Research Article

Intentional snake road-kill: a case study using fake snakes on a Brazilian road

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Abstract

Records of snakes are common in fauna road-kill monitoring studies in different Brazilian regions. To determine the intentionality of snake road-killing on a Brazilian road, the following hypotheses were tested: (1) more fake snakes are intentionally killed on the road than objects not similar to snakes; (2) the time elapsed until the first intentional fake snake road-kill is less than that for dissimilar objects; (3) the proportion of intentional collisions with fake snakes does not depend on the type of vehicle; (4) objects positioned in the center of the road are more frequently road-killed than those positioned on the roadside; (5) variation in the number of intentional road-kills is linked to variation of vehicular traffic. Fake snakes and PET bottles were placed in different positions on the MG-010 road (Minas Gerais State), and monitored for 96 hours by cameras that recorded the movement of vehicles on the lane. The numbers of intentional snake road-kills and control objects presented no differences, and the time elapsed until the first intentional road-kills was also similar. Cars and trucks are the vehicle categories with highest incidence of collisions. Objects were struck more often when positioned in the center of the road. This study proves that intentional road-killing occurs and that any small object on the road is subject to being struck by a moving vehicle. This behavior by some drivers on Brazilian roads may pose a threat to the conservation of species that venture onto these roads.

Keywords: wildlife–vehicle collisions; reptile conservation; human behavior; road ecology

Resumo

Registros de serpentes são recorrentes em trabalhos de monitoramento de fauna atropelada em diferentes regiões brasileiras. A fim de verificar se atropelamentos de serpentes em rodovias brasileiras ocorrem de maneira intencional, o presente estudo testou as seguintes hipóteses: (1) o número de atropelamentos intencionais de moldes de serpentes é maior do que o de atropelamentos intencionais de objetos não assemelhados com serpentes; (2) o tempo decorrido até o primeiro atropelamento intencional dos moldes de serpentes é menor do que de objetos não assemelhados; (3) a proporção de atropelamentos intencionais dos moldes de serpentes independe da categoria do veículo; (4) objetos posicionados no centro da rodovia são atropelados intencionalmente com maior frequência do que quando comparados aos posicionados nas margens; (5) a variação do número de atropelamentos intencionais está atrelada a variação do tráfego de veículos. Moldes de serpentes e garrafas pet foram dispostos em diferentes posições na rodovia MG-010 (Minas Gerais), e monitorados durante 96 horas, através de câmeras fotográficas que registraram o movimento dos veículos na pista. O número de atropelamentos intencionais de serpentes e objetos controle não apresentou diferença, assim como o tempo decorrido até o primeiro atropelamento intencional. Carros e caminhões constituem as categorias de veículos com maior incidência de atropelamento intencional. Quando posicionados no centro da rodovia, os objetos foram mais frequentemente atropelados. Este estudo comprova a existência da prática de atropelamento intencional de qualquer pequeno objeto que possa estar presente na rodovia, o que pode representar uma ameaça à conservação de espécies que se aproximam deste ambiente.

Palavras-chave: atropelamento de fauna; conservação de répteis; comportamento humano; ecologia de estradas

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Introduction

Due to worldwide demand for transportation of products and raw materials, as well as for human travel, road networks are constantly expanding, thereby fragmenting natural environments in diverse regions of the globe [1]. Among road impacts, vehicle collisions are the leading cause of direct mortality of animal populations [2-4]. In certain circumstances, a severe reduction in the population size of species subject to high road-kill rates results in a subsequent biodiversity loss [5].

Roads may constitute a barrier (partial or complete), disrupting the movement of different species [6-10]. Roads may also represent linear clearings, hindering the approach of species inhabiting deep forests. These road features are liable to reduce the number of resource exploitation areas [13], thus promoting the isolation of natural populations [11, 12]. Furthermore, the barrier effect can also promote road-killing when species utilize highways to disperse to different areas, hindering the natural distribution of such species among the fragmented areas [14, 15]. In both situations, there will be negative effects on the species abundance. The interference strength caused by the barrier effect will depend on the behavior of the affected species, as well as on landscape features and highway characteristics [16, 17].

