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# How Many Mammals Are Killed on Brazilian Roads? Assessing Impacts and Conservation Implications

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**Abstract:** Millions of animals are killed on roads annually due to collisions with vehicles, particularly medium–large mammals. Studies on mammal road-kill flourished in Brazil in the last decade and an assessment of research on road-kill impacts at a country level will help define science-based conservation strategies. In this study, we used the compiled scientific literature to provide the state of knowledge on medium and large-sized mammals killed by road traffic in Brazil, their conservation status, and an approximation of the road-kill magnitude. We reviewed a total of 62 scientific papers that reported road-kill data accounting for 11.817 individuals. Of the 102 species of medium–large mammals found in the IUCN list, more than half (n = 62; 61%) were recorded as road-kill on Brazilian roads. The Carnivora order comprises over a quarter (n = 23; 37%) of the total road-killed species. A total of 9 species (14.5%) were classified as threatened, with a further 10 (16%) as Near Threatened. Over half of the road-killed species (n = 33, 53%) showed declining population trends according to their IUCN conservation status. Our extrapolation of the results for the entire Brazilian paved road network showed that the number of medium–large road-killed mammals can reach almost 9 million yearly (maximum 8.7 million; mean 1.3 million), representing a biomass of more than 10,000 tons. The highest roadkill rates were recorded for common generalists and least concern species, although there were also threatened and near threatened species within the top 15 highest road-kill rates. The declining population trends found for most species reflect serious conservation concerns, since there is a lack of information on the mortality effects at population levels. Our results suggest that medium–large mammals are severally affected by road mortality in Brazil. More investigations are needed at local and abundance population levels, in a way that allows the inclusion of road network as an important threat for target species impacted by road-kill in the national territory, in order to develop adequate plans to mitigate those impacts.

**Keywords:** medium–large mammals; Brazil; road-kill rates; biological conservation; road ecology

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## 1. Introduction

Despite their socio-economic and geopolitical importance, roads are among the most pervasive human-made infrastructures affecting wildlife globally [1–3]. They are classified by the IUCN Red List as one of the main human-caused impacts responsible for reducing species populations worldwide. Road networks destroy and fragment habitats [4,5]) and create barriers and filters to animal movement [6,7], but the most well-described deleterious effect is the additional mortality due to collision with vehicles [8–11].

Medium and large-sized mammals are particularly susceptible to the negative effects of road mortality [12,13]. Given their large spatial requirements, including high capacity and need to move between different habitats, and their specific life-history traits such as low reproductive rates and low population densities, additional mortality due to road-kill can drive populations to extinction more easily [14–16].

In Brazil, where road network is estimated at ~1.6 million km of paved and unpaved roads [17] with a 0.031 km/km$^2$ density of paved roads [18], road mortality of mammals has recently started to be described [19,20]. According to Grilo et al. [21], a first step to better understand the effects of road mortality on wildlife is to quantify the number of animals killed and to identify which species are more affected. Estimations account for more than 2 million mammals killed on Brazilian roads annually [22]. Nearly 40,000 medium–large mammals die annually only on roads in São Paulo Federal State (~199,000 km of roads), including threatened species such as the maned wolf (*Chrysocyon brachyurus*), the giant anteater (*Myrmecophaga tridactyla*), and wild cats [23]. Understanding road-kill rates at the national level is important to head strategies on animal conservation [24,25], human safety [26], and road mitigation [27,28]. Considering that 80 species of native mammals in Brazil (~10% of all mammals in the country) are included in some global threat category by the IUCN [29], the need for more information about the effects of road mortality on these animals is evident.

In this study, we compiled the scientific literature on medium and large-sized mammals (≥1 kg) that are road-killed in Brazil. To this end, we updated a recent database on vertebrate road-kill rates to provide: (1) the state of knowledge on road-killed medium and large mammals; (2) an approximation of how many individuals die annually on Brazilian roads and the amount of mammalian biomass lost to road kills; and (3) the road-killed species' conservation status and threats. This study is a contribution to the growing literature on the impacts of roads on Brazilian wildlife to better guide conservation management.

