BRAZIL ROAD-KILL – a dataset of wildlife terrestrial vertebrate road-kills

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INTRODUCTION

Mortality from collision with vehicles is the most visible impact of roads on wildlife (Van der Ree et al. 2015). There are records of billions of fatalities occurring each year around the world (e.g. Lalo 1987, Seiler et al. 2004, Erickson et al. 2005, Bishop and Brogan 2013). Mortality due to roads (hereafter road-kill) can affect the dynamic of populations and increase the risk of local decline or extinction for several species, particularly for those that are already threatened (e.g. Ceia-Hasse et al. 2017). Such issue has prompted research centres, universities, and road agencies to routinely collect animal carcasses to understand the mechanisms underlying road-kill likelihood, assess the impact on wildlife populations and provide guidance for government environmental agencies and decision makers to reduce road-kill rates. For an efficient assessment of road impacts on wildlife and indeep understanding of processes that explain road-kill risk requires a large dataset. However, road surveys are costly, which usually leads to short-term surveys on a limited number of select road segments. Big data has become a reality on many study fields. Recently, the Ecology journal are publishing the ATLANTIC SERIES, which congregate a huge amount of biodiversity data on Fruvirogy (Bello et al. 2017), Small mammals (Bovendorf et al. 2017), Camera-trap on medium- and large-sized mammals (Lima et al. 2017), Bats (Muylaert et al. 2017), Birds (Hasui et al. 2018), Mammal Traits (Gonçalves et al. 2018) and Amphibians (Vancine et al. in press) – see https://github.com/LEEClab/Atlantic_series. The use of big data has increased the interest of both researchers and practitioners on developing quantitative assessments and defining valuable strategies for more environmentally sustainable transportation infrastructure. Citizen science has given the opportunity to accumulate a great amount of road-kill data in many countries (e.g. Shilling et al. 2015, Vercayie and Herremans 2015, Bíl et al. 2017). However, the accuracy of species identification is still one of the main limitations of this approach.

Generating large datasets from science-based road surveys can guarantee a high level of accuracy on species identification. Moreover, sharing road-kill datasets with students, researchers, road managers and conservacionists can bring new knowledge to develop more innovative and high-impact research. In a consequence, this can allow us to drive solutions to the challenges that we will face on biodiversity conservation under the scenarios of road upgrading and network expansion (Ciocheti et al. 2017). This is especially true in Brazil, where biodiversity hotspots biomes – i.e. areas with high species richness, high levels of endemisms and intensive habitat loss and degradation – such as Atlantic Forest and Cerrado (Myers et al. 2000; Klink and Machado, 2005; Ribeiro et al. 2009) coincide with plans of road network expansion (Reid and de Souza 2005, Fearnside 2015). Researchers, conservationists and road planners have the opportunity to define a national strategy that combines road network development with wildlife conservation.

The main goal of this dataset is a compilation of geo-referenced road-kill data from published and unpublished road surveys appearing in peer-reviewed international journals, dissertations, reports, and other types of grey literature. It is a large-scale synthesis of terrestrial vertebrate road-kills in Brazil. The dataset comprises 21,512 road-kill records, 83% of which are identified to the species level (n = 450 species). The dataset includes records of 31 amphibian species, 90 reptile species, 229 bird species, and 99 mammal species. One species is classified as Endangered, eight as Vulnerable and twelve as Near Threatened (IUCN 2017).

METADATA

CLASS I Dataset Descriptors

Dataset identity - BRAZIL ROAD-KILL – a dataset of wildlife terrestrial vertebrate road-kills

A.

