UNIVERSIDADE FEDERAL DO OESTE DO PARÁ

INSTITUTO DE CIÊNCIAS E TECNOLOGIA DAS ÁGUAS

PROGRAMA DE PÓS-GRADUAÇÃO EM BIODIVERSIDADE

ANDRÉA COELI GOMES DE LUCENA COSTA

ENTENDENDO FATORES QUE INFLUENCIAM O ATROPELAMENTO DE FAUNA EM UMA ÁREA PROTEGIDA NA FLORESTA AMAZÔNICA

SANTARÉM- PA

2022

UNIVERSIDADE FEDERAL DO OESTE DO PARÁ

INSTITUTO DE CIÊNCIAS E TECNOLOGIA DAS ÁGUAS

PROGRAMA DE PÓS-GRADUAÇÃO EM BIODIVERSIDADE

ANDRÉA COELI GOMES DE LUCENA COSTA

ENTENDENDO FATORES QUE INFLUENCIAM O ATROPELAMENTO DE FAUNA EM UMA ÁREA PROTEGIDA NA FLORESTA AMAZÔNICA

Dissertação apresentada ao Programa de Pós-Gaduação em Biodiversidade da Universidade Federal do Oeste do Pará, como requisito para obtenção de grau de Mestre em Biodiversidade.

Orientador: Prof. Dr. Samuel Campos Gomides

SANTARÉM- PA

2022

Dados Internacionais de Catalogação-na-Publicação (CIP)
Sistema Integrado de Bibliotecas – SIBI/UFOPA

C837e Costa, Andréa Coeli Gomes de Lucena
Entendendo fatores que influenciam o atropelamento de fauna em uma área protegida na Floresta Amazônica./ Andréa Coeli Gomes de Lucena Costa. – Santarém, 2022.
107 p. : il.
Inclui bibliografias.

Orientador: Samuel Campos Gomides.
Dissertação (Mestrado) – Universidade Federal do Oeste do Pará, Instituto de Ciências e Tecnologia das Águas, Programa de Pós-Graduação em Biodiversidade.

1. Atropelamento – Vertebrados selvagens. 2. Ecologia - estradas. 3. Hotspots. 4. Variação espacial - Atropelamento. 5. Variação temporal - Atropelamento. I. Gomides, Samuel Campos, *orient*. II. Título.

CDD: 23 ed. 596.09811

Bibliotecária - Documentalista: Cátia Alvarez – CRB/2 843

Universidade Federal do Oeste do Pará

PROGRAMA DE PÓS GRADUAÇÃO EM BIODIVERSIDADE

ATA Nº 28

Em acordo com o Regimento do Programa de Pós Graduação em Biodiversidade da Universidade Federal do Oeste do Pará, a dissertação de mestrado é julgada por uma Banca Avaliadora não presencial, constituída por cinco avaliadores, sendo um deles obrigatoriamente externo ao curso, com título de doutor (Artigo 56 do referido regimento). O acadêmico é considerado aprovado quando ao menos três membros avaliadores emitirem pareceres aprovado. Alternativamente, o discente será dispensado da banca avaliação da dissertação, quando comprovar o aceite ou publicação de pelo menos um artigo resultante da sua dissertação, como primeiro autor, em co-autoria com orientador, ou orientador e coorientador quando o orientador for um docente colaborador, em periódico indexado com percentil mínimo de 75 (setenta e cinco) ou superior referente às métricas mais recentes do maior percentil utilizado pelo Journal Citation Reports (Clarivate) ou pelo Scientific Journal Rankings (Scimago), cabendo ao discente apenas a apresentação pública do trabalho (Artigo 58). O discente que teve sua dissertação aprovada deverá apresentá-la em sessão pública com duração de até 50 (cinquenta) minutos obrigatoriamente até no máximo 15 (quinze) dias após a aprovação, e no prazo máximo de vínculo com o curso, ou seja, 24 (vinte e quatro) meses após o início do primeiro semestre letivo do discente no curso (artigo 64). Assim, aos dezenove dias do mês de dezembro do ano de dois mil e vinte e dois, às nove horas e trinta minutos, de forma remota através da plataforma GoogleMeet, instalou-se a apresentação de seminário público da dissertação de mestrado da aluna ANDRÉA COELI GOMES DE LUCENA COSTA. Deu-se início a abertura dos trabalhos, onde o Professor Dr. SAMUEL CAMPOS GOMIDES, após esclarecer as normativas de tramitação da defesa e seminário público, de imediato solicitou a candidata que iniciasse a apresentação da dissertação, intitulada "FATORES QUE INFLUENCIAM O ATROPELAMENTO DE FAUNA EM UMA UNIDADE DE CONSERVAÇÃO NA AMAZÔNIA". Concluída a exposição, o professor comunicou a discente que a versão final da dissertação deverá ser entregue ao programa, no prazo de 60 dias; contendo as modificações sugeridas pela banca examinadora e constante nos formulários de avaliação da banca. A banca examinadora foi composta pelos examinadores professores doutores listados abaixo. Os pareceres assinados seguem em sequência.

SAMUEL CAMPOS GOMIDES
Orientador

Andréa Coeli Gomes de Lucena Costa

ANDRÉA COELI GOMES DE LUCENA COSTA
Discente

Universidade Federal do Oeste do Pará

PROGRAMA DE PÓS GRADUAÇÃO EM BIODIVERSIDADE

Dra. LARISSA OLIVEIRA GONÇALVES

Examinadora Externa à Instituição

Dra. CLARISSA ALVES DA ROSA

Examinadora Externa à Instituição

Dra. FERNANDA ZIMMERMMAN TEIXEIRA

Examinadora Externa à Instituição

Dr. RODRIGO FERREIRA FADINI, UFOPA

Examinador Interno

Dr. ALFREDO PEDROSO DOS SANTOS JUNIOR, UFOPA

Examinador Interno

ANDRÉA COELI GOMES DE LUCENA COSTA
Mestrando

Dedico este trabalho, primeiramente, a Deus, que sempre me iluminou durante esta caminhada. À minha amada mãe, que me apoiou e me apoia em todos os meus passos dados. Ao meu querido pai, que mesmo não estando mais presente em vida, sei que está ao meu lado em todos os momentos, em especial neste.

AGRADECIMENTOS

Primeiramente, agradeço a Deus por ter me dado o dom da vida, por ter me fornecido força, coragem e perseverança para enfrentar as dificuldades durante este período que percorri, por me amar incondicionalmente como sua filha, por ser meu guia, minha luz, meu refúgio.

A Nossa Senhora, por interceder por mim em todos os momentos de minha vida, me levando e me mostrando o melhor caminho, sempre.

Ao meu "Painho", que não está mais presente de corpo, mas para sempre em minha memória e em meu coração. Agradeço-o, pois ele sempre acreditou em mim e me incentivou com os estudos, mostrando-o como exemplo.

À minha "Mainha", que é a minha base, a minha fortaleza, que sempre me ajuda e me apoia em todas as minhas decisões. Sem ela, não teria conseguido. Obrigada pelo amor, pelo carinho, pela compreensão e apoio de sempre.

Aos meus irmãos que tanto amo, Andrezza e André Luiz, que sempre desejam o meu sucesso e me querem bem.

À minha sobrinha, Ana Laura, que entendia quando não podia brincar com ela, pois tinha que estudar.

A Nuno Ricardo, por ter entrado na minha vida, fazendo parte dela, trazendo amor, carinho, incentivo e um grande apoio desde sempre.

A todos os meus familiares e amigos, que torceram e torcem por mim até hoje e por estarem comigo sempre.

A Guilherme Ferreira, pelas contribuições para o desenvolvimento deste estudo, por ter me ajudado com os dados, com a área de estudo e, pela enorme paciência e por muitos momentos de aprendizado que tive junto a ele.

À Mineração Rio do Norte S/A, pelo fornecimento dos dados da fauna atropelada.

A todos os meus colegas de turma, os quais não conheço nenhum pessoalmente, obrigada pelo conhecimento compartilhado, acerca da biodiversidade, das particularidades regionais de cada um, da solidariedade, da empatia, do companheirismo, dos inúmeros e diferentes sotaques e gírias. Obrigada, em especial, a Bia e a Débora, pela amizade e grande parceria que firmamos durante a caminhada do mestrado. Tenho certeza que as levarei comigo para sempre. Vocês são lindas de corações lindos!

Ao meu Orientador, o Professor Dr. Samuel Campos Gomides, pela orientação, pela paciência, pela atenção, pela ajuda, pelas palavras de incentivo, pela compreensão, pela oportunidade do conhecimento e pela confiança depositada. Com ele, aprendi bastante coisa. Sem ele, essa vitória jamais poderia ser conquistada.

A UFOPA, pela oportunidade de realizar esse sonho.

Aos meus professores do Programa de Pós-Graduação em Biodiversidade da Universidade Federal do Oeste do Pará, por não desistirem da educação de forma tão bela, tão perseverante e tão desafiadora e, também, por contribuírem com maestria em minha formação acadêmica. Sou muito grata a todos pelos ensinamentos e conhecimentos compartilhados.

A CAPES, pelo financiamento da bolsa de estudos.

Ao Programa de Pós-Graduação em Biodiversidade da Universidade Federal do Oeste do Pará, pelos recursos financeiros obtidos durante o mestrado.

À minha banca examinadora composta pelos(as) professores(as) Doutores (as), Clarissa Alves da Rosa, Rodrigo Ferreira Fadini, Fernanda Zimmermann Teixeira, Larissa Oliveira Gonçalves e Alfredo Pedroso dos Santos Júnior. Obrigada por aceitarem participar da banca de avaliação e pelas contribuições enriquecedoras para este estudo.

“Ainda que eu falasse as línguas dos homens e dos anjos [...] e ainda que tivesse toda a fé, de maneira tal que transportasse os montes, e não tivesse amor, eu nada seria.”

(1 Coríntios 13)

RESUMO

A morte por atropelamento em vertebrados constitui um importante impacto em áreas naturais. Apesar disso, dados sobre esse tema no domínio amazônico ainda são escassos, sobretudo dentro de áreas protegidas. Neste estudo, nós analisamos os dados de dois anos de monitoramento de anfíbios, répteis, mamíferos e aves atropelados em cinco tipos de vias de tráfego (rodovia, ferrovia, área urbana, estradas asfaltadas e estradas de terra) em uma unidade de conservação na Amazônia brasileira. Nós testamos quais foram as classes de vertebrados e as guildas alimentares mais atingidas, além da influência da sazonalidade e o padrão espacial dos atropelamentos. Na área estudada foram registrados 2.795 atropelamentos, sendo os anfíbios os mais registrados. A maior parte dos atropelamentos ocorreu durante a estação chuvosa. Corrigindo os dados de atropelamento através do uso dos dados de eficiência do observador e do tempo de permanência de carcaças com base em dados da literatura, concluímos que as taxas de mortalidade podem estar subestimadas em até 40 vezes quando comparadas aos dados brutos. Não houve diferença significativa entre as guildas alimentares quanto às fatalidades e, a pluviometria e temperatura tiveram efeito significativo nos atropelamentos de todas as classes de vertebrados. O padrão espacial de atropelamentos variou entre os tipos de vias de tráfego e a classe dos vertebrados. Os resultados apontam que os anfíbios são os mais impactados por atropelamentos, embora sejam negligenciados em muitos monitoramentos de vias de tráfego. As medidas mitigatórias para esse tipo de impacto devem levar em consideração épocas nas quais ocorre maior número de mortes, uma vez que a pluviometria e a temperatura influenciam esse tipo de acidente, ou seja, os atropelamentos diminuem conforme a temperatura aumenta e a pluviosidade diminui. Da mesma forma, diferentes classes de vertebrados têm padrão de concentração dos impactos diferenciado ao longo das vias de tráfego, o que torna o planejamento mitigatório mais complexo. Portanto, o planejamento para diminuir as mortes de vertebrados por atropelamentos deve levar em consideração a particularidade de cada táxon.

Palavras-chaves: Atropelamentos de vertebrados selvagens. Ecologia de estradas. Hotspots. Variação espacial de atropelamentos. Variação temporal dos atropelamentos.

ABSTRACT

Vertebrate's roadkill constitutes an important impact in natural areas. However, data on this topic in the Amazon domain are still scarce, especially within protected areas. In this study, we analyzed data from two years of monitoring amphibians, reptiles, mammals, and birds that were run over in five types of traffic routes (highway, railroad, urban area, paved roads, and dirt roads) in a conservation unit in the Brazilian Amazon. We tested which vertebrate classes and feeding guilds were most affected, besides the influence of seasonality and the spatial pattern of roadkill. In the studied area, 2,795 roadkills were registered, with amphibians being the most registered. Most roadkills occurred during the rainy season. Correcting the roadkill data using observer efficiency data and carcass permanence time based on data from the literature, we conclude that mortality rates may be underestimated by up to 40 times when compared to the raw data. There was no significant difference between the feeding guilds in terms of fatalities, and rainfall and temperature had a significant effect on road kills of all classes of vertebrates. The spatial pattern of roadkills varied between the types of traffic routes and the class of vertebrates. The results indicate that amphibians are the most impacted by roadkill, although they are neglected in many monitoring of traffic routes. Mitigation measures for this type of impact should take into account times when the highest number of deaths occur since rainfall and temperature influence this type of accident, that is, pedestrian accidents decrease as the temperature increases and rainfall decreases. Likewise, different classes of vertebrates have different impact concentration patterns along traffic routes, which makes mitigation planning more complex. Therefore, planning to reduce vertebrate deaths by roadkill must take into account the particularity of each taxon.

Keywords: Wildlife vertebrate's roadkill. Road Ecology. Hotspots. Roadkill spatial variation. Roadkill temporal variation.

LISTA DE ILUSTRAÇÕES

LISTA DE TABELAS

LISTA DE ABREVIATURAS E SIGLAS

CAFeCapes – Comunidade Acadêmica Federada da Coordenação de Aperfeiçoamento de Pessoal de Nível Superior

Capes – Coordenação de Aperfeiçoamento de Pessoal de Nível Superior

p – Eficiência do observador

TR – Tempo característico de remoção das carcaças

IUCN – International Union for Conservation of Nature (em português: União Internacional para a Conservação da Natureza)

ICMBIO – Instituto Chico Mendes de Conservação da Biodiversidade

FNST – Floresta Nacional de Saracá-Taquera

CITES – Convention on International Trade in Endangered Species of Wild Fauna and Flora

GLM – Generalized Linear Model (em português: Modelo Linear Generalizado)

SNUC - Sistema Nacional de Unidades de Conservação

MRN – Mineração Rio do Norte S/A

GPS – Global Positioning System (em português: Sistema de posicionamento global)

AIC - Akaike information criterion (em português: Critério de Informação de Akaike)

ANOVA – Análise de variância

Sumário

INTRODUÇÃO GERAL

Segue o modelo para submissão da *Frontiers for Young Minds*. Disponível em: https://kids.frontiersin.org/participate/authors

NAS ESTRADAS, OS ANIMAIS TAMBÉM PODEM SER VÍTIMAS

Andréa Coeli Gomes de Lucena Costa*[1], Samuel Campos Gomides[1]

[1] Universidade Federal do Oeste do Pará, Programa de Pós-Graduação em Biodiversidade, Unidade Tapajós, Santarém, PA, Brasil.

Os animais também estão na pista!

Você já parou para pensar quantos animais são mortos todos os dias nas estradas que cortam as florestas tropicais? Para responder essa questão, muitos pesquisadores percorrem as estradas em buscas desses animais que são atropelados em diversos tipos de vias de tráfego. Eles estudam quais os fatores que tornam esses animais vulneráveis aos atropelamentos por carros e caminhões nas estradas. As causas das mortes de animais nas estradas podem variar bastante de acordo com o comportamento específico de cada espécie de animal [1], além das características do ambiente onde eles vivem. Estimativas sugerem que mais de 14,7 milhões de vertebrados silvestres morrem atropelados todos os anos no Brasil [2]. Na Amazônia, há poucos estudos realizados no intuito de avaliar o impacto da colisão da fauna local com os veículos [3,4]. Essa região é uma área de alta biodiversidade e de grande importância ambiental e, atualmente, é a que mais sofre no Brasil com a expansão da malha viária. Isso traz não só mais colisões, mas um conjunto de outros impactos, como por exemplo, mudança e fragmentação do habitat, promoção de poluição, expansão das atividades humanas, como caça e desmatamento. Por isso, nossa pesquisa teve como objetivo compreender o impacto negativo que os atropelamentos causam na fauna silvestre em uma área da Amazônia brasileira. Para fazer isso, avaliamos quais fatores ambientais influenciam a morte de animais vertebrados atropelados em cinco tipos de vias de tráfego no interior de uma área protegida na Amazônia do Brasil.

