

Monitoring of Wildlife Mortality on a State Road in Rondônia, Western Amazon

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Abstract— Objective: describe the monitoring of the mortality of wild animals on a state road located in the municipality of Cacaulândia, state of Rondônia, Western Amazon, caused by the hit of vehicles. **Method:** the methodological procedure follows that recommended in the manual of the Brazilian Center for Road Ecology Studies (CBEE). **Result:** in the 19-month study period, the identification of animals run over and killed by vehicles reaches 2.57 animals per day, corresponding to an average of 77.1 animals per month and totaling 1,464.9 animals. This value corresponds to 0.073 animals killed per km traveled. The most victimized animal class was that of reptiles with a relative frequency of 51%, followed by mammals with 26.5%, birds with 14.3% and amphibians with 8.2%. **Conclusions:** peak deaths of wild animals occur on rainy days in the Amazon region. However, in the warm season and in the period of forest fires in the region, wildlife mortality rates remain quite high. What is expected is that this study will serve as an elementary basis so that managers of public policies of the infrastructure service in which the road component of the state of Rondônia is a part can adopt mitigating measures consecrated with the effectiveness in reducing / mitigating impacts in different biological groups, in the specific case of wildlife mortality.

Keywords— Wild animals. Run over and deaths. Road 140. Rondônia. Western Amazon.

I. INTRODUCTION

The Brazilian road system has expanded considerably in recent decades. According to several authors, among them, Bandeira; Floriano [1], Silva [2], Weiss; Viana [3] these road networks provide great benefits to society by enabling land transport, improving the efficiency of transporting people and the circulation of commercial products, generating more jobs and giving more access to information, education, health and leisure. However, according to Weiss; Viana [3] these same highways and roads cause damage to nature, influencing people's quality of life and changing the natural patterns of biodiversity, becoming one of the main elements when it comes to impacts on the natural environment. In addition to these impacts caused by the construction of highways, it is possible to list the running over of wild animals, as the main cause of death on the roads [4].

According to Freitas [5], highways and roads are becoming a threat to fauna diversity because they directly influence the mortality of wild animals due to being run over, a fact that implies greater attention on the part of public bodies so that this rate decreases. Silva [2] clarifies that the direct and indirect negative impact of highways on the environment ranges from planning to its effective construction and maintenance. The evolution of animals does not follow the development of the road system that changes territories without changing natural boundaries, that is, it fragments the habitat. They also impose a very significant barrier to the survival of wild animals in terms of being run over [2].

According to Bergallo, Vera and Conde [6], roads are among the environmental changes that have caused the most extensive impacts on natural landscapes of the 20th century. For Forman and Alexander [7], their ecological effects are not restricted to the road, but extend across the landscape, generating physical impacts, such as erosion and alteration of local hydrology; chemical products, such as dispersion of pollutants; biological, such as destruction of natural environments, barrier effect that subdivides populations and runs over wild animals. Roads and highways can cause isolation and fragmentation of environments and force populations of animals to cross them. This fact increases the likelihood of running over wild animals [8]. The highways interfere with the animals' natural route, which when trying to cross it in search of food or refuge, can become a victim of being run over. These victimized animals are attractive to others, such as carnivores, and can cause new accidents [2]; [3]. Santana [9] warns that the alarming number of running

over of wild animals in road networks often occurs due to the flow of nearby vehicles, and even within Conservation Units. Another reason is the availability of food, such as grains, which attracts animals to the track. Both can cause the loss of local biological diversity [9].

For Brandt et al [10], highways can function as ecological barriers, subdividing populations of wild animals, causing water and soil pollution and leading to mortality by being run over. Schonewald-Cox and Buechner [11] show concern when stating that the mortality of wild animals due to being run over can be a serious threat to the persistence of species that exist in low densities, such as those threatened with extinction. The presence of the highway in the life area of certain species and the availability of food on the highways are the main causes of accidents with wild animals [12]. Lima and Obara [12] argue that the high incidence of animals killed on the highways is due to two reasons: first, the highways cut through habitats and directly interfere with the natural displacement of species; second, food is available along the highway. In the latter, the garbage generated by the negligence of the drivers, the fruits and seeds of the shrub and tree species close to the road, and the carcass of run over animals, which attracts the carnivorous mastofauna, are presented. Bissonette [13] eases the situation by arguing that highways should be permeable to the movement of animals, and ways to avoid being run over and facilitate crossing should be part of planning the construction or expansion of roads.

