consequences to the microclimate in areas surrounding these transportation lanes (LAURANCE *et al.*, 2009).

Although there is no consensus on the effect of seasonality on mammals killed by vehicular traffic (CARVALHO *et al.*, 2017), studies demonstrate a correlation between vehicle-related deaths (roadkills) of wild mammals and seasonality (BRUM *et al.*, 2017), which is likely associated with dispersal and migration movements related to foraging and reproduction (BRAZ & FRANÇA, 2016).

Roads serve as barriers to animal movements between forest fragments (TUMELEIRO *et al.*, 2006) and constitute a potential risk for the occurrence of roadkills, especially on roadways with high traffic flow passing through areas that serve as refuge for wild animals (VIEIRA, 1996).

Deforestation and habitat destruction in the Amazon basin have been associated with the proximity to roadways, especially towards the southeast of this biome, with the Belém-Brasília highway (BR-010), Trans-Amazonia highway (BR-319), and BR-364 playing important roles (LAURENCE *et al.*, 2002). Roadway BR-364 in the state of Rondônia has a high vehicular traffic flow and crosses one of the regions with the highest rates of deforestation for conversion into pastures as well as the strongest pressures stemming from human occupation in the Amazon (FEARNSIDE, 2006). The isolation of populations and habitat fragmentation caused by deforestation intensify the occurrence of mammals on roadways and promote changes in the behavior of species. Such changes increase the mortality rate due to roadkills and the limitations imposed on the availability of resources, even for discreet, reclusive species that avoid roads and open areas (TROMBULAK & FRISSEL, 2000).

The aims of the present study were to identify large and medium-sized mammals that have been victims of roadkill along a stretch of federal roadway BR-364 in the state of Rondônia (northern Brazil), to evaluate the potential of environmental effects (temperature and precipitation) on the occurrence of roadkill in the stretch analyzed, to perform a comparative analysis of the study area and roadkill records of wild mammals in other regions of Brazil based on the available literature, and to identify priority regions and biomes for conservation.

MATERIAL AND METHODS

Study area. The study area comprised the 60-km stretch of the BR-364 between the municipalities of Ouro Preto do Oeste (10°S, 62°W) and Presidente Médici (11°S, 61°W) in the state of Rondônia, which are equidistant from the municipality of Ji-Paraná (Fig. 1).

The stretch of the roadway studied is paved and passes through a matrix of pastures and isolated fragments of natural and secondary rainforest under strong human pressure, between large indigenous reserves and some conservation units, with remaining areas having a low degree of species regeneration of the primitive vegetation (LISBOA *et al.*, 1991). The study area is located at the southern limit of the Amazon rainforest (Amazonia) near its transition area to the Cerrado (savanna) eco-region located in the southern portion of the state of Rondônia (MIRANDA *et al.*, 2006).

Sampling. Sampling was performed between June 2007 and June 2008, covering a 60-km stretch of the central region of roadway BR-364, between the municipalities of Presidente Médici (south) to Ouro Preto D'Oeste (north). To locate dead mammals along the roadway, 22 trips totaling 1320 km were performed by two observers on a motorcycle traveling at 15-day intervals, preferably in the morning period, at an approximate velocity of 50 km/h (SOUSA &

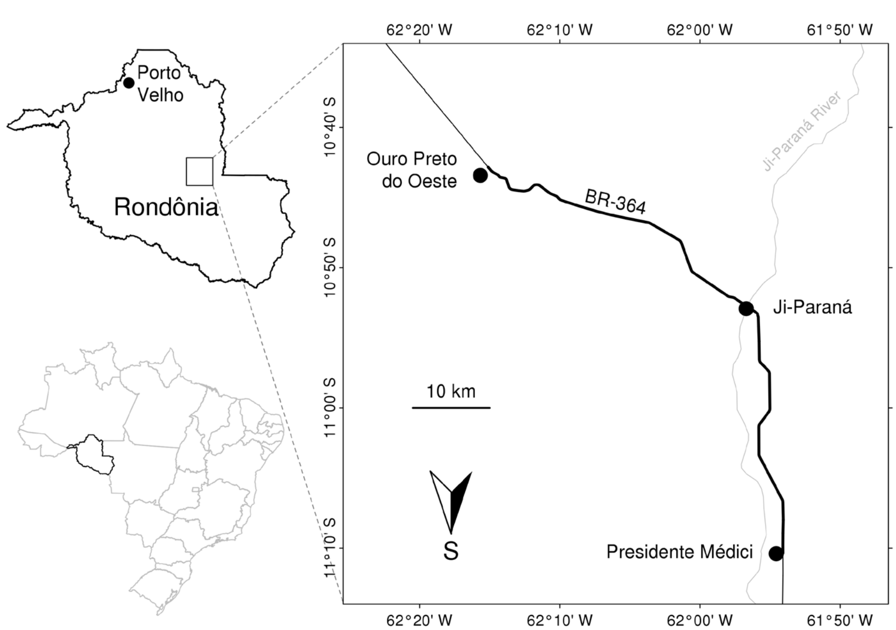

Fig. 1. Study area located on roadway BR 364 in central region of state of Rondônia in southwestern portion of Amazon biome. The stretch sampled is in bold in the figure.

Miranda, 2010; Corrêa *et al.*, 2017). Roadkilled mammals within urban areas of municipalities, deaths by unknown causes and the carcasses of domesticated animals were not quantified in this study (Hengemühle & Cademartori, 2008).

The specimens were photographed and identified by external characteristics with the aid of a taxonomic key (Emmons & Feer, 1997) and identification guides (Borges & Tomás, 2004; Reis *et al.*, 2006). Small rodents (N = 4) and bats (N = 23) were not included in the analyses, but marsupials, such as *Didelphis* Linnaeus, 1758, were included due to the ease to identify them in the field. Non-identified specimens (N = 2) and exotic species (N = 6) were not considered in the calculation of species and roadkill rates on roadways.