Como foi feito esse estudo sobre os atropelamentos?

O estudo foi realizado na Floresta Nacional de Saracá-Taquera, uma área protegida localizada no noroeste do estado do Pará, Brasil. É uma Unidade de Conservação que tem como objetivo o uso sustentável de recursos florestais, e atualmente permite a extração regulamentada de madeira e de um tipo de minério, a bauxita. Dentro dessa floresta tem cinco tipos diferentes de vias de tráfego usadas para locomoção e transporte de pessoas e cargas que são: 1) a área urbana, que está inserida dentro da vila de moradores, 2) a rodovia, que é a via que corre paralela à ferrovia, 3) a ferrovia, por onde o trem transporta o minério extraído, 4) as estradas de terra e 5) as estradas asfaltadas. Nós analisamos os dados de mortalidade de animais vertebrados atropelados entre os anos de 2016 e 2018 ao longo das cinco vias de tráfego nessa área protegida. Esses dados foram coletados por equipes técnicas que percorreram todas essas vias em busca de carcaças de animais. Com esses dados, calculamos as taxas de mortalidade por tipo de via de tráfego, verificamos qual foi a guilda alimentar, ou seja, o tipo de alimentação que foi mais afetado pelos atropelamentos, analisamos se a chuva, a temperatura e a umidade do ar influenciam nas fatalidades, se o período de chuva ou o de seca teve mais atropelamentos e avaliamos quais são os locais dentre as vias de tráfego que os animais mais morrem atropelados.

Como as vias de tráfego em áreas protegidas afetam a fauna local de vertebrados?

Nosso estudo contabilizou 2.795 animais silvestres mortos por atropelamentos durante o período da pesquisa. Dentre todas as vias de tráfego, a rodovia foi a que teve a maior taxa de mortalidade. Por grupo taxonômico, o grupo dos anfíbios foi o mais atingido. A estação chuvosa (entre os meses de dezembro e maio) foi o período de maior fatalidade, com um pico de registros no grupo dos anfíbios no mês de dezembro (Figura 1).

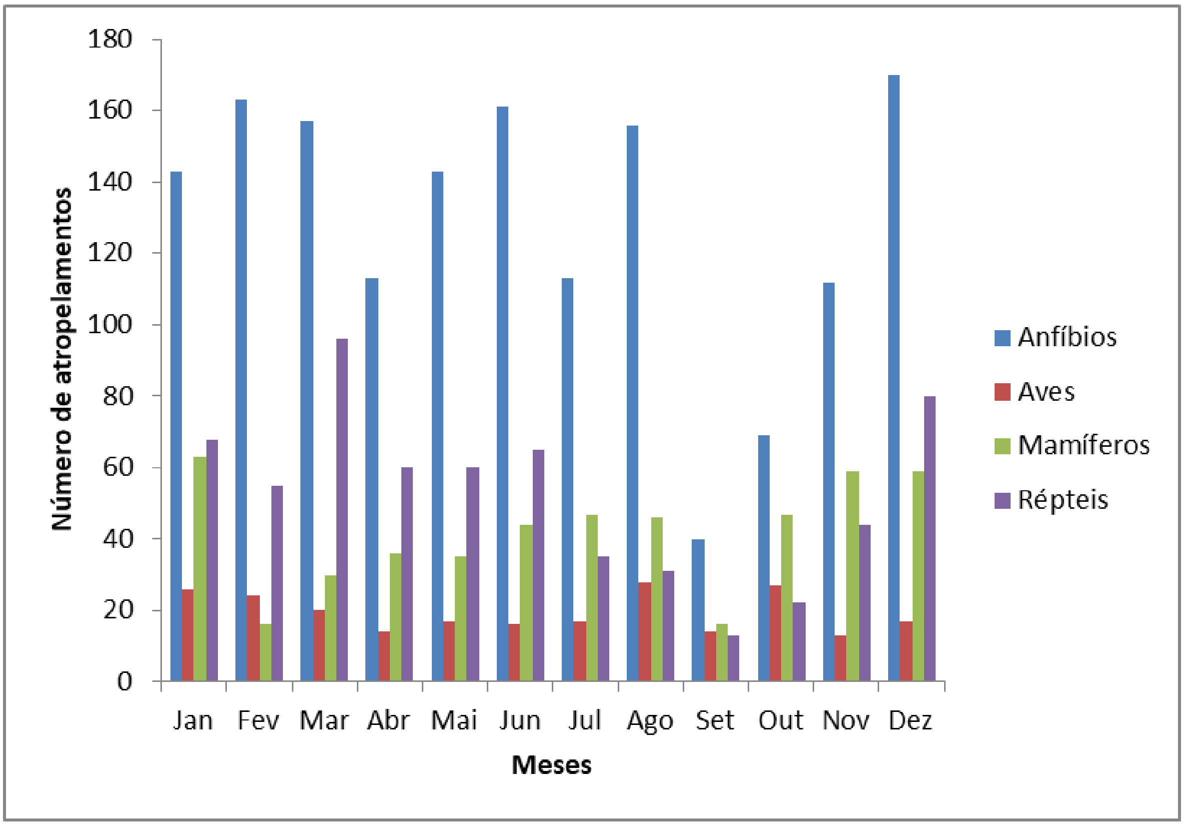


Figura 1 - Variação mensal do número de atropelamentos de anfíbios, aves, mamíferos e répteis em todas as vias de tráfego entre os anos de 2016 e 2018 na Floresta Nacional de Saracá-Taquera no estado do Pará, Brasil.

No geral, as espécies insetívoras, ou seja, aquelas que se alimentam de insetos, foram as mais atropeladas neste estudo. A temperatura e as chuvas influenciam significativamente nas mortes da fauna silvestre por veículos, ou seja, quanto mais a temperatura aumenta e a pluviosidade diminui, menor a quantidade de atropelamentos. Existem vários locais ao longo das vias de tráfego onde há uma frequência maior de atropelamentos, variando muito pelo tipo de via e pelo grupo de vertebrado. Isto é, existem certos pontos onde as mortes estão mais concentradas.

Esses resultados indicam que as vias de tráfego em áreas protegidas na Amazônia são um fator importante para mortes de vertebrados por atropelamento. Isso deve ser levado em consideração desde o planejamento de aberturas de novas vias de tráfego até a construção e operação delas. Os gestores de unidades de conservação precisam criar mecanismos de monitoramento dos atropelamentos e criar soluções para diminuir os acidentes, como a utilização de passagens de fauna, de cercas, e de radares de velocidade nos pontos de concentração dos atropelamentos, adotar o fechamento de alguns trechos das vias durante algum período do dia ou algum período sazonal, entre outras soluções. Outro resultado importante é a indicação de uma maior atenção ao grupo da herpetofauna (anfíbios e répteis) que agrupa o maior número de vítimas atingidas durante o estudo.

Entender os padrões dos atropelamentos de animais silvestres, como e onde eles ocorrem mais frequentemente e em qual época do ano eles são mais prováveis de ocorrer é muito importante para a criação de medidas que visem reduzir o número de mortes.

Glossário

Bauxita: é um minério com coloração avermelhada que, após refinado, gera a alumina. Esta, levada a fornos e submetida a correntes elétricas, se transforma em alumínio primário — primeiro em estado líquido e, depois, sólido.

Guilda alimentar: um grupo de espécies que exploram a mesma classe de recursos alimentares de uma maneira semelhante.

Herpetofauna: conjunto dos répteis e anfíbios existentes numa região.

Referências

[1] Garrah, E, Danby, RK, Eberhardt, E, Cunnington, GM, Mitchell, S. 2015. Hot Spots and Hot Times: Wildlife Road Mortality in a Regional Conservation Corridor. *Environmental Management*. 56(4):874–889.

[2] Dornas, RAP, Kindel, A, Bager, A, Freitas, SR. 2012. Avaliação da mortalidade de vertebrados em rodovias no Brasil. In: *Ecologia de estradas*: *tendências e pesquisas*, Lavras, UFLA:139-152..

[3] Maynard, RJ, Aall, NC, Saenz, D, Hamilton, PS, Kwiatkowski, MA. 2016. Road-Edge Effects on Herpetofauna in a Lowland Amazonian Rainforest. *Tropical Conservation Science*. 9(1):264–290.

[4] Silva, I, Crane, M, Savini, T. 2021. The road less traveled: Addressing reproducibility and conservation priorities of wildlife-vehicle collision studies in tropical and subtropical regions. *Global Ecology and Conservation*, *27*, e01584.

CAPÍTULO ÚNICO

The article follows the model of *Austral Ecology*. Available at:

https://onlinelibrary.wiley.com/page/journal/14429993/homepage/forauthors.html

DISENTANGLING DRIVERS OF VERTEBRATE ROADKILL IN A PROTECTED AREA IN THE AMAZON RAINFOREST

Andréa Coeli Gomes de Lucena Costa*[1] and Samuel Campos Gomides[1]

[1] Programa de Pós-Graduação em Biodiversidade, Universidade Federal do Oeste do Pará (UFOPA), Rua Vera Paz, s/n (Unidade Tapajós), Bairro Salé, CEP 68040-255, Santarém, Brazil

*Corresponding author. Email: andreacoeligomes@hotmail.com, Phone: (93) 2101-4923

Acknowledgments

The authors would like to thank Mineração Rio do Norte S/A for providing data on the roadkilled fauna. We thank Guilherme Ferreira (Universidade Federal Oeste do Pará) for his contributions to the development of this study. ACGLC thanks CAPES for funding the scholarship and the Post-graduate Program in Biodiversity of the Universidade Federal Oeste do Pará for the financial resources obtained from the grants 02/2020 and 02/2021 - Programa de apoio ao desenvolvimento acadêmico.

DISENTANGLING DRIVERS OF VERTEBRATE ROADKILL IN A PROTECTED AREA IN THE AMAZON RAINFOREST

Abstract

Vertebrates' roadkill impacts many species in natural areas. However, data on this topic in the Amazon domain are still scarce, especially within protected areas. In this study, we analyzed data from two years of monitoring amphibians, reptiles, mammals, and birds' roadkill on five types of terrestrial transport infrastructure in a protected area in the Brazilian Amazon. We tested which vertebrate classes were most affected, the feeding guilds most prone to mortality, the influence of seasonality, and the spatial pattern of roadkill. In the studied area, 2,795 roadkills were recorded, with amphibians being the most affected. Most of the roadkills occurred during the rainy season (57%). Correcting the roadkill data using observer efficiency and carcass persistence time data, we concluded that mortality rates might be underestimated by up to 40 times when compared to raw data. There was no significant difference between feeding guilds concerning the number of fatalities, and rainfall and temperature significantly affected the roadkill pattern of all vertebrate classes. The spatial pattern of roadkill varied between traffic routes and vertebrate class types. The results indicate that amphibians are the most impacted by roadkill, although they are neglected in many roadkill monitoring. Mitigation measures for this type of impact must take into account times when the highest number of deaths occurs since rainfall and temperature influence this type of accident. In addition, different classes of vertebrates have different patterns of impact concentration along traffic routes, which makes mitigation planning more

complex. Therefore, planning to reduce vertebrate deaths from roadkill must consider each taxon's particularity.

Keywords: Hotspots. Hot moment. Road ecology. Roadkill spatial variation. Wildlife roadkill.

Introduction

Many tropical regions have been extensively modified by human actions, including the expansion of the transport network (Gibbs *et al*. 2010; Foley *et al*. 2011; Laurance *et al*. 2014; Dornas *et al.* 2019). The vast majority of terrestrial transport infrastructure has been built in developing countries in tropical forest regions, covering areas with enormous biodiversity and endemism, such as the Amazon Rainforest (Laurance *et al*. 2014; Botelho *et al*. 2022). These transport infrastructures are one of the main factors that lead to forest modification by deforestation (Southworth *et al*. 2011; Chen *et al*. 2015), due to the development of large initiatives – such as agribusiness and mining, for example - increasing threats to protected areas (Barber *et al*. 2014).

The Amazon region is threatened by the increased presence of railways and roads (Barber *et al*. 2014; Fearnside 2015), which can lead to increased deforestation in the region (Ferrante *et al*. 2021). Despite the road network expansion in the Amazon region, studies of the impacts of traffic routes on Amazonian wildlife are considered scarce, especially in comparison to other domains (Maynard *et al*. 2016). Although there are already implementations and expansions of highways in the Amazonia, such as the BR-174, BR-319, and BR-163 roads (Secco *et al*. 2018), the impact of traffic routes inside protected areas is still little understood, especially in these megadiverse environments (Hartmann *et al*. 2011). Above all, the impact on wildlife by railways has received less attention when compared to highways (Borda-de-Água *et al*. 2017). Furthermore, the effects of railroads on wildlife remain an open field for research (Dorsey *et al*. 2015), and there are still considerable gaps in Amazonia. Although transport infrastructure is associated with negative impacts on wildlife, animal roadkill rates can respond differently to different types of transport infrastructure. This response will follow the environmental factors in which the roads are inserted (Bueno *et al*. 2015) and their characteristics (Santos *et al*. 2013). However, no work has addressed how different types of roads and railroads can interfere with wildlife roadkill rates in protected areas of the Amazon region.

These threats to wildlife compromise animal populations, ecological functions, and ecosystem services performed (Dirzo *et al*. 2014), such as the role of different trophic guilds (Root 1967; Stoner *et al*. 2007). Mammals are responsible for several ecosystem functions and services, such as seed dispersal (Stoner *et al*. 2007) and the control of animal and plant populations (Terborgh *et al*. 2001; Bergstrom 2017). Amphibians and reptiles act to control invertebrate populations, seed dispersal and can be indicators of water quality (Cortés-Gomez *et al*. 2015). Some bird species help in controlling invertebrate populations (Pinowski 2005), seed dispersal (Ramos *et al*. 2011), and contribute as bioindicators of ecosystems (Almeida 1997). Therefore, documenting which feeding guilds are most prone to roadkill mortality can help to alert about the potential impacts on some ecosystem services.

Roadkills may not occur stochastically over the time scale (Ferregetti *et al*. 2020). Some studies show that temporal variations in roadkills are associated with seasonal patterns (Smith-Patten & Patten 2008; Lagos *et al*. 2012; Rodríguez-Morales *et al*. 2013). Attributes influenced by seasonality, such as precipitation and temperature, are known to impact roadkill rates (Seiler 2001; Machado *et al*. 2015; D'Amico *et al*. 2016; Carvalho *et al*. 2017). Therefore, investigating whether there is a relationship between abiotic factors and roadkills on a temporal scale helps understand the possible patterns that govern the fluctuation of wildlife mortality on transport infrastructure.

Spatial and temporal patterns of mortality may be related by the association and interaction of inherent factors, such as the physiology, reproduction, or foraging behavior of the species (Barthelmess & Brooks 2010; Andrews *et al*. 2015), or by climatic patterns (Crawford *et al*. 2014; Sosa & Schalck 2016). There is a tendency for roadkills to occur more frequently in places where there are favorable environmental conditions, such as in points where there is an aggregation of resources used by organisms (Coelho *et al*. 2012; Barthelmess 2014; D'Amico *et al*. 2015). This distribution of fatalities on traffic routes may vary according to the spatial behavior of the species (Canal *et al*. 2018), and it may be species-specific (Garrah *et al*. 2015). Reptiles and amphibians, for example, present concentrated occurrences throughout the year (Garrah *et al*. 2015). Roaming animals, such as mammals, have a more uniform distribution of roadkill, decreasing the chances of significant spatial aggregation (Santos *et al*. 2017). These patterns help to predict the interventions needed in these locations to reduce animal roadkills (Crawford *et al*. 2014; Andrews *et al*. 2015).

Considering the negative impact of roadkills on wildlife populations and the information gaps on this topic in Amazonia, this study evaluated the factors that influence vertebrate roadkills in five types of terrestrial transport infrastructure within a protected area from data collected between 2016 and 2018. Our goals were: 1) to assess whether mortality rates were affected by the type of transport infrastructure (highway, urban area, dirt roads, paved roads, and railroads), 2) whether there was a significant difference in mortality between different feeding guilds, 3) whether there were environmental factors influencing mortality (temperature, rainfall, and relative air humidity), and 4) whether there was a spatial and temporal concentration of roadkills (hotspots and hot moments). We hypothesize that road kills will be higher on the highway where the traffic is more intense and insectivores will be the most affected, considering the high richness of amphibians and reptiles in the region (Ávila-Pires *et al.* 2010).