According to the Brazilian Center for Studies in Road Ecology (CBEE) 1.3 million animals die daily and at the end of a year, up to 475 million wild animals are run over in Brazil, that is, studies show that every second, approximately 15 animals die from being run over on Brazilian roads. Small vertebrates, such as frogs, small birds, snakes, among others, are part of the vast majority of animals killed by being run over. Of these dead animals, 45 million are divided into 40 million medium-sized animals (eg hares, opossums, monkeys) and 5 million are large (eg pumas, maned wolves, jaguars) guinea fowl, tapirs, capybaras [14]. The Guimarães study [15] "The main cause of death of wild animals in Brazil" makes reference to the data presented by CBEE, where it corroborates that 90% of the deaths of wild animals, are of small vertebrates. Forman and Alexander [7] running over animals is the primary source of road death. Vieira [16] in "Mortality on mammal roads in central Brazil" corroborates this thought. Silveira's studies [17] "Ecology and conservation of carnivorous mammals in the Parque

Nacional das Emas, Goiás”; Rodrigues et al [18] “Impact of highways on the fauna of the Ecological Station of Água Emendadas-DF; Rosa and Mauhs [19] “Running over wild animals on the RS-040 highway” are unanimous in stating that running over wild animals is a serious problem, but little evidenced. Although for Carvalho and Pereira [20], a run over animal causes a very noticeable ecological impact. The trampling of wild animals shows that there are patterns determined by the surroundings of the trampling area, having as reference the vegetation, the climate and the habits of the different species [21]. There are numerous studies on the mortality of wild animals on highways, mainly from research carried out in other countries and with different methodologies and approaches such as those of researchers Seibert and Conover [22]; Rosen and Lowe [23]; Bissonette [24]; Massemin [25]; Pinowski [26]; Orłowski and Nowak [27]; Clevenger et al [28]; Saeki and McDonald [29]; Kanda et al [30].

According to Sassi et al [31], the search for information on the dimensions of the impact generated by the highways has received the attention of researchers in several countries, among which stand out the studies by Van der Zande, Ter Keues, Metikoshl [32] “The impact of roads on the densities of four bird species in an open field habitat - evidence of a long distance effect”; Kuiken [33] “Consideration of environment and landscape factors in highway planning in valued landscapes: in Australian survey”; Vieira [16] in Highway mortality of mammals in central Brazil; Philcox, Grogan, MacDonald [34] “Patterns of otter *Lutra lutra* road mortality in Britain”. Some important studies carried out in Brazil have contributed to the discussion on the subject in the academic and technical environment. These studies include the research by Jácomo, Silveira, Crawshaw [35]; Prada [36], Rodrigues et al [18]; Rosa and Mauhs [19]; Mathias [37]; Pereira et al [38]; Prado et al [39]; Tumeleiro et al [40]; Melo and Santos-Filho [41]; Cherem et al [4]; Oliveira et al [42]; Rodrigues et al [43] and Fischer [44].

Regardless of the methodology adopted in studies on the mortality of wild animals on roads, there is a consensus that there is an underestimation of the frequency of dead animals. On the roads of the Brazilian Amazon, studies on the behavior of wild animals are still scarce, including being run over and killed. According to Sousa and Miranda [45], the mortality caused by being run over can be highly impactful for natural populations, especially for species threatened with extinction and for those with relatively large areas of life and low reproduction rates. The theoretical basis

of the research is based on what Forman and Alexander [7] proposed as Road Ecology. It refers to ecological research whose theme grows over the years, based on evidence that dramatic effects on the ecosystem and ecological processes are related to road construction, a theme that is built from engineering and planning, ecology, geography, space. The Ecology of Roads comprises the study of the effects that a road can cause on fauna and flora and from these negative effects find solutions that prevent or minimize these effects [7]; [46]. Brazilian Road Ecology is emerging from the embryonic phase to become an important line of applied research. There is an increase in the number of researchers and research on the subject and publications [47].