For the evaluation of roadways with the highest roadkill rates in Brazil, bibliographic searches were performed in Google, Google Scholar, the SciELO site, and the Brazilian periodical site *Portal da Capes*, for studies addressing roadkilled wild fauna on Brazilian roadways, using the following search terms: "atropelamento de mamíferos", "roadkill mammals", "vertebrates roadkill" and "wildlife roadkill". We only considered studies on roads in Brazil that discriminated the distance in kilometers travelled, duration of the study in months, and number of individuals and species of large and medium-sized mammals, excluding domesticated and exotic animals. For each article selected (N = 37), stretches of roadways were included in the main eco-regions of the country: Amazon rainforest (Amazonia), tropical dry forest (Caatinga), savanna (Cerrado), coastal rainforest (Atlantic Forest), lowlands in the southern region of the country (Pampa), and wetlands in the central-western region of the country (Pantanal) (MMA, 2002).

Data analysis. Relative abundance was estimated based on the percentage of absolute records of roadkilled individuals of each species: relative abundance of a given species = absolute n° of individuals of a given species x 100 / total n° of roadkilled animals. Relative abundances of each species were compared between the dry season (May to October) and rainy season (November to April). The Mann-Whitney test was used to determine seasonal differences with a 5% level of significance.

For each season (dry and rainy), precipitation and temperature data from the closest meteorological station were acquired from the National Meteorological Institute (www.inmet.gov.br). Pearson's test was used to evaluate the correlation between the climatic data and the ecological variables (number of individuals and number of species) using the BioEstat 5.3 software (Ayres *et al.*, 2007).

The degree of impact of the stretch analyzed in comparison to other roadways analyzed in previous studies was determined based on the roadkill rate calculated by the number of individuals and species divided by total kilometers travelled (adapted from Carvalho *et al.*, 2014). The mean was obtained from the total of individuals and species divided by total kilometers travelled. For the comparison of data, the results were subsequently divided by the total number of sampling months multiplied by 12 to standardize the individual (individual roadkill index [IRI]) and species (species roadkill index [SRI]) roadkilled in a one-year period for each study. The mean general IRI and SRI were calculated by the sum of all values of each index divided by the number of studies analyzed.

The species identified in the 37 papers included in the bibliographic review and those from the present study were categorized based on the degree of endangerment [extinct in the wild (EW), critically endangered (CR), endangered (EN), and vulnerable (VU)], using official lists of endangered species (Bergallo *et al.*, 2000; Marques *et al.*, 2002; Fontana *et al.*, 2003; Mickich & Bernils, 2004; Passamani & Mendes, 2007; Drummond *et al.*, 2008; Percequillo & Kierulff, 2009; COPAM, 2010; MMA, 2014; IUCN, 2018).

The ratio EN/ST in each study was determined based on the number of endangered species (EN) divided by the total number of mammals (ST) listed in each study.

The comparative analysis of the roadkill records in the different eco-regions was performed applying the Kruskal-Wallis test, followed by Dunn's test for significant results ($p < 0.05$) in the BioEstat 5.3 software (Ayres *et al.*, 2007). The Caatinga and Pantanal biomes had few studies and were therefore excluded from the comparisons with the other eco-regions (Amazonia, Cerrado, Atlantic Forest and Pampa).

RESULTS

Two hundred twenty roadkilled wild mammals were recorded over the 1320 km traveled, corresponding to 3.38 individuals/km/year (IRI) during the study period. These mammals represented a total of 13 species (Fig. 1).

The orders Cingulata and Pilosa were the most represented, accounting for nearly 68% of the roadkill occurrences (Tab. I). The order Carnivora accounted for 19% of the roadkill records and the order Didelphimorphia was the third most represented in the study (Tab. I). In terms of species, the nine-banded armadillo (*Dasypus novemcinctus*) accounted for 57% of the roadkilled mammals, followed by the lesser anteater (*Tamandua tetradactyla*, 10.5%), crab-eating fox (*Cerdocyon thous*, 8.2%), crab-eating raccoon (*Procyon cancrivorus*, 5.9%) and common opossum (*Didelphis marsupialis*, 6.4%) (Tab. I).

Although the rainfall data indicated significant differences in the precipitation volume between the dry (May to October) and rainy (November to April) seasons ($U = 2.00$; $Z[U] = 2.56$; $p = 0.0104$), the temperature and rainfall data were not correlated with the number of individuals (temperature: $r = 0.0564$, $p = 0.8617$; rainfall: $r = 0.0677$, $p = 0.8343$) or number of species (temperature: $r = 0.0574$, $p = 0.8594$; rainfall: $r = -0.3088$, $p = 0.3288$).

Comparison of Brazilian roadways. The bibliographic review and the present study resulted in 38 papers distributed among the six eco-regions of Brazil; Amazonia (N = 6), Caatinga (N = 2), Cerrado (N = 9),

Tab. I. Roadkilled mammals on roadway BR-364 between municipalities of Presidente Médici (PM) and Ouro Preto do Oeste (OP) in state of Rondônia between June 2007 and June 2008 (N^{ra}, roadkill records of each species in rainy season; N^{dr}, roadkill records of each species in dry season; %, roadkill frequency based on total number of individuals).

Taxonomic group	Popular name	N^{ra}	N^{dr}	%
MAMMALIA				
Didelphimorphia				
Didelphidae				
Didelphis marsupialis Linnaeus, 1758	Opossum	5	9	6.4
Cingulata				
Dasypodidae				
Dasypus novemcinctus Linnaeus, 1758	Nine-banded armadillo	89	36	56.8
Pilosa				
Bradypodidae				
Bradypus variegatus Schinz, 1825	Three-toed sloths	1	1	0.9
Myrmecophagidae				
Tamandua tetradactyla Linnaeus, 1758	Lesser anteater	12	11	10.4
Primata				
Cebidae				
Saimiri sciureus (Linnaeus, 1758)	Common squirel monkey	0	2	0.9
Carnivora				
Felidae				
Leopardus braccatus (Cope, 1889)	Pantanal cat	0	2	0.9
Canidae				
Cerdocyon thous (Linnaeus, 1766)	Crab-eating fox	5	13	8.2
Procyonidae				
Nasua nasua (Linnaeus, 1766)	Coatis	3	0	1.4
Procyon cancrivorous (Cuvier, 1798)	Crab-eating raccoon	7	6	5.9
Mustelidae				
Eira barbara Linnaeus, 1758	Tayra	3	2	2.3
Rodentia				
Hydrochaeridae				
Hydrochaerus hydrochaeris (Linnaeus, 1766)	Capybara	4	0	1.8
Cuniculidae				
Cuniculus paca (Linnaeus, 1766)	Spotted paca	3	0	1.4
Erethizontidae				
Coendou prehensilis (Linnaeus, 1758)	Porcupine	2	4	2.7
		134	86	100
TOTAL		220		