Methods

Study Area

The study was carried out using the database of road kills recorded along the terrestrial transport infrastructure inside the Saracá-Taquera National Forest (FNST). The FNST is a category of public protected area for sustainable and multiple uses of forest resources dedicated to scientific research, emphasizing methods for sustainable exploitation of native forests (SNUC 2000). The FNST is located in the municipalities of Oriximiná, Faro, and Terra Santa, in the northwest of the state of Pará, Brazil (01°40'S, 56°00'W) (Calaça *et al*. 2018). The FNST is predominantly formed by dense tropical forest, interspersed with areas of alluvial forest, igapó forest, and, to a lesser extent, campinarana forest (Gomes *et al*. 2014). The climate in this region is Köppen's Am type, with rainy summers and dry winters. The period of most significant rainfall is between December and May. The dry season is between June and November (ICMBIO 2001). The average annual rainfall is approximately 2,200 mm, and temperatures vary between 20 and 35 °C (Parrota *et al*. 1997) (Fig. 1 and 2). The FNST encompasses a large mining company, MRN (Mineração Rio do Norte S.A.), which has a mining decree for bauxite exploration of up to 39950,026 hectares, 4.11% have been explored so far (17688.565 ha) of its total area (441.152 ha).

The northern portion of Pará is located in the Guiana Shield region, one of the areas of highest endemism in the Amazonia (Silva *et al*. 2005). Fifty-four species of amphibians (15 families), 126 reptiles (25 families), 433 birds (28 families), and 72 mammals (30 families) were recorded in the FNST (ICMBIO 2001; Morato *et al*. 2018;

Calaça *et al*.2018). Of this total, there are records of 19 species of endangered birds and 11 endangered mammals (IUCN 2021; ICMBIO 2022).

Within the FNST, there are five different types of routes used for mobility and transport of people and cargo (Fig. 3): 1) urban area (28.23 km) – all roads within the urban perimeter in Vila de Porto Trombetas; 2) paved road (21.5 km) – all paved roads, except those belonging to the urban area; 3) dirt road (60.6 km) – all unpaved roads; 4) railroad (27 km) – railway line; and, finally, 5) the highway (25 km) – a paved road that is positioned parallel to the railway. The highway is parallel to the railway, with a distance of 1.5m between them (Fig. 4). We treat the highway separately from the paved road due to the influence it suffers on its surroundings by the movement of trains that transport the ore. Some of the roads do not have artificial lighting. The urban area, the paved roads, and one of the dirt roads (located on the mining plateau) are the roads that have artificial lighting during the night period. Regarding the flow of vehicles, all cars that circulate inside the FNST (except for the urban perimeter) and on the railway (as it is a railway line) are at the service of MRN or vehicles of outsourced companies linked to the company.

Roadkill data

We analyzed the mortality data of vertebrates killed by vehicles between November 2016 and December 2018 along the five types of roads (total of 162.33 km). Data collection was carried out by technical teams composed of a biologist and field assistants. Data were collected daily throughout the week on the different types of roads. Only on the railroad, sampling was carried out fortnightly with three days to cover approximately 27 km. On the highway, in the urban area, on dirt roads, and on paved roads, data were collected with the support of a vehicle that traveled the sections at a maximum and average speed of 40 km/h. On the railroad, the monitoring was carried out on foot by the fieldwork team. Data on the fauna that was roadkilled were collected with the aid of GPS equipment, recorded in a field notebook, and, at the same time, photographic records were made. The abundance of specimens, the geographic coordinates of each roadkill event, and the taxonomic category of the individual (to the lowest level) were recorded. The dead animals that were in a good state of conservation were collected and sent to the Capão de Imbuia Natural History Museum, Curitiba, Paraná, Brazil. Animals in an advanced state of decomposition or unfeasible for scientific use were collected and discarded in septic graves at the FNST.

Efficiency of the observation method and carcass characteristic removal time

Raw data from roadkill may contain sampling biases caused, among other things, by the limitation of researchers in recording all events occurring in the studied area stretch. Therefore, the analysis must take into account the observer's efficiency and the carcass's persistence time on different types of roads. Carcass persistence time is the period in which a carcass remains detectable before it is decomposed by traffic or removed by other animals or humans (Korner-Nievergelt *et al*. 2015). Carcass detectability is the probability of a carcass being detected by researchers in monitoring. Thus, the mortality rates in this study were corrected through calculations that take into account the value of the efficiency of the observation method (p) and the carcass characteristic removal time (TR) (Loss *et al*. 2014). As "p" and "TR" were not measured directly in this study, we performed a literature search for references that contained data on observer efficiency (p) and carcass removal characteristic time (TR) for similar types of roads sampled in the FNST. With this, it was possible to calculate the estimates of mortality rates for each type of studied road.

We searched these data by accessing the CAPES platform (CAFeCAPES), a Brazilian government portal that allows access to several databases that bring together academic and scientific works. Additionally, we consulted the SciELO database and Google Scholar (Appendix S1 and S2). We performed the search manually in the primary search tab using the keywords: carcass persistence, efficiency method, detectability, carcass removal, paved road, urban area, roadkill, roadway, railway, railroad, highway, dirt road, and unpaved road. After the search, we compiled all the data found and used the minimum, maximum, and median values of all data for "p" and for "TR" for each type of road to perform further statistical analysis.

Feeding guilds

To assess which ecosystem services performed by vertebrates were the most affected, we characterized through the literature the feeding guilds of each taxon included in the roadkill database (Appendix S3). The species were classified into: herbivorous, carnivorous, insectivorous, omnivorous, frugivorous, and nectarivorous (Reis *et al*. 2006; Reis *et al*. 2013). Roadkill data that did not contain taxonomic accuracy were disregarded for this analysis.

Abiotic aspects

We collected temperature, relative air humidity, and pluviosity data (from the Environmental Control Department – GSA of Mineração Rio do Norte) for each sampled day to assess the influence of these environmental factors related to roadkill events by each taxonomic group and the total sample.

Data analysis

We used the "mortality rate estimation" function in Siriema v. 2.0 (Coelho *et al*. 2014) to estimate the roadkill rate by type of road (Teixeira *et al*. 2013). To carry out this analysis, the following data were used: length of the road segment, the total number of roadkills, observer efficiency (p), characteristic removal time (TR), number of samplings, and the interval between samplings. The number of samplings is the number of monitoring days. Seven hundred thirty (730) days were compiled for all road types in the two years of monitoring; on the railroad, as monitoring took place fortnightly, the number of inspections was equal to 48. Then, we calculated the estimates of mortality rates in each traffic lane as follows: we used the lowest values found in the literature (minimum values) of p and TR for each type of road, and we calculated the mortality rate using these minimum values with the other necessary data (already mentioned) to make this estimated rate. We did the same with the highest values found in the literature (maximum values) of p and TR for each type of road. Finally, we calculated the medians of the p and TR values found in the literature for each traffic lane and used them to calculate the median mortality rates by lane type.

We used a Kruskal-Wallis to test whether feeding guilds were significantly more affected by roadkill in each taxonomic group. The tests were performed using the Past statistical program (Hammer *et al*. 2001).

We analyzed the influence of rainfall, temperature, and relative air humidity on the number of roadkills, by taxonomic group, and across the entire sample using Generalized Linear Models (GLM) using the Gaussian family data distribution. First, we evaluated the multicollinearity between the predictor variables and checked which ones could be included in these models. After that, we based the selection of models on the Akaike Information Criterion (AIC) values, considering the best models as those with the lowest AIC values and keeping as plausible models those with $\Delta AIC < 2$

(Burnham & Anderson 2002). To compare the best models and identify the one with the greatest strength of evidence, we used the values of the Akaike weight (wi). We performed the analysis with the packages "bbmle", "stats4", "corrplot" and "ggplot2" in Program R 4.0.3 (R Core Team 2020). Subsequently, ANOVA and Tukey's test were used to assess whether there was a significant difference between the dry and rainy seasons in the number of roadkills for each vertebrate class. The analyzes were performed in the R 4.0.3 Program (R Core Team 2020) with the packages "ggplot2", "psych", "hnp", dplyr", "visreg" and "stats".

We first tested clustering in the spatial distribution of roadkill from all roads with all taxonomic groups to assess hotspots using Ripley's K statistic in the Past statistical program (Hammer *et al*. 2001). Ripley's K statistic is used to assess the scattering of roadkill events at multiple scales (Newton & Ripley 1984; Cressie 1994). It estimates the expected number of random points within a distance "r" of a randomly chosen point along a line, and it can be used to calculate whether the points are randomly distributed along that line or not. Values above the confidence limits (95%) indicate scales with significant clustering, while values below the limits indicate scales with significant scattering (Coelho *et al*. 2014). It is vital to identify whether the distribution of roadkills has significant spatial clustering and at what scales they occur before deriving the hotspots. After identifying the clusters, we identified roadkill hotspots by the intensity of roadkills in each heat map generated using Kernel Density Estimation through QGIS 3.16 (QGIS Development Team 2020). We did tests to verify the best radius to use. We initially tested with a radius of 100 m, then 200 m and 300 m. For all roads, we ran with a radius of 300 m (Coelho *et al*. 2012), except for the urban area, where we used a 100 m radius because the 300 m radius is not feasible for this type of road.

Results

The data collected over two years of monitoring vertebrates' roadkilled within the protected area recorded a total of 2,795 dead specimens. The road with the highest number of fatalities was the highway, with 1,307 deaths (47%) and the one with the lowest number of fatalities was the unpaved roads with 96 records (3%). Amphibians were the most affected group of vertebrates, with a record of 1,478 fatal roadkills (53% of all roadkills). The group with the lowest record numbers was birds with 221 deaths (8%) (Table 1).

Considering the months monitored in two years of research and using the entire dataset, the month with the highest number of roadkills was December, with 326 records (Fig. 5). In the rainy season (57% of the deaths), there was a concentration of 54% of roadkills in the amphibian group, 25% of fatalities in reptiles, 14% in mammals, and 7% in the bird group. The month of September presents a sharp drop in the total number of roadkills, coinciding with the peak of the dry season. In the statistical analysis, for all taxonomic groups, there was no significant difference between the dry and rainy seasons for the number of roadkills, except for the reptile group ($p < 0.05$).

We found 24 published articles that addressed the observer's efficiency (p) and 26 that addressed the characteristic removal time in days (TR), that is, the carcass persistence time, divided into paved roads, unpaved (dirt) roads, on highways, railways and in urban areas (Appendix S4 and S5). The compiled values (minimum, maximum, and medians) for the observer efficiency (p) and for the characteristic removal time in days (TR) in the urban area, on paved roads, on unpaved (dirt) roads, on the highway, and the railway are in Appendix S6 and S7.

From the estimated mortality rates per day and also per kilometer/day of wild animals on roads, we found that animal mortality may have been higher on all roads (using the maximum values of p and TR) than the data suggested, being up to almost 40 times higher (in the case of the highway) than the data observed in the field (Table 2 and Table 3). We estimated, by medians, total mortality rates of 13.9 per day and 0.52 per kilometer/day of wildlife in all roads (Tables 2 and 3).

Feeding guilds of 2,611 specimens roadkilled on all roads in the study area were identified. In general, insectivorous species were the most recorded guild ($n = 1,753$), with most of this number composed of amphibians ($n = 1,478$) (Table 4). Statistically, in all cases analyzed (by taxonomic group), we did not find any significant difference in the number of roadkills between the vertebrate feeding guilds ($p > 0.05$).

In the selection of models, all selected models (with $\Delta AIC < 2$) presented temperature x rainfall as a variable with a significant effect on the observed number of roadkills (Table 5). Temperature and relative air humidity are negatively related (high relationship), except for reptiles ($r = 0.5$). Relative air humidity and rainfall are positively related, but there is a low relationship in all groups and in general ($r < 0.6$). Temperature and rainfall are negatively related, but there is also a low relationship in all groups and for the entire sample ($r < 0.6$) (Fig. 6).

Ripley's K statistic showed that significant aggregation of carcasses from all taxonomic groups is found in all types of roads analyzed (Fig. 7). However, dirt roads were the road type that presented the lowest aggregation of fatalities, especially in the birds' group.

The Kernel Density Estimate analysis indicated hotspots in several locations along the roads with a higher frequency of roadkills. The highway presented several hotspots with high intensities of roadkills compared to other roads for all taxonomic groups, especially for amphibians (Fig. 12A-D). On the highway, there are several hotspots close to the urban perimeter for birds and mammals (Fig. 12B, C). For reptiles, there are hotspots along the entire length of the road (Fig. 12D), and for amphibians, there are some hotspots close to water bodies (Fig. 12A). In the urban area, amphibian hotspots appear close to water bodies and, for this same group and for reptiles, hotspots appear in less anthropized and fragmented locations (Fig 8A, D). On the railway, there is a hotspot close to a water body for amphibians (Fig. 11A). We found a few low-intensity roadkill hotspots on dirt roads for all taxonomic groups (Fig. 10A-D).

Some sections with roadkill hotspots (e.g., for amphibians and reptiles in the urban area and birds and reptiles on the paved road) coincided for different taxonomic groups (Fig. 8A, D; Fig. 9B, D). It also happened that some groups had unique hotspots, with different aggregations from the other taxonomic groups, that is, specific hotspots for that group and for that traffic route (e.g., reptiles in the urban area and amphibians on the railway) (Fig. 8D; Fig. 11A).

Discussion

One of the most visible environmental impacts caused by roads is direct wildlife mortality due to roadkill, which affects a diversity of vertebrate animal species in several different biomes worldwide (Seiler 2001). The high number of wildlife roadkills recorded within the Saracá-Taquera National Forest (Flona) reveals that the roads in the study area are a significant threat and a continuous source of mortality for several species. In our study, this roadkilled vulnerability was concentrated in the rainy season. Statistical tests showed that there was a significant variation between the dry and rainy seasons only for reptile roadkills. Temperature and rainfall affected the distribution of roadkill, which explains the concentration in the rainy season. We could also see a spatial concentration (hotspots) of roadkill per taxonomic groups on the roads.

In addition to roadkill deaths, transport infrastructure causes other damage to wildlife (Laurance *et al*. 2009; Ahmed *et al*. 2014; Fearnside 2015). The negative effects on tropical biodiversity extend to creating barriers to dispersal, habitat changes and fragmentation, noise pollution, and microclimate changes, making the spread of invasive species and expansion of human activities such as hunting and deforestation easier (Goosem & Marsh 1997; Laurance *et al*. 2009).

The greater abundance of roadkills concentrated in amphibians and reptiles is different from other studies carried out in the Amazon domain, in which amphibians and birds and/or reptiles and birds were recorded as the most affected groups (Turci & Bernarde 2009; Pinheiro & Turci 2013). However, these studies differ in monitoring methodology and study duration. They used motorcycles to monitor, and the study time was up to 13 months. The pattern we found for most roadkilled classes is similar to that of Costa-Silva *et al.* (2022) on a stretch of the BR-307 in western Acre state, Brazil. Generally, the amphibian group is the least recorded in car monitoring (Coelho *et al.* 2008; Teixeira *et al.* 2013; Santos *et al.* 2017), except for monitoring using a speed lower than 40 km/h (Glista *et al.* 2008; Garriga *et al.* 2012; Rocha *et al.* 2020). However, these animals may be the vertebrates most affected by roadkill (Coelho *et al.* 2012), as we record in this study, as they are abundant in the region due to the climate and evolutionary characteristics of the Neotropical region (Pyron & Wiens 2013).