Studies suggest that in regions with a high level of habitat loss and fragmentation, some ecological processes are negatively affected [48]. This seems to be the case in the Amazon Region, where different environmental conditions and engineering aspects are part of each road. However, there is no way to generalize a solution, as there are different situations for each road. Thus, studies of wild fauna must be carried out on the roads under construction, so that it is possible to identify species and areas that most need protection. Educational initiatives, implantation of road surveillance devices and even users when correctly implanted are part of a set of measures to protect fauna in the vicinity of roads. The use of fences to prevent animals from crossing roads, causing them to cross lower passages are important devices used to avoid being run over. The association of these passages with wide bridges and culverts, also, can be inferior passages, constructed for this purpose. Preventive and warning signs and speed control devices are important protection mechanisms [49]. The aim of this study is to describe the monitoring of the mortality of wild animals on a state road located in the municipality of Cacaupônia, state of Rondônia, Western Amazon, caused by vehicle being run over. It is expected to contribute with subsidies to establish strategies to mitigate the mortality of wild animals on Rondônia's roads.

II. METHOD

2.1. Methodological procedure

The work was carried out in the municipality of Cacaupônia, State of Rondônia, Western Amazon, Brazil, from March of the first year of study to September of the second year, totaling nineteen months of data collection. Systematic monitoring of the running over of wild fauna on

state road 140 and its surroundings was carried out, according to the methodology standardized by Maia and Bager [50]. This methodology is derived from the methodology of Projeto Malha, developed by the Brazilian Center for Studies in Road Ecology (CBEE), from the Federal University of Lavras / MG, which aims to create an integrated process of collecting, storing, analyzing and proposing mitigation measures of impacts of linear undertakings (roads) on the trampling of wild fauna. The most detailed visualization procedure possible should be adopted [51].

The route, previously defined, consists of the RO 140 highway in a 25.0 km route; surroundings I c25 with 5 km and surroundings II c15 with 5 km long. The daily route was traveled at a speed of approximately 30 km / hour, on a 125-cylinder motorcycle. If the animal was on the track, it was safely removed and taken off the road. In hit and run locations, the carcass was photographed. Monitoring start

and end times were also recorded. The animals found dead, after being identified and photographed, were sent to the Biology Laboratory of a private college in the region. For a better understanding of the identification of the areas where the occurrence of these events is greater, a schematic drawing is made that represents the points where they found carcasses and their spatial distribution on a road. (Figure 1). In the example, the monitored road was divided into five sections (A, B, C, D, E). This scheme identifies where there are more wild animals run over and killed, visualizing the distribution of occurrence points [52].

Identifying stretches of road where there is a greater number of animals run over is a fundamental step in planning the implementation of measures to mitigate the impacts that victimize wild animals. The marking of the geographical positions of the accidents also makes it possible to correct errors in the geographic coordinates.

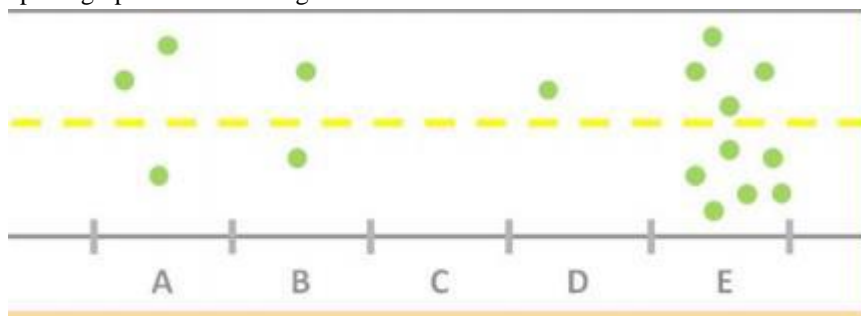


Fig.1: schematic drawing on the distribution of animals run over along the highway. Green circles represent run over individuals. Sections A, B, C, and E represent sections of the monitored road [14].

2.2. Data Collection Location

Cacaulândia is a new municipality, separated from the Municipality of Ariquemes, on February 13, 1992. It is located 61 km from Ariquemes and 207 km from Porto Velho. Formed by the Managed Settlement projects - PAD Burareiro and Marechal Dutra, divided into plots of 250 ha, respectively. It originated from a project created by Polonoroeste to provide support to farmers in the region, called the Núcleo Urbano de Apoio Rural - NUAR, receiving the name Cacaulândia, because it is a large cocoa producer. It is located at latitude 10° 20' 21" south and at longitude 62° 53' 43" west, being at an altitude of 205 meters. It has an area of 1,962 km². The 490 road has precarious infrastructural conditions, requiring maintenance of constantly plugging holes, and the neighboring or surrounding roads do not have asphalt covering.