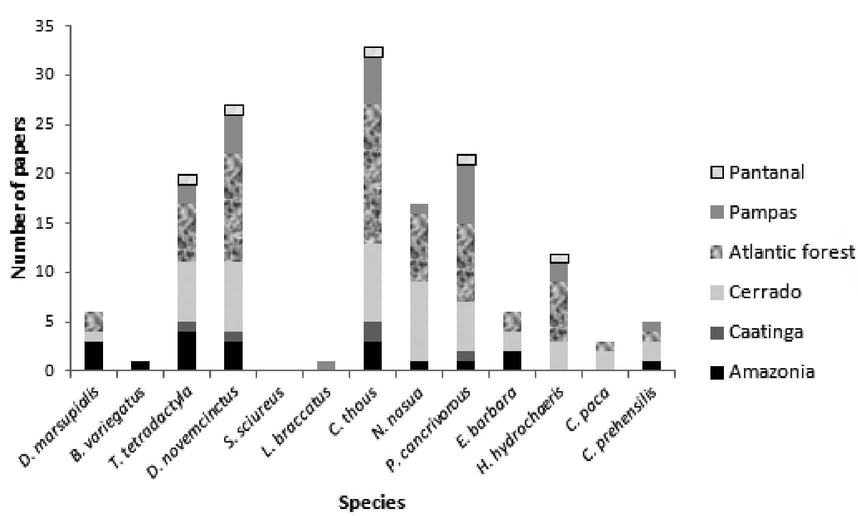

Fig. 2. Number of articles evaluated with records of the 13 species identified in this study and the distribution in each of the six Brazilian eco-regions (Amazonia, Caatinga, Cerrado, Atlantic Forest, Pampa and Pantanal).

Atlantic Forest (N = 14), Pampa (N = 6) and Pantanal (N = 1) (Fig. 2). The roadkill indices on Brazilian roads ranged from 0.12 to 5.5 individuals per kilometer per year (IRI), with a mean of 1.47 (IRI), and from 0.01 to 1.67 species per kilometer per year (SRI), with a mean of 0.27 (SRI).

Among the 13 species recorded in the present study, the crab-eating fox (33 papers: 87%) was the most frequently reported species in the 38 articles, followed by the nine-banded armadillo (27 papers: 71%), crab-eating raccoon (22 papers: 58%) and lesser anteater (20 papers: 53%). The common squirrel monkey was only recorded in the present study (Fig. 2).

Roadkill index: number of records, number of species and ratio of endangered species. The data from different roadways in Brazil indicate that roadway BR-364 has a comparatively high roadkill index based on the number of individuals and number of endangered mammals killed. The stretch of BR-364 had the sixth highest index for large and medium-sized mammals (IRI = 3.38) among the 38 studies involving different roadways in the country. This index was more than twice the national average (IRI = 1.47) (Tab. II).

The stretch of the BR-364 ranked sixteenth with regard to the roadkilled species index (SRI = 0.20) among the 38 roadways evaluated. This index was close to the national

Tab. II. Comparison of roadkill indices among Brazilian roadways based on number of records per year (IRI), species per year (SRI), eco-regions of sampled stretch of road, and ratio between endangered species and total species (ES/TS), in 38 references considering large and medium-sized mammals.

References	Unit of federation	Eco-region	IRI	SRI	EN/TS
This study	RO	Amazon Rainforest	3.38	0.20	0.46
Almeida & Cardoso-Junior, 2014	SP	Atlantic Forest	1.74	0.41	0.00
Braz & França, 2016	GO	Brazilian Savanna	0.94	0.10	0.62
Brum *et al.*, 2017	MT	Brazilian Savanna	2.52	0.36	0.61
Caceres *et al.*, 2010	MS	Atlantic Forest	3.50	0.30	0.53
Caceres *et al.*, 2010	MS	Brazilian Savanna	1.06	0.07	0.65
Caceres *et al.*, 2012	MS	Wetland	0.47	0.06	0.40
Caceres *et al.*, 2012	MS	Brazilian Savanna	0.53	0.06	0.61
Carvalho *et al.*, 2014	MS	Brazilian Savanna	0.37	0.07	0.50
Cherem *et al.*, 2007	SC	Atlantic Forest	0.12	0.01	0.40
Corrêa *et al.*, 2017	RS	Brazilian Pampa	3.11	0.44	0.40
Costa & Dias, 2013	GO	Brazilian Savanna	1.33	0.24	0.36
Costa, 2011	SC	Atlantic Forest	0.90	0.24	0.20
Cunha *et al.*, 2010	GO	Brazilian Savanna	0.86	0.06	0.35
Cunha *et al.*, 2015	RS	Brazilian Pampa	5.50	1.67	0.20
Deffaci *et al.*, 2016	RS	Atlantic Forest	4.25	0.58	0.14
Guimier-Costa & Sperber, 2009	PA	Amazon Rainforest	0.91	0.14	0.50
Hegel *et al.*, 2012	RS	Atlantic Forest	1.57	0.30	0.38
Hengemühle & Cademartori, 2008	RS	Brazilian Pampa	3.50	0.90	0.22
Machado *et al.*, 2015	MG	Atlantic Forest	0.89	0.27	0.17
Melo & Santos-Filho, 2007	MT	Brazilian Savanna	1.89	0.24	0.47
Milli & Passamani, 2006	ES	Atlantic Forest	0.64	0.21	0.50
Oliveira *et al.*, 2017	MG	Brazilian Savanna	0.88	0.23	0.50
OmenaJr. *et al.*, 2012	AM	Amazon Rainforest	0.76	0.05	0.40
Orlandin *et al.*, 2015	SC	Atlantic Forest	0.40	0.07	0.38
Pereira *et al.*, 2006	PA	Amazon Rainforest	0.61	0.08	0.33
Pinheiro & Turci, 2013	AC	Amazon Rainforest	1.77	0.55	0.25
Preuss *et al.*, 2015	SC	Atlantic Forest	1.09	0.10	0.43
Ramos-Abrantes *et al.*, 2018	PB	Tropical Dry Forest	0.58	0.04	0.29
Rosa & Mauhs, 2004	RS	Brazilian Pampa	0.41	0.09	0.00
Santana, 2012	RS	Brazilian Pampa	0.86	0.04	0.31
Santos *et al.*, 2012	MG	Atlantic Forest	0.92	0.46	0.33
Saranholi *et al.*, 2016	SP	Atlantic Forest	0.75	0.52	0.55
Sássi *et al.*, 2013	MG	Atlantic Forest	1.06	0.09	0.30
Silva *et al.*, 2013	RS	Brazilian Pampa	4.03	0.41	0.33
Sousa & Miranda, 2010	PB	Atlantic Forest	0.36	0.04	0.00
Turci & Bernarde, 2009	RO	Amazon Rainforest	0.54	0.05	0.20
Veras *et al.*, 2016	PI	Tropical Dry Forest	1.00	0.50	0.00
	BRAZIL	MEAN	1.47	0.27	0.34