In road ecology studies, mammals are the most investigated class of all vertebrate groups. Probably because their carcasses are more evident and the risk to life they pose to drivers motivated by accidents, especially when large animals are involved

(Rosa *et al.* 2012; Bennett 2017). Our study showed that amphibians are the animals that die the most on traffic routes - especially on the railway - unlike other works that studied vertebrates in general (for example, Santos *et al.* 2016; Santos *et al.* 2017; Filius *et al.* 2020). The railways have a different structure related to other traffic routes, making it difficult for small animals to cross the railway line. For small animals such as amphibians, there is a probability that only individuals that can jump and land at the head of the tracks are at risk of being roadkilled by the train (Dornas *et al.* 2019). Cururu toads, for example, may be unable to climb rails or jump above 15 cm in height, with the possibility of walking several meters alongside the rails until a passage is located (Etienne *et al.* 2003). Some specimens found dead on the railroad may even have died due to being trapped between the rails, probably due to high temperatures in the railroad structures, exposure to the sun without protection, or even barotrauma (Dornas *et al.* 2019). As they are ectothermic, exposure to high temperatures and direct sunlight can lead to the animal's death (Navas *et al.* 2007). This may explain the death of many amphibians on the railroad. An additional factor is the sampling method on the railroad was done on foot. It is essential to highlight that the sampling frequency on the railway was lower than on other routes, and therefore, this number should be considered under-sampled.

The reptile group also presented a high number of roadkills on all roads. Reptile roadkills are mainly associated with thermoregulation in open areas, foraging behavior, driver behavior, and their abundance around highways (Gonçalves *et al.* 2018). When reptiles look for roads to thermoregulate, they become very vulnerable to being roadkilled. In addition to the occasional fatality, they are likely to be killed by the driver's intention (Secco *et al.* 2014).

In terms of mortality rate, we estimate from the medians that 0.519 vertebrates are road killed per day and per kilometer in the five types of traffic routes inserted in the interior of the Saracá-Taquera Flona. This rate is higher than the rates found in other studies carried out in the Amazonia, such as the rate found in a stretch of the BR-174 highway in the Waimiri Atroari Indigenous Land (Roraima state) with 0.013 per kilometer and per day (Medeiros 2019), from the National Forest of Carajás (Pará state) with a rate of 0.004 roadkill per kilometer (Gumier-Costa & Sperber 2009), on Rodovia RO-383 in Rondônia state with 0.078 roadkill per kilometer (Turci & Bernarde 2009) and on BR-307 in Acre state where the rate found was 0.138 roadkill per kilometer (Pinheiro & Turci 2013). These rates cited in other studies are underestimated estimates due to carcasses removed by other organisms, undetected carcasses, or even by roadkill animals that die far from the traffic lane, which are factors that influence the estimates of mortality due to being roadkilled (Teixeira *et al.* 2013; Ratton *et al.* 2014). These studies didn't correct the mortality rate values, and may present underestimated results. This demonstrates the importance of considering the carcasses' persistence and the observer's efficiency in these types of studies.

In our study, we found differences in the estimated mortality rate values between the types of road per day and day and kilometer, corroborating other studies (Sosa & Schalk 2016). The works with the monitoring of fauna roadkill must seek to measure in loco the rate of carcass removal and the efficiency of the observer as a way to make the results more accurate. Although our database did not contain these data, we searched for these values in the literature to infer these rates, thus estimating values closer to the accurate data (Teixeira *et al.* 2013; Barrientos *et al.* 2018).

Vertebrate animals play an important ecological role, providing ecosystem services such as pollination, seed dispersal, and insect control (Kunz *et al.* 2011; Braga

2019). Although no feeding guild was significantly more affected by roadkill, there were many insectivorous amphibians roadkilled. Probably, what explains the high number of insectivorous roadkilled is the abundance of this group. Every year more roads are paved, resulting in the surrounding landscape's fragmentation and degradation. This scenario increases the number of roadkills of these wild animals (Coffin 2007). Thus, the number of insectivorous animals killed by roadkill becomes a worrying result, as these animals are essential predators and controllers of invertebrate populations (Cleveland *et al.* 2006; Boyles *et al.* 2011). The ecosystem services these animals provide in the tropical region can be affected due to the high rates of roadkill observed.

In Amazonia, seasonality is characterized by periods of intense and less intense rainfall. How rainfall and temperature (D'Amico *et al.* 2016; Carvalho *et al.* 2017) generate marked changes in the landscape in these areas (Laurance *et al.* 2009) and influence the movement of fauna (Hartmann *et al.* 2011; Pinheiro & Turci 2013; Machado *et al.* 2015). We observed that these associated factors significantly affect the number of roadkills in the studied area. We believe that the greater availability of resources during more significant rainfall would lead the fauna to move more, increasing the number of collisions. Our result about the rainfall contrasts with a study carried out in the Carajás National Forest in Pará state (Gumier-Costa & Sperber 2009), where no significant relationship was observed between road kills by vertebrate animals and rainfall. In fact, for amphibians, the highest number of road kills was recorded in December. This month (as well as November) is the beginning of the rainy season in the region and coincides with the beginning of the reproductive season (Costa-Silva *et al.* 2022). However, some studies find a higher rate of roadkill during the dry season (Pereira *et al.* 2006; Turci & Bernarde 2009). For reptiles, the second group with the most records of being roadkilled in this study, this is explained by the more significant activity of these animals in the rainy season, both for foraging and for reproduction (Sosa & Schalk 2016). Then, after the dry and hot period, there is a softening of temperature and an increase in humidity and rainfall. In this period, the herpetofauna begins to enter into reproductive activity and migrate to reproduction zones, explaining these groups' high number of roadkills.

Effective mitigation strategies must identify the factors that influence the roadkill of fauna and, above all, which are the places where the vulnerability of roadkill is more remarkable than expected by chance (hotspots) (Garrah *et al.* 2015). This is particularly useful in places with rich and diverse biodiversity, such as the Saracá-Taquera Flona. There was an overlap of roadkill hotspots for amphibians and reptiles in the urban area and for birds and reptiles on paved roads. Amphibians had more aggregation points of roadkill events compared to other vertebrate classes. Possibly, behavioral and ecological characteristics, such as the mode of mobility (Laurance *et al.* 2009) are the answer to this pattern. However, it is noteworthy that roadkill hotspots can also be scale-dependent and spatially different, with a tendency to increase similarity at larger radius (Teixeira *et al.* 2013). More effective monitoring should be done daily or at least every two days, especially for small species (Santos *et al.* 2017). In this study, monitoring was carried out daily throughout the week, which gives robustness to the results presented.

There are other national sustainable-use forests in the region. These forests, in addition to roadkill, suffer from the extraction of renewable natural resources (wood and other non-wood products) and other non-renewable ones, such as bauxite mining, for example. So, this human disturbance, from using resources in an unplanned and inappropriate way, has led to the defaunation of vertebrates (Rosa *et al.* 2021; Castro *et al.* 2022).

Considering the results obtained in this study, roads in protected areas in Amazonia may be an important factor for vertebrate deaths by roadkill. This vulnerability must be considered when planning and executing road construction. Therefore, managers need to create mechanisms to monitor roadkills, create policies to reduce accidents, and create solutions to reduce the impacts that roads cause, especially for the dispersion of species with small body sizes. Another critical point is the need to pay attention to groups usually neglected in this type of monitoring, such as small ectothermic vertebrates. Seasonal mitigation measures should be taken as they can help curb reptiles and amphibians' mortality. Still, it is necessary to monitor specific points of the roads that are more susceptible to mortality and lack mitigating measures, such as speed reducers, tunnels, and fences. Understanding the patterns, where and when roadkills are more likely to occur is very important to reduce collisions between wild animals and vehicles, minimizing the loss of fauna biodiversity, especially in protected areas and megadiverse areas like the Amazon Rainforest.

References

Ahmed S. E., Lees A. C., Moura N. G., Gardner T. A., Barlow J., Ferreira J. & Ewers R. M. (2014) Road networks predict human influence on Amazonian bird communities. *Proceedings of the Royal Society B: Biological Sciences*. 281(1795).

Almeida A. (1997) Análise sinecológica da avifauna nas reservas nativas da Eucatex em Itatinga, SP. Rio Claro: UNESP / IB/DZ. 134.

Andrews K. M., Langen T. A. & Struijk R. P. J. H. (2015) Reptiles: Overlooked but Often at Risk from Roads. *Handbook of Road Ecology*. 271– 280.

Andrews K. M., Nanjappa P. & Riley S. P. D. (2015) Roads and ecological infrastructural: Concepts and applications for small animals. *Roads and Ecological Infrastructurel: Concepts and Applications for Small Animals*. 1– 281.

Ávila-Pires T. C. S. D., Hoogmoed M. S. & Rocha W. A. D. (2010) Notes on the Vertebrates of northern Pará, Brazil: a forgotten part of the Guianan Region, I. Herpetofauna.

Barber C. P., Cochrane M. A., Souza C. M. & Laurance W. F. (2014) Roads, deforestation, and the mitigating effect of protected areas in the Amazon. *Biological Conservation.* 177, 203– 209.

Barrientos R, Martins R. C., Ascensão F., D'Amico M., Moreira F. & Borda-de-Água L. (2018) A review of searcher efficiency and carcass persistence in infrastructure-driven mortality assessment studies. *Biological Conservation.* 222, 146– 153.

Barthelmess E. L. & Brooks M. S. (2010) The influence of body-size and diet on road-kill trends in mammals. *Biodiversity and Conservation.* 19(6), 1611– 1629.

Barthelmess E. L. (2014) Spatial distribution of road-kills and factors influencing road mortality for mammals in Northern New York State. *Biodiversity and Conservation*. 23(10), 2491– 2514.

Bennett V. J. (2017) Effects of Road Density and Pattern on the Conservation of Species and Biodiversity. *Current Landscape Ecology Reports.* 2(1), 1– 11.

Bergstrom B. J. (2017) Carnivore conservation: Shifting the paradigm from control to coexistence. *Journal of Mammalogy.* 98(1), 1– 6.

Borda-de-Água L., Barrientos R., Beja P. & Pereira H. M. (2017) Railway ecology. *Railway Ecology.* 1– 320.

Botelho Jr. J., Costa S. C., Ribeiro J. G. & Souza Jr C. M. (2022) Mapping Roads in the Brazilian Amazon with Artificial Intelligence and Sentinel-2. *Remote Sensing.* 14(15), 3625.

Boyles J. G., Cryan P. M., McCracken G. F. & Kunz T. H. (2011) Economic importance of bats in agriculture. *Science.* 332(6025), 41– 42.

Braga P. L. M. (2019) Conectando biogeografia histórica e assembleias locais de aves de sub-bosque na Amazônia: áreas de endemismo, diversidade de espécies e proporcionalidade de guildas. 55.

Bueno C., Sousa C. O. M. & Freitas S. R. (2015) Habitat or matrix: which is more relevant to predict road-kill of vertebrates? *Brazilian Journal of Biology*. 75(4 suppl 1), 228– 238.

Burnham K. P. & Anderson D. R. (2002) Model selection and multimodel inference: A practical information theoretic approach. New York: Springer.

Calaça A., Faria M. B., Silva D. A., Fialho Á. O. & de Melo F. R. (2018) Mammals of the saracá-taquera national forest, northwestern pará, Brazil. *Biota Neotropica*. 18(4).

Canal D., Camacho C., Martín B., de Lucas M. & Ferrer M. (2018) Magnitude, composition and spatiotemporal patterns of vertebrate roadkill at regional scales: A study in southern Spain. *Animal Biodiversity and Conservation*. 41(2), 281– 300.

Carvalho C. F., Custódio A. E. I. & Júnior O. M. (2017) Influence of climate variables on roadkill rates of wild vertebrates in the cerrado biome, Brazil. *Bioscience Journal*. 1632– 1641.

Castro A. B., Bobrowiec P. E. D., Castro S. J., Rodrigues L. R. R. & Fadini R. F. (2022) Influence of reduced-impact logging on Central Amazonian bats using a before-after-control-impact design. *Animal Conservation*. *25*(2), 311- 322.

Chen G., Powers R. P., de Carvalho L. M. T. & Mora B. (2015) Spatiotemporal patterns of tropical deforestation and forest degradation in response to the operation of the Tucuruí hydroelectric dam in the Amazon basin. *Applied Geography*. 63, 1– 8.

Cleveland C. J., Betke M., Federico P., Frank J. D., Hallam T. G., Horn J., … & Kunz T. H. (2006) Economic value of the pest control service provided by Brazilian free-tailed bats in south-central Texas'. *Frontiers in Ecology and the Environment.* 4(5), 238– 243.

Coelho I. P., Kindel A. & Coelho A. V. P. (2008) Roadkills of vertebrate species on two highways through the Atlantic Forest Biosphere Reserve, southern Brazil. *European Journal of Wildlife Research.* 54(4), 689– 699.

Coelho I. P., Teixeira F. Z., Colombo P., Coelho A. V. P. & Kindel A. (2012). Anuran road-kills neighboring a peri-urban reserve in the Atlantic Forest, Brazil. *Journal of environmental management.* 112, 17- 26.

Coelho A. V. P., Coelho I. P., Teixeira F. T., Kindel A. (2014) Siriema: road mortality software. Manual do Usuário V. 2.0. NERF, UFRGS, Porto Alegre, Brasil. Disponível em: www.ufrgs.br/siriema

Coffin A. W. (2007) From roadkill to road ecology: A review of the ecological effects of roads. *Journal of Transport Geography.* 15(5), 396– 406.

Core Development Team R. (2020) A Language and Environment for Statistical Computing. *R Foundation for Statistical Computing*. http://www.r-project.org.

Cortés-Gomez A. M., Ruiz-Agudelo C. A., Valencia-Aguilar A. & Ladle R. J. (2015) Ecological functions of neotropical amphibians and reptiles: A review. *Universitas Scientiarum.* 20(2), 229– 245.

Costa-Silva A. L., Roper J. J. & Machado R. A. (2022) Vertebrate Road kills in the western Brazilian Amazon. Natureza online. 20 (1), 061- 077.

Crawford B. A., Maerz J. C., Nibbelink N. P., Buhlmann K. A., Norton T. M. & Albeke, S. E. (2014) Hot spots and hot moments of diamondback terrapin road-crossing activity. *Journal of Applied Ecology*. 51(2), 367– 375.

Cressie N. A. C. (1994) Statistics for Spatial Data, Revised Edition. *Biometrics*. 50(1), 319.

D'Amico M., Román J., de los Reyes L. & Revilla E. (2015) Vertebrate road-kill patterns in Mediterranean habitats: Who, when and where. *Biological Conservation*. 191, 234– 242.

D'Amico M., Périquet S., Román J. & Revilla E. (2016) Road avoidance responses determine the impact of heterogeneous road networks at a regional scale. *Journal of Applied Ecology*. 53(1), 181– 190.

Development Team QGIS. (2016). QGIS Geographic information system. Open source geospatial foundation project. In *Http://www.Qgis.org/*. http://qgis.osgeo.org

Dirzo R., Young H. S., Galetti M., Ceballos G., Isaac N. J. & Collen B. (2014) Defaunation in the Anthropocene. *Science*. 345(6195), 401– 406.

Dornas R. A. P., Teixeira F. Z., Gonsioroski G. & Nóbrega R. A. (2019) Strain by the train: Patterns of toad fatalities on a Brazilian Amazonian railroad. *Science of the Total Environment*. 660, 493– 500.

Dorsey B., Olsson M. & Rew L. J. (2015). Ecological effects of railways on wildlife. *Handbook of road ecology*. 219- 227.

Etienne R. S., Vos C. C. & Jansen M. J. W. (2003) Ecological Impact Assessment in Data-Poor Systems: A Case Study on Metapopulation Persistence. *Environmental Management.* 32(6), 760– 777.

Fearnside P. M. (2015) Highway Construction as a Force in the Destruction of the Amazon Forest. *Handbook of Road Ecology.* 414– 424.

Ferrante L., de Andrade M. B. T., Leite L., Junior C. A. S., Lima M., Junior M. G. C., ... & Fearnside P. M. (2021) Brazils Highway BR-319: The road to the collapse of the Amazon and the violation of indigenous rights. *DIE ERDE–Journal of the Geographical Society of Berlin. 152*(1), 65- 70.

Ferreguetti A. C., Graciano J. M., Luppi A. P., Pereira-Ribeiro J., Rocha C. F. D. & Bergallo H. G. (2020) Roadkill of medium to large mammals along a Brazilian road (BR-262) in Southeastern Brazil: spatial distribution and seasonal variation. *Studies on Neotropical Fauna and Environment*. *55*(3), 216- 225.

Filius J., van der Hoek Y., Jarrín-V P. & van Hooft P. (2020) Wildlife roadkill patterns in a fragmented landscape of the Western Amazon. *Ecology and Evolution*. 10(13), 6623– 6635.