B. Dataset identification code

Brazil_Roadkill_20180527.csv

C. Dataset description

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C2. Abstract

Mortality from collision with vehicles is the most visible impact of road traffic on wildlife. Mortality due to roads (hereafter road-kill) can affect the dynamic of populations of many species and can, therefore, increase the risk of local decline or extinction. This is especially true in Brazil, where plans for road network upgrading and expansion overlaps biodiversity hotspot areas, which are of high importance for global conservation. Researchers, conservationists and road planners face the challenge to define a national strategy for road mitigation and wildlife conservation. The main goal of this dataset is a compilation of geo-referenced road-kill data from published and unpublished road surveys. This is the first datapaper on the BRAZIL SERIES (search by ATLANTIC and NEOTROPICAL series of datapapers within Ecology journal), which aims make public road-kill data for species in the Brazilian Regions. The dataset encompasses road-kill records from 45 personal communications and 26 studies published in peer-reviewed journals, theses and reports. The road-kill dataset comprises 21,512 records, 83% of which are identified to the species level (n = 450 species). The dataset includes records of 31 amphibian species, 90 reptiles species, 229 birds species, and 99 mammals species. One species is classified as Endangered, eight as Vulnerable and twelve as Near Threatened. The species with the highest number of records are: *Didelphis albiventris* (n = 1,549), *Volatinia jacarina* (n = 1,238), *Cerdocyon thous* (n = 1,135), *Helicops infrataeniatus* (n = 802), and *Rhinella icterica* (n = 692). Most of the records came from southern Brazil. However, observations of the road-kill incidence for non-Least Concern species are more spread across the country. This dataset can be used to identify which *taxa* seems to be vulnerable to traffic, analyze temporal and spatial patterns of road-kill at local, regional and national scales and also used to understand the effects of road-kill on population persistence. It may also contribute to studies that aims to understand the influence of landscape and environmental influences on road-kills, improve our knowledge on road-related strategies on biodiversity conservation and be used as complementary information on large-scale and macroecological studies.

C3. Description

The dataset comprises 21,523 records, 83% of them identified to the species level, represented by 450 species from all terrestrial vertebrate classes. Around 8% are amphibian records, 21% are reptiles, 28% are birds, and 42% are mammals). This is a result of a compilation of geo-referenced records from 71 systematic and opportunistic road surveys (45 personal communications and 26 publications) from northern to southern Brazil covering all geographic regions and biomes of the country (Figure 1). Systematic studies were performed mostly in southern Brazil (Figure 2a). The incidence of all records (Figure 2b) and of non-Least Concern species show that systematic surveys (Figure 2c) should focus on other areas where threatened species seem to be vulnerable to traffic. We recorded road-kills from nine threatened and 12 near threatened species according to IUCN: one ENDANGERED (*Ctenomys flamarioni* [N = 1]), seven VULNERABLE (*Bradypus torquatus* [2], *Chaetomys subspinosus* [2], *Crax fasciolata* [2], *Leopardus guttulus* [110], *Leopardus tigrinus* [27], *Mazama nana* [1], *Myrmecophaga tridactyla* [39] and *Tapirus terrestris* [1]), and 12 NEAR THREATENED (*Acanthochelys spixii* [159], *Alipiopsitta xanthops* [3], *Aratinga auricapillus* [1], *Chrysocyon brachyurus* [266], *Dasypus hybridus* [18], *Laniisoma elegans* [1], *Leopardus colocolo* [33], *Leopardus wiedii* [70], *Lontra longicaudis* [44], *Neothraupis fasciata* [3], *Panthera onca* [18] and *Sapajus nigritus* [12]). The NEAR THREATENED and VULNERABLE species with more than 100 road-kill records were: *Chrysocyon brachyurus* [266], *Acanthochelys spixii* [159] and *Leopardus guttulus* [110] (Figure 3). The species with the highest number of records were: *Didelphis albiventris* [1,549], *Volatinia* *jacarina* [1,238], *Cerdocyon thous* [1,135], *Helicops infrataeniatus* [802], and *Rhinella icterica* [692]. From this dataset we detected 133 species with just one record. Most of the records (52%) were from 2012 to 2016 (Figure 4a) and come from systematic surveys up to four years of monitoring (Figure 4b). Sampling frequency was once or twice a month (Figure 4c) and most frequent monitored roads had the length over 100 km (Figure 4d).

D. Keywords – Brazil, 1988-2017, road mortality, wildlife-vehicle collisions, amphibians, reptiles, birds, mammals, road effects, road survey, species occurrence.

CLASS II Research Origin Descriptors

A. Overall project description

A1. Identity: A database incorporating records of terrestrial vertebrate road-kills from road surveys in Brazil.

A2. Period of study: Road-kill data range from 1988 to 2017.

A3. Objectives: The main goals of the road-kill dataset were to: 1) make available the geo-referenced road-kill data from published and unpublished road surveys to a high variety of stakeholders (research centres, road agencies, environmental agencies, conservation organizations); 2) contribute with data for species distribution mapping and modelling in Brazil; 3) summarize the available information on road-kill research (e.g. location, species composition, sampling effort, survey period); 4) highlight the main species at risk due to collision with vehicles; 5) outline the road segments with high incidence of road-kills; and 6) identify gaps of knowledge and information to provide guidance to decision-makers for future sampling efforts. This dataset is part of the goals of BIOINFRA - a Brazilian network of various stakeholders with the aim to develop actions in several topics (research, public policy, environmental education, human resources training and dissemination/communication) to promote more environmentally friendly transportation in Brazil.