average (SRI = 0.27). The stretch of BR-364 ranked 12th with regard to the number of endangered species, with 46% of the species listed in some endangered category.

Comparison of eco-regions. No significant differences among eco-regions were found regarding the number of records or number of species (km/year). Regarding the ratio of endangered species recorded in each eco-region, the Cerrado (savanna) had significantly higher occurrences in comparison to the Pampa (H = 9.5011; G.L. 3; $p = 0.0233$), with an average of 52% and 24% of the roadkill records, respectively. The Pantanal (wetlands) and Caatinga (tropical dry forest), which were not included in the statistical analysis, had proportions of 40% and 15%, respectively.

DISCUSSION

The higher roadkill rates of large and medium-sized mammals for the stretch of BR-364 studied (IRI = 3.38) in the state of Rondônia may be explained by the high vehicle traffic for the flow of cargo associated with the fragmentation and loss of natural habitats. Moreover, the state of Rondônia is situated in Amazonia, with a recent history of intensive deforestation and fragmentation of areas, associated mainly with the paving of roadway BR 364 (Fearnside, 2005; Sathler *et al.*, 2018). Therefore, animals are more exposed to the risk of being killed by vehicular traffic due to their use of roadways as simpler routes to follow in search of new habitats given the limitation of natural areas and the opportunity to exploit new food resources made available by the roads.

The high roadkill indices for *D. novemcinctus*, *T. tetradactyla*, *C. thous*, *D. marsupialis* and *P. cancrivorous* in this study demonstrate that the occurrence of these species is relatively common in different eco-regions. Species of Cingulata, Pilosa and Carnivora are largely generalists and have broad distribution, with records in several regions of Brazil (Pereira *et al.*, 2006; Melo & Santos-Filho, 2007; Caceres *et al.*, 2010; Machado *et al.*, 2015; Ramos-Abrantes *et al.*, 2018). These animals are also exposed to frequent roadway crossings due to their necrophagous habits (Scoss *et al.*, 2004). Moreover, some species may experience a population increase in highly fragmented habitats. As generalist species tend to be invasive and opportunistic, they have greater success in terms of establishment and expansion in areas with inferior environmental quality (Marvier *et al.*, 2004).

The high roadkill rate of the nine-banded armadillo may be related to its opportunistic capacity to adapt to the conditions of the environment (Redford, 1994). This animal is a generalist insectivore that is abundant in forest fragments and the edges of forests (Loughry & McDounough, 1997). Roadkill records may also be associated with aggregations in reproductive periods (Clevenger *et al.*, 2003).

The lesser anteater is adapted to a large variety of habitats (Redford, 1994). However, this animal is very selective in its choice of habitat and is dependent on forest cover and wet areas (Desbiez *et al.*, 2009). The high frequency of roadkill records (Cherem *et al.*, 2007; Cunha *et al.*, 2010; Costa, 2011; Caceres *et al.*, 2012) may be due to its limited sight and hearing as well as its exposure during slow movements between forest fragments intercepted by roadways (Brum *et al.*, 2017).

The crab-eating fox is a nocturnal carnivore in Neotropical regions with a large home range and high capacity for an opportunistic, generalist, omnivorous diet (Cheida *et al.*, 2006). High occurrences of roadkill affecting the crab-eating are found in diverse regions (Pereira *et al.*, 2006; Cherem *et al.*, 2007; Caceres *et al.*, 2010; Caceres *et al.*, 2012; Costa & Dias, 2013; Carvalho *et al.*, 2014; Brum *et al.*, 2017; Ramos-Abrantes *et al.*, 2018), which reflects its highly mobile behavior, exposing the animal during its constant crossings of roadways associated to its necrophagous diet (Melo & Santos-Filho, 2007; Sousa & Miranda, 2010).

The crab-eating raccoon is a solitary species with nocturnal habits and broad distribution (Cheida *et al.*, 2006). This animal occupies a large variety of habitats, travels large distances and is tolerant to human disturbances (Arispe *et al.*, 2008). It depends on areas with sources of water and is vulnerable to the destruction of forest corridors, preferring to travel along open paths and trails in the vegetation (Trolle & Kéry, 2005). Indeed, the occurrence of this species in roadkill fauna is very common in Brazil (Cherem *et al.*, 2007; Caceres *et al.*, 2012; Preuss, 2015).

The common opossum occurs in both natural and human-altered habitats, with the ability to adapt well to large urban centers (Cordero-Rodriguez, 2000). High roadkill rates are found in different regions of Brazil (Gumier-Costa & Sperber, 2009; Omena-Junior *et al.*, 2012; Sássi *et al.*, 2013), which may be related to the attraction of this animal to carcasses on roadways. The common opossum adapts to different types of climate, vegetation and diet, exploiting a wide range of environments, including demarcated human routes (Vaughan & Hawkins, 1999).