2.3. Statistical analysis

The collected data were organized in tables with the aid of the spreadsheet editor program "Microsoft Office Excel 2010" and the chi-square test was performed.

III. RESULTS AND DISCUSSION

In the study period corresponding to 19 months, the identification of animals run over and killed by vehicles on a state road and two secondary roads in the municipality of Cacaulândia in Rondônia, Brazilian Amazon, reaches a figure of 2.57 animals per day, corresponding to the average 77.1 animals per month and totaling 1,464.9 animals. Considering that it is only a stretch (25 km) of a state road and two secondary roads of 5 km each, in only one municipality in the state of Rondônia, it can be inferred that

the number of animals run over and killed on the roads of the Brazilian Amazon are extremely worrying.

In this study, only a sample equivalent to 1 (one) day / from each of the 19 months of monitoring was considered, where the absolute frequency of 51 animals affected and killed was found. Of these, only 49 were run over and killed were considered to be able to perform the taxonomic classification. The comparisons between state highway 140 and its two surroundings and the period considered in relation to the total number of dead animals are shown in Table 1. Bearing in mind that the chi-square value found was lower than that in the table, the data obtained in the survey are thus considered valid, since it demonstrates independence from each other and the deviations are not considered significant. The value found in relation to the methodology adopted corresponds to 0.073 animals killed per day per km traveled.

Table 2 shows the comparison between taxonomic groups, at the class level, by monitored stretch. Data analysis shows that the most victimized class was that of reptiles with a relative frequency of 51%, followed by mammals with 26.5%. Birds with a relative frequency of 14.3% and amphibians with 8.2% complete the sample group of run over and killed wild animals identified and classified in the research sample. The data showed a predominance for reptiles in relation to others, a fact that can be linked to the fact of the mobility of these animals, since when they crawl or move around the land they are not seen by drivers. It is very relevant to demonstrate that the animals run over have a higher peak on rainy days in the region, very close to those that occur on hot days and in the period of forest fires. Considering that the chi-square value found was lower than the tabulated one, as well as the deviations were practically insignificant, therefore making the data found valid.

According to Guimarães [15] the animals most affected, corresponding to 90% of deaths, are small vertebrates, such as frogs, snakes and smaller birds. Bager, Fontoura [47] suggest that for birds and reptiles, the increase in trampling is positively related to rainy seasons, being more expressive in the summer. On climatic seasonality, studies by Fischer [44], Rosa and Mauhs [19], Prada [36], Mathias [37], Melo and Santos-Filho [41] have already pointed out that in some regions the mortality of wild animals varies seasonally. While the study by Ferreira da Cunha et al [52], revealed the same frequency of running over of wild animals during the different months of the year and the dry and rainy seasons. The study by Rodrigues et al

[18] also found no changes in the number of animals run over in different climatic seasons. Pereira et al [38] also found no significant difference.

Authors like Bencke and Bencke [54]; Seibert and Conover [22]; Seiler [55] suggest that accidents with wild animals occur mainly in the rainy season, which is generally associated with the reproductive period and the greater availability of food sources, such as fruits, seeds, flowers and other animals that stimulate the movement of fauna, increasing thus the probability of crossing the highways and, consequently, the chances of collision with cars. Forman and Alexander [7]; Pinowski [26] corroborates this evidence.

Ferreira da Cunha et al [53] recorded 308 animals run over, 86% of which were mammals, 11% birds and 3% reptiles. For this author and collaborators, it is difficult to compare the hit and run mortality rate between the works carried out on Brazilian highways due to the different methodologies applied and the characteristics of the road, such as surrounding vegetation, proximity to conservation units, vehicle flow, number of lanes rolling, weather data, etc. The mortality rate found in the study by Ferreira da Cunha et al [53] using the methodology of running over animals per km traveled (0.014 animals / km traveled) was lower than those found by other studies such as Prada's [36] of 0.048, Silveira [17] of 0.054, Jácomo, Silveira, Crawshaw [35] of 0.06 and by Rodrigues et al [18] of 0.168. Sássi et al [31] found 228 animals run over. In the study by Sássi et al [31] mammals represent the majority of run over animals, followed by birds, amphibians and reptiles, in the following order: mammals (128), birds (72), amphibians (26) and reptiles (2). Sássi et al [31] used the kilometer traveled methodology and found an average of running over 0.010 animals / km traveled. Fischer [44], Rosa and Mauhs [19] and Melo and Santos-Filho [41] in their studies also found the highest frequencies of mammals run over on the roads. Other studies such as Mathias [37], Prado et al [39], Prada [36] and Rodrigues et al [18] registered the majority of birds, while Rodrigues et al [43] registered the majority of amphibians.