## 2. Material and Methods

### *2.1. Study Area and Data*

Our study area is the entire Brazilian territory, which is divided into six major biomes: Amazon, Pantanal, Caatinga, Cerrado, Atlantic Forest, and Pampa (Figure 1). We used the IUCN species occurrence data to compile a list of the mammal species that occur in Brazil [30]. We then filtered only for species with more than 1 kg (referred to here as medium–large mammals) based on Jones et al. [31]) and Smith et al. [32].

For road-kill data compilation, we used road-kill data provided by Grilo et al. [19] and Pinto et al. [33] with an additional update incorporating peer-reviewed studies published between 2018 and 2021. Our search for updating followed the same method as described by Pinto et al. [33]. We recalculated all rates using road-kill correction factors (see Section 2.2).

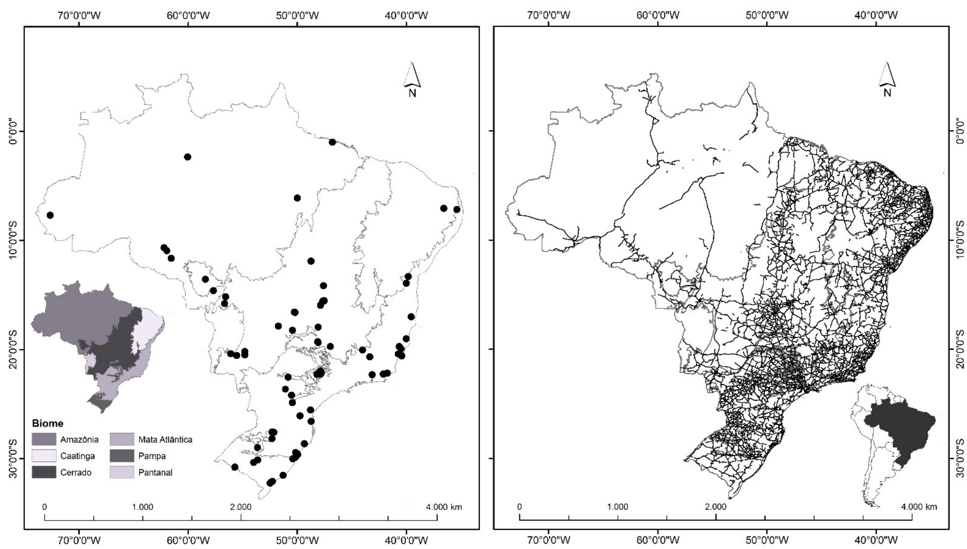


**Figure 1.** Brazilian biomes, the location of road-kill studies used in the analysis (black dots, **left**); and paved road network (**right**).

### *2.2. State of Mammal Road-Kill and Quantification of Annual Mortality*

We calculated the proportion of mammals found in our road-kill compilation in relation to the IUCN list of mammals that occur in Brazil (filtered for medium–large sized). The road-kill rates of medium–large mammals were recalculated using the "mortality rate estimation" tool of the Siriema v.2 software [34] (https://github.com/nerf-ufrgs/siriema.) (Accessed on 1 April 2022), which calculates "mortality rate (road-kill/day)" and "mortality rate per km (road-kill/day/km)" based on data from "road length (km)", "total number of roadkill", "observer efficiency (p)", "typical removal time (Tr (days))", "number of inspections" and "interval between inspections (Ts (days))". Based on Teixeira et al. (2013), we considered the "characteristic removal time (Tr (days))" to be 4.93 (estimate for mammals) and the "observer efficiency (p)" 0.73 (estimate for large body-sized animals).

To obtain the road-kill estimate, we considered the total length of paved roads within the geographical distribution of each species in Brazil. The data for geographical distribution of the species were obtained from the IUCN Red List [30] and processed in the QGIS 3.16.8 environment. The data of Brazilian roads were obtained from the Brazilian Institute of Geography and Statistics [35]. We excluded four species from the analysis due to inconsistencies on the IUCN range map. Two of them were introduced in Brazil, the European hare (*Lepus europaeus*) and the wild boar (*Sus scrofa*). The Linnaeus's two-toed sloth, *Cholopeus didactylus*, does not have records in the IUCN database. The common tapeti (*Sylvilagus brasiliensis*) received a recent taxonomic reclassification that suggests a restricted endemic distributional area in northeast Brazil [36] contrasting with the wide distributional area described before 2019.

