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Survey of wildlife rescued and treated from 2014 to 2016 in Joinville (SC), Brazil

Levantamento dos animais silvestres resgatados e atendidos de 2014 a 2016 em Joinville (SC), Brasil

Carolina Konkel Barbosa[1], *José Eduardo Basilio de Oliveira Gneiding*[2], *Túlio Tácito Ribeiro*[3], *Edevaldo Antonio Iachinski*[1], *Igor Christian Magno Gonçalves*[4], *Cláudia Turra Pimpão*[1]

ABSTRACT

Natural ecosystems are in constant conflict with the growing and disordered urban expansion, arising from the mismanagement of human developments and infrastructure, facing an accelerated rate of deforestation and defaunation. The intense pressure on natural environments impacts the local fauna through various incidents, generating high mortality, such as hit-and-run, window-crashing, attacks by domestic animals, dissemination of diseases and electrocution. The purpose of this study was to carry out a retrospective survey of the wild fauna rescued and treated at a clinic associated with the environmental police in the region of Joinville - SC. A total of 379 wild animals were treated at the clinic from 2014 to 2016. Of these, 262 (69.13%) were birds, 107 (28.23%) mammals, 9 (2.37%) reptiles and 1 (0.26%) amphibian. The main causes of referral for clinical care were due to trauma (50.66%), seizures (1.32%) and other causes (48.02%), such as home invasion and orphaned puppies. Among the reasons for traumas, pedestrian accidents were the most prevalent, representing 39.58% of the cases treated, followed by animals found to be debilitated without a defined cause (31.77%), attack by domestic animals (14.58%) and window-crashing (9.89%). The data obtained in this study show a rich diversity of species in Joinville. These species are exposed to several anthropogenic challenges and barriers derived mainly from intense displacement and human invasion, causing many animals to move in order to adapt to urban areas.

Keywords: fauna; hit-and-run; atlantic forest; infrastructure; urbanization.

RESUMO

Os ecossistemas naturais estão em constante conflito com a crescente e desordenada expansão urbana, oriunda da má gestão de empreendimentos e infraestruturas humanas, enfrentando uma acelerada taxa de desmatamento e defaunação. A intensa pressão sobre os ambientes naturais impacta a fauna local através de incidentes variados gerando alta mortalidade, como atropelamentos, colisão em vidraças, ataques por animais domésticos, disseminação de doenças e eletrocussão em redes elétricas. O objetivo deste estudo foi realizar um levantamento retrospectivo da fauna silvestre resgatada e atendida em uma clínica conveniada à polícia ambiental na região de Joinville – SC. Um total de 379 animais silvestres foram atendidos na clínica no período de 2014 a 2016. Destes, 262 (69,13%) eram aves, 107 (28,23%) mamíferos, 9 (2,37%) répteis e 1 (0,26%) anfíbio. As principais causas de encaminhamento para atendimento clínico foram devido a traumas (50,66%), apreensões (1,32%) e outras causas (48,02%) como a invasão de residências e filhotes órfãos. Dentre os motivos de traumas, os atropelamentos foram os mais prevalentes, representando 39,58% dos casos atendidos, seguido por animal encontrado debilitado sem causa definida (31,77%), ataque por animal doméstico (14,58%) e colisão com vidraças (9,89%). Os dados obtidos neste estudo mostram uma rica diversidade de espécies em Joinville. Essas espécies são expostas a diversos desafios e barreiras antropogênicas derivadas principalmente do intenso deslocamento e à invasão humana, fazendo com que muitos animais tenham que se deslocar para se adaptar a viver em áreas urbanas.

Palavras-chave: fauna; atropelamento; mata atlântica; infraestrutura; urbanização.

[1]School of Life Sciences, Pontifícia Universidade Católica do Paraná – Curitiba (PR), Brazil.

[2]Centro Universitário, Sociedade Educacional de Santa Catarina – Blumenau (SC), Brazil.

[3]Faculdade Cesumar – Curitiba (PR), Brazil.

[4]Clínica Dr. Selvagem Medicina de Animais Silvestres e Exóticos – Joinville (SC), Brazil.

Correspondence address: Carolina Konkel Barbosa – Rua Imaculada Conceição, 1.155 – Prado Velho – CEP: 80215-901 – Curitiba (PR), Brazil. E-mail: carolinakonkel@gmail.com

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Introduction

Tropical ecosystems are facing an accelerating rate of deforestation and defaunation. Consequently, anthropogenic alteration of natural environments triggered the sixth largest extinction event in history, causing widespread changes in the global distribution of fauna and flora (Chapin et al., 2000). Landscape modification and habitat fragmentation are the main drivers of this widespread species loss as a result of the interaction of exogenous and endogenous threats, including habitat loss, degradation and isolation, changes in biology, behavior and species interactions, as well as threatening additional factors, such as logging and farming, fires, hunting, illegal trade, introduction of exotic species, edge effects and urbanization (Fischer and Lindenmayer, 2007; Symes et al., 2018).