According to Forman et al. [1] and Jaeger et al. [18], species exhibit two main types of behavioral responses to highway presence. The first response is animal attraction to sites near the highway, lured by lane temperature, artificial lighting and availability of food resources. This type of behavior tends to increase the frequency of lane crossings, and consequently increases the risk of road-killings. The second response is road avoidance behavior, due to traffic noise, road surface, or presence of vehicles. Certain organisms are able to avoid vehicles by identifying the approaching vehicle and moving in the opposite direction. This type of behavior is interpreted as an attempt to move away from the danger, thereby minimizing the risk of being road-killed. Studies show that various species (including amphibians, reptiles, birds and mammals) are able to identify a moving vehicle and trigger some type of behavioral response [19-22].

Experiments with snake movements on highways revealed different types of behavioral responses to the presence of vehicles. These responses may vary according to life history, size, activity pattern, and habitat preferences of each snake species [19]. Some species, when moving on the highway, act towards moving vehicles in the same way that they do when they recognize a predator in the natural environment. The observed reactions are to interrupt the crossing and stand motionless (with variable immobilization time) or to increase speed, rapidly completing the crossing to the other side of the highway [19, 23].

Road-kill monitoring data from different regions of Brazil reveal that snake records are quite common [e.g., 24-28]. Studies developed in other countries warn about the intentionality (by the drivers) of snake road-kills [e.g., 29, 30] and the consequent hazards to the persistence of snake populations [23]. According to Beckmann and Shine [31], the intentional road-killing of target species, such as snakes, is associated primarily with fear and contempt by the drivers. Cultural background is one of the major problems in the conservation of Brazilian snake species. When snakes are spotted, people usually attempt to kill them, mainly because they believe that snakes are dangerous and represent a threat to human lives [32].

The Brazilian territory shows remarkable snake diversity [33], with 381 species recorded, among which several endemic species are described. This number has increased in recent years due to greater research efforts, but the mortality of individuals by road-kills may threaten the persistence of snake populations, including unknown species. This scenario can become a greater conservation issue as highways approach areas near conservation units such as Serra do Cipó National Park (Minas Gerais State, Brazil), where this study was conducted and 29 snake species are reported [34].

Given the potential impact of road-killing on snake populations, we evaluate the occurrence of intentional snake road-killing on a Brazilian road. For this, we tested the following hypotheses: (1) more fake snakes are intentionally road-killed than objects not similar to snakes (control); (2) the time elapsed until the first intentional fake snake road-kill is shorter than for dissimilar objects; (3) the proportion of intentional collisions with fake snakes does not depend on the type of vehicle; (4) objects positioned in the center of the road are more frequently road-killed than those positioned on the road edges; and (5) variation in the number of intentional road-kills is linked to variation in vehicular traffic.

Methods

Study area

The study area was a stretch of MG-010 road, between the Sumidouro State Park (19º33’28.43”S, 43º54’43.19”W) and the Serra do Cipó National Park (19º19’13.25”S, 43º36’33.01”W), Minas Gerais, Brazil (Fig. 1). The two protected areas are located in the Serra do Espinhaço. This region is considered to have high ecological relevance because of its remarkable diversity of animal and plant species, including endangered species [35]. The MG-010 is a two-way paved road that provides access to important conservation units. The road has average traffic of 130 vehicles/hour during the week, which can double on weekends (estimation made during the sampling for this study).

Intentional road-kill evaluation

To evaluate intentional road-kill, we used fake snakes and control objects exposed on the road. The fake snakes were made from green meter-long cloth, painted to appear as much like real snakes as possible, and then filled with sand (Fig. 2). In addition to the fake snakes, we used green PET (polyethylene terephthalate) bottles (two liters) as control objects, partially filled with sand.

This experiment had a total duration of four days (two weekdays and two weekend days); on each day a different stretch of road, with six sampling points, was used. At each sampling point (separated by a minimum distance of 1.5 km), an object of each type (snake and control) was placed, interspersed at different positions: in the center of the lane on the central stripe (Middle

Route), the side of the lane going to the Sumidouro State Park (SCNP to SSP Route) and the side of the lane towards the Serra do Cipó National Park (SSP to SCNP Route) (Fig. 1). Thus, on each sampling day, objects of each type (snake and control) were arranged in three possible positions (center and two sides), totaling six sampled objects.

The average exposure time of objects on the road was four hours per day, at random hours between 6:00 a.m. and 6:00 p.m. Two hours after the beginning of each sampling, the objects were inspected, and in cases of damage or theft, they were replaced by identical replicas in the initial position. After four days of sampling, 24 objects were sampled (12 snakes and 12 controls) over 9 hours.