A4. Sources of funding –

AM, BHS, CG, DFOB, FPT, ICF, KGRC, LC, LE, LGS, GB, PMGJr, Teixeira et al. (2012), Teixeira et al. (2013a, 2013b), Ferreira et al. (2014), and Figueiró et al. (2015) studies were funded by CNPq. FPT, TCM, RAPD, Carvalho et al. (2015) and Gonçalves et al. (2018) studies were supported through grants from CAPES. AB was supported by Centro Brasileiro de Estudos em Ecologia de Estradas and FAPEMIG (Fundação de Amparo à Pesquisa do Estado de Minas Gerais) - Processo APQ-00604-17. AB and AQ was funded by Universidade Federal of Uberlândia. Bueno and Almeida (2010) study was funded by Companhia de Concessão Rodoviária Juiz de Fora-Rio (Concer). Carvalho et al. (2015) were supported by the Universidade Federal of Uberlândia. LC, LGS and Figueiró et al. (2015) were supported by FACEPE (Fundação de Amparo à Ciência e Tecnologia do Estado de Pernambuco). BHS and PMGJr were funded by FAPESP (Fundação de Amparo a Ciência e Tecnologia do Estado de São Paulo). Cherem and Althoff (2015) study and JC were supported by the following enterprises: ETS - Energia, Transporte e Saneamento, Maurique Consultoria Ambiental, Socioambiental Consultores Associados and Gehidro Consultoria e Assessoria Ltda. Coelho et al. (2008, 2012), Teixeira et al. (2013a, 2013b) studies were partially suppported by the Instituto de Biociências of Universidade Federal do Rio Grande do Sul. JZPR, DFOB and RATS were supported by Universidade Estadual do Sudoeste da Bahia. Pereira et al. (2006) study was funded by Laboratório de Ecologia de Manguezal of Universidade Federal do Pará. NC was supported by CEMIG e Fundação Zoo-Botânica de Belo Horizonte. Reis (2015) study and TXR were funded by the Universidade da Região da Campanha. RG was supported by Universidade Estadual de Goiás. Secco et al. (2015) study was funded by Concessionária Autopista Fluminense/Arteris. TCT and MMAJ were supported by Fundação Zoobotânica do Rio Grande do Sul (FZBRS)/SEMA. Teixeira and Kindel (2012) and Teixeira et al. (2013a, 2013b) were funded by Biolaw Consultoria Ambiental Ltda. Teixeira and Kindel (2012) and Teixeira et al. (2013a, 2013b) were supported by PPG Ecologia (UFRGS), CECLIMAR (UFRGS), UERGS, SEMA-RS, DNIT, Biolaw Consultoria Ambiental Ltda and Fundação Grupo Boticário de Proteção a Natureza. VAGB received support from the TULIP Laboratory of Excellence (ANR-10-LABX-41 and 394 ANR-11-IDEX-002-02) and from a Region Midi-Pyrenees project (CNRS 121090). FPT was supported by PPG Zoologia (PUCRS) and Departamento de Zoologia (UFRGS). RHE was funded by Fundação Araucaria (PR). CFH was supported by Fundação Cultural de Araxá (FCA), Grupo Zema e Novo Colégio. BHS and PMGJr were supported by IDEA WILD, Neotropical Grassland Conservancy – NGC. ABanhos, GS, BS, MM, LGS, SLM, APP, DS were supported by Fundação de Amparo à Pesquisa e Inovação do Espírito Santo (FAPES). MS was supported by DNIT (Departamento Nacional de Infraestrutura de Transportes). Figueiró et al. (2015) was also supported by Universidade de São Carlos, Associação pró-Carnivoros, MGO Rodovias and Instituto Onça Pintada.