Four road-kill rates were calculated for each species: minimum, representing the lowest rate for the species between all studies; maximum, representing the highest rate for the species between all studies; mean, that is the mean of rates considering all studies in which the species was recorded; and median, that is the median rate considering all studies in which the species was recorded. The rates are presented in function of the numbers of days and kilometers (No of road-kill records/day/km). We multiplied each rate by 365, representing the number of days in one year, and by the total length of roads (km) inside the area of occurrence of each species, representing the roads where they can be road-killed. In that way, we obtained for each species an estimation on the total number of individuals killed by roads per year in Brazil, with maximum, minimum, median, and mean values (Table S2). We summed the estimated numbers for each species to obtain the total number of medium–large sized mammals killed per year. Additionally, for each species, we calculated the biomass lost on roads by multiplying the total number of individuals killed per year by the mass in kg of each species. We obtained the data on species weight in two databases [31,32].

### *2.3. Species Conservation Status and Taxonomic Names*

To assess the conservation status of the studied species, we matched the road-kill rate list to the current International Union for Conservation of Nature (IUCN) Red List assessment [30], searching on categories of extinction risks, and direction of population trend. The IUCN categories include Least Concern, Near Threatened, Vulnerable, Endangered, Critically Endangered, Extinct in the Wild, Extinct, and Data Deficient. Species classified as Vulnerable, Endangered, and Critically Endangered are collectively referred to as 'threatened'. The categories of direction of population trend include Increasing, Stable, Decreasing, and Unknown [30]. The IUCN Red List assessments also have a threat classification based on different human-caused impacts, and we used the subcategory "Roads and Railroads" of the category "Transportation and Service corridors" to evaluate species classified as threatened by roads [30]. Taxonomic names used in this study followed the current IUCN taxonomy database [30]. For this analysis, the exotic species (European hare and wild boar) were considered in the general medium–large mammals' road-kill assessment due to their relevance in safety issues on Brazilian highways and importance for monitoring invasive species [11,37]. The conservation status of the common tapeti (*Sylvilagus brasiliensis*) was considered here in accordance with the IUCN classification before 2019.

## 3. Results

### 3.1. State of Mammal Road-Kill and Quantification of Annual Mortality

Of the 102 Brazilian medium–large mammals from the IUCN list, more than half (n = 62, 60.7%) were recorded as road-kill. All of the taxonomic orders (n = 9) had at least one species recorded as road-kill (Figure 2). Primates and Carnivora had the highest species richness with 32 and 25 species, respectively. A total of 15% of the Primates species richness were recorded as road-kill (n = 5), and the proportion reached 92% of the Carnivora species (n = 23), which also represented 37% of all road-killed mammals (Figure 2). Three orders had 100% of their representants recorded as road-kill, Didelphimorphia (opossums), Lagomorpha (rabbits and hares), and Perissodactyla (represented by a single species, the Brazilian tapir, *Tapirus terrestris*).

We analyzed 62 papers and communications ( Supplementary Material File S1) reporting mammal road-kill in Brazil accounting for 11.817 road-killed individuals across 738 observed road-kill rates. The observed road-kill rates (expressed here as individuals/day/100 km) ranged from 0.0002 for the Brazilian porcupine (*Coendou prehensilis*), to 5.317 for the Molina's hog-nosed skunk (*Conepatus chinga*); mean = 0.101 (±0.33), median = 0.021 (Table S2). The crab-eating fox (*Cerdocyon thous*) was the most frequent species recorded across all studies (n = 54), with road-kill rates ranging from 0.0014 to 1.1208 (individuals/day/100 km).