Maintaining biodiversity in these landscapes is complex and faces a multitude of challenges. Their response to habitat disturbance differs between species and ecological groups, between landscapes and regions, depending on landscape heterogeneity (Ewers and Didham, 2006; Arroyo-Rodríguez et al., 2013). Furthermore, the negative effects of habitat modification and wildlife exploitation have ripple and cumulative effects that affect not only the target species, but also the structure, function and resilience of the forest due to the loss of critical animals for maintenance. environmental, which leads to changes in plant composition, animal communities and ecosystem dynamics that, associated with the development of anthropogenic infrastructures facilitating human access to wildlife habitats, aggravates the effects of deforestation (Ward et al., 2015; Sobral-Souza et al., 2017; Symes et al., 2018).

The Brazilian Atlantic Forest has high species richness and a long history of human disturbance. It is made up of a great diversity of ecosystems, being considered one of the five most important hotspots of global biodiversity, housing about 261 species of mammals (55 endemic), 1020 of birds (188 endemic), 340 of amphibians (90 endemic), 197 of reptiles (60 endemic) and 350 of fish (133 endemic), in addition to containing most of the Brazilian species threatened with extinction (Myers et al., 2000; Arruda and Sá, 2004; Fundação SOS Mata Atlântica and INPE, 2020).

However, the rate of destruction of the Atlantic Forest has increased in recent decades due to the occupation and exploitation of its resources, resulting in severe changes in this ecosystem, caused by the high fragmentation of habitats and the loss of biodiversity. The current result is the almost total loss of the original intact forests and the continuous devastation of the existing forest remnants, making this biome one of the most endangered ecosystems in the world (Brasil, 2010).

The State of Santa Catarina is inserted within this biome in all its extension, and is the third state with the largest area of remnants of the Atlantic Forest in the country, currently possessing about 17.46% of the original biome preserved (Reserva da Biosfera Mata Atlântica, 2008). Due to intense displacement and human invasion, long peri-urban areas are being incorporated into cities, leading to environmental imbalance and great destruction of natural habitats, causing many animals to move in order to adapt to urban areas.

In addition, the intense pressure on the areas still forested results in several encounters between the population and the fauna, with various incidents generating high mortality of the surrounding wild fauna, such as hit-and-run, window-crashing, attacks by domestic animals, disease dissemination and electrocution. A small part of these animals is found still alive, and is sent to the Wild Animal Screening Centers (CETAS), responsible for receiving, sorting, recovering, rehabilitating and disposing of wild animals (IBAMA, 2018).

Considering that most CETAS are located in a single city in the state, some clinics may have a contract with the Brazilian Institute for the Environment and Renewable Natural Resources - IBAMA or Environmental Institutes in the state, to provide emergency care to these animals before they are sent there. Considering this scenario, the purpose of this study was to carry out a survey and diagnosis of the fauna rescued alive in a clinic associated with the Environmental Police of Itajaí, aiming to identify critical points in the survival and conservation of wild species in anthropomorphized areas in the region of Joinville, Santa Catarina - Brazil.

Material and Methods

Description of the study area

The data were obtained from the clinic Dr. Selvagem – Wild and Exotic Animal Medicine, located in the city of Joinville – State of Santa Catarina, Brazil. The clinic provides specialized care for birds, reptiles, mammals, amphibians and privately owned fish that are legalized as required by IBAMA. Since 2006, it has been providing emergency care for free-living wild animals rescued by the environmental police, victims of trafficking, abuse, car crashes and electrical wiring, or at risk, which, after being discharged, are sent to the wild animal rehabilitation center (CETAS) or Fauna Keepers registered by IBAMA for rehabilitation and release.

Design and data analysis

A retrospective observational study was carried out by surveying the clinical care records of free-living wild animals rescued by the environmental police from April 2014 to July 2016, later tabulated in Microsoft Excel 2016 software, according to the date of entry, class, order, family, common name, scientific name, age group, type of rescue, reason for rescue and destination registered in the veterinary records. Data were descriptively analyzed and shown in percentages.

Results

A total of 379 animals were rescued by the environmental institute of Santa Catarina State in charge in the region of Joinville, and sent to a clinic specializing in wild animal care, from April 2014 to July 2016. Of these, 262 (69.13%) were birds, 107 (28.23%) were mammals, 9 (2.37%)

were reptiles and 1 (0.26%) was amphibian. The distribution of visits to birds and mammals according to month and year during this period is shown in Figures 1 and 2. According to Figure 1, it can be seen that there was no homogeneous distribution over the months.