Monitoring of wild fauna run over around the Carijós Ecological Station, Gleba Ratones, carried out by Martin [56], showed that there was no difference between the three stretches covered in the run over rate. Of the 78 identified run over animals, 49 were mammals (62.83%). The frequency of species and animals run over was approximately constant over the months. This fact suggests that these animals use the fragments around the highway as a

dispersion route for their daily activities. Some species run over on highways can be attracted to the road to feed on carcasses [19]; [57] or from grains falling during transport by trucks [36]; [58]. In a work by Pinowski [26], there was a higher incidence of *Didelphis marsupialis* (Didelphidae) and snakes (Ophidia). Possum deaths may be related to the eating habits of these animals. Snakes and lizards are often attracted to hot asphalt, especially after rain, and are crushed by cars [59].

In the study by Ramos-Abrantes et al [60], 188 specimens of run over vertebrates were recorded. Mammalia was the most representative group with 108 specimens (57.4%) registered, followed by Reptilia with 37 specimens (19.7%), Birds (14.3%) and Amphibia (8.6%). *Cercopithecus* (Linnaeus, 1766) was the species with the highest number of individuals run over, alone accounted for almost half of the records (N = 87; 46.5%). In the study by Pereira Corrêa, Barbosa Sales [61] 130 animals run over were

recorded and identified. There were four groups of animals with different frequency of deaths. Opossums (*Didelphis marsupialis*), black-headed vulture (*Coragyps atratus*), rodents (Rodentia) and Quatis (*Procyonidae Nasua nasua*), were the most frequent rate of animals run over during the month / day. The other groups, Lizards (Iacertia), Tamandua-mirins (*Tamandua tetradactyla*), Tatu Galinha (*Dasypus novemcinctus*), Sloth (*Bradypus variegatus*), Ocelot (*Leopardus pardalis*), Jararacas (*Bothrops jararaca*), Porco do masto-queixada *Tayassu pecari*, were the least frequent, month / day ratio. Some taxa could not be identified due to the crushing of the carcasses. Therefore, as can be seen, there is differentiation of individuals and species, depending on the biographical units of the fauna, climatic variations, breeding season, seasonal movements, habits and behavior of animals and a series of variables in environmental, social and economic contexts, among others.

Table 1. Absolute number of I (one) day / month of wild animals run over and killed on state highway 140, mean and standard deviation.

| I (one) day / month | Road/Nº Total Animals | | | | Standard deviation |
|---------------------|-----------------------|-------|--------|---------|--------------------|
| | RO140* | C25** | C15*** | Average | |
| I | 1 | 1 | 0 | 0.3333 | 0.5774 |
| II | 2 | 2 | 0 | 1.3333 | 1.1547 |
| III | 4 | 2 | 0 | 2.0000 | 2.0000 |
| IV | 2 | 0 | 0 | 0.6666 | 1.1547 |
| V | 0 | 0 | 1 | 0.3333 | 0.5774 |
| VI | 1 | 0 | 0 | 0.3333 | 0.5774 |
| VII | 1 | 0 | 0 | 0.3333 | 0.5774 |
| VIII | 0 | 1 | 1 | 0.6666 | 0.5774 |
| IX | 3 | 2 | 0 | 1.6666 | 0.5275 |
| X | 0 | 1 | 1 | 0.6666 | 0.5774 |
| XI | 1 | 0 | 0 | 0.3333 | 0.5774 |
| XII | 1 | 1 | 0 | 0.6666 | 0.5774 |
| XIII | 1 | 1 | 2 | 1.3333 | 0.5774 |
| XIV | 2 | 1 | 1 | 1.3333 | 0.5774 |
| XV | 0 | 3 | 0 | 1.0000 | 1.7321 |
| XVI | 1 | 1 | 0 | 0.6666 | 0.5774 |
| XVII | 3 | 0 | 1 | 1.3333 | 1.5275 |

| | | | | | |
|---------|--------|--------|--------|--------|--------|
| XVIII | 1 | 0 | 0 | 0.6666 | 0.5774 |
| XIX | 3 | 0 | 0 | 1.0000 | 1.7321 |
| Average | 1.3684 | 0.8421 | 0.3684 | 0.8772 | 0.9346 |

RO140* State road in Cacaulândia / Rondônia. Surrounding Road I** Surrounding Road II***.