The objects were monitored by cameras arranged along different stretches of the MG-010 road. At each sampling point a camera (Day 6 Outdoors, model Plotwatcher Pro Time Lapse HD Video Cam) was installed, so that its position and angle allowed it to register the approach and trajectory of the moving vehicles. Cameras were painted as camouflage and placed on tree branches on the road verges, so they could not be seen by motorists or people walking on that stretch. All cameras were programmed to shoot every second, monitoring the object during the entire exposure period.

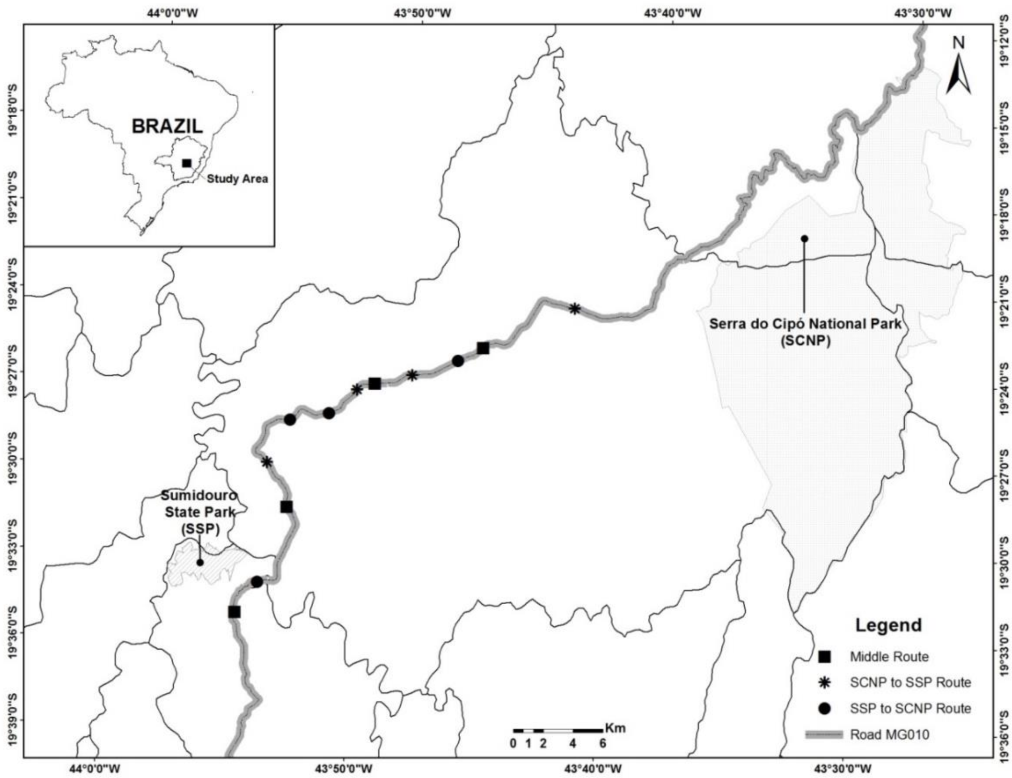

Fig. 1. Stretch of road MG-010 used for the sampling of road-kill, between the Sumidouro State Park and the Serra do Cipó National Park, Minas Gerais, Brasil. Middle Route represents the points at which the objects were placed in the center of the lane between the two directions of the road, Route SCNP to SSP represents the points at which the objects were placed on the margin of the lane in the direction Serra do Cipó National Park – Sumidouro State Park, and SSP to SCNP Route represents the points at which the objects were placed on the margin of the lane in the Sumidouro State Park – Serra do Cipó National Park direction.

Data analysis

The road-kills were classified as intentional only in cases where the vehicle changed its natural trajectory in the lane, clearly moving towards the object. Road-kill caused by overtaking vehicles was not considered, and a minimum of 30 seconds between registrations of intentional road-kills was set to avoid road-kill from consecutive passes. The significance level for statistical tests was $p \leq 0.05$, and the results are presented as the mean ± standard deviation.

Fig. 2. A fake snake exposed on the side of the road MG-010.

To test whether the snakes were intentionally road-killed more frequently than the control objects, we used the Mann-Whitney non-parametric test for independent samples, considering that the data arise from non-normal count data (road-kill records). Thus, we compared the number of intentional road-kills of the two types of objects on each sampling day.