Foley J. A., Ramankutty N., Brauman K. A., Cassidy E. S., Gerber J. S., Johnston M., Mueller N. D., O'Connell C., Ray D. K., West P. C., Balzer C., Bennett E. M., Carpenter S. R., Hill J., Monfreda C., Polasky S., Rockström J., Sheehan J., Siebert S. & Zaks D. P. M. (2011) Solutions for a cultivated planet. *Nature*. 478(7369), 337– 342.

Garrah E., Danby R. K., Eberhardt E., Cunnington G. M. & Mitchell S. (2015) Hot Spots and Hot Times: Wildlife Road Mortality in a Regional Conservation Corridor. *Environmental Management*. 56(4), 874– 889.

Garriga N., Santos X., Montori A., Richter-Boix A., Franch M. & Llorente G. A. (2012) Are protected areas truly protected? The impact of road traffic on vertebrate fauna. *Biodiversity and Conservation*. 21(11), 2761– 2774.

Gibbs H. K., Ruesch A. S., Achard F., Clayton M. K., Holmgren P., Ramankutty N. & Foley J. A. (2010) Tropical forests were the primary sources of new agricultural land in the 1980s and 1990s. *Proceedings of the National Academy of Sciences of the United States of America*. 107(38), 16732– 16737.

Glista D. J., DeVault T. L. & DeWoody J. A. (2008) Vertebrate road mortality predominantly impacts amphibians. *Herpetological Conservation and Biology*. 3(1), 77– 87.

Gomes R., Morato S. A. A., Calixto P. O., Mendes L. R., Melo F. R., Miretzki M., Faria M. B., Calaça A. M. & Oliveira A. F. (2014) Guia Fotográfico de Identificação de Mamíferos Terrestres e Aquáticos da Floresta Nacional de Saracá-Taquera, Estado do Pará. *STCP Engenharia de Projetos Ltda*. 95.

Gonçalves L. O., Alvares D. J., Teixeira F. Z., Schuck G., Coelho I. P., Esperandio I. B. & Kindel A. (2018) Reptile road-kills in Southern Brazil: Composition, hot moments and hotspots. *Science of the Total Environment*. 615, 1438– 1445.

Goosem M. & Marsh H. (1997) Fragmentation of a small-mammal community by a powerline corridor through tropical rainforest. *Wildlife Research*. 24(5), 613– 629.

Gumier-Costa F. & Sperber C. F. (2009) Atropelamentos de vertebrados na Floresta Nacional de Carajás, Pará, Brasil. *Acta Amazonica*. 39(2), 459– 466.

Hammer Ø., Harper D. A. T. & Ryan P. D. (2001) Past: Paleontological statistics software package for education and data analysis. *Palaeontologia Electronica*. 4(1).

Hartmann P. A., Hartmann M. T. & Martins M. (2011) Snake road mortality in a protected area in the Atlantic Forest of southeastern Brazil. *South American Journal of Herpetology*. 6, 35- 42.

ICMBIO (2001) *Instituto Chico Mendes de Conservação da Biodiversidade*. https://www.icmbio.gov.br/portal/images/stories/docs-planos-de-manejo/pm_flona_saraca_taquera.pdf (Accessed: 1 June 2021).

ICMBIO (2022) *Instituto Chico Mendes de Conservação da Biodiversidade, Curitiba-PR*. https://www.icmbio.gov.br/cepsul/images/stories/legislacao/Portaria/2020/P_mma_148_2022_altera_anexos_P_mma_443_444_445_2014_atualiza_especies_ameacadas_extincao.pdf (Accessed: 1 June 2022).

IUCN (2021) *União Internacional para a Conservação da Natureza*. https://www.iucnredlist.org/ (Accessed: 25 November 2021).

Korner-Nievergelt F., Behr O., Brinkmann R., Etterson M. A., Huso M. M., Dalthorp D., ... & Niermann I. (2015) Mortality estimation from carcass searches using the R-package carcass-a tutorial. *Wildlife Biology*. 21(1), 30– 43.

Kunz T. H., Braun de Torrez E., Bauer D., Lobova T. & Fleming T. H. (2011) Ecosystem services provided by bats. *Annals of the New York academy of sciences*. *1223*(1), 1- 38.

Lagos L., Picos J. & Valero E. (2012) Temporal pattern of wild ungulate-related traffic accidents in northwest Spain. *European Journal of Wildlife Research*. 58(4), 661– 668.

Laurance W. F., Goosem M. & Laurance S. G. W. (2009) Impacts of roads and linear clearings on tropical forests. *Trends in Ecology and Evolution*. 24(12), 659– 669.

Laurance W. F., Clements G. R., Sloan S., O'Connell C. S., Mueller N. D., Goosem M., Venter O., Edwards D. P., Phalan B., Balmford A., Van Der Ree R. & Arrea I. B. (2014) Corrigendum: A global strategy for road building. *Nature*. 514(7521), 262.

Loss S. R., Will T. & Marra P. P. (2014) Estimation of bird-vehicle collision mortality on U.S. roads. *Journal of Wildlife Management*. 78(5), 763– 771.

Machado F. S., Fontes M. A., Moura A. S., Mendes P. B. & Romao B. D. S. (2015) Roadkill on vertebrates in Brazil: Seasonal variation and road type comparison. *North-Western Journal of Zoology*. 11(2), 247– 252.

Maynard R. J., Aall N. C., Saenz D., Hamilton P. S. & Kwiatkowski M. A. (2016) Road-Edge Effects on Herpetofauna in a Lowland Amazonian Rainforest. *Tropical Conservation Science*. 9(1), 264– 290.

Medeiros A. (2019) Vertebrados Atropelados Na Amazônia: Monitoramento Em Longo Prazo, Influência Do Fluxo De Veículos E Alternância De Hotspots Em Um Trecho Da Rodovia Br-174, Brasil. *Acta Botanica Brasilica*. 11(2), 277– 281.

Morato S. A. A., Ferreira G. N. & Scupino M. R. C. (2018) Herpetofauna da Amazônia Central: Estudos na FLONA de Saracá-Taquera. 210.

Navas C. A., Antoniazzi M. M., Carvalho J. E., Suzuki H. & Jared C. (2007) Physiological basis for diurnal activity in dispersing juvenile Bufo granulosus in the Caatinga, a Brazilian semi-arid environment. *Comparative Biochemistry and Physiology - A Molecular and Integrative Physiology*. 147(3), 647– 657.

Newton J. & Ripley B. D. (1984) Spatial Statistics. *Biometrics*. *40*(1), 280.

Parrotta J. A., Knowles O. H. & Wunderle J. M. (1997) Development of floristic diversity in 10-year-old restoration forests on a bauxite mined site in Amazonia. *Forest Ecology and Management*. 99(1–2), 21– 42.

Pereira G. F. P. A., Andrade G. A. F. & Fernandes B. E. M. (2006) Dois anos de monitoramento dos atropelamentos de mamíferos na rodovia PA458, Bragança, Pará. Museu de Biologia Emílio Goeldi. v. 1, 77- 83.

Pinheiro B. F. & Turci L. C. B. (2013) Vertebrados atropelados na estrada da Variante (BR-307), Cruzeiro do Sul, Acre, Brasil. *Natureza on line*. 11(2), 68– 78.

Pinowski J. (2005) Roadkills of Vertebrates in Venezuela. *Revista Brasileira de Zoologia*. 22(1), 191- 196.

Pyron R. A. & Wiens J. J. (2013) Large-scale phylogenetic analyses reveal the causes of high tropical amphibian diversity. *Proceedings of the Royal Society B: Biological Sciences*. *280*(1770), 20131622.

Ramos C. C. O., de Lima D. P., Zawadzki C. H. & Benedito E. (2011) The biology and ecology of birds is an important factor for explaining road kill frequencies. *Neotropical Biology and Conservation*. 6, 201- 212.

Ratton P., Secco H. & da Rosa C. A. (2014) Carcass permanency time and its implications to the roadkill data. *European Journal of Wildlife Research*. 60(3), 543–546.

Reis N. R., Peracchi A. L., Pedro W. A. & Lima I. P. (2006). Mamíferos do Brasil. In *Mamíferos do Brasil*. 437- 437.

Reis N. R., Fregonezi M. N., Peracchi A. L. & Shibatta O. A. (2013). *Morcegos do Brasil: Guia de Campo*; Technical Books Editora: Rio de Janeiro, Brazil.

Rocha L. M. D., Rosa C., Secco H., & Lopes E. V. (2023) Hotspots and hot moments of wildlife roadkills along a main highway in a high biodiversity area in Brazilian Amazonia. *Acta Amazonica*. *53*, 42- 52.

Rodríguez-Morales B., Díaz-Varela E. R. & Marey-Pérez M. F. (2013) Spatiotemporal analysis of vehicle collisions involving wild boar and roe deer in NW Spain. *Accident Analysis and Prevention*. 60, 121– 133.

Root R. B. (1967) The Niche Exploitation Pattern of the Blue-Gray Gnatcatcher. *Ecological Monographs*. 37(4), 317– 350.

Rosa C. A., Cardoso T. R., Teixeira F. Z. & Bager A. (2012) Atropelamento de fauna selvagem: amostragem e análise de dados em ecologia de estradas. In: BAGER, A. *Ecologia de Estradas: Tendências e pesquisas*. 79- 100.

Rosa D. C. P., Brocardo C. R., Rosa C., Castro A. B., Norris D. & Fadini R. (2021) Species-rich but defaunated: the case of medium and large-bodied mammals in a sustainable use protected area in the Amazon. *Acta Amazonica. 51*, 323- 333.

Santos S. M., Lourenço R., Mira A. & Beja P. (2013) Relative effects of road risk, habitat suitability, and connectivity on wildlife roadkills: The case of tawny owls (Strix aluco). *PLoS ONE*. 8(11).

Santos R. A. L., Santos S. M., Santos-Reis M., De Figueiredo A. P., Bager A., Aguiar L. M. S. & Ascensão F. (2016) Carcass Persistence and Detectability: Reducing the Uncertainty Surrounding Wildlife-Vehicle Collision Surveys. *PLoS ONE.* 11(11).

Santos R. A. L., Ascensão F., Ribeiro M. L., Bager A., Santos-Reis M. & Aguiar L. M. (2017) Assessing the consistency of hotspot and hot-moment patterns of wildlife road mortality over time. *Perspectives in Ecology and Conservation*. 15(1), 56– 60.

Secco H., Ratton P., Castro E., da Lucas P. S. & Bager A. (2014) Intentional snake road-kill: A case study using fake snakes on a Brazilian road. *Tropical Conservation*

Science. 7(3), 561– 571.

Secco H., da Rosa C. A. & Gonçalves P. R. (2018) Biodiversity crisis on Brazilian roads. *Biodiversity*. 19(3–4), 219– 220.

Seiler A. (2001) Ecological effects of roads: a review. Uppsala: Swedish University of Agricultural Sciences.

Silva J. M. C., Rylands A. B. & Fonseca G. A. B. (2005) The fate of the Amazonian areas of endemism. C*onservation Biology*. 19(3), 689- 694.

Smith-Patten B. D. & Patten M. A. (2008) Diversity, seasonality, and context of mammalian roadkills in the southern Great Plains. *Environmental Management*. 41(6), 844– 852.

SNUC (2000) *Sistema Nacional de Unidades de Conservação*. São Paulo: Conselho Nacional da Reserva da Biosfera da Mata Atlântica, 2ª edição, 76. https://www.rbma.org.br/rbma/pdf/Caderno_18_2ed. pdf>. Acessado em 29 de Abril de 2021.

Sosa R. & Schalk C. M. (2016) Seasonal activity and species habitat guilds influence road-kill patterns of neotropical snakes. *Tropical Conservation Science*. 9(4).

Southworth J., Marsik M., Qiu Y., Perz S., Cumming G., Stevens F., Rocha K., Duchelle A. & Barnes G. (2011) Roads as drivers of change: Trajectories across the tri-national frontier in MAP, the southwestern Amazon. *Remote Sensing*. 3(5), 1047– 1066.

Stoner K. E., Riba-Hernández P., Vulinec K. & Lambert J. E. (2007) The role of mammals in creating and modifying seed shadows in tropical forests and some possible consequences of their elimination. *Biotropica*. 39(3), 316– 327.

Teixeira F. Z., Coelho I. P., Esperandio I. B., Oliveira N. R., Peter F. P., Dorneles S. S., Delazeri N. R., Tavares M., Martins M. B. & Kindel A. (2013) Are Road-Kill Hotspots Coincident Among Different Vertebrate Groups?. *Oecologia Australis*. 17(1), 36– 47.

Terborgh J., Lopez L., Nuñez P. V., Rao M., Shahabuddin G., Orihuela G., Riveros M., Ascanio R., Adler G. H., Lambert T. D. & Balbas L. (2001) Ecological meltdown in predator-free forest fragments. *Science*. 294(5548), 1923– 1926.

Turci L. C. B. & Bernarde P. S. (2009) Vertebrados atropelados na Rodovia Estadual 383 em Rondônia, Brasil. *Biotemas.* 22(1), 121.

Tables

Table 1. Data from wild animals' roadkills that occurred on the roads of the Saracá-Taquera National Forest in the state of Pará, Brazil between 2016 and 2018.

	Vertebrate road kills by type of road and per kilometer										
	Highway		**Railway**		**Urban roads**		**Paved road**		**Dirt road**		
	Total	**Deaths/km**	**Total**	**Deaths/km**	**Total**	**Deaths/km**	**Total**	**Deaths/km**	**Total**	**Deaths/km**	**Total/class**
Birds	129	5,16	23	0,85	30	1,06	22	1,02	17	0,28	**221**
Mammals	281	11,24	105	3,89	44	1,55	28	1,3	20	0,33	**478**
Amphibians	552	22,08	696	25,78	176	6,23	40	1,86	14	0,23	**1.478**
Reptiles	345	13,8	86	3,19	66	2,33	76	3,53	45	0,74	**618**
Total	**1.307**	**52,28**	**910**	**33,71**	**316**	**11,17**	**166**	**7,71**	**96**	**1,58**	**2.795**

Table 2. Estimated mortality rates per day on all road types in the Saracá-Taquera National Forest in the state of Pará, Brazil between 2016 and 2018, using minimum, maximum, and median values of p (efficiency of the observation method) and TR (carcass characteristic removal time) to calculate the estimates of mortality rates.

	Estimated mortality rates per day		
Types of road	**Max (p) x Max (TR)**	**Min (P) x Min (TR)**	**Median (p) x Median (TR)**
Highway	70,786	1,989	2,850
Railway	66,033	5,100	9,516
Dirt road	1,863	0,200	0,309
Paved road	1,497	0,355	0,641
Urban roads	0,704	0,139	0,562

Table 3. Estimated mortality rates per day and kilometer on all roads in the Saracá-Taquera National Forest in Pará, Brazil, between 2016 and 2018, using minimum, maximum, and median values of p (efficiency of the observation method) and TR (carcass characteristic removal time) to calculate estimates of mortality rates.

	Estimated mortality rates per day and kilometer		
Types of road	**Max (p) x Max (TR)**	**Min (P) x Min (TR)**	**Median (p) x Median (TR)**
Highway	2,831	0,079	0,114
Railway	2,445	0,188	0,352
Dirt road	0,030	0,003	0,005
Paved road	0,069	0,016	0,029
Urban roads	0,024	0,004	0,019

Table 4. The number of roadkills by taxonomic group and by feeding guild on all roads between 2016 and 2018 in the Saracá-Taquera National Forest in Pará, Brazil.

	Total roadkill by taxonomic group and by feeding guilds					
Taxonomic group	**Omnivorous**	**Insectivorous**	**Frugivorous**	**Herbivorous**	**Carnivorous**	**Nectarivorous**
Amphibians	0	1.478	0	0	0	0
Bids	32	90	32	11	12	1
Mammals	214	80	82	16	3	2
Reptiles	4	105	0	22	427	0
Total	**250**	**1.753**	**114**	**49**	**442**	**3**

Table 5. Values of the Akaike information criterion (AIC) and Akaike weight (wi) were calculated in generalized linear models to verify the relationship between environmental variables and the number of individual roadkill in each vertebrate class and in general on all roads between 2016 and 2018 in the Saracá-Taquera National Forest in the state of Pará, Brazil. Models with AIC values in bold had ΔAIC < 2.