The number of clinical consultations performed in birds during 2014 increased in November, concentrated in October and December 2015 and in January 2016. The registered occurrences of mammals showed dispersion according to the relevant year, and from July to September 2014 they had a larger sample of clinical care. In 2015 the records were mainly concentrated in January, March and June, and in 2016 until July, January and May there was a greater number of records. As for the occurrence of reptiles, clinical consultations were carried out only in 2015, with the majority of records in January (6/9).

The main causes of referral for clinical care due to trauma were 50.7% (n = 192) and other causes amounted to 48% (n = 182), such as home invasion and orphaned puppies, and 1.3% had been seized (n = 5). The trauma category included accidents involving hit-and-run, attack by domestic animals, window-crashing, entanglement in nets and fences, projectiles and animals found weakened without a defined cause. Tables 1, 2 and 3 list the order and animal species with the type of occurrence and conservation status according to the Endangered Species List – MMA (Brasil, 2018a, 2018b, 2018c, 2018d). Several groups of species treated at the clinic had more than one type of occurrence, indicating that the effects of anthropomorphized areas can be cumulative.

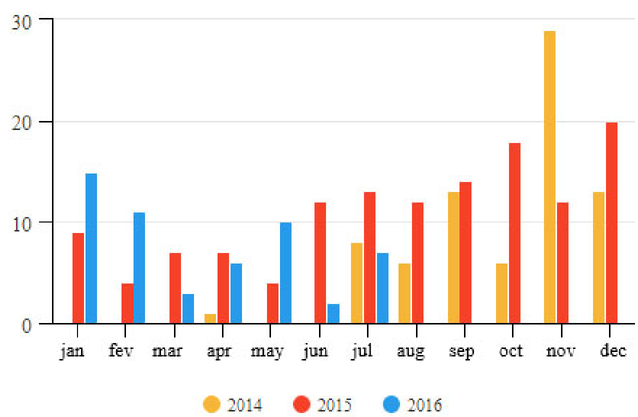

Figure 1 – Distribution of records of free-living birds rescued by the environmental police from April 2014 to July 2016 and treated at the clinic.

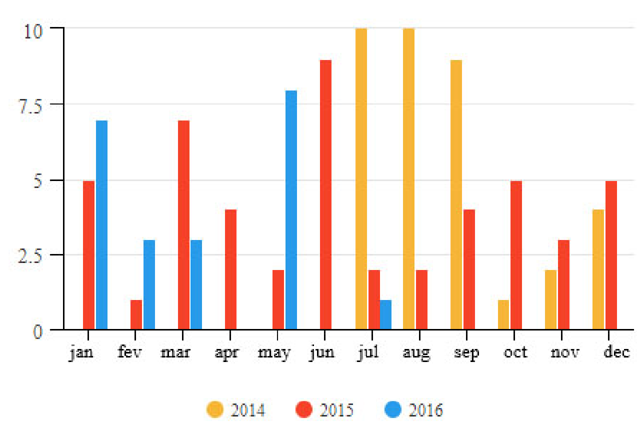

Figure 2 – Distribution of records of free-living mammals rescued by the environmental police from April 2014 to July 2016 and treated at the clinic.

In all, 94 different species of mammals, birds, reptiles and amphibians rescued by the Environmental Police were recorded and received emergency clinical care at Clínica Dr. Selvagem, highlighting the high species richness and a long history of anthropogenic disturbances experienced by the Atlantic Forest biome. As for the conservation status, almost threatened species (NT) were registered: magellanic penguin (*Spheniscus magellanicus*), with 1.06% (n = 4), saffron toucanet (*Pteroglossus bailloni*) (0.26%, n = 1) and the azure jay (*Cyanocorax caeruleus*) (0.26%, n = 1); vulnerable to extinction (VU): white-necked hawk (*Buteogallus lacernulatus*) (0.26%, n = 1), howler monkey (*Alouatta guariba*) (0.26%, n = 1) and northern tiger cat. (*Leopardus tigrinus*) (0.53%, n = 2) and endangered (EN): vinaceous-breasted Parrot (*Amazona vinacea*) (0.26%, n = 1) and Jaguarundi (*Puma yagouaroundi*) (0.26%, n = 1).

Among the reasons for trauma, hit-and-run was the most prevalent, representing 39.6% (n = 76) of the cases treated, followed by animals found debilitated without a defined cause (31.8%, n = 48), attack by domestic animals (14.6%, n = 28), birds in window-crashing accidents (9.9%, n = 19) and other reasons (Figure 3).