B. Site description

Brazil is the largest country in South America with at least 8.5 million km^2 and with over 200 million inhabitants (IBGE 2014). Brazil is one of the most biodiverse countries in the world (Mittermeier et al. 1997, Brandon et al. 2005) and a high priority for conservation (Jenkins et al. 2013) with 4483 known terrestrial vertebrates species: amphibians (n = 1080; Segalla et al. 2016), reptiles (n = 795; Costa and Bérnils 2018), birds (n = 1919; Piacentini et al. 2015), and mammals n = 701; Paglia et al. 2012). Brazil comprises six biomes (Amazonia, Cerrado, Caatinga, Atlantic forest, Pantanal and Pampa), two of which are world biodiversity hotspots (Myers et al. 2000). Cerrado and Atlantic forest hotspots contain roughly 2% of the endemic plants and vertebrates worldwide and encompass more than two-thirds of the species richness in Brazil (Myers et al. 2000). The natural capital of Brazil is severely threatened by growing industrial agriculture, mining, and timber sectors of the economy, posing many challenges to find ways to combine the benefits of sustainable development and environmental protection (Laurance et al. 2001). Currently, the Brazilian road network consists of 1,6 million km of road, 14.5% of which are paved and mainly located in the southeast (SNV 2015). A national infrastructure plan includes the expansion of the road network by 20% in the next 20 years (Bager et al. 2015). Thus, identifying the “bad roads and good roads” (Laurance 2015) in order to improve or avoid them is a critically urgent challenge that will benefit from data like those provided here.

C. Research methods

C1. Data compilation: We obtained the road-kill data using the three steps: 1) Search for road-kill studies (technical reports, proceedings of scientific conferences, MSc and PhD theses, and papers from peer-reviewed journals) and in online academic databases (Researchgate, Google

Scholar, Scielo, Scopus, JSTOR); 2) screening of references cited in the literature found in step 1; and 3) contact by email authors of the studies and experts having unpublished data (most listed in the paper or via the Lattes CV platform http://lattes.cnpq.br) inviting them to contribute with geo-referenced coordinates of road-kill records.

We used the following English keywords and their translations to Portuguese to search for publications: ("road-kills" OR "road mortality") AND ("amphibians" OR "reptiles" OR "birds" OR "mammals" OR "vertebrates"). We contacted 437 authors, 16% of which sent us geo-referenced raw data from 71 systematic and opportunistic road surveys (26 publications in peer-reviewed journals and 45 personal communications). We collected unpublished records (pers. comm.) (Table 1) and records from the following publications (in alphabetic order): Adania et al. (2016), Bagatini 2006, Braz and França (2016), Bueno and Almeida (2010), Carvalho et al. (2015), Cherem and Althoff (2015), Cherem et al. (2007), Ciocheti et al. (2017), Coelho et al. (2008), Coelho et al. (2012), Correia Jr and Correa (2013), Deffaci et al. (2016), Ferreira et al. (2014), Figueiró et al. (2015), Gonçalves et al. (2018), Hannibal (2014), IBRAM (2017), Mantovani (2001), Pereira et al. (2006), Queirolo et al. (2011), Reis (2015), Secco et al. (2017), Silva et al. (2014), Teixeira and Kindel (2012), Teixeira et al. (2013a), Teixeira et al. (2013b). We checked and tidied all the information using R packages 'dplyr' (Wickham et al. 2017), 'stringr' (Wickham 2018) and 'lubridate' (Grolemund and Wickham, 2011). All data from different coordinate systems and datum were converted to a common geographic coordinate system using decimal degrees and WGS84 datum.

Datasets comprised four groups of information (*taxon*, record, survey and contributor) (Table 2, Brazil_Roadkill_20180527.csv): 1) *Taxon* is the associated taxonomic classification of each record (Class, Order, Family, Genus and Scientific name), common name, and IUCN status; 2) Each record was assigned the date (year, month, day) and the latitude and longitude coordinates in decimal degrees; 3) Survey includes the period (first month and year and last month and year of survey), survey duration, frequency of the survey and the identification of the road surveyed (name of the road, road length and latitude and longitude coordinates of the road endpoints). Contributor corresponds to publications or unpublished data from personal communications (researcher/professional or leader of the group of contributors) (Reference_ID at Table 2). We excluded domestic animals from the dataset. Records not identified to species level were also included the same dataset (Brazil_Roadkill_20180527.csv) with the same information as described for Table 2, except the scientific name, common name and IUCN status.

C2. Taxonomy and systematics

We used the R package rredlist (Chamberlain 2017) in addition to IUCN website (IUCN, 2017) to standardize the taxonomic classification and to describe the conservation status for each species.