MODEL VARIABLES	AMPHIBIANS		BIRDS		MAMMALS		REPTILES		GENERAL	
	AIC	w_i	AIC	w_i	AIC	w_i	AIC	w_i	AIC	w_i
Temperature (°C)	4991.8 (2)	<0.001	781.1 (2)	<0.001	1769.9 (2)	<0.001	2293.7 (2)	<0.001	9919.3 (2)	<0.001
Rainfall (mm)	12538.3 (5)	<0.001	1743.2 (5)	<0.001	3943.5 (5)	<0.001	5086.1 (5)	<0.001	23372.3 (5)	<0.001
Relative air humidity (%)	9602.2 (3)	<0.001	1476.7 (3)	<0.001	3162.9 (3)	<0.001	3951.6 (3)	<0.001	18238.8 (3)	<0.001
Temperature x Rainfall	**4786.7** (1)	1	**731.7** (1)	1	**1705.3** (1)	1	**2246.3** (1)	1	**9551.6** (1)	1
Rainfall x Air humidity	12360.7 (4)	<0.001	1710.2 (4)	<0.001	3885.1 (4)	<0.001	5041.6 (4)	<0.001	23053.3 (4)	<0.001

Figure legends

Figure 1. Historical monthly averages of temperature (°C) and relative air humidity (%) in the Saracá-Taquera National Forest in northwest Pará state, Brazil.

Figure 2. Historical monthly average of precipitation (mm) in the Saracá-Taquera National Forest in the northwest of the state of Pará, Brazil.

Figure 3. Map the location of the different types of roads in the Saracá-Taquera National Forest in the northwest of the state of Pará, Brazil, where data on roadkills of mammals, reptiles, birds, and amphibians were collected during the years 2016 to 2018. Light spots refer to areas deforested for mining-related activities.

Figure 4. Highway and Railway areas embedded in the Saracá-Taquera National Forest, in the northwest of Pará, Brazil. The photo indicates the highway and railway width and the distance between them.

Figure 5. Monthly variation in the number of roadkills by amphibians, birds, mammals, reptiles, and all vertebrates on all roads between 2016 and 2018 in the Saracá-Taquera National Forest in the state of Pará, Brazil.

Figure 6. Relationships between roadkills (by taxonomic group and across the entire sample) and abiotic factors in all traffic routes between 2016 and 2018 in the Saracá-Taquera National Forest in Pará, Brazil.

Figure 7. Ripley's K statistic (black line) of amphibian, bird, mammal, and reptile fatalities in the urban area, on paved roads, on dirt roads, on the railway, and on the highway in the Saracá-Taquera National Forest in the state of Pará, Brazil, concerning scale distance (radius), with 95% confidence limits (red lines). The "L" function

evaluates the aggregation intensity. Values above the upper limit of the confidence interval (red lines) indicate significant clustering of roadkill.

Figure 8A-D. Heat maps with the intensity of aggregations of roadkills of amphibians (A), birds (B), mammals (C), and reptiles (D) in the urban area (roadkill hotspots) in the Saracá-Taquera National Forest in the state of Pará, Brazil. The greater the intensity (red color), the greater the aggregation of roadkill.

Figure 9A-D. Heat maps with the intensity of aggregations of roadkills of amphibians (A), birds (B), mammals (C), and reptiles (D) on paved roads (roadkill hotspots) in the Saracá-Taquera National Forest in the state of Pará, Brazil. The greater the intensity (red color), the greater the aggregation of roadkill.

Figure 10A-D. Heat maps with the intensity of aggregations of roadkills of amphibians (A), birds (B), mammals (C), and reptiles (D) on unpaved roads (roadkill hotspots) in the Saracá-Taquera National Forest in the state of Pará, Brazil. The greater the intensity (red color), the greater the aggregation of roadkill.

Figure 11A-D. Heat maps with the intensity of aggregations of roadkills of amphibians (A), birds (B), mammals (C), and reptiles (D) on the railroad (roadkill hotspots) in the Saracá-Taquera National Forest in the state of Pará, Brazil. The greater the intensity (red color), the greater the aggregation of roadkill.

Figure 12A-D. Heat maps with the intensity of aggregations of roadkills of amphibians (A), birds (B), mammals (C), and reptiles (D) on the highway (roadkill hotspots) in the Saracá-Taquera National Forest in the state of Pará, Brazil. The greater the intensity (red color), the greater the aggregation of roadkill.

Supporting information

Appendix S1. Studies that have the efficiency of the observation method (p) to calculate estimated mortality rates by traffic road type.

Appendix S2. Studies that have the carcass removal characteristic time (TR) in days to calculate the estimated mortality rates by traffic road type.

Appendix S3. Vertebrates species roadkilled in the traffic routes of the Saracá-Taquera National Forest between the years 2016 and 2018 and the feeding guilds identified through literature. H = herbivorous, C = carnivorous, I = insectivorous, O = omnivorous, F = frugivorous, N = nectarivorous.

Appendix S4. Observer efficiency values (p) found in the literature by road type. Each point represents an observer efficiency value found in the literature for each type of traffic road.

Appendix S5. Characteristic carcass removal time (TR) values in days found in the literature road types. Each point represents a distinct carcass removal time value in days found in the literature for each type of traffic road.

Appendix S6. Minimum, maximum, and median values were calculated for the observation method efficiency (p) in different types of roads. Data was collected from the consulted literature (see text for details).

Appendix S7. Minimum, maximum, and median values were calculated for the carcass removal characteristic time (TR) in days in different road types. Data was collected from the consulted literature (see text for details).

Figures

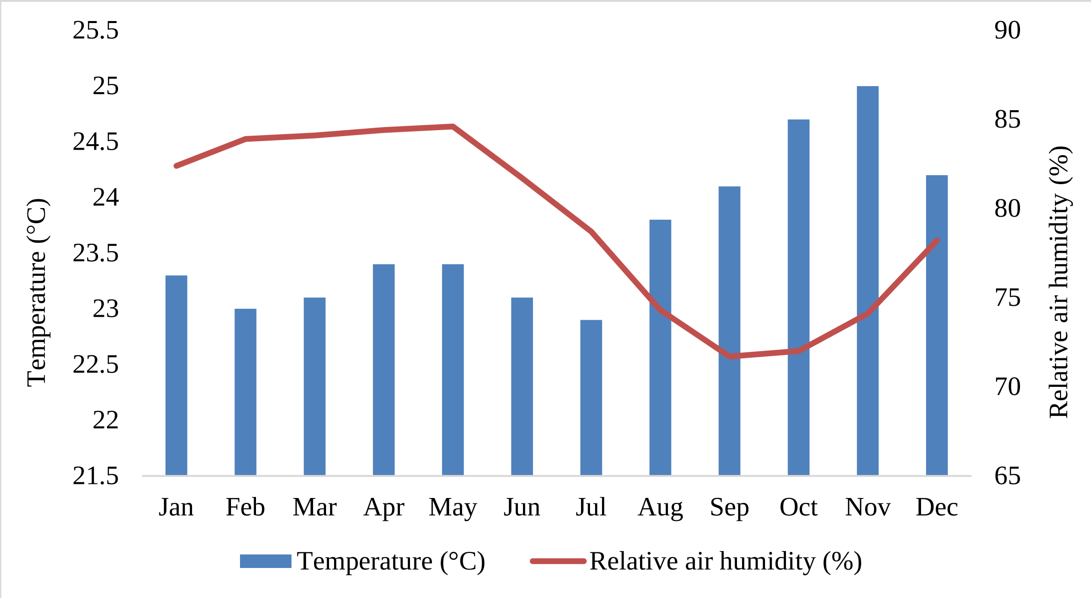


Figure 1. Historical average monthly temperature (°C) and relative air humidity (%) in the Saracá-Taquera National Forest in northwest Pará state, Brazil. Source: ICMBIO (2001).

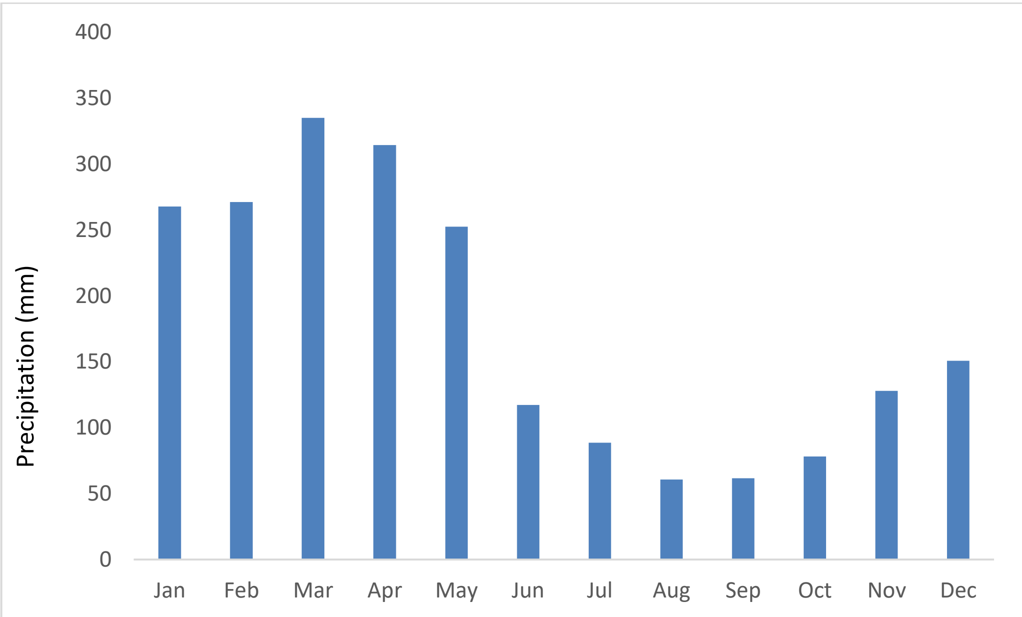


Figure 2. Historical average monthly precipitation (mm) in the Saracá-Taquera National Forest in the northwest Pará state, Brazil. Source: ICMBIO (2001).

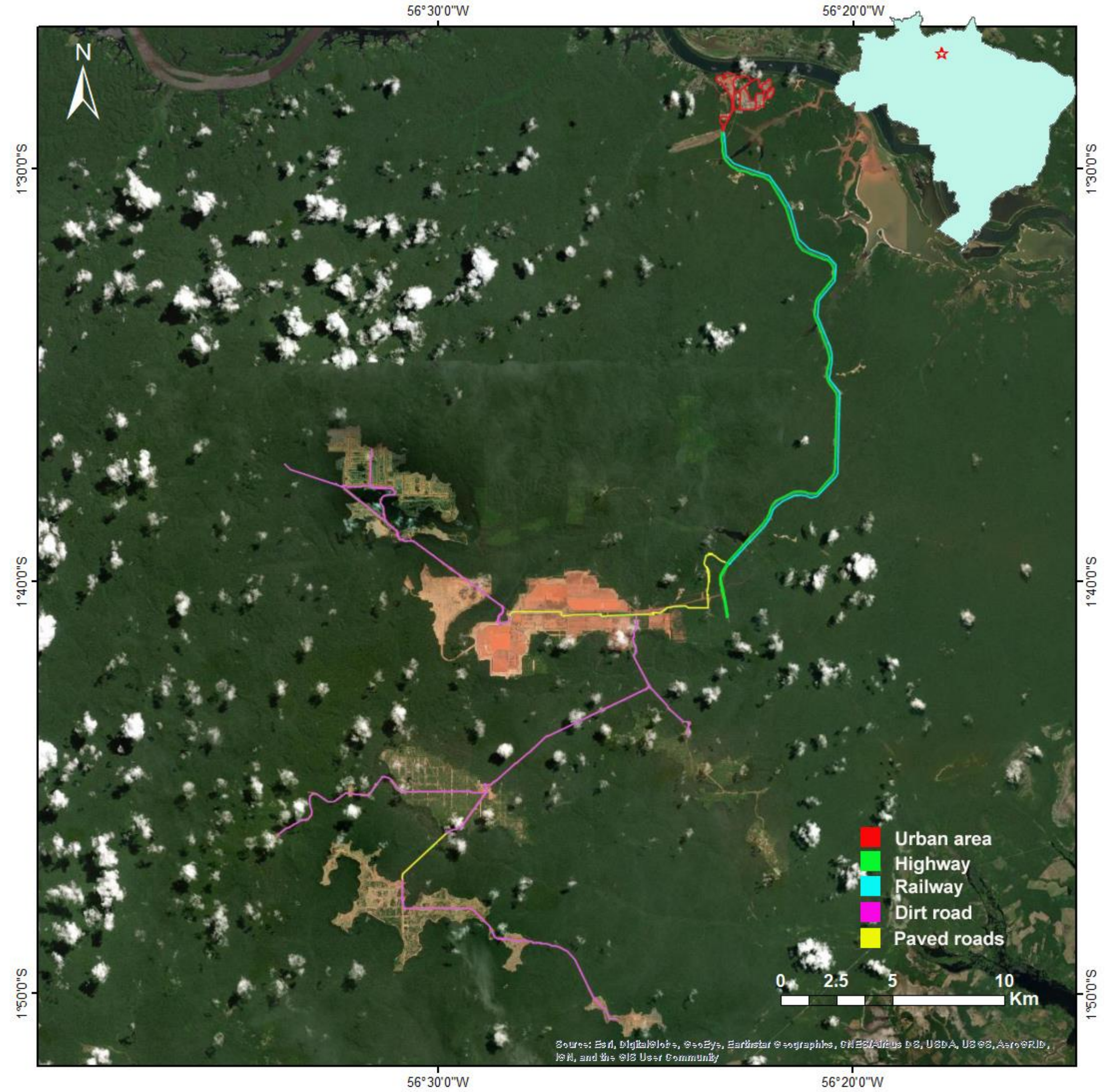


Figure 3. Map of the location of the different types of roads in the Saracá-Taquera National Forest in the northwest Pará state, Brazil, where data on roadkills of mammals, reptiles, birds, and amphibians were collected during the years 2016 to 2018. Light spots refer to areas deforested for mining-related activities.

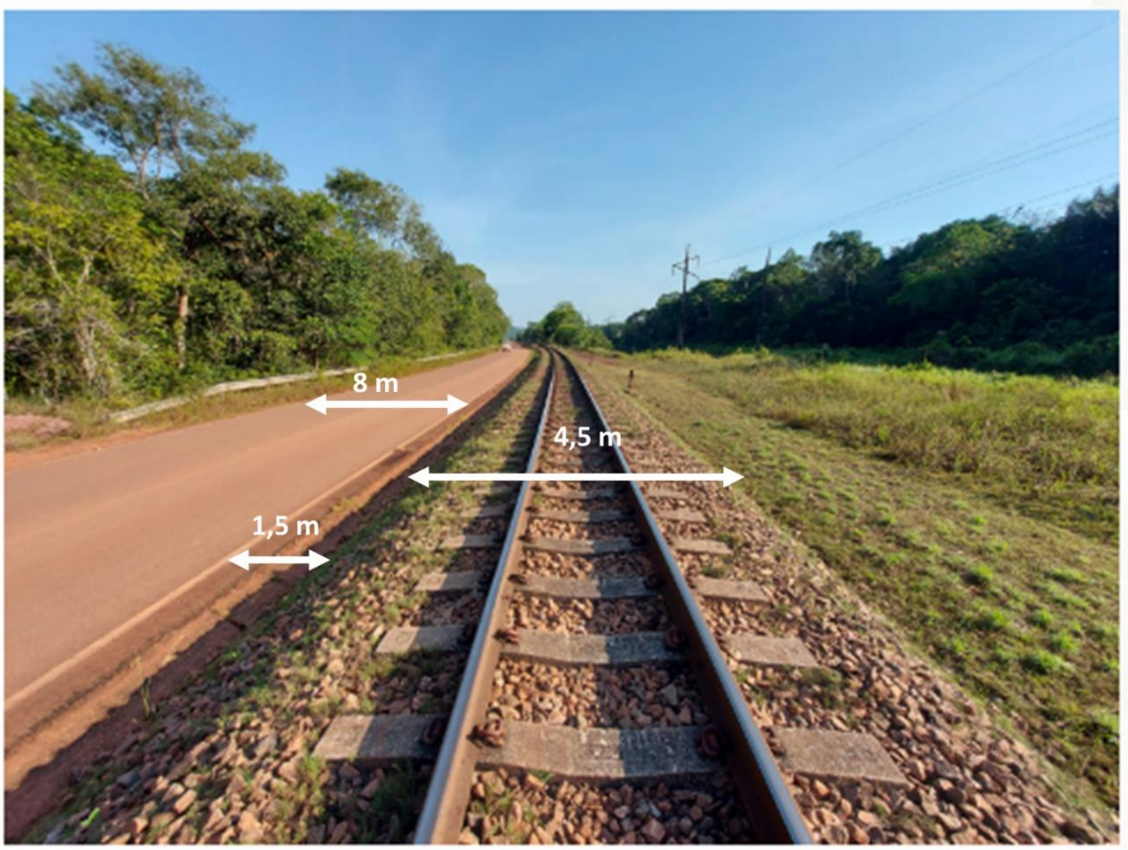


Figure 4. Highway and railway areas embedded in the Saracá-Taquera National Forest, in the northwest Pará state, Brazil. The photo indicates the highway and railway width and the distance between them. Photograph: Guilherme Ferreira (2021).