The other occurrences not related to trauma represented 48.02% (182/379) of the visits, with the main reason for rescue being related to orphan puppies (36.3%, n = 66), invasion of residence (31%, n = 56), causes not reported (27.5%, n = 50) and falls from the nest (5.5%, n = 10). Of the total number of occurrences recorded in the survey period, most of the animals treated (44.6%, n = 169) were, after stabilization in the clinic, sent to CETAS-SC. In 32.5% (n = 123) the type of destination was not entered in the clinical records, 17.7% (n = 67) of the animals died, 4.7% (n = 18) were destined for release.

Among the animals sent to the clinic due to hit-and-run, 41.7% (31/76) died, 30.2% (23/76) were sent to CETAS-SC, which was not informed in the clinical records (27.6%, 21/76) and only 1 (1/76) was discharged and sent for release. Considering the classes involved in accidents with vehicle collisions, mammals had the highest number of occurrences (60.5%, n = 46), followed by birds (38.2%, n = 29), and only one (1.3 %) species of reptile was registered. Within the Mammalia class, the order Didelphimorphia (43.5%, n = 20) was the most abundant. Additional orders also sampled were Rodentia (15.2%, n = 7), Pilosa (13%, n = 6), Carnivora and Primate (10.9%, n = 6), Cingulata (4.3%, n = 2) and Artiodactyla (2.2%, n = 1).

In birds, individuals of the order Strigiformes were the most recorded group (31%, n = 9), followed by Galiformes (20.7%, n = 6), Gruiformes (13.8%, n = 4), Accipitriforms (10.3%, n = 3) and others. Only one black-and-white Tegu (*Salvator merianae*) belonging to the reptile class was treated at the clinic due to a vehicle collision.

Table 1 – Type of occurrence of mammals rescued by the Environmental Police and sent to Clínica Dr. Selvagem, from 2014 to 2016.

Species	Type of occurrence	Conservation Status	Total
Didelphimorphia			67
Didelphis albiventris	A, B, D	LC	9
Didelphis aurita	A, B, C, D	LC	58
Artiodactyla			1
Not identified	A	-	1
Carnivora			7
Cerdocyon thous	A, C	LC	2
Leopardus tigrinus	A	VU	2
Procyon cancrivorus	A, E	LC	2
Puma yagouaroundi	A	EN	1
Chiroptera			1
Nyctinomops aurispinosus	D	LC	1
Cingulata			3
Dasypus novemcinctus	A, B	LC	3
Pilosa			9
Tamandua tetradactyla	A, D, E	LC	9
Primata			9
Alouatta guariba	E	VU	1
Callithrix penicillata	A, C, D	LC	6
Sapajus apella	A	LC	2
Rodentia			10
Cavia aperea	A, B	LC	2
Coendou prehensilis	A	LC	1
Dasyprocta aguti	A, C, E	LC	3
Hydrochoerus hydrochaeris	A, B	LC	4
Total			107

A: Vehicle collision; B: Domestic Animal Attack; C: Found Debilitated; D: Home Invasion; E: Orphan; LC: Out of danger; VU: Vulnerable; EN: In danger; CR: Critically Endangered.

Table 2 – Type of occurrence of birds rescued by the Environmental Police and sent to Clínica Dr. Selvagem, from 2014 to 2016.

Species	Type of occurrence	Conservation Status	Total
Galliformes			10
Ortalis guttata	A, H, K	LC	8
Penelope obscura	A, E	LC	2
Accipitriformes			13
Buteo brachyurus	E	LC	1
Buteogallus lacernulatus	A	VU	1
Not identified	A, C, E, G, K	-	7
Parabuteo unicinctus	A	LC	1
Rupornis magnirostris	E, G	LC	3
Anseriformes			2
Cairina moschata	A	LC	1
Dendrocygna bicolor	G	LC	1
Apodiformes			3
Not identified	C	-	3
Caprimulgiformes			1
Hydropsalis parvula	B	LC	1
Charadriiformes			13
Larus dominicanus	C, K	LC	2
Larus sp.	K	-	3
Thalasseus maximus	F	LC	1
Vanellus chilensis	A, E, G, H, K	LC	7
Columbiformes			18
Columba livia	G	LC	2
Columbina sp.	B, C, G, H, K	-	14
Geotrygon violacea	B	LC	1
Patagioenas picazuro	H, J	LC	1
Coraciiformes			1
Chloroceryle americana	B	LC	1
Cuculiformes			1
Piaya cayana	E	LC	1
Falconiformes			7
Caracara plancus	A, H, J, K	LC	4
Falco femoralis	G	LC	1

Continue...