We tested whether the time elapsed until the first snake road-kill was less than that for the control objects using the ANOVA one-way parametric test, after verifying the data normality using the Lilliefors test. For this analysis, we considered each object (snake and control) positioned in the center of the road as a sampling unit and the elapsed time (minutes) to the first intentional road-kill recorded as the response variable. We used only objects positioned in the center of the lane on each sampling day, so they were exposed to the same volume of vehicle traffic from the time they were simultaneously installed.

To verify whether there is a predominance of any specific vehicle category in intentional snake road-killing on the road, we tested the difference in the number of intentional snake road-kills among different vehicle categories. Because the data originated from non-normal count data (road-kill records), we used the non-parametric Kruskal-Wallis test, with the Student-Newman-Keuls test *a posteriori,* to compare the road-kill averages among the vehicle categories. To account for the effect of traffic volume on the incidence of intentional road-kill on the road, the rate of intentional snake road-killing was relativized in relation to the total traffic in each category by dividing the number of road-kills by the number of recorded vehicles. Each intentionally road-killed fake snake was considered as a sampling unit, and the number of vehicles responsible for the road-kill in each category (car, motorcycle, pickup truck, truck and bus) was considered as the response variable.

We used multiple linear regression to assess the influence of the variables regarding the object type, vehicle traffic and position of objects on the number of intentional road-kills. The response variable was represented by the number of intentional road-kills recorded for each of the objects sampled on the road. Type and position of the objects were inserted in the model as independent variables through assigned values (snake = 1/control = 0; center = 1/sideway = 0). Traffic was also inserted as an independent variable, represented by the number of vehicles recorded during the exposure time of each object normalized by logarithmic transformation.

Results

During sampling, 42 intentional snake and 31 intentional control object road-kills were registered, totaling 73 road-kills classified as intentional from a total of 141 road-kills (51.8% of the total). Over the four sampling days, the average number of intentional snake road-kills (10 ± 4) and control object road-kills (8 ± 6) was similar ($Z = 0.866$, $p = 0.193$). In addition, the time before the first intentional road-kill was similar ($F = 0.615$, $p = 0.533$) between snakes (39 ± 36 min) and control objects (61 ± 44 min).

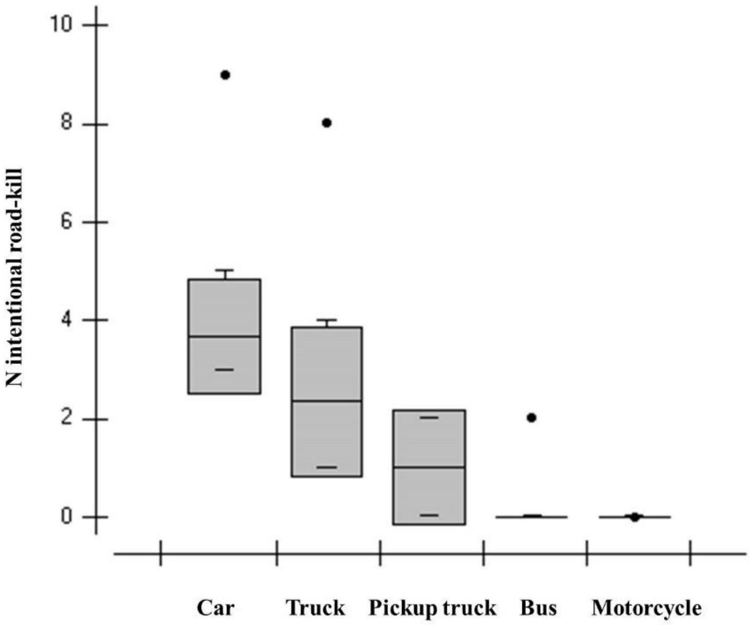

Fig. 3. Box-Plot of intentional snake road-kill among vehicle categories. The horizontal lines of each box represent the arithmetic mean (central line) and standard deviation (upper and lower lines). Black circles represent data outliers.

Vehicles belonging to different categories showed differences in the number of intentional snake road-kills ($H = 13.913$, $p = 0.016$). Cars road-killed more than all other categories; however, when statistically compared, they were no different from trucks ($p = 0.565$) (Fig. 3). The truck, in turn, is the second category with the most road-kills, but there is no difference when statistically compared to cars and pickup trucks ($p = 0.565$ and $p = 0.154$, respectively). Comparing the rates of intentional road-kills caused by each vehicle category/traffic in each category, we observed the following order of representativeness: truck (0.016), pickup truck (0.012), bus (0.008), car (0.003), and motorcycle (0.001) (Fig. 4).