C3. Data limitations, contributions and implications for road mortality studies

We identified four main limitations of our dataset: **1) Geographic bias** - The majority of records were obtained from southern Brazil and therefore other regions lack of representation. This dataset represents mostly the regions where surveys were performed, but not necessarily where roads with high impact occur (see the list of references). However, our dataset can help address knowledge gaps by providing guidance on where to focus sampling effort on roads and regions that lack surveys. Additionally, not all studies published with road-kills contributed with geo-referenced records and the majority of contacts did not contribute with records. **2) Detectability and carcass removal bias** - Although several studies had a high frequency of road surveys (e.g., one survey per day), carcass persistence on roads can be of short duration (less than a day) and thus may have not been recorded during road surveys (Ratton et al. 2014). Moreover, the low detection ability of the survey method, especially for small-sized species – e.g. amphibians, snakes and birds – results in an underestimation of number of records of these taxa (Teixeira et al. 2013a). Species that occur in low densities also are rarely detected along roads. However, even low mortality rates can affect these populations and surveys targeting those species by focusing on their habitats can provide valuable information on which species are vulnerable to road-kill and what is the impact on their populations. **3) Differences in sampling effort** - This dataset included opportunistic data and records from systematic surveys with high variability of survey duration and frequency. Consequently, the species with the highest records may not be the ones most vulnerable to traffic-related mortality. Systematic surveys should focus on other areas where threatened species are at risk and vulnerable to road-kill (Figure 3). **4) Species identification** – Around 17% of the records were not identified to species level mainly due to the high degree of decomposition of carcasses.

Although we recognize these limitations, this is the largest available dataset of road-kills of terrestrial vertebrates in Brazil. Using the records from systematic surveys, it is possible to estimate road-kill rates, examine the spatial and temporal patterns of road-kills, model the factors that may explain the road-kill risk for a wide variety of species, and analyze the potential impact on populations. Using both systematic and opportunistic data, it is possible to list the species experiencing road-related mortality, identify which threatened species may be at risk, analyze at local and landscape level factors that may explain mortality probability (using presence-only approaches). Moreover, this dataset allow us to detect gaps in road surveys to guide scientists and road agencies in locating where study efforts should be made. Beyond road ecology, the dataset will increase presence-only point samples for distribution modeling or other macroecological and conservation studies.

CLASS III. DATA SET STATUS AND ACCESSIBILITY

A. Status

Latest update: March 2018

Latest archive date: March 2018

Metadata status: Last updated May 2018, version submitted

Data verification: We checked the geographic coordinate using Google Earth and correction when necessary.

B. Accessibility

B1. Contact person(s): Clara Grilo (clarabentesgrilo@gmail.com), Andreas Kindel (andreaskindel@gmail.com)

Proprietary restrictions: Please cite this data paper when the data are used in publications.

B2. Storage Location and Medium: BRAZIL ROAD-KILL dataset can be accessed at ECOLOGY repository. Updated versions and additional information will be available at the

BRAZIL SERIES datapapers Github repository at

https://github.com/LEEClab/BRAZIL_SERIES

B3. Copyright restrictions: None

CLASS IV. DATA STRUCTURAL DESCRIPTORS

A. Data set file

A1. Identity:

Brazil_Roadkill_20180527.csv

A2. Size

Brazil_Roadkill_20180527.csv, 21,512 records, 5.4 MB

A3. Format and storage mode

Available as comma-separated values (*.csv)

File encoding: CP1252

Alphanumeric attributes: Mixed

Data anomalies: records with no information in specific fields are filled with NA (Not Available).

Acknowledgements

This study was part of the project “Road Macroecology: analysis tools to assess impacts on biodiversity and landscape structure” funded by CNPq (Nº 401171/2014-0, AJT Nº 300021/2015-1). We would like to thank Simone Freitas for helping us get in contact with researchers and Flávio Z Ferreira for making a first literature review. Thanks to Cristiana Prada, Joares May, Dênis Sana, Leonora Pires Costa, Frederico Gemesio Lemos, and Márcio Reppening for their road-kill collection records. Special thanks to Anthony P Clevenger for the comments and English review. We acknolewdge the Spatial Ecology and Conservation lab – LEEC (UNESP) for managing the road-kill database in their plataform.