Table 2 – Continuation.

Species	Type of occurrence	Conservation Status	Total
Milvago chimachima	A, C	LC	2
Gruiformes			10
Aramides saracura	A, H, K	LC	8
Gallinula galeata	A	LC	1
Porphyrio martinicus	G	LC	1
Nyctibiiformes			2
Nyctibius sp.	G, K	-	2
Passeriformes			67
Cacicus haemorrhous	C	LC	1
Coereba flaveola	B	LC	1
Cyanocorax caeruleus	E	NT	1
Furnarius rufus	C, G	LC	2
Molothrus bonariensis	D, E	LC	3
Myiodynastes maculatus	K	LC	1
Not identified	B, C, H, I, K	-	12
Passer domesticus	B	LC	2
Pitangus sulphuratus	B, C, H, E, I	LC	14
Sicalis flaveola	G	LC	1
Tachyphonus coronatus	E	LC	1
Tangara sp.	E, K	-	4
Thraupis sayaca	K	LC	1
Turdus albicollis	K	LC	1
Turdus amaurochalinus	G, K	LC	4
Turdus flavipes	A, B, K	LC	3
Turdus leucomelas	E	LC	1
Turdus rufiventris	D, E, G, H, I, K	LC	11
Tyrannus melancholicus	C, E, H	LC	3
Pelecaniformes			9
Ardea alba	C, E	LC	3
Nycticorax nycticorax	H, K	LC	2
Phimosus infuscatus	A, G	LC	3
Tigrisoma lineatum	K	LC	1
Piciformes			19
Colaptes campestris	G	LC	1

Continue...

Table 2 – Continuation.

Species	Type of occurrence	Conservation Status	Total
Not identified	I	-	1
Pteroglossus bailloni	K	NT	1
Ramphastos dicolorus	B, E, G, K	LC	10
Ramphastos vitellinus	E, G, H, K	VU	5
Selenidera maculirostris	K	LC	1
Procellariiformes			1
Diomedea sp.	E	-	1
Psittaciformes			16
Amazona vinacea	E	EN	1
Brotogeris tirica	C, E, K	LC	5
Forpus sp.	E	-	2
Pionus maximiliani	B, E, H, K	LC	7
Pyrrhura frontalis	K	LC	1
Sphenisciformes			4
Spheniscus magellanicus	E	NT	4
Strigiformes			57
Asio clamator	A, E, G, H, K	LC	7
Asio stygius	A, C, F, G	LC	8
Athene cunicularia	A, E, F, G	LC	5
Megascops choliba	E	LC	1
Megascops sanctaecatarinae	A, I	LC	3
Not identified	A, C, E, G, H, K	-	17
Pulsatrix koeniswaldiana	E, F	LC	2
Pulsatrix perspicillata	E, G	LC	3
Strix virgata	C	LC	1
Tyto furcata	A, E, G, H, K	LC	10
Sulidae			2
Sula leucogaster	E	LC	2
Suliformes			5
Fregata magnificens	E	LC	2
Phalacrocorax brasilianus	E, K	LC	3
Total			262

A: Vehicle collision; B: Domestic Animal Attack; C: Window-crashing; D: Seizures; E: Found Debilitated; F: Entanglement; G: Home Invasion; H: Orphan; I: Fall from the Nest; J: Firearm; K: Not Informed; LC: Least Concern; NT: Nearly Threatened; VU: Vulnerable; EN: In danger; CR. Critically Endangered.

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Table 3 – Type of occurrence of reptiles and amphibians rescued by the Environmental Police and sent to Clínica Dr. Selvagem, from 2014 to 2016.

Species	Type of occurrence	Conservation Status	Total
Testudinata			
Hydromedusa tectifera	D	LC	1
Trachemys dorbigni	B, C	LC	3
Squamata			
Anguis fragilis	D	LC	1
Boa constrictor	D	LC	1
Micrurus corallinus	D	LC	1
Salvator merianae	A, C	LC	2
Anura			
Rhinella marina	D	LC	1
Total			10

A: Vehicle collision; B: Seizure; C: Found Debilitated; D: Home Invasion; LC: Out of danger; VU: Vulnerable; EN: In danger; CR: Critically Endangered.

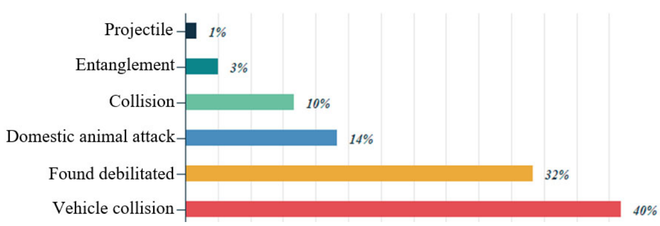

Figure 3 – Type of occurrence of trauma in birds, mammals and reptiles treated at Clínica Dr. Selvagem from April 2014 to July 2016.