The model that considered only vehicle traffic and object position on the road was the most explanatory regarding the number of intentional road-kills ($p < 0.001$, $R^2 = 0.642$). The position of the objects is directly related to the number of intentional road-kills ($p < 0.001$) (Fig. 5), while the log of vehicle traffic was not a determinant ($p = 0.054$). The object type variable was not considered in the model as it was not associated with the occurrence of intentional road-kill.

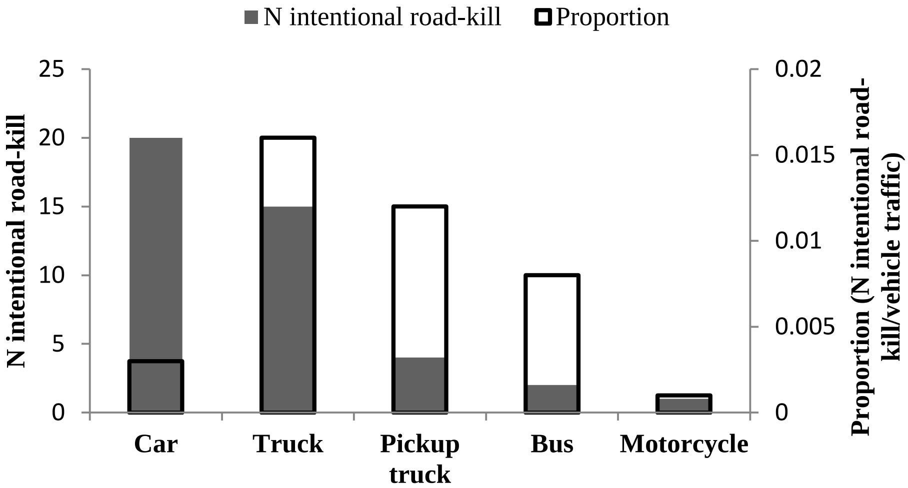

Fig. 4. Representativeness of vehicle categories among intentional snake road-kills.

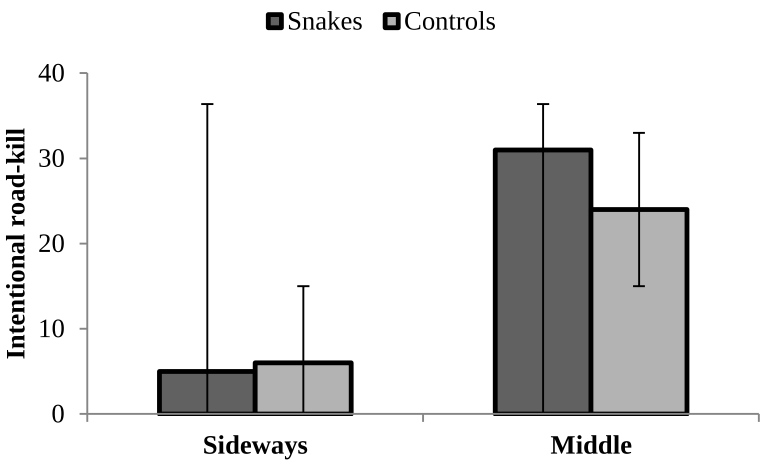

Fig.5. Intentional snake and control object road-kill among the different positions of the objects on the road. The boxes represent the number of recorded intentional road-kills and vertical lines represent the associated standard deviation.

Discussion

There was no difference in the number of intentional road-kills between snakes and control objects. Our results are not consistent with previous studies that assessed snake road-kill intention [e.g. 29-31]. However, we observed that more than half of all road-kills recorded during the study were classified as intentional, making deliberate road-killing a common practice of drivers who travel on Brazilian roads, regardless of the object type.

A study using fake snakes and rubber hoses on a rural road in Kansas (USA) found that rubber snakes were road-killed at higher frequency than hoses [30]. Ashley et al. [29] conducted a similar study in Ontario (Canada) to assess whether intentional road-killing of reptiles (snakes and amphibians) was more frequent than expected by chance, and found that intentional snake road-killing was 2.4 times higher than control objects. In our study, the difference is subtle and not statistically significant, the incidence of intentional snake road-kill being only 1.3 times higher than control object collisions.