The process of changes in the original forest cover occurring in the region has favored species with opportunistic habits and has maintained species more dependent on the forest environment. Moreover, generalist omnivorous mammals benefit from their adaptability and plasticity, but are also more vulnerable to being struck by vehicles due to their attraction to a broad gamut of food sources, which are often more available in these altered environments (Cook & Blumstein, 2013).

The records of the three-toed sloth and common squirrel monkey may be related to the presence of new clusters of vegetation with the structural pattern of the primitive forest, many of which are near or intercepted by the roadway. The occasional records may be related to the potential effect that the ecological barriers roadways pose for species with tree-climbing habits (Laurance *et al.*, 2006). However, records of roadkilled primates on Brazilian roads are not rare (Gumier-Costa & Sperber, 2009; Caceres *et al.*, 2010; Omena-Junior *et al.*, 2012; Costa & Dias, 2013; MACHADO *et al.*, 2015; BRUM *et al.*, 2017; CORRÊA *et al.*, 2017).

The lack of significant seasonality in the roadkill records for BR 364 and other roadways (PEREIRA *et al.*, 2006; CUNHA *et al.*, 2010; COSTA & DIAS, 2013; SILVA *et al.*, 2013; ORLANDIN *et al.*, 2015) may reflect the tendency toward a predominance of species with a high capacity for adaption to varied environments. Thus, the dry and rainy seasons offer distinct resources that can be exploited by species with opportunistic generalist habits, as those occurring along BR 364. The high frequency in the rainy season is associated with the large number of records of the nine-banded armadillo, coinciding with the mating season of the species (CLEVENGER *et al.*, 2003), and is probably due to the greater availability of food sources in this season (ROCHA *et al.*, 2006).

Despite the high number of roadkilled individuals, the low species diversity may be explained by the characteristics of the roadway, which favors species with a more generalist habitat and diet (GONZÁLEZ-SUÁREZ *et al.*, 2018). Specialist and larger mammals may avoid human environments, such as roads. Moreover, the low diversity of large mammals may stem from the reduction in natural environments (NEWMARK, 1996; COFFIN, 2007) as well as secondary impacts of poaching in areas occupied by humans (LAURANCE *et al.*, 2006). Therefore, the high degree of habitat fragmentation in Rondônia may have a negative impact on the diversity of mammals through one or a combination of factors.

The high index of roadkilled mammals in the Pampa and Atlantic Forest eco-regions may be related to greater number of roads that cross conservation units (BAGER *et al.*, 2015) or the greater number of species that occur in larger concentrations in areas near roads. This process may be related to the availability of food sources, reproductive behavior or a greater frequency of travelling along the road by species with a large living area (CUNHA *et al.*, 2015).

The higher incidence of roadkilled mammals may be attributed to biomes with greater species diversity (hotspots) (MYERS *et al.*, 2000). Moreover, the number of roadkilled individuals and species may not be only related to eco-regions, but also to the roadway systems that pass through these biomes, with heavy traffic flow crossing highly populated regions in the coastal zone of Brazil. According to COFFIN *et al.* (2007), the conversion of forests for the establishment of rural areas in regions with a low population density in Belize is more common in areas with better soil quality and easier access. Thus, the greater records of roadkills may be associated with converted areas of quality that are closer to roadways.

The comparative findings demonstrate that, despite the smaller number of threatened species in comparison to other eco-regions, the Pampas are also fundamental to the conservation of mammals. Large and medium-sized species use forest fragments for shelter and feeding; moreover, rare species occur in an environment that is considerably threatened by fragmentation and the replacement of natural fields with agricultural activities and grazing pastures (ESPINOSA *et al.*, 2016).

One hypothesis to explain the high number of endangered species in the mammal community in the Cerrado (savanna) would be related to the structure of the biome, with its greater richness of families and species and consequently more endangered species (CACERES *et al.*, 2010). The native vegetation may not be the preferred route for many large and medium-sized mammals in highly fragmented environments, as occurs in the Cerrado. Therefore, roadways may serve as connection routes between populations among forest areas and the courses of rivers in an eco-region dominated by agriculture and grazing pastures, as observed in the Cerrado as well as a seriously threatened eco-region, such as the Atlantic Forest, which are part of the biodiversity hotspots for conservation priorities (MYERS *et al.*, 2000).

There is a need to understand the effects of roadways on the conservation of biodiversity and the challenges of integrating plans that can avoid, minimize, and compensate for the environmental impacts generated by transportation, which is an expanding sector (BAGER *et al.*, 2015).

Urgently, practical measures for avoiding and minimizing collisions with animals are fundamental to the conservation of wild fauna. More discerning environmental analyses should prioritize specific plans and projects that can minimize the impact of roadways on wild life population, especially along more vulnerable roadways and in more threatened eco-regions in Brazil.

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REFERENCES

ALMEIDA, V. M. & CARDOSO JÚNIOR, J. C. S. 2014. Registros de Atropelamentos de Animais Silvestres na Rodovia Vicinal Antônio Joaquim de Moura Andrade entre os Municípios de Mogi Guaçu-SP e Itapira-SP. **Foco 5**(7):99-116.

ARISPE, R.; VENEGAS, C. & RUMIZ, D. 2008. Abundancia y Patrones de Actividad del Mapache (*Procyon cancrivorus*) en un Bosque Chiquitano de Bolivia. **Mastozoología Neotropical 15**(2):323-333.

AYRES, M.; AYRES JR., M.; AYRES, D. L. & SANTOS, A.S. 2007. **BioEstat**. Versão 5.3, Sociedade Civil Mamirauá, MCT – CNPq, Belém, Pará, Brasil.

BAGER, A.; BORGHI, C. E. & SECCO, H. 2015. The influence of economics, politics, and environment on road ecology in South America. *In*: VAN DER REE, R.; SMITH, D. & GRILO, C. eds. **Handbook of road ecology**. Oxford, Wiley-Blackwell, p. 407-413

BERGALLO, H. G.; ROCHA, C. F. D.; ALVES, M. A. S. & SLUYS, M. V. org. 2000. **A Fauna Ameaçada de Extinção do Estado do Rio de Janeiro**. Rio de Janeiro, EDUERJ. 166p.