Discussion

The type of interaction is directly related to the ecology and behavioral biology of each animal species. Mammals had a higher hit-and-run rate, while birds were concentrated in attacks by domestic animals, collisions with windows, hunting and seizures. Several groups of species treated at the clinic had more than one type of occurrence, indicating that the effects of anthropomorphization in the areas are overlapping and cumulative.

For example, the Mammalia class is the most sensitive and vulnerable group to the rapid development of road infrastructure, due to the specific characteristics of its life history. Many studies have shown that roadside mortality can reduce survival and population densities, and that vehicle collisions are a major source of mortality for many species (Forman and Alexander, 1998; Forman et al., 2003; Fahrig and Rytwinski, 2009; Grilo et al., 2009).

Impacts generated by road development range from direct mortality due to vehicle collisions to secondary effects, such as modification of animal behavior, alteration of the physical and chemical environment, dissemination of exotic species or the disruption of links between populations (Trombulak and Frissell, 2000; Ward et al., 2015). Among the main influences that lead to pedestrian accidents, vehicle speed and traffic volume, food abundance along the roads and the behavior of the species stand out (Forman et al., 2003). This interaction is, in most cases, fatal, decimating several animals daily (Rosa and Bager, 2012).

The effects of road mortality are not evenly distributed in time and space, and it is necessary to assess hotspots, propose mitigation periods and locations (Gunson et al., 2011). Only a small portion of these individuals is found alive, requiring emergency care for these species in specialized clinics associated with the Environmental Police. This study represents only a small portion of the animals that are found trampled alive, making the prognosis of threatened species difficult from an ecological point of view.

This translocation of wildlife to urban environments is probably linked to the suppression of natural resources caused by habitat fragmentation. Thus, with the distribution of habitats in highly fragmented landscapes, it is randomly dispersed, so animals are forced to overcome this great diversity of barriers in search of resources for their survival, and end up invading homes, coming into conflict with human beings (Cervinka et al., 2015).

Another important factor is the seasonality of these events. According to Ferreguetti et al. (2020), temporal variations are directly related to the behavior and period of activity of mammals, and in this study, carried out in a fragment of BR-262 immersed in the Atlantic Forest in the State of Espírito Santo, the months with the highest rates of roadkill were December, January and February, and those with the lowest rates were April, August and September, being significantly higher during the rainy season than during the dry season. These data do not corroborate those found in the present study, where there was no concentration of the number of fixed cases in a certain period. The explanation for this may be due to the high mortality rate, as these animals may die even before receiving any kind of clinical care.

According to a survey of human-fauna impact events conducted by the non-governmental organization Associação Mata Ciliar carried out by Hilário et al. (2021), mortality was not homogeneous along the roads, being determined with data from animals that were taken to non-governmental organizations after getting involved in these events, influenced by the detection of the relationship between the length of roads and the number of animals run over, which corroborates our survey.

Despite the high number of deaths recorded, in developing countries, efforts to reduce wildlife mortality on the roads are still an obstacle, mainly due to the lack of research, which can be extremely costly due to the high sampling effort required, but also due to other priorities generally dictated by the country's socioeconomic situation (Collinson et al., 2015; Williams et al., 2019). However, to preserve the animal habits and needs, structures that allow their safe passage on highways have been used (Gaisler et al., 2009; Freitas, 2010), particularly galleries, dry boxes, overpasses wildlife corridor and fauna viaducts.

One of the great building challenges is the diverse number of species that would depend on these passages and their particular habits, which must be taken into account in planning and construction. In addition, collisions with wild animals can generate several impacts, both for economy and human safety (Ascensão et al., 2021), which makes efforts to elucidate the interaction of linear constructions with these animals fundamental to the reduction of accidents that may promote human and animal mortality.

The introduction of faunal passages of different types and sizes is an important factor in increasing their use by wild animals (Huijser et al., 2007). Some species have a predilection for large and open passages, while others for smaller and confined areas. The study and knowledge of the local fauna is extremely important for the successful implementation of these structures (Clevenger and Waltho, 2005; Huijser et al., 2007). Studies carried out in Canada have shown falls of 80% or more in collisions between large species and vehicles, when structures such as underpasses or wildlife viaducts associated with conduction fences are used (Clevenger et al., 2001; Huijser et al., 2007).