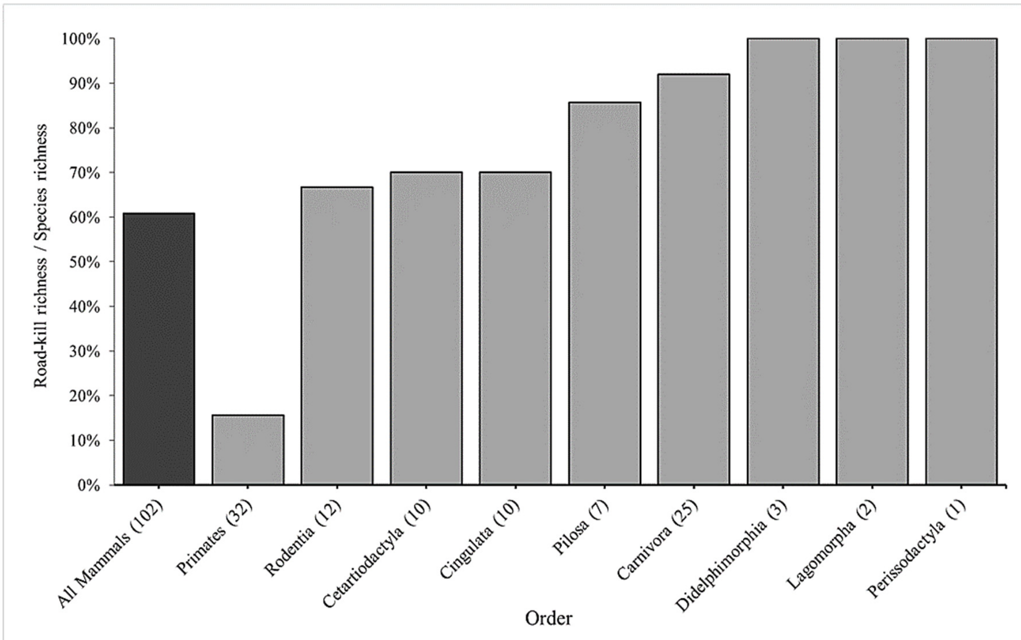


**Figure 2.** Proportion between road-killed species richness and total species richness of medium–large mammals. In parentheses: total species richness by taxonomic order.

Based on the observed road-kill rates, we estimated that the number of medium–large mammals road-killed in Brazil can reach almost 9 million per year (maximum of 8.7 million and a mean of 1.3 million). This result represents nearly 11,000 tons of biomass of mammals lost per year in Brazil due to road-kill, on average, with 76% represented by the 15 most road-killed species (Table 1). Of the top 15 species with the highest estimated road-kill rates, 33% were from Carnivora order, with the white-eared opossum (*Didelphis albiventris*) showing the highest mean estimated road-kill rate, followed by the seven-banded armadillo (*Dasypus septemcinctus*) and by the crab-eating fox (*Cerdocyon thous*) (Table 1).

**Table 1.** Top 15 species with estimated average individuals and road-kill rates, conservation status, and threats (ranked by average-estimate).