BORGES, P. A. L. & TOMÁS, W. M. 2004. **Guia de rastros e outros vestígios de mamíferos do pantanal**. Corumbá, Embrapa Pantanal. 148p.

BRAZ, V.S. & FRANÇA, F. G. R. 2016. Impacto do atropelamento de vertebrados do Parque Nacional da Chapada dos Veadeiros no Brasil Central. **Biota Neotropica** http://dx.doi.org/10.1590/1676- 0611-BN-2014-0182.

BRUM, T. R.; SANTOS-FILHO, M.; CANALES, G. R. & IGNACIO, R. A. 2017. Effects of roads on the vertebrates diversity of the Indigenous Territory Paresi and its surrounding. **Brazilian Journal of Biology 78**(1):125-132. http://dx.doi.org/10.1590/1519-6984.08116.

CACERES, N. C.; CASELLA, J. & SANTOS-GOULART, C. 2012. Variação espacial e sazonal atropelamentos de mamíferos no bioma cerrado, rodovia BR 262, Sudoeste do Brasil. **Mastozoología Neotropical 19**(1):21-33.

Caceres, N. C.; Hannibal, W.; Freitas, D. R.; Silva, E. L.; Roman, C. & Casella, J. 2010. Mammal occurrence and roadkill in two adjacent ecoregions (Atlantic Forest and Cerrado) in southwestern Brazil. **Zoologia 27**:709-717.

Carvalho, N. C.; Bordignon, M. O. & Shapiro, J. T. 2014. Fast and furious: a look at the death of animals on the highway MS-080, Southwestern Brazil. **Iheringia**, Série Zoologia **104**(1):43-49.

Carvalho, C. F.; Custódio, A. E. I. & Marçal Júnior, O. 2017. Influence of climate variables on roadkill rates of wild vertebrates in the Cerrado biome, Brazil. **Bioscience Journal 33**(6):1632-1641.

Cheida, C. C.; Nakano-Oliveira, E.; Fusco-Costa, R.; Rocha-Mendes, F. & Quadros, J. 2006. Ordem Carnivora. *In*. Reis, N. R.; Peracchi, A. L.; Pedro, W. A. & Lima, I. P. eds. **Mamíferos do Brasil**. Londrina. 437p.

Cherem, J.; Kammer, M.; Ghizoni-Jr, I. R. & Martins, A. 2007. Mamíferos de médio e grande porte atropelados em rodovias do estado de Santa Catarina sul do Brasil. **Biotemas 20**(2):81-96.

Clevenger, A. P.; Chruszcz, B. & Gunson, K. 2003. Spatial patterns and factors influencing small vertebrate fauna road-kill aggregations. **Biological Conservation 109**:15-26.

Coffin, A. W. 2007. From roadkill to road ecology: A review of the ecological effects of roads. **Journal of Transport Geography 15**:396-406.

Cook, T. C. & Blumstein, D. T. 2013. The omnivore's dilemma: Diet explains variation in vulnerability to vehicle collision mortality. **Biological Conservation 167**:310-315.

COPAM – Conselho Estadual de Política Ambiental. 2010. **Lista de Espécies Ameaçadas de Extinção da Fauna do Estado de Minas Gerais**. Deliberação Normativa. COPAM Nº147, de 30 de abril de 2010.

Cordero-Rodriguez, G. 2000. The biology of the opossum (*Didelphis marsupialis*) in urbanized enviroments from Northern Venezuela. **Acta Biologica Venezuelica 20**(2):13-28.

Corrêa, L. L. C.; Silva, D. E.; Oliveira, S. V.; Finger, J. V. G. Santos, C. R. & Petry, M. V. 2017. Vertebrate road kill survey on a highway in southern Brazil. **Acta Scientiarum**, Biological Sciences **39**(2):219-225.

Costa, L. S. 2011. Levantamento de mamíferos silvestres de pequeno e médio porte atropelados na Br 101, entre os municípios de Joinville e Piçarras, Santa Catarina. **Bioscience Journal 27**(3):666-672.

Costa, R. R. G. F. & Dias, L. A. 2013. Mortalidade de Vertebrados por Atropelamento em um Trecho da GO-164, no Sudoeste Goiano. **Revista de Biotecnologia & Ciência 2**(2):58-74.

Cunha, G. G.; Hartmann, M. T. & Hartmann, P. A. 2015. Atropelamentos de vertebrados em uma área de Pampa no sul do Brasil. **Ambiência 11**(2):307-320.

Cunha, H. F.; Moreira, F. G. A. & Silva, S. S. 2010. Road kill of wild vertebrates along the GO-060 road between Goiânia and Iporá, Goiás State, Brazil. **Acta Scientiarum,** Biological Sciences **32**(3):257-263.

Deffaci, A. C.; Silva, V. P.; Hartmann, M. T. & Hartmann, P. A. 2016. Diversidade de aves, mamíferos e répteis atropelados em região de floresta subtropical no sul do Brasil. **Ciência e Natura 38**(3):1205-1216.

Desbiez, A. L. J.; Bodmer, R. E. & Santos, S. A. 2009. Wildlife habitat selection and sustainable resources management in a Neotropical wetland. **International Journal of Biodiversity and Conservation 1**(1):11-20.

Drummond, G. M.; Machado, A. B. M.; Martins, C. S.; Mendonça, M. P. & Stehmann, J. R. 2008. **Listas Vermelhas das Espécies da Fauna e da Flora Ameaçadas de Extinção em Minas Gerais**. 2ed. Belo Horizonte, Fundação Biodiversitas. CD-ROM.

Emmons, L. H. & Feer, F. 1997. **Neotropical rainforest mammals: A field guide**. 2ed. Chicago, The University of Chicago Press. 307p.

Espinosa, C. C.; Galiano, D.; Kubiak, B. B. & Marinho, J. R. 2016. Medium- and large-sized mammals in a steppic savanna area of the Brazilian Pampa: survey and conservation issues of a poorly known fauna. **Brazilian Journal of Biology 76**(1):73-79.