Source of data: [52].

Degree of freedom = 38 / level of significance $p = 0.05$ or 5% / chi-square value tabulated for this degree of significance is 26.509.

Table 2. Absolute frequency of the collection sample of 1 (one) day / month of animals run over and killed according to the taxonomic class on highway 140 and two surroundings in Cacaulândia-Rondônia.

| 1 (one) day / month | Fa | Mammal | bird | Reptile | Amphibian |
|---------------------|--------|------------|-----------|----------|-----------|
| I | 1 | 0 | 0 | 1 | 0 |
| II | 4 | 1 | 0 | 3 | 0 |
| III | 6 | 0 | 1 | 4 | 1 |
| IV | 2 | 2 | 0 | 0 | 0 |
| V | 1 | 0 | 1 | 0 | 0 |
| VI | 1 | 0 | 1 | 0 | 0 |
| VII | 1 | 0 | 0 | 1 | 0 |
| VIII | 2 | 1 | 0 | 1 | 0 |
| IX | 5 | 1 | 2 | 0 | 2 |
| X | 2 | 0 | 0 | 2 | 0 |
| XI | 1 | 0 | 1 | 0 | 0 |
| XII | 2 | 0 | 0 | 2 | 0 |
| XIII | 4 | 0 | 0 | 4 | 0 |
| XIV | 4 | 1 | 0 | 2 | 1 |
| XV | 3 | 0 | 0 | 3 | 0 |
| XVI | 2 | 1 | 1 | 0 | 0 |
| XVII | 4 | 3 | 0 | 1 | 0 |
| XVIII | 1 | 0 | 0 | 1 | 0 |
| XIX | 3 | 3 | 0 | 0 | 0 |
| Total | 49 | 13 (26.5%) | 7 (14.3%) | 25 (51%) | 4 (8.2%) |
| Average | 2.5789 | 0.6842 | 0.3684 | 1.3158 | 0.2105 |
| Standard deviation | 1.5390 | 1.0029 | 0.5973 | 1.3765 | 0.5353 |

Fa Absolute frequency. Collection (C) In this study, the collection refers only to a sample equivalent to 1 (one) day / month.

Source of data: [52].

Degree of freedom = 54 / level of significance $p = 0.05$ or 5% / chi-square value tabulated for this degree of significance is 34.764.

Figure 2 shows a reptile run over on road 140, with vegetation in a stream on both sides of the road with a small forest, while figure 3 shows a dead mammal.



Fig.2: Dead reptile on the road. Photograph: [52].

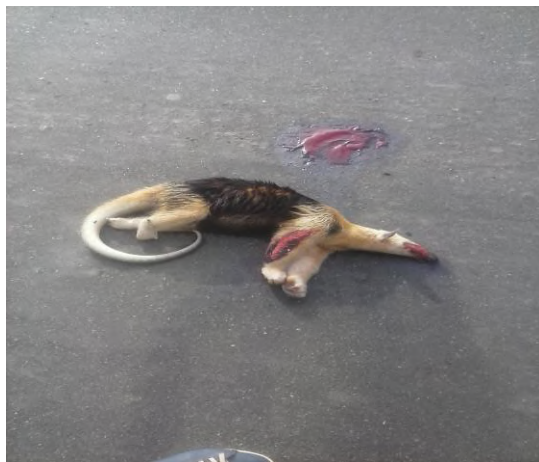


Fig.3: Dead mammal on the road. Photograph: [52].

Figure 4 below shows a bird run over and killed on road 140, with vegetation grazing on both sides of the road and Figure 5 shows an amphibian run over and killed.



Fig.4: Bird run over and killed. Photograph: [52].



Fig.5: Amphibian run over and killed. Photograph: [52].