| Family | Scientific Name | Average-Estimate (ind./Year) in Brazil | Average-Mortality Rate (ind./Day/100 km) | Average Total Roadkilled Biomass (kg/Year) | IUCN Red List Category | IUCN Population Trend | IUCN Threats: Transportation and Service Corridors |
|---|---|---|---|---|---|---|---|
| Didelphidae | *Didelphis albiventris* | 221,381.6 | 0.4385 | 228,127.1 | Least Concern | Stable | |
| Chlamyphoridae | *Dasypus septemcinctus* | 194,008.7 | 0.3808 | 296,181.5 | Least Concern | Unknown | |
| Canidae | *Cerdocyon thous* | 124,679.2 | 0.2043 | 715,865.7 | Least Concern | Stable | |
| Mephitidae | *Conepatus chinga* | 112,069.5 | 0.5354 | 214,893.3 | Least Concern | Decreasing | |
| Chlamyphoridae | *Euphractus sexcinctus* | 82,219.5 | 0.1328 | 388,993.4 | Least Concern | Stable | |
| Caviidae | *Hydrochoerus hydrochaeris* | 65,846.7 | 0.1040 | 3,170,184.5 | Least Concern | Stable | |
| Myrmecophagidae | *Tamandua tetradactyla* | 60,400.3 | 0.0953 | 289,921.4 | Least Concern | Unknown | Roads and railroads |
| Procyonidae | *Procyon cancrivorus* | 43,482.8 | 0.0685 | 301,410.8 | Least Concern | Decreasing | |
| Chlamyphoridae | *Dasypus novemcinctus* | 42,510.7 | 0.0670 | 167,875.3 | Least Concern | Stable | |
| Tayassuidae | *Tayassu pecari* | 40,473.0 | 0.0908 | 1,286,987.7 | Vulnerable | Decreasing | |
| Myrmecophagidae | *Myrmecophaga tridactyla* | 29,520.6 | 0.0668 | 871,796.5 | Vulnerable | Decreasing | Roads and railroads |
| Mustelidae | *Galictis cuja* | 23,735.4 | 0.0409 | 23,735.4 | Least Concern | Unknown | Roads and railroads |
| Didelphidae | *Didelphis aurita* | 22,488.1 | 0.0714 | 24,869.2 | Least Concern | Stable | |
| Cervidae | *Mazama gouazoubira* | 19,223.8 | 0.0345 | 319,751.9 | Least Concern | Decreasing | Roads and railroads |
| Procyonidae | *Nasua nasua* | 17,371.1 | 0.0380 | 65,584.7 | Least Concern | Decreasing | |

### *3.2. Conservation Status*

Of the 62 road-killed species, 9 (14.5%) were considered Threatened (Vulnerable), with a further 10 (16%) classified as Near Threatened (Figure 3). A total of 41 species (66%) were classified as Least Concern, while 2 species showed Deficient Data status (the Azara's agouti, *Dasyprocta azarae*, and the red brocket, *Mazama americana*). Over one-quarter (35%) of the Carnivora species showed Threatened or Near Threatened status, two of them as Vulnerable, the southern tiger cat (*Leopardus guttulus*) and northern tiger cat (*Leopardus tigrinus*) (Figure 3). 'Rapid Declines' (according to Red List criterion A, 45%) was the common reason for classifying a species as Threatened (Vulnerable), followed by 'Small and Declining Range' (criterion B, 22%), then a 'Small and Declining Population' (Criterion C, 11%) (See Table S1). The threatened species with the highest number of records was the giant anteater (n = 19), with the highest road-kill rate (0.2268 ind./day/100 km) observed in the central Brazil region [38], followed by the northern tiger cat (n = 10) with the highest observed road-kill rate (0.080 ind./day/100 km) in southern Brazil [39].

More than half of the road-killed mammals (n = 33, 53%) had declining population trends, nearly one-quarter (n = 14, 23%) had stable population trends, while 24% (n = 15) had unknown status about the direction of their population trends (Figure 3). Among the seven species from the Pilosa order (sloths and anteaters), four had unknown population trend status, while two species showed declining trends and were classified as Vulnerable: the Brazilian three-toed sloth, *Bradypus torquatus*, and the giant anteater, *Myrmecophaga tridactyla*). All of the five Primates species recorded as road-kill showed decreasing population trends.

Over a quarter of the road-killed species (n = 17, 27.5%) were assigned as Threatened in the 'Transportation and Service Corridors' category, more specifically, by roads and railroads. Nearly 60% of these species were from the Carnivora order, mostly Felidae species (47%) (Table S1). Among the top 15 species, almost all of them (87%) were classified as Least Concern according to their IUCN Red List Status, while 6 (40%) (*Conepatus chinga*, *Procyon cancrivorus*, *Tayassu pecari*, *Myrmecophaga tridactyla*, *Mazama Gouazoubira*, and *Nasua nasua*) showed decreasing population trends (see Table 1).