Fearnside, P. M. 2005. Deforestation in Brazilian Amazonia: history, rates and consequences. **Conservation Biology 19**:680-688.

Fearnside, P. M. 2006. Desmatamento na Amazônia: Dinâmica, Impactos e Controle. **Acta Amazonica 36**(3):395-400.

Fearnside, P. M. 2015. Highway construction as a force in destruction of the Amazon forest. *In*: van der Ree, R.; Smith, D. J. & Grilo, C. eds. **Handbook of Road Ecology**. Oxford, UK, John Wiley & Sons Publishers, p. 414-424.

Fontana, C. S.; Bencke, G. A. & Reis, R. E. org. 2003. **Livro Vermelho da Fauna Ameaçada de Extinção no Rio Grande do Sul**. Porto Alegre, EDIPUCRS. 632p.

González-Suárez, M.; Ferreira, F. Z. & Grilo, C. 2018. Spatial and species-level predictions of road mortality risk using trait data. **Global Ecology Biogeography 27**:1093-1105.

Gumier-Costa, F. & Sperber, C. F. 2009. Atropelamentos de vertebrados na Floresta Nacional de Carajás, Pará, Brasil. **Acta Amazonica 39**(2):459-466.

Hegel, C. G. Z.; Consalter, G. C. & Zanella, N. 2012. Mamíferos silvestres atropelados na rodovia RS-135 e entorno. **Biotemas 25**:165-170.

Hengemühle, A. & Cademartori, C. V. 2008. Levantamento de Mortes de Vertebrados Silvestres Devido a Atropelamento em um Trecho da Estrada do Mar (RS-389). **Biodiversidade Pampeana 6**(2):4-10.

IUCN. 2018. **IUCN Red List of Threatened Species**. Version 2018. 1. Available at <www.iucnredlist. org>. Accessed on 15 January 2018.

Laurance, W. F.; Albernaz, A. K. M.; Schroth, G.; Fearnside, P. M.; Bergen, S.; Venticinque, E. M. & Costa, C. 2002. Predictors of deforestation in the Brazilian Amazon. **Journal of Biogeography 29**:737-748.

Laurance, W. F.; Croes, B. M.; Tchignoumba, L.; Lahm, S. A.; Alonso, A.; Lee, M. E.; Campbell, P. & Ondzeano, C. 2006. Impacts of roads and hunting on central African rainforest mammals. **Conservation Biology 20**:1251-1261.

Laurance, W. F.; Goosem, M. & Laurance, S. G. 2009. Impacts of roads and linear clearings on tropical forests. **Trends Ecology and Evolution 24**:659-669.

Lisboa, P. L. B.; Maciel, U. N. & Prance, G. T. 1991. Some effects of colonization on the tropical flora of Amazonia: a case study from Rondonia. **Kew Bulletin 46**(2):187-204.

Loughry, W. J. & McDounough, C. M. 1997. **Survey of the Xenarthrans Inhabiting Poço das Antas Biological Reserve**. **Edentata. IUCN/SSC Edentate Specialist Group 3**(1):5-7.

Machado, F. S.; Fontes, M. A. L.; Mendes, P. B.; Moura, A. S. & Romão, B. 2015. Roadkill on vertebrates in Brazil: seasonal variation and road type comparison. **North-Western Journal of Zoology 11**(2):247-252.

Marques, A. A. B.; Fontana, C. S.; Vélez, E.; Bencke, G. A.; Schneider, M. & Reis, R. E. 2002. **Lista de Referência da Fauna Ameaçada de Extinção no Rio Grande do Sul**. Decreto no 41.672, de 11 junho de 2002. Porto Alegre: FZB/MCT–PUCRS/PANGEA, 2002. 52p.

Marvier, M.; Kareiva, P. & Neubert, M. G. 2004. Habitat destruction, fragmentation, and disturbance promote invasion by habitat generalists in a multispecies metapopulation. **Risk Analysis 24**:869-878.

Melo, E. S. & Santos-Filho, M. 2007. Efeitos da BR-070 na Província Serrana de Cáceres, Mato Grosso, sobre a comunidade de vertebrados silvestres. **Revista Brasileira de Zoociências 9**(2):185-192.

Mickich, S. B. & Bérnils, R. S. ed. 2004. **Livro Vermelho da Fauna Ameaçada no Estado do Paraná**. Curitiba, Instituto Ambiental do Paraná. 764p. CD ROM.

Milli, M. S. & Passamani, M. 2006 Impacto da Rodovia Josil Espíndula Agostini (ES-259) sobre a mortalidade de animais silvestres (Vertebrata) por atropelamento. **Natureza on line 4**(2):40-46.

Miranda, I. S.; Almeida, S. S. & Dantas, P. J. 2006. Florística e estrutura de comunidades arbóreas em cerrados de Rondônia, Brasil. **Acta Amazonica 36**(4):419-430.

MMA. 2002. **Avaliação e identificação de áreas e ações prioritárias para a conservação, utilização sustentável e repartição dos benefícios da biodiversidade nos biomas brasileiros**. Brasília, MMA/SBF, 2002. 404p.

MMA. 2014. **Lista Nacional Oficial de Espécies da Fauna Ameaçadas de Extinção**. Portaria No – 444, de 17 de dezembro de 2014. Diário Oficial da União – Seção 1 Nº 245, quinta-feira, 18 de dezembro de 2014, p. 121-126.

Myers, N.; Mittermeier, R. A.; Mittermeier, C. G.; Fonseca, G. A. B. & Kent, J. 2000. Biodiversity hotspots for conservation priorities. **Nature 403**:853-858.

Newmark, W. D. 1996. Insularization of Tanzanian Parks and the Local Extinction of Large Mammals. **Conservation Biology 10**(6):1549-1556.

Oliveira, P. A. S.; Sousa, E. F. & Silva, F. B. 2017. Levantamento de Animais Vertebrados Vítimas de Atropelamentos em Trechos das Rodovias MG-223, MG-190 e BR-352. **Getec 6**(14):128-148.