However, due to financial constraints and lack of knowledge about the material costs caused by collisions in most regions, it is rarely realistic to fence off an entire road network simultaneously, and thus mitigating specific road sections can be more cost-effective than fencing all roads (Ascensão et al., 2013; Spanowicz et al., 2020).

Due to the wide diversity of environments and behaviors and, consequently, greater exposure to negative effects associated with habitat transformation, such as mortality from window collisions, exposure to new diseases and predators, birds have been used to study the effects of urbanization on the diversity of species (Carvajal-Castro et al., 2019).

For birds, the greatest risks that cause fatalities directly in anthropogenic landscapes include predation by domestic animals and collision with man-made structures and vehicles (Parkins et al., 2015). The animals sent to the clinic due to attacks by domestic animals and collisions on mirrored surfaces and windows represented 6.33% (24/379) and 5.01% (19/379) of the records, and all species registered were birds.

Collisions with man-made structures such as windowpanes or moving vehicles like automobiles and planes pose threats to birds. According to Riding et al. (2021), the seasonal peaks of collision rates occur in late spring and early autumn with increasing latitude, corroborating what was evidenced in this study. Furthermore, Loss et al. (2019), showed variation in collision correlates between spring and autumn migration and among bird species, whose factors influencing collision fatalities also influence the number of colliding species, and the proportion, and potentially the area, of glass illuminated at night are associated with collisions (Loss et al., 2019).

Study carried out by Klem et al. 2009, determined the fatality of bird crashes on windows in New York, with 475 and 74 crashes in 2006 fall and 2007 spring being recorded. 82% and 85%, respectively, were fatal, partially corroborating the present study, where this event was concentrated in the spring months (September to December). Thus, factors related to the reproductive phenology of birds may have contributed to the observed monthly and seasonal collision patterns.

Among birds, the most affected species in collisions with vehicles were of the family of Strigiformes [*Asio clamator* (1), *Asio stygius* (2), *Athene cunicularia* (1), *Megascops sanctaecatarinae* (2)], Galliformes [*Ortalis guttata* (5), *Penelope obscura* 1], Gruiformes [*Aramides saracura* (3), *Gallinula galeata* (1)] and Accipitriformes [*Buteogallus lacernulatus* (1), *Parabuteo unicinctus* (1)].

The main species of birds affected were of the order of passerines and columbiformes. These species have synanthropic habits and, therefore, live in urban areas, making their nests in homes, being more susceptible to predation by domestic animals and collisions with urban structures. However, some registered species, such as Amazona vinacea, are on the red list of threatened species, and it is extremely important to record and survey these interactions to understand the impact generated and assess the degree of susceptibility of the species.

The number of bird colliding with glass structures is underestimated, receiving greater scientific interest for conservation and political attention recently due to high mortality. In the US alone, bird mortality from this type of structure has been estimated at between 365 and 988 million per year, requiring the adoption of mitigation measures to avoid major losses of bird biodiversity (Barton et al., 2017).

The negative impacts generated by domestic animals represent specific conservation issues, as they are closely linked to the economic, social and political values of local populations and, therefore, require interdisciplinary cooperation to assess the effects of predation, competition, disturbance, hybridization and transmission of diseases from domestic animals under wild populations (Young et al., 2011).

As the human population spread, so did the intentional and accidental introduction of many species into a variety of habitats and ecosystems. An example of this is the transmission of diseases such as rabies and canine distemper virus, which can seriously affect wild species. Randall et al. (2006) observed a 75% reduction in the Ethiopian wolf population (*Canis simensis*) in the last 20 years due to the incidence of rabies transmitted by domestic dogs.

With regard to hunting and seizure among all the animals involved, birds are the class with the highest number of seizures. Trafficking of wild animals is the third largest illegal activity in the world and the second largest in Brazil (Dias Junior et al., 2013). Estimates point to the removal of more than 400 bird species, which represents 23% of the native bird species in Brazil (Alves et al., 2013). In our study, the main species involved in seizures were the Shiny Cowbird (*Molothrus bonariensis*), Rufous-bellied Thrush (*Turdus rufiventris*) and D'Orbigny's slider (*Trachemys dorbigni*), which were strongly linked to animal trafficking. We have also obtained records of gunshot traumas in two specimens of Southern Caracara (*Caracara plancus*) and a Picazuro Pigeon (Patagioenas picazuro).

A useful way to understand the potentially negative effects of landscape modification on native animals is to consider the range of processes that can threaten a particular individual species (Fischer and Lindenmayer, 2007). For example, the orders Rodentia and Didelphimorphia are groups of small mammals, composed of small rodents and marsupials, highly specialized in the maintenance of neotropical ecosystems, with a relevant role in seed dispersal and consequently in the recovery and reforestation process of impacted areas (Grazzini et al., 2015). Many species of these two orders are threatened by habitat loss and fragmentation, which have led to a pronounced decline in their richness and abundance (Grazzini et al., 2015).