Trombulak and Frissell [8] have already announced that road construction is an important cause of ecological imbalance and can cause several impacts, such as: changes in animal behavior; change in physiological state; introduction of exotic species due to changes in habitat; stress and / or removal of native species; food chain modification; fragmentation and alteration of habitats by edge effect; interception of corridors of natural dispersion of terrestrial fauna; population isolation and loss of individuals by collision with vehicles. Cherem et al [4] adds that in addition to these impacts caused by the construction of highways, it is

possible to list the running over of wild animals, the primary cause of death on roads. For Hengemuhle and Cademartoti [62], roads cause several impacts to the environment and the running over of wild animals can reduce the population of certain species to worrying levels. According to Ferreira da Cunha et al [53], these accidents can be reduced by decreasing the speed of vehicles, with obstacles that compel the driver to respect them, such as the installation of speed reducers (electronic barriers and / or circuit breakers) at the points mentioned above and in the places considered critical points. Rodrigues et al [18] suggested including the content about the running over of wild fauna in the training program for the acquisition of the national transit card.

According to Hengemuhle and Cademartoti [62], the so-called road fauna can have several functions, such as indicating local biodiversity, teaching about displacement behavior, seasonal dynamics of species present in the surroundings. For Oliveira [21], animals cross roads to supply diverse needs, such as migration, search for food and occupation of territory, and are daily exposed to the imminent risk of being run over. Bager [63] asks another question when stating that the main impacts to local biodiversity caused by roads and highways can be acute (immediate destruction of habitat) or chronic (long-term consequences). Glista, Devault and Dewood [64] explain that roads are necessary, but it is undeniable that they directly affect the habitat of wildlife. According to these three authors, road ecology is a new field and has developed many important works, but there are still few studies comparing the before and after the implementation of measures aimed at reducing accidents with wild animals. Without these studies, it is impossible to assess their effectiveness, but there are measures with a low degree of complexity that certainly have an effectiveness in reducing animal deaths from being run over, such as: manhole tubes (also called amphibian tunnel), passage of lower fauna, passage of upper fauna and use of barriers along with fauna passages. For IBAM [65], different mitigating measures can be used together to minimize the problem of high rates of animals run over on roads: speed reducers, signaling, environmental education, landscape management around the road and wildlife crossing. Of these, some aim to educate drivers and thereby contribute to a change of habit (for example: license plates, speed reducers) and others serve to change the habits of animals, such as

fauna passages, airline tickets, fauna viaducts, elevated, fences or driving fences.

Ideally, there should be prior planning so that at the time of construction of the highway, these measures were already included in the project. This would make the structural mitigation measure more economical. But the reality is that, in general, these measures are only thought after the construction of the highway, which demands the diagnosis of the critical points of running over of fauna [65]. According to DNIT [66] there is no way to generalize a solution, as there are different situations for each road. Thus, studies of wild fauna must be carried out on the highways under construction, so that it is possible to identify species and areas that most need protection so that wild animals are not run over. Educational initiatives, implantation of highway inspection devices and even users when correctly implanted are part of a set of measures to protect fauna in the vicinity of roads. The use of fences to prevent animals from crossing the roads, causing them to cross lower passages are important devices used to avoid being run over. The association of these passages with bridges and wide culverts can also be lower crossings, called droughts, which are built for this purpose. Preventive and warning road signs and speed control devices are structures that depend on the need [66].

Iuell et al [67] in "Wildlife and traffic: A European handbook for identifying conflicts and designing solutions" highlight that several measures have been proposed and implemented over time to minimize the impact of highways on fauna. Objective to avoid accidents with wild animals in susceptible points and to restore some degree of connectivity [67]. For Sássi et al [31] the running over of wild animals, known as "road fauna", can serve as indicators of local biodiversity, in addition to providing ecological data on the natural history of some species. Monitoring road fauna can reveal interesting aspects, such as the pattern of displacement and the seasonal dynamics of some populations of species present in the community. Fischer [44] adds that with this information, it is possible to assess the degree of local conservation and establish priority areas for conservation.

Table 3 shows the known mitigating measures, the effectiveness in reducing / mitigating impacts on different biological groups.