Omena-Junior, R.; Pantoja-Lima, J.; Santos, A. L. W.; Ribeiro, G. A. A. & Aride, P. H. R. 2012. Caracterização da fauna de vertebrados atropelada na rodovia BR–174, Amazonas, Brasil. **Revista Colombiana de Ciencia Animal 4**(2):291-307.

Orlandin, E.; Piovesan, M.; Favretto, M. A. & D'Agostini, F. M. 2015. Mamíferos de médio e grande porte atropelados no Oeste de Santa Catarina, Brasil. **Biota Amazonica 5**(4):125-130.

Passamani, M. & Mendes S. L. 2007. **Espécies da fauna ameaçadas de extinção no Estado do Espírito Santo. Os mamíferos ameaçados de extinção no Estado do Espírito Santo**. Vitória, Instituto de Pesquisas da Mata Altântica - IPEMA. 140p.

Percequillo, A. R. & Kierulff, M. C. M. 2009. Mamíferos. *In*: Bressan, P. M.; Kierulff, M. C. M. & Sugieda, A. M. orgs. 2009. **Fauna Ameaçada de Extinção no Estado de São Paulo: Vertebrados**. São Paulo, Fundação Parque Zoológico de São Paulo, Secretaria do Meio Ambiente, p. 31-85.

Pereira, A. P. F. G.; Andrade, F. A. G. & Fernandes, M. E. B. 2006. Dois anos de monitoramento dos atropelamentos de mamíferos na rodovia PA-458, Bragança, Pará. **Boletim do Museu Paraense Emílio Goeldi,** Ciências Naturais **1**(3):77-83.

Pinheiro, B. F. & Turci, L. C. 2013. Vertebrados atropelados na estrada da Variante (BR-307), Cruzeiro do Sul, Acre, Brasil. **Natureza on line 11**(2):68-78.

Preuss, J. F. 2015. Composição e Caracterização da Fauna de Mamíferos de Médio e Grande Porte Atropelados em Trecho da BR-282, Oeste do Estado de Santa Catarina. **Unoesc & Ciência** - ACBS [S.l.] **6**(2):179-186.

Ramos-Abrantes, M. M.; Carreiro, A. N.; Araújo, D. V. F.; Souza, J. G.; Lima, J. P. R.; Cezar, H. R. A.; Leite, L. S. & Abrantes, S. H. F. 2018. Vertebrados silvestres atropelados na rodovia BR-230, Paraíba, Brasil. **PUBVET 12**(1):1-7.

Redford, K. H. 1994. The Edentates of the Cerrado. ***Edentata. IUCN/SSC Edentate Specialist Group*** **1**(1):4-10.

Reis, N. R. dos; Peracchi, A. L.; Pedro, W. A. & Lima, I. P. de. 2006. **Mamíferos do Brasil**. Londrina. 437p.

Rocha, E. C. C.; Silva, E.; Martins, S. V. & Barreto, F. C. C. 2006. Evaluación Estacional de la Riqueza y Abundancia de Especies de Mamíferos en la Reserva Biológica Municipal "Mário Viana", Mato Grosso, Brasil. **Revista de Biología Tropical 54**:879-888.

Rosa, A. O. & Mauhs, J. 2004. Atropelamento de Animais na Rodovia RS-040. **Caderno de Pesquisa**, Série Biologia **16**(1):35-42.

Santana, S. G. 2012. Fatores influentes sobre atropelamentos de vertebrados na região central do Rio Grande do Sul, Brasil. **Neotropical Biology and Conservation 7**:26-40.

Santos, A. L. P. G.; Rosa, C. A. & Bager, A. 2012. Variação sazonal da fauna selvagem atropelada na rodovia MG 354, Sul de Minas Gerais – Brasil. **Biotemas 25**(1):73-79.

Saranholi, B. H.; Bergel, M. M.; Ruffino, P. H. P.; Rodrígues-C., K. G.; Ramazzotto, L. A.; Freitas, P. D. & Galletti Jr., P. M. 2016. Roadkill hotspots in a protected area of Cerrado in Brazil: planning actions to conservation. **Revista MVZ Córdoba** 21(2):5441-5448.

Sássi, C. M.; Nascimento, A. A. T.; Miranda, R. F. P. & Carvalho, G. D. 2013. Levantamento de animais silvestres atropelados em trecho da rodovia BR482. **Arquivo Brasileiro de Medicina Veterinária e Zootecnia 65**(6):1883-1886.

Sathler, D.; Adamo, S. B. & Lima, E. E. C. 2018. Deforestation and local sustainable development in Brazilian Legal Amazonia: an exploratory analysis. **Ecology and Society 23**(2):30.

Scoss, L. M.; De Marco Jr., P.; Silva, E. E. & Martins, S. V. 2004. Uso de parcelas de areia para o monitoramento de impacto de estradas sobre a riqueza de espécies de mamíferos. **Revista Árvore 28**(1):121-127.

Silva, D. E.; Corrêa, L. L. C.; Oliveira, S. V. & Cappellari, L. H. 2013. Monitoramento de vertebrados atropelados em dois trechos de rodovias na região central do Rio Grande do Sul, Brasil. **Revista de Ciências Ambientais 7**(1):27-36.

Sousa, M. A. N. & Miranda, P. C. 2010. Mamíferos terrestres encontrados atropelados na rodovia BR-230/PB entre Campina Grande e João Pessoa. **Biofar: Revista de Biologia e Farmácia 4**:72-82.

Trombulak, S. C. & Frissell, C. A. 2000. Review of Ecological Effects of Roads on Terrestrial and Aquatic Communities. **Conservation Biology 14**:18-30.

Trolle, M. & Kéry, M. 2005. Camera-trap study of ocelot and other secretive mammals in the northern Pantanal. **Mammalia 69**:409-416.

Tumeleiro, L. K.; Koenemann, J.; Ávila, M. C. N.; Pandolfo, F. R. & Oliveira, E. V. 2006. Notas sobre mamíferos da região de Uruguaiana: estudo de indivíduos atropelados com informações sobre a dieta e conservação. **Biodiversidade Pampeana 4**:38-41.