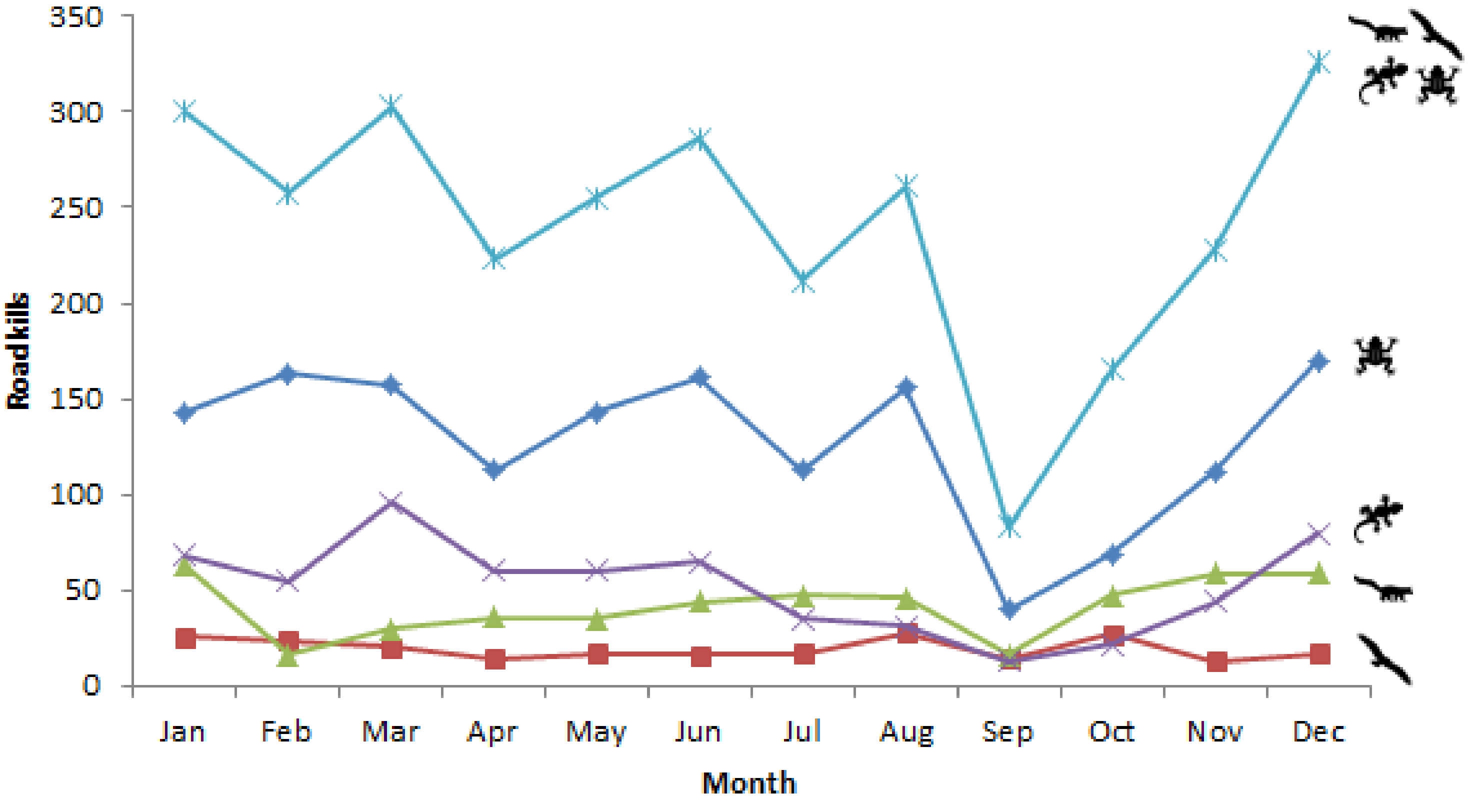


Figure 5. Monthly variation in the number of observed roadkills of amphibians, birds, mammals, reptiles, and all vertebrates on all roads between 2016 and 2018 in the Saracá-Taquera National Forest in the Pará state, Brazil.

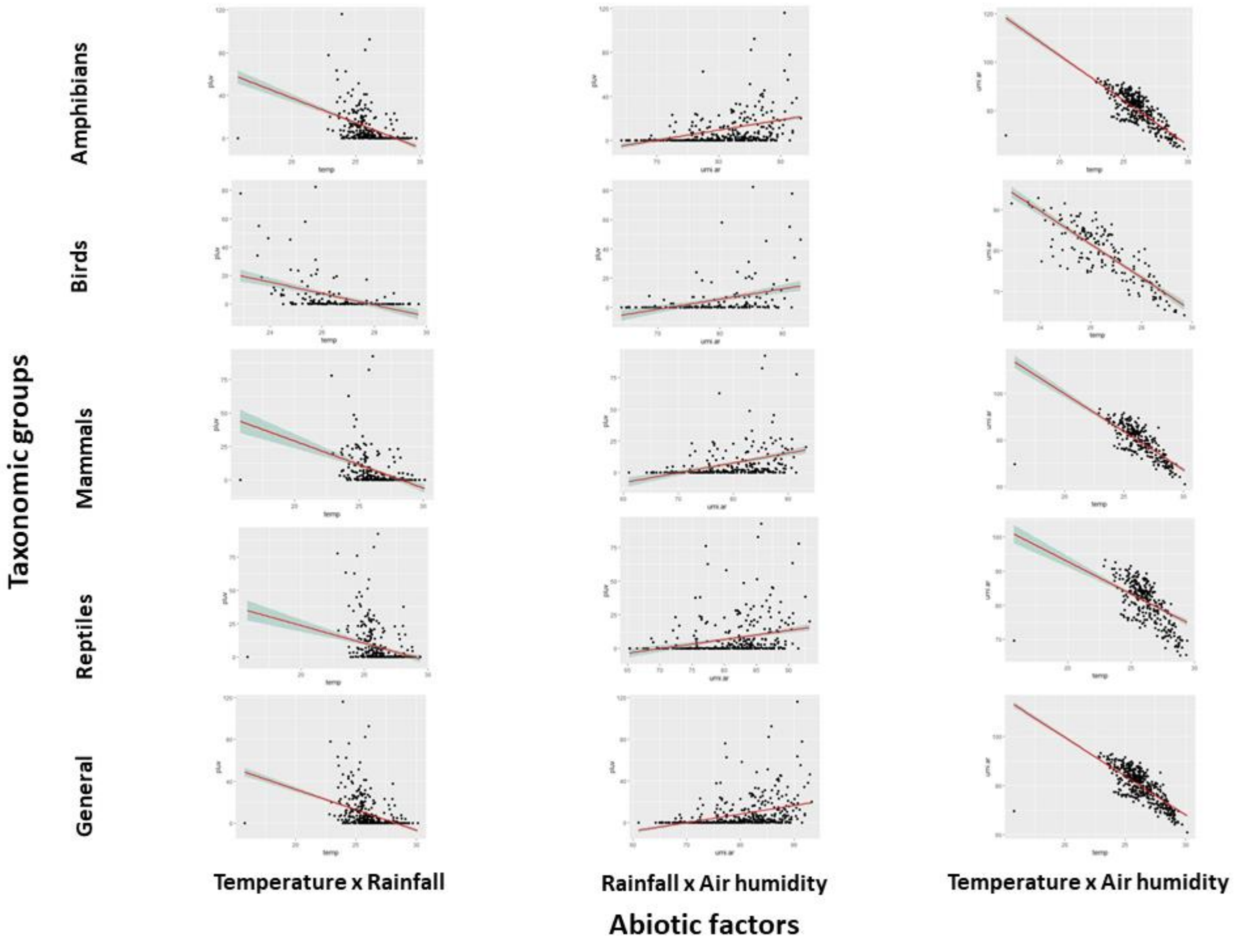


Figure 6. Relationships between roadkills (by taxonomic group and across the entire sample) and abiotic factors in all traffic routes between 2016 and 2018 in the Saracá-Taquera National Forest in Pará state, Brazil.

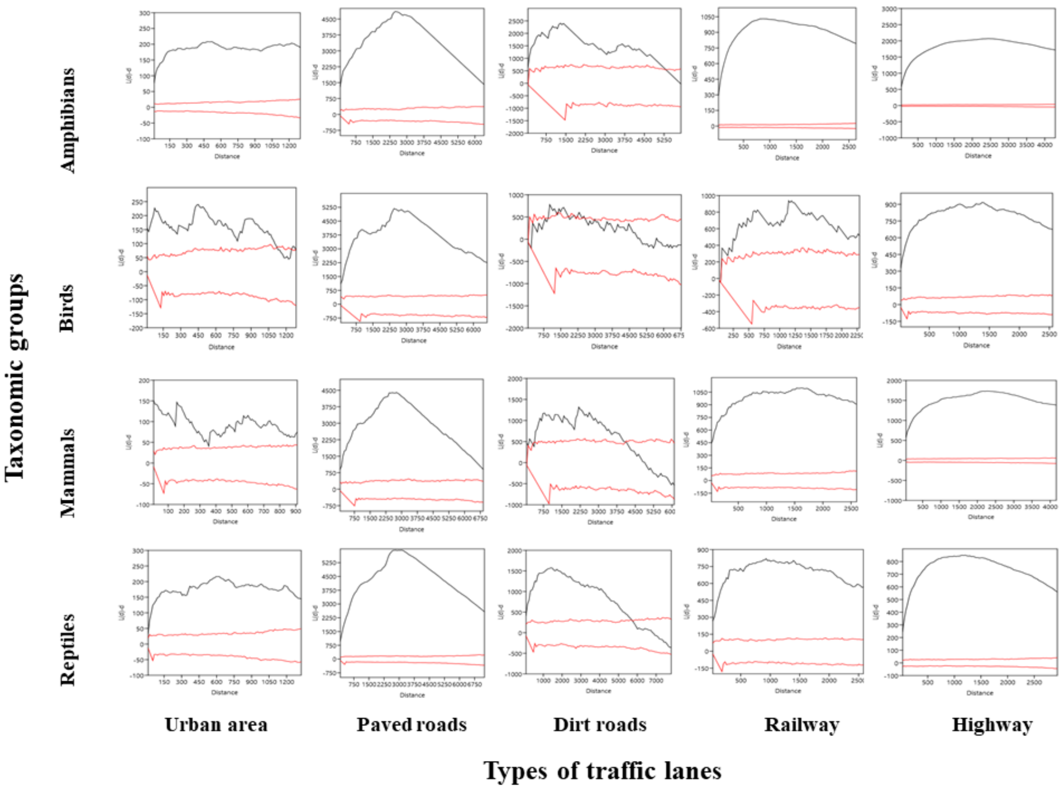


Figure 7. Ripley's K statistic (black line) of amphibian, bird, mammal, and reptile fatalities in the urban area, on paved roads, on dirt roads, on the railway, and on the highway concerning scale distance (radius), with 95% confidence limits (red lines) in the Saracá-Taquera National Forest in Pará state, Brazil. The "L" function evaluates the aggregation intensity. Values above the upper limit of the confidence interval (red lines) indicate significant clustering of roadkill.

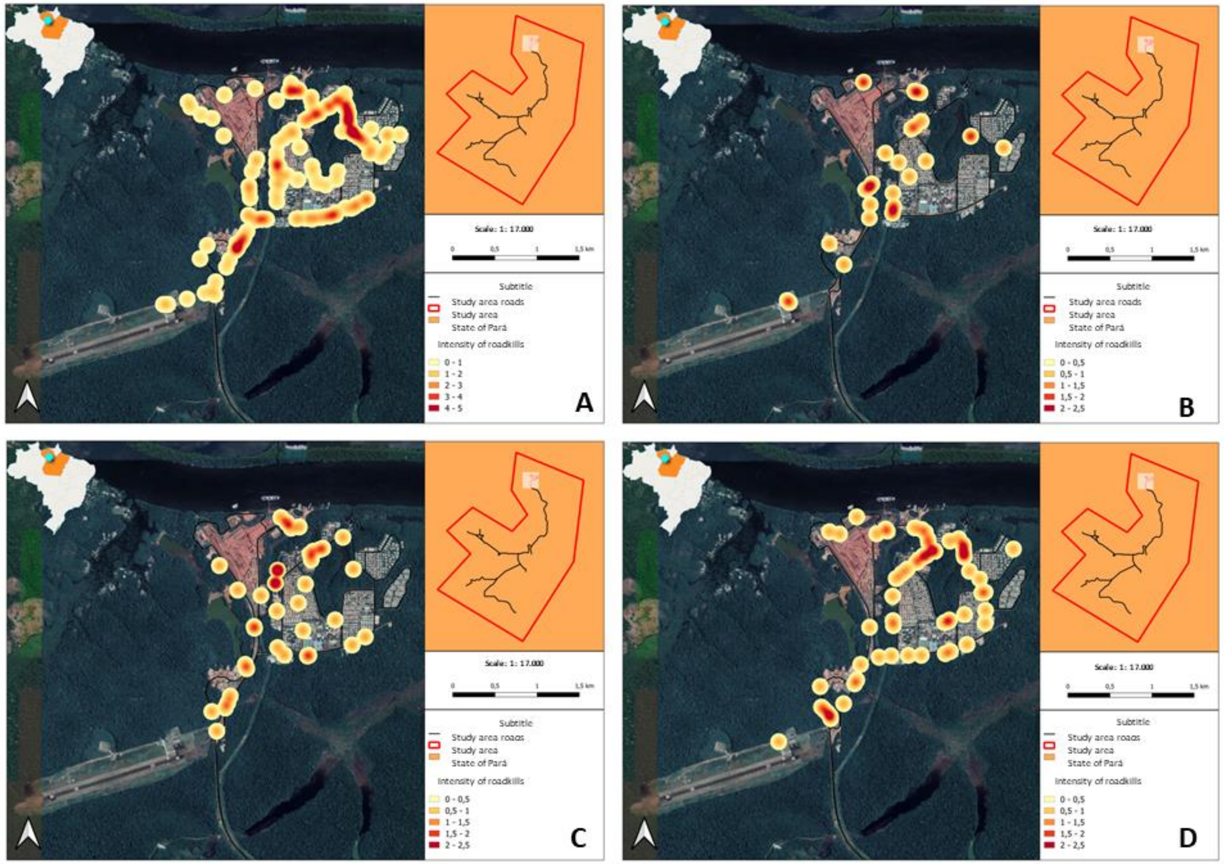


Figure 8A-D. Heat maps with the intensity of aggregations of roadkills of amphibians (A), birds (B), mammals (C), and reptiles (D) in the urban area (roadkill hotspots) in the Saracá-Taquera National Forest in Pará state, Brazil. The greater the intensity (red color), the greater the aggregation of roadkill.