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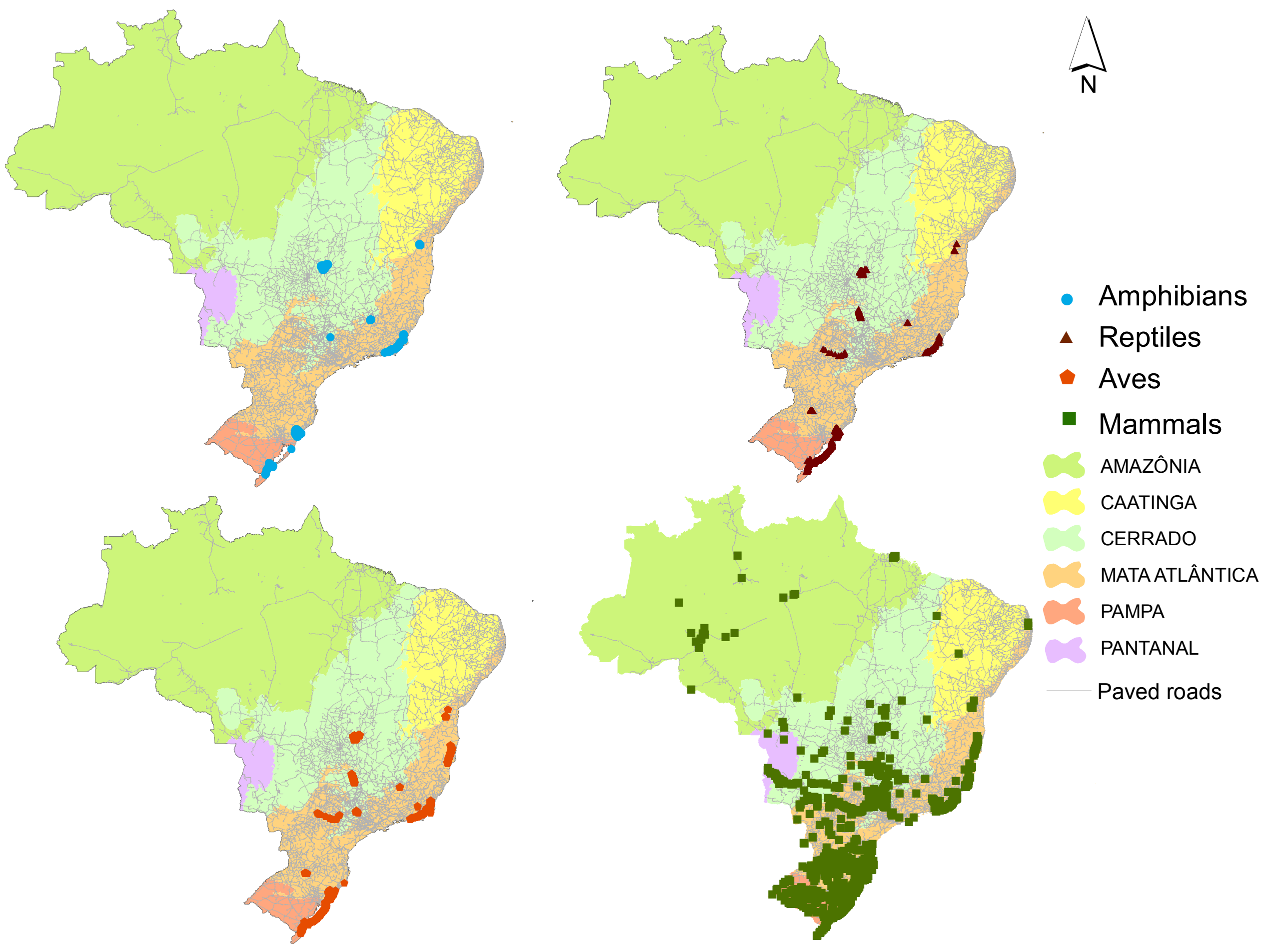

Figura 1 – Location of road-kill records for amphibians, reptiles, birds and mammals superimposed to Brazilian biome limits and paved road network.