The Big-eared Opossum (*Didelphis aurita*) and the White-eared opossum (*D. albiventris*), are didelphid marsupials that, despite not being threated of extinction, are opportunistic and tolerant to altered environments, being found in highly fragmented landscapes, such as urban centers (Abreu et al., 2011). This approximation may justify the greater number of calls registered among the species sampled in our study.

The Rodentia order occupied the second group of mammals with the highest incidence of roadkill in the present study. The families Caviidae, Hydrochaeridae, Dasyproctidae and Erethizontidae were observed, represented respectively by the Brazilian Guinea Pig (*Cavia aperea*), capybaras (*Hydrochaeris hydrochaeris*), Azara's Agouti (*Dasyprocta azarae*) and Orange-spined Hairy Dwarf Porcupine (*Sphiggurus villosus*).

Capybaras (*Hydrochaeris hydrochaeris*) were the rodents with the highest incidence of rescues and visits at Clínica Dr. Selvagem. They are widely distributed in Central and South America, inhabiting different environments, from riparian forests to seasonally flooded savannas, up to 500 m away from the water (Bonvicino et al., 2008). It can compete with cattle for pasture and invade crops, especially in the dry season, being often attracted to urban areas.

Carnivores (Mammalia: Carnivora) are the most sensitive and vulnerable group to accidents due to the rapid development of road infrastructure due to the specific characteristics of their life history, such as low population density and large living areas. Since animals with large ranges of motion typically have low reproduction rates (e.g., large carnivores), they cannot quickly compensate for higher mortality through increased reproduction, so mortality leads to population decline (Spellerberg, 1998).

In this study, two individuals of *Leopardus tigrinus* (northern tiger cat) and one *Puma yagouaroundi* (Jaguarundi) were registered. Felids are species that have relatively low population densities, but inhabit large territorial zones (Cardillo et al., 2004). However, their populations are severely fragmented, being severely reduced by the conversion of their natural habitat into plantations and pastures (Payan and Oliveira, 2016), increasing the need to understand their response to human pressures on large scales (Boyd et al., 2008). Furthermore, local populations tend to decline where roadkill rates exceed those of reproduction and migration (Forman and Alexander, 1998). There was also an occurrence of the white-necked hawk (*Buteogallus lacernulatus*), categorized as vulnerable (VU) by the C2a(i) criteria, in view of the decline due to the loss of area and habitat quality and the removal of individuals from the wild.

In general, most species that feed near roads are more vulnerable to being run over, which includes many predators, scavengers and grass-eating herbivores (Coffin, 2007; Laurance and Useche, 2009). Mammals are victims of roadkill when they travel along highways crossing their area of residence or when they are attracted by available resources in the surrounding area (Laurance and Useche, 2009). Birds are attracted to roads by the availability of perches around the roads, the abundance of small mammals that serve them as food, the grain that falls from vehicles and the carcasses of animals (Grilo et al., 2010). The main risks of reptiles being run over are associated with slow movements and the behavior of heating up on roads as a means of thermoregulation (Laurance and Useche, 2009; Grilo et al., 2010).

Conclusion

The data obtained in this study point to a rich diversity of species in the Joinville region. These species are exposed to several anthropogenic challenges and barriers mainly derived from intense displacement and human invasion, with the incorporation of long peri-urban areas to cities, drastically modifying the landscape and its natural resources, causing many animals to have to move in order to adapt to life in urban areas.

However, only animals rescued still alive and taken to emergency care were measured. Despite this, part of the individuals died, mainly as a result of being run over. Hit-and-run was the main reasons for trauma seen at the clinic during the survey period. However, no data, such as the exact location of each event, or temporal data, such as climate, rainfall, local characteristics of roads were obtained, which could allow exploring the effects of other variables or even identifying hotspots of different species for planning and implementation of urban mitigation measures, such as fauna passages, to reduce the impact generated on local biodiversity. In addition, another variable that can also influence the reported sample is related to the characteristics of the animals, such as size, charisma or whether the animal represents any danger to people.

Thus, the region of Joinville is constituted as a territory covered by native vegetation in constant conflict with anthropogenic activities, leading to dualism in the occupation of environments between wildlife and human population, with the occurrence of accidents on highways, in homes through attacks by domestic animals or collisions on windows, requiring further studies covering different field measurement techniques and data on the care of these animals.

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Contribution of authors:

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