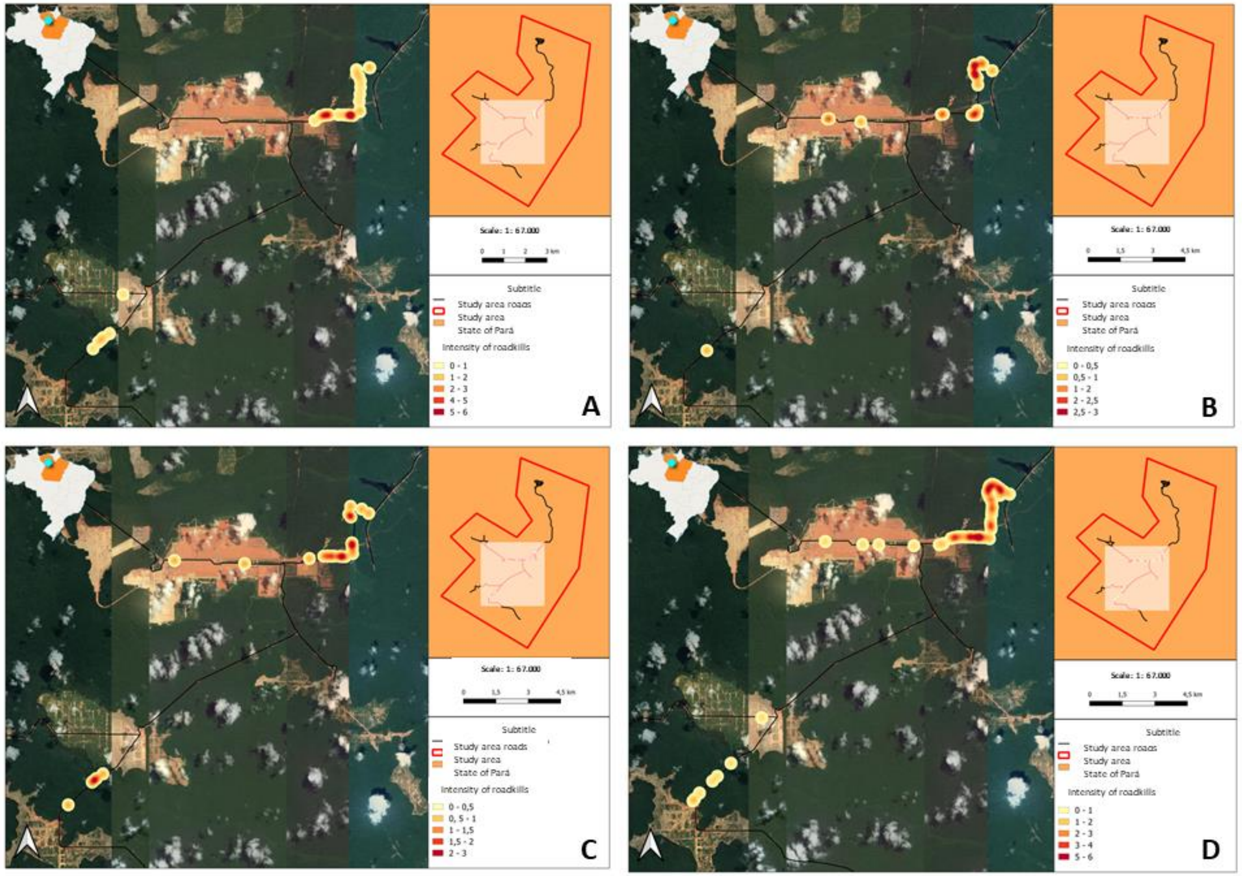


Figure 9A-D. Heat maps with the intensity of aggregations of roadkills of amphibians (A), birds (B), mammals (C), and reptiles (D) on paved roads (roadkill hotspots) in the Saracá-Taquera National Forest in Pará state, Brazil. The greater the intensity (red color), the greater the aggregation of roadkill.

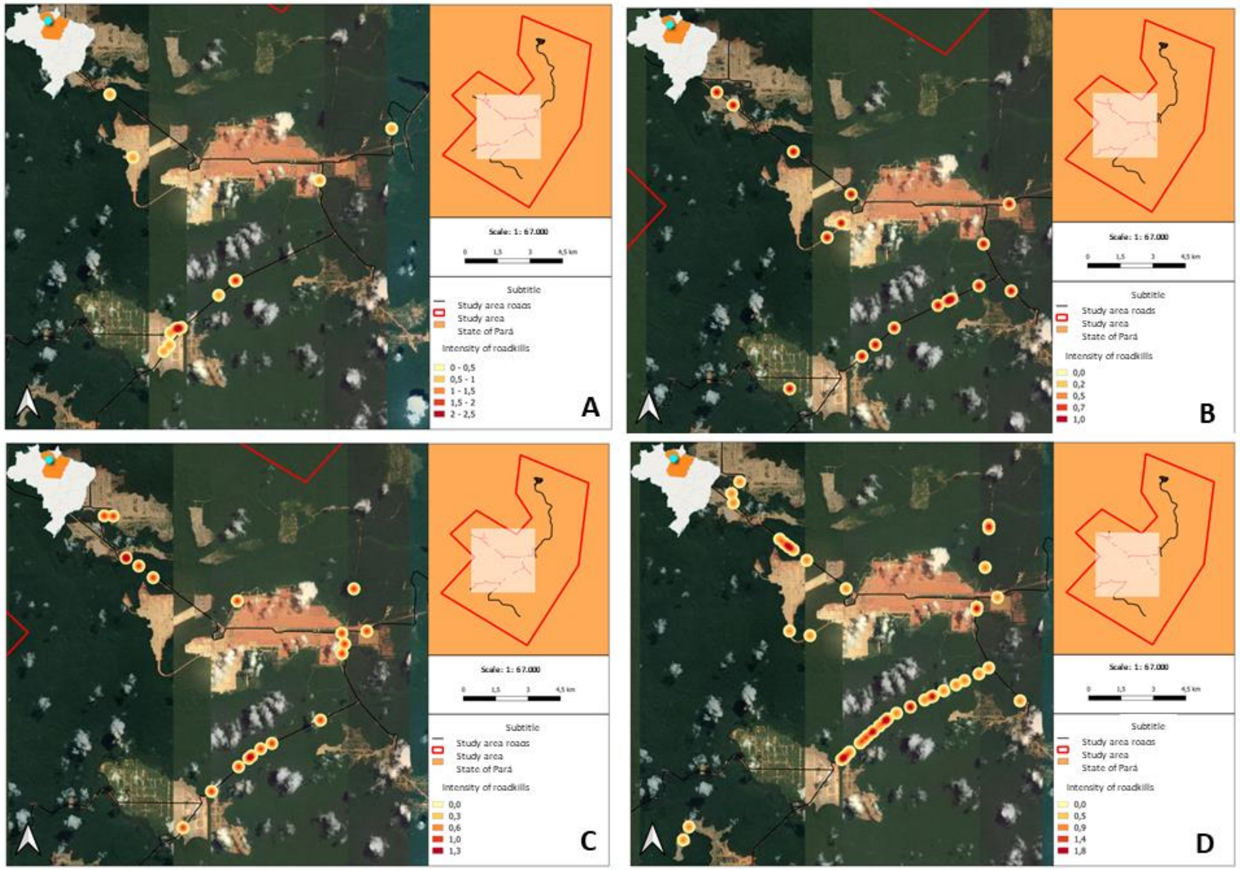


Figure 10A-D. Heat maps with the intensity of aggregations of roadkills of amphibians (A), birds (B), mammals (C), and reptiles (D) on unpaved roads (roadkill hotspots) in the Saracá-Taquera National Forest in Pará state, Brazil. The greater the intensity (red color), the greater the aggregation of roadkill.

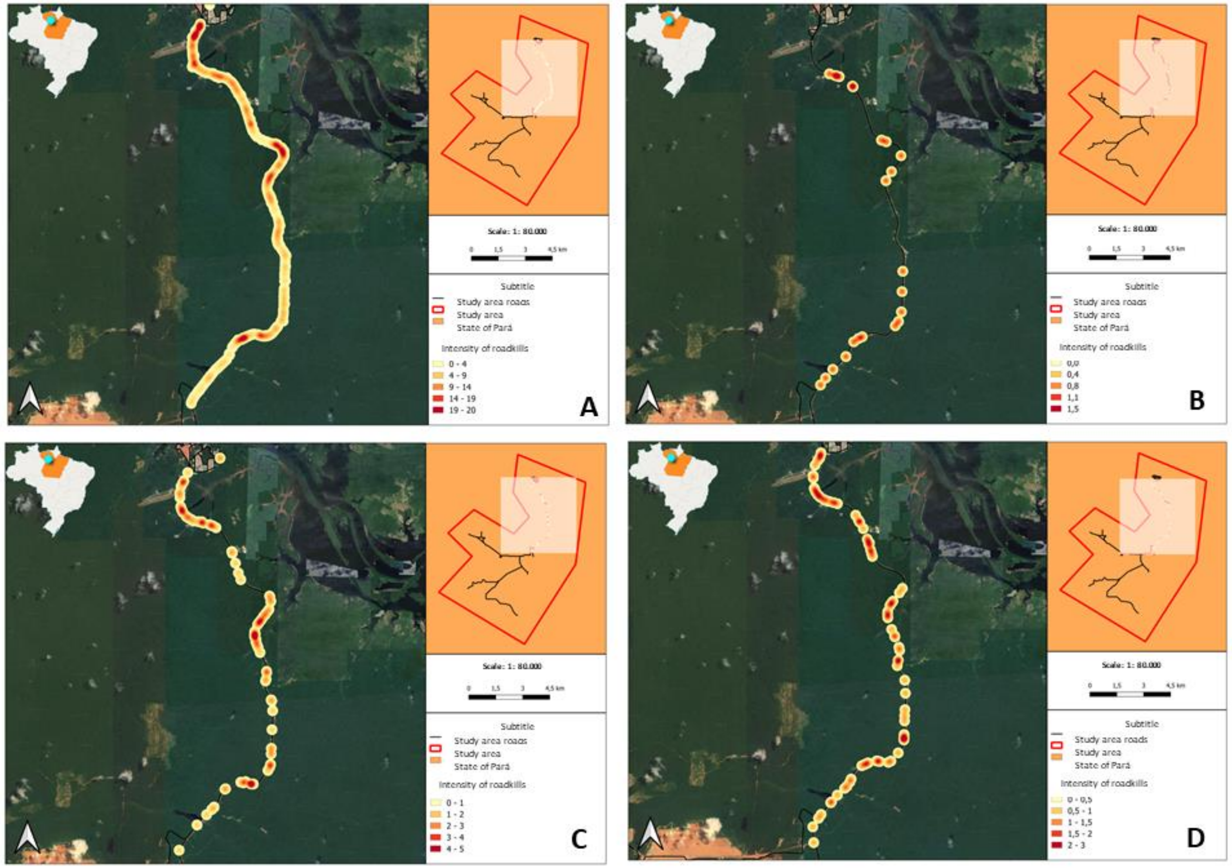


Figure 11A-D. Heat maps with the intensity of aggregations of roadkills of amphibians (A), birds (B), mammals (C), and reptiles (D) on the railroad (roadkill hotspots) in the Saracá-Taquera National Forest in Pará state, Brazil. The greater the intensity (red color), the greater the aggregation of roadkill.

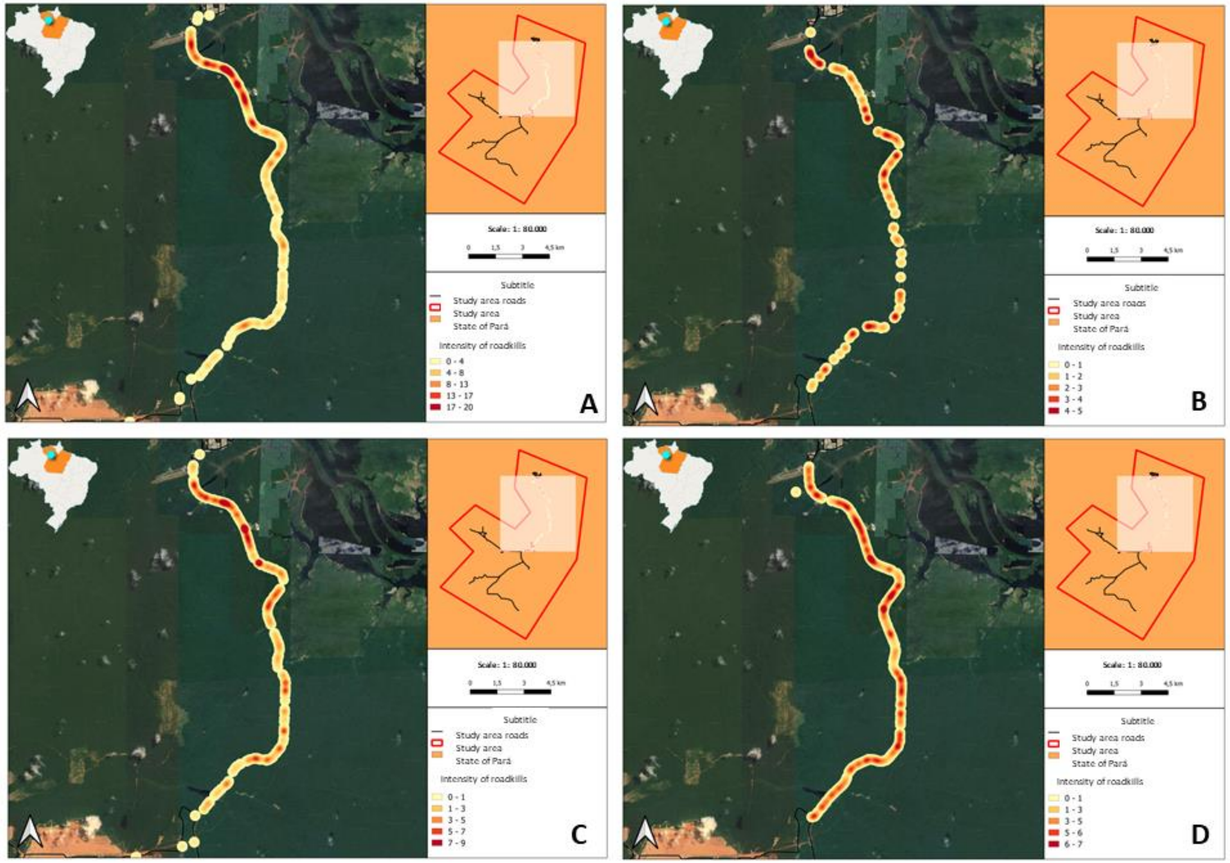


Figure 12A-D. Heat maps with the intensity of aggregations of roadkills of amphibians (A), birds (B), mammals (C), and reptiles (D) on the highway (roadkill hotspots) in the Saracá-Taquera National Forest in Pará state, Brazil. The greater the intensity (red color), the greater the aggregation of roadkill.

Appendix S1

Studies that have the efficiency of the observation method (p) to calculate estimated mortality rates by traffic road type.

Traffic lane type	p	Reference
Highway	0.05	Teixeira *et al.* 2013
	0.2	Teixeira *et al.* 2013
	0.21	Santos *et al.* 2016
	0.26	Gonçalves *et al.* 2018
	0.47	Teixeira *et al.* 2013
	0.55	Pinheiro 2016
	0.59	Pacheco *et al.* 2013
	0.61	Franceschi *et al.* 2021
	0.68	Franceschi *et al.* 2021
	0.72	Plante *et al.* 2019
	0.80	Franceschi *et al.* 2021
	0.82	Gonçalves *et al.* 2018
	0.9	Ascensão *et al.* 2021
Unpaved road	0.21	Santos *et al.* 2016
	0.25	Pinheiro 2016
	0.5	Henry *et al.* 2021
	0.53	Ponce *et al.* 2010
Railway	0.29	Dasoler *et al.* 2020
	0.80	Dornas *et al.* 2019
	0.95	Garcia de la Morena *et al.* 2017
Paved road	0.5	Henry *et al.* 2021
	0.5	Santos & Ascensão 2019
Urban area	0.73	Riding & Loss 2018
	1.0	Kummer *et al.* 2016

Appendix S2

Studies that have the carcass removal characteristic time (TR) in days to calculate the estimated mortality rates by traffic lane type.

Traffic lane type	TR	Reference
Highway	0.51	Teixeira *et al.* 2013
	0.74	Franceschi *et al.* 2021
	0.83	Gonçalves *et al.* 2018
	0.87	Franceschi *et al.* 2021
	0.89	Franceschi *et al.* 2021
	1.95	Pinheiro 2016
	2.2	Santos *et al.* 2016
	2.45	Teixeira *et al.* 2013
	2.81	Pacheco *et al.* 2013
	4.0	Ascensão *et al.* 2021
	4.93	Teixeira *et al.* 2013
	5.3	Gonçalves *et al.* 2018
Unpaved road	1.0	Santos & Ascensão 2019
	0.34	Hubbard & Chalfoun 2012
	1.27	Pinheiro 2016
	2.0	Ponce *et al.* 2010
	2.2	Santos *et al.* 2016
	2.7	Henry *et al.* 2021
Railway	0.99	Dasoler *et al.