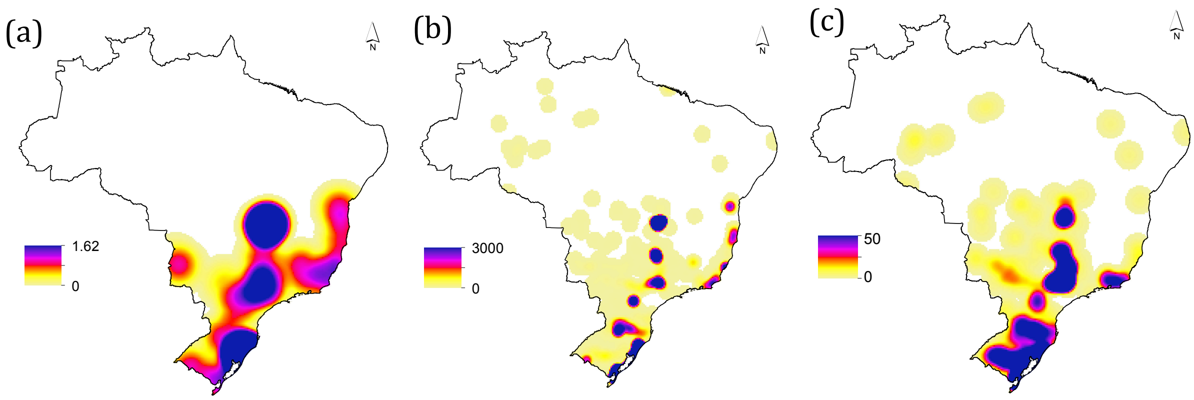

Figure 2 – Incidence of systematic studies in Brazil (a), number of road-kills (b), and number of non-Least Concern species (c) estimated using the Kernel density approach.

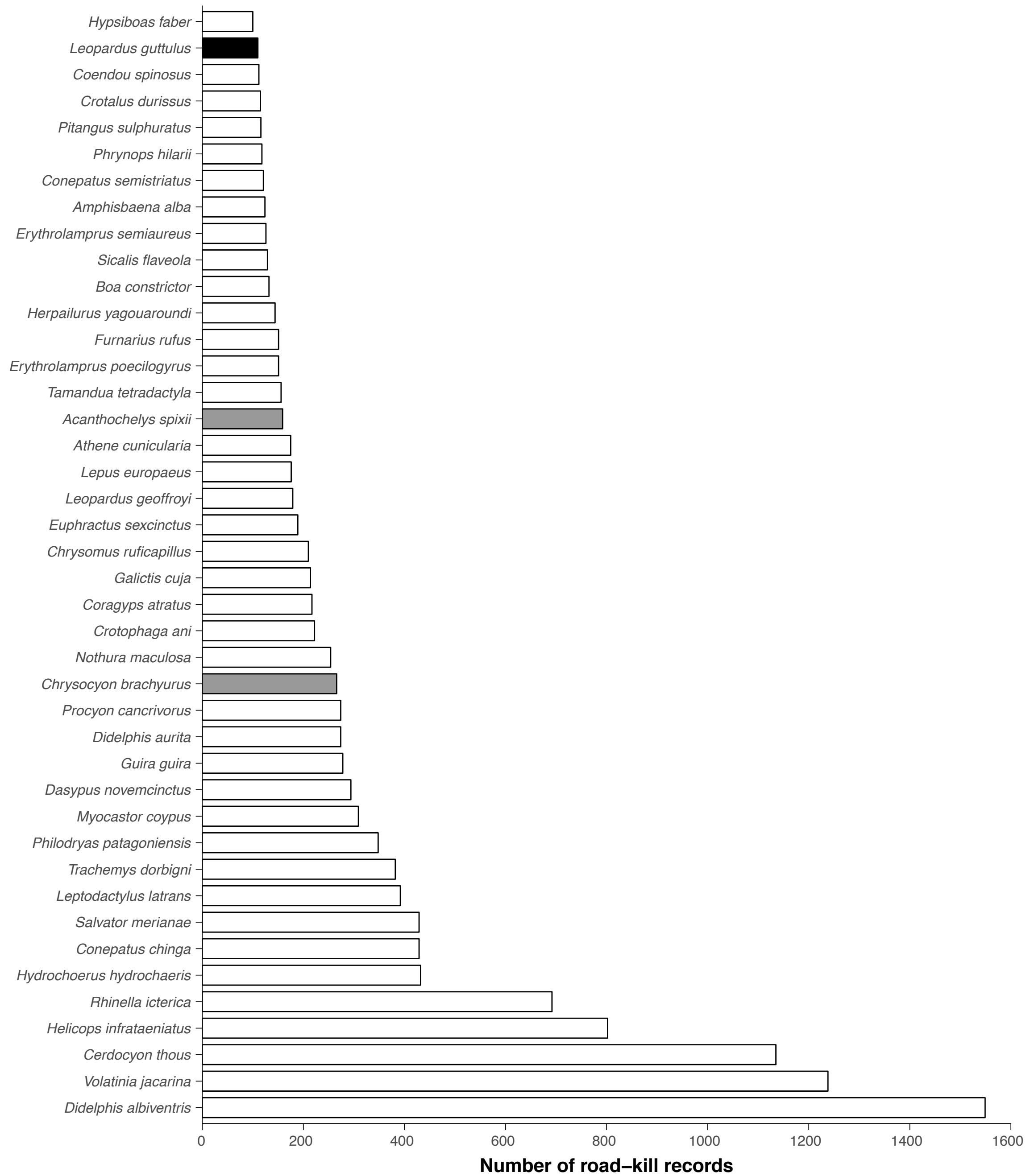

Figure 3 – Number of road-kills for species with more than 100 records within Brazil (1988-2017). IUCN status: White = Least Concern or Not Evaluated; Grey = Near Threatened; Black = Vulnerable.

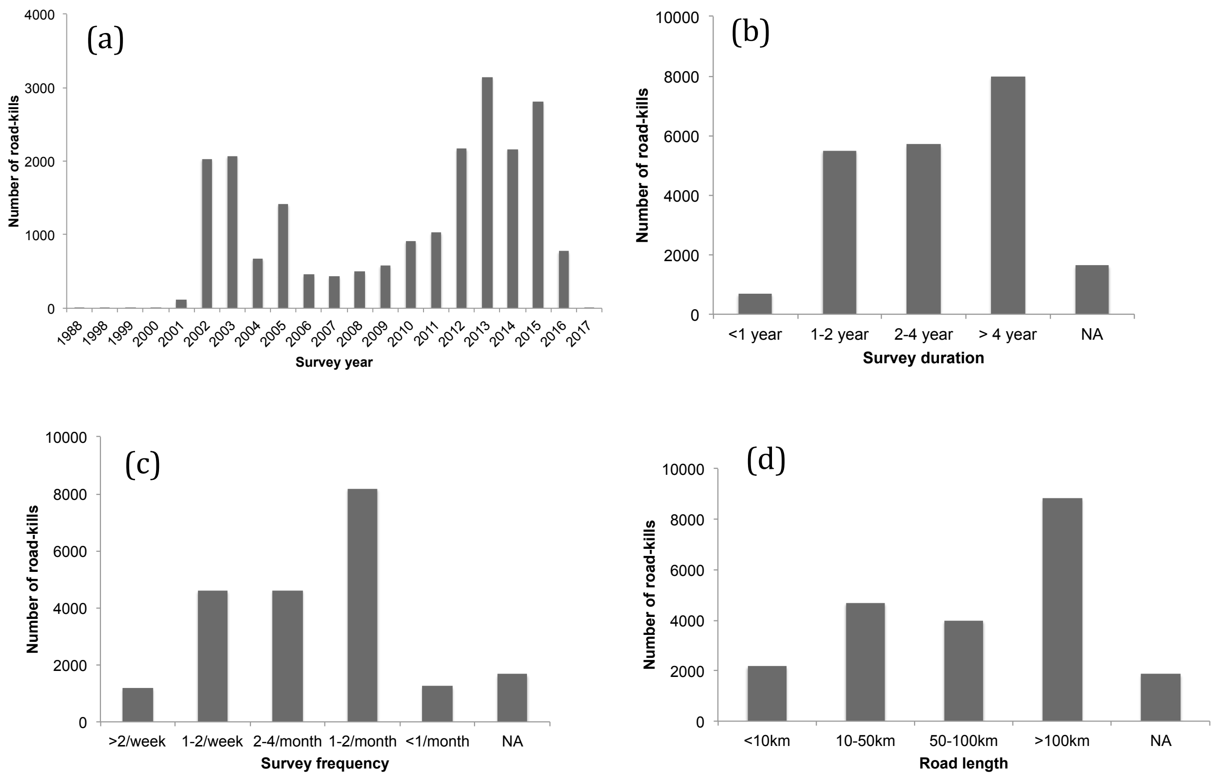

Figure 4 – Number of recorded road-kills within Brazil (1988-2017) according to survey year (a), survey duration (b), survey frequency (c) and road length (d).