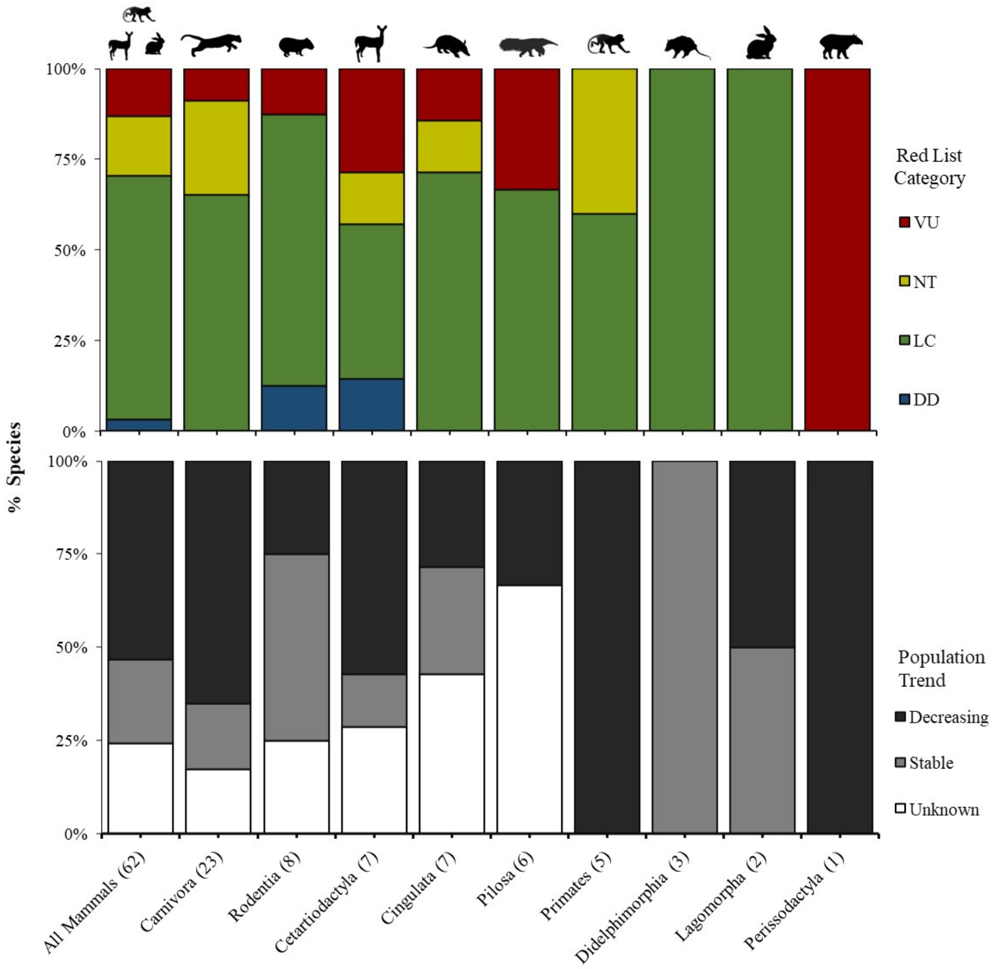


**Figure 3.** Percentage of medium–large mammals road-killed in Brazil according to the IUCN Red List category (Data Deficient (DD), Least Concern (LC), Near Threatened (NT), Vulnerable (VU)), and direction of population trends by taxonomic order. In parenthesis: road-kill species richness.

## 4. Discussion

Our results indicated that road-kills impose serious risks for mammal conservation in Brazil, affecting most of the medium and large-sized species, and highlight the importance of specific efforts on further research and mitigation, especially for conservation concern taxa.

Previous studies provided compilations about mammal road-kill in Brazil [19,33] and also about ecological traits related to road-kill risks at the national level [22], but our results provided the first assessment focused on medium and large mammal conservation and a current estimative of the road-kill magnitude at the national level.

Some studies demonstrated that mammals' road-kill risk in Latin America is not random and could be associated with biological and ecological traits, such as greater body mass and home range area, scavenger diet, and also their taxonomic order see [22,40]. The Carnivora order is particularly exposed to road-kill in Brazil [41] and globally [42]. From the 25 Brazilian carnivore species assessed here, 23 were found as road-kill; the 2 exceptions were the giant otter (*Pteronura brasiliensis*) and the jaguar (*Panthera onca*). The former has most parts of its ecological activities in the water and, therefore, it is not expected that it uses terrestrial environments significantly, which could explain the result. Moreover, both species occur in low densities in the Brazilian territory, so it is possible that road-kill is rare because there are already few individuals in nature [43]. This is particularly true for jaguars, whose populations have been reduced or extirpated from most parts of their range [44]. Moving beyond the quantification of road-kill rates, other studies highlighted that some carnivore species are particularly vulnerable at the population level in Brazil, such as the maned-wolf (*Chrysocyon brachyurus*) and the little spotted cat (*Leopardus tigrinus*), increasing their risk of extinction in specific regions of their distributional range, if the observed road-kill levels persist [16].