Recently, Beckmann and Shine [31] conducted an experiment with fake snakes, different species of frogs, and control objects exposed on a highway in northern Australia. They compared field and empirical results derived from interviews with drivers on the frequency with which they intentionally road-killed the evaluated species. As in other previous analogous studies, differences were observed in the proportion of intentional road-kills among different types of objects. One fake frog species in particular was the most road-killed, followed by the fake snakes. The authors explained this result in terms of frogs being similar to the species *Rhinella marina*, known for being toxic and invasive and responsible for many negative impacts in the study area, an incentive for drivers to intentionally run them over.

Our results can be explained in the following way: intentional snake road-killing on Brazilian roads is not associated with visual identification of snakes on the road. Instead, we believe that when drivers traverse long road sections that require greater travel time, some of them intentionally run over any small object present in the lane. We believe that the frequency with which intentional road-kill occurs varies depending on the road stretch, travel speed, and distance between vehicles. These factors provide different safety conditions for drivers to deviate from their natural trajectory on the lane.

We also observed no difference in the time elapsed until the first intentional road-kill between fake snakes and controls. This is the first study to evaluate the relationship between object type and the time elapsed until the first intentional road-kill. Langley et al. [30] reported the average time elapsed between the intentional road-kill of fake snake replicas and rubber hoses (control) set out on the road. Their results demonstrated that intentional collision with fake snakes occurred at shorter time intervals than control objects. Our result corroborates what was previously suggested, that intentional road-kill does not depend on the type of object exposed on the road, a fact that is reflected in both the frequency and intensity of road-kills.

Despite the fact that cars represent the vehicle category with the highest number of registered intentional road-kills, they also contribute most to the total vehicle traffic on the road. Trucks are less numerous and still are responsible for a similar number of intentional road-kills, thus becoming the category that proportionally causes more intentional road-kills. One of the few studies that highlight this type of influence is that of Langley et al. [30], in which fake snakes were mostly road-killed by trucks.

We believe that the size of the vehicle is related to the frequency of intentional road-killing of various objects. Drivers in larger vehicles such as trucks can kill more often and more safely because the chance of damage to the vehicle caused by striking a small object is minimal compared to the potential damage to smaller-sized vehicles. Another relevant aspect is that trucks are normally driven at controlled speeds, slower than passenger vehicles. When driving at lower speeds, drivers have more time to identify objects on the road and opt to intentionally run them over.

However, cars represent the vehicle category with the highest number of intentional road-kills of both snakes and control objects. This result can be explained due to much higher vehicular traffic in this category than in the others categories (according to the estimates of vehicular traffic from the videos in the sample), due to the intense tourist activity in the region of Serra do Cipó, to which the MG-010 road gives access. Although the increase in traffic was not proportionately reflected in the number of intentional road-kills, it increases the frequency with which vehicles encounter the objects, and thus increases the likelihood of unintended road-killing.

The position of objects on the road proved to be a dominant factor in the occurrence of intentional road-killing. The objects located in the center of the lane were road-killed more often than those located at the margins. Langley et al. [30] also observed this pattern with fake snakes located in the median strip of the road (between the two traffic directions). We believe that this is attributable to the fact that a change of trajectory towards the center of the lane is safer than towards the edge. This movement is similar to that conducted by the driver when beginning to pass another on a single-lane road. To perform an intentional road-kill on the margin of the road, the driver is exposed to a greater risk of being involved in an accident, because this change of course requires the vehicle to leave part of the lane to reach the object. Slow-moving animals, for instance, may remain exposed on the lane for longer periods and therefore could have greater chances of being road-killed intentionally because drivers are able to identify them more easily.

Despite an innovative research in Brazilian territories, demonstrating existence of intentional road kills, this study has limitations that can be improved in future studies on the theme, such as total sampling effort, sampling time during data collection, sampling size, as well as the number of roads sampled. In this context, we recommend that further studies on intentional road-killing of wild animals be conducted on other roads to evaluate possible regional differences associated with this practice, using a robust sampling design.

Implications for conservation

Our study confirms the practice of intentional road-killing on Brazilian roads, as has been reported for other countries. This driver behavior increases animal mortality. Those species that are more likely to cross roads should be more affected, adding intentional road-killing to the accidental casualties. Thus, we emphasize the need for mitigation measures that prevent small animals, such as snakes, from entering and moving on roads, because drivers tend to intentionally hit any object that is present in the lane. Models developed to determine the magnitude of the road-killing mortality effect on the population viability of affected species must consider the influence of intentional road-killing to avoid underestimating the negative effects caused by roads. The snake diversity in Brazil and the frequency with which these are recorded as road-kill, are matters of great significance, and may pose a serious threat to species conservation.

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