Table 3: known measures to mitigate the direct impacts of highways on wildlife.

| Type | | Mitigating measures | Biological groups | | | |
|--------------------------|-------------------|--|-------------------|---|---|---|
| | | | I | H | A | M |
| Structural interventions | | 1. underpasses | | | | |
| | | 2. large underpasses | | | | |
| | | 3. multipurpose underpasses | | | | |
| | | 4. tunnels for amphibians and reptiles | | | | |
| | | 5. ecoducts or ecosystem bridges | | | | |
| | | 6. overpasses | | | | |
| | | 7. multipurpose overpasses | | | | |
| | | 8. tree extract passages | | | | |
| | | 9. road tunnels | | | | |
| | | 10. elevated overpasses | | | | |
| | | 11. bridges and pontoons | | | | |
| | | 12. modified manholes | | | | |
| | | 13. noise barriers | | | | |
| | | 14. expansion of the central construction site | | | | |
| Management | For those who use | 1. educational campaigns | | | | |
| | | 2. road signs | | | | |
| | | 3. speed limitation | | | | |
| | | 4. reduced traffic volume | | | | |
| | | 5. temporary ban | | | | |
| | | 6. fauna detention systems | | | | |
| | Biological | 7. alert and chase away | | | | |
| | | 8. beacons | | | | |
| | | 9. food | | | | |
| | | 10. carcass removal | | | | |
| | | 11. habitat modification | | | | |
| | | 12. fences and barriers | | | | |
| | | 13. population reduction | | | | |

Subtitle:

| | |
|--|-------------|
| | Recommended |
| | Inadequate |

| | |
|------------|----------------------------|
| | Possibly adequate |
| | Undetermined effectiveness |
| xxxxxxxxxx | No known use in Brazil |

I= ichthyofauna, H= herpetofauna, A= birdlife, M= mastofauna.

Figure 6 shows the existing alternatives in the context of environmental licensing.

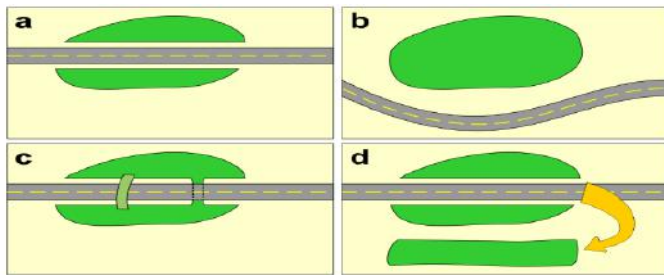


Fig.6: Schematic representation: a) impact caused by the road (habitat fragmentation), b) neutralization of the potential impact by altering the route, c) mitigation of the impact caused by the implantation of fauna crossing structures and d) compensation through the allocation of equivalent habitat for conservation purposes. Adapted from Iuell et al [67].

IV. CONCLUSIONS

The present study allowed us to describe the monitoring of the mortality of wild fauna victims of being hit by vehicles on a state road located in the municipality of Cacaúlândia, state of Rondônia, Western Amazonia, aiming in the future to generate subsidies to establish strategies to mitigate mortality caused by run over. We used a methodology derived from the methodology of Projeto Malha, developed by the Brazilian Center for Studies in Road Ecology (CBEE), from the Federal University of Lavras / MG. This methodology aims to create an integrated process of collection, storage, analysis and propose measures to mitigate the impacts of linear developments (roads) on the trampling of wild fauna.

In the study period corresponding to 19 months, the identification of animals run over and killed by vehicles on a state road and two secondary roads in the municipality of Cacaúlândia in Rondônia, Brazilian Amazon, reaches a figure of 2.57 animals per day, corresponding to the average 77.1 animals per month and totaling 1,464.9 animals. This value corresponds to 0.073 animals killed per km traveled.

Considering that it is only a stretch (25 km) of a state highway and two secondary roads of 5 km each, in only one municipality in the state of Rondônia, it can be inferred that the number of animals slaughtered by vehicles on Brazilian Amazon roads is extremely loud and worrying.

In this study, only a sample equivalent to 1 (one) day / month of monitoring was considered, where the absolute frequency of 51 animals hit and killed was found. Of these, only 49 animals hit and killed were considered. The most victimized animal class was that of reptiles with a relative frequency of 51%, followed by mammals with 26.5%, birds with 14.3% and amphibians with 8.2%. The results showed a predominance for reptiles over others, a fact that can be linked to the fact of the mobility of these animals, since when they crawl or move around the land they are not seen by drivers. It is very relevant to demonstrate that wild animal deaths have a higher peak on rainy days in the Amazon region. However, in the warm season and in the period of forest fires in the region, the rates of trampling and killing of wild animals remain quite high.

What is expected is that this study will serve as an elementary basis so that managers of public policies of the infrastructure service in which the road component of the state of Rondônia is a part can adopt mitigating measures consecrated with the effectiveness in reducing / mitigating impacts in different biological groups, in the specific case of wildlife mortality.

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