On the other hand, only 15% of Primate species showed road-kill records, probably due to the fact that many species do not use the ground or rarely do so for displacement but see [45]. The impacts of transportation infrastructure on Primate species seem to be more related to the habitat loss effects due to land conversions rather than road-kill itself [46]; however, additional mortality on roads added to other associated human impacts such as poaching, illegal trade, and barrier effect can increase their vulnerability [47]. Five of the twenty-five world's most endangered primates occur in Brazil [48] and a better understanding of the ecological effects of roads on such species is urgent to guide more sustainable road projects that integrate management and conservation planning [49].

The order Pilosa was represented mainly by the road-kill of the southern tamandua, *Tamandua tetradactyla*, and the giant anteater, *Myrmecophaga tridactyla*. The road-kill of the former has been increasing in different Brazilian ecosystems, which may be related to the nocturnal habits, limited vision, and also limited hearing of the species, which, together with its slow movements, increase their vulnerability when crossing roads [50,51]). The giant anteater is a threatened species that has been regularly detected on road-kill monitoring for decades in Brazil [52,53], and it was found in 30% of all studies compiled here. Recent studies demonstrated that the road-kill rates can impose serious risk for giant anteater population persistence at regional [54,55] and at national levels [56]. Local studies aimed at monitoring threatened mammal populations which are particularly vulnerable to road mortality (such as the giant anteater and the Brazilian tapir, *Tapirus terrestris*) are urgent to define better mitigation strategies (see 'Anteater and Highways Project'—www.giantanteater.org (accessed on 15 July 2022).

Of the most road-killed species, all can be considered as highly tolerant to open environments, even those threatened with extinction. Some of them are known for being very abundant, such as *Didelphis* genera, the crab-eating fox, and the capybara, *Hydrochoerus hydrochaeris*. The road-kill of capybaras has been associated with proximity to rivers, high herbaceous and low forest coverage [57], and can cause several human damages due to their large body mass when colliding with vehicles [58]. *Euphractus sexcinctus* and *Conepatus chinga*, in addition to being tolerant to open areas, have opportunistic scavenger behaviour [59], increasing their risk of being road-killed. *Didelphis* sp. and *Cerdocyon thous* both have generalist and opportunistic habits [50] and are common species killed on Latin American roads [40]. The species of *Didelphis* have great densities and the ability to adapt to urban and peri-urban areas that tend to have a greater vehicle flow and, therefore, higher rates of species being road-killed [60]. In the same way, also common near cities, and inhabited areas, *Cerdocyon thous* travels a lot through the landscape using roads [61], where the species can also find food resources such as insects and even small animal carcasses, leaving the species more vulnerable to being road-killed. Road mortality of *Cerdocyon thous* has been associated with human-modified landscapes, such as agriculture and pasture [62].

In general, the list of the 15 most road-killed species is very similar to other previous works using published data [63], showing that using rates or absolute numbers can bring similar results. The difference between road-kill rates and road-kill estimates is that the former gives us the potential number of individuals road-killed by day and by km, and the latter shows us the total number of road-kill per year, considering all the territory where the species can occur. Therefore, when we order the species by the top rates, we will not have the same result as when we order them by top estimates. Sometimes a species in a study or group of studies has high road-kill rates, but has small distribution along the territory, so road-kill estimates are smaller. The opposite is also true. For example, on Table 1, we found a rate of 0.5354 (ind./day/100 km) and 0.4385 (ind./day/100 km) for *Conepatus chinga* and

*Didelphis albiventris*, respectively. *Conepatus chinga* only occurs in the center-south of Brazil, and *Didelphis albiventris* can be found throughout the entirety of Brazil (with the exception of the Amazon rain forest). In that way, the estimated number of individuals road-killed by year is greater for *Didelphis albiventris* even when this species presented lower rates when compared to *Conepatus chinga*.

Our results indicated that at least 30% of the medium–large mammals road-killed in Brazil are at risk when considering the threatened and the near threatened conservation status. It is urgent that further research on road ecology focus on a better understanding on how the additional mortality can increase the risk of extinction for these species see [16]. Mathematical population models are important methodological tools focused on preventing the impact of road-kill on wildlife [15,64,65]. Important population parameters such as local population density and ecological and life history traits, which are essential to refine those models, are still scarce. For example, nearly a quarter of the road-killed species (including more than 50% of Pilosa order species) have an unknown status about the direction of their population trend on IUCN.

More than half of the road-killed mammals assessed here showed decreasing population trends, which reinforces the need for research on the vulnerability of these species due to roads. Among the 15 most road-killed species in our analysis, 2 are considered threatened: *Tayassu pecari* and *Myrmecophaga tridactyla*. Six among the fifteen have a decreasing population trend, showing that road mortality is an important threat that might influence their conservation status in the future. One of the vulnerable species in the list—*Myermecophaga triadctila*—has its road-kill records mainly related to mosaics of pasture and forest [62] and also to proximity to urban areas [66], which are common landscapes across the country, increasing the risks for the species. *Tayassu pecari* is a species with a large distribution on Brazilian territory, which lives in large groups, but it is known that the species is much more abundant in the north and midwest than in other regions [67]. The highest road-kill rates for this species may be in these locations, which are less studied than the south and southeast areas. This could have created a bias in our results, since we found road-kill of *Tayassu pecari* in just two of the analyzed papers. In that way, when we estimated *Tayassu pecari*'s road-kill based on total distribution area of the species, it may have inflated the total number of road-kill estimates found.

Of the total number of species found, just 27% are considered threatened by transportation infrastructure. Considering the results found here, this shows a gap between the potential impacts of road-kill and what is currently considered a threat for each mammal species. Brazil has been adopting numerous mitigation measures aimed at increasing population connectivity and reducing mammal road mortality, including fenced and unfenced wildlife crossings [58,68–70]. However, it is possible that these measures are still not enough to guarantee the safety of Brazilian mammals that live in environments with high road densities. Additionally, endangered species with long-life cycles and low reproductive rates (e.g., *Myrmecophaga tridactyla* and *Chrysocyon brachyurus*) need specific conservation programs on Brazilian roads, since there is a risk of losing individuals at rates much higher than populations are able to replace.

## 5. Conclusions

We found that less than one-third of the mammal species found road-killed in Brazil was assigned as threatened by roads and railroads in the IUCN. Thus, most of the mammals studied here are threatened by roads in some degree that is not considered by the IUCN. We contributed to identifying, on a national scale, which animals have road-kill registers, the level of concern and the frequency of mortality—given by the road-kill rates. We presented, for the first time in the Brazilian territory, an estimate of how many medium–large mammals are killed by roads, for each species, considering only the roads where they potentially occur. The numbers can reach 9 million individuals annually, with some species reaching more than 200,000 individuals per year.

Despite the advance provided by our study in quantifying and estimating the road-kill damage, the impacts of road-kill on the reduction of populations, especially for threatened medium–large mammals, need to be more deeply studied. How much the mortality on roads affects population size and imposes local and regional extinction risks for each species? This is a central question for further research aimed at understanding the real impact of roads on mammal species. The answer can be achieved only through population and abundance data in different regions of the country. With that information, it will be possible to incorporate plans and actions to mitigate the effects of roads on mammal species in order to reduce the deleterious effects of road mortality on mammal populations.

**Supplementary Materials:** The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/d14100835/s1, Supplementary Material File S1: list of reviewed studies used for road-kill compilation [71–117]; Table S1: List of species with observed road-kill rates, conservation status and threats; Table S2: List of species with estimated road-kill rates and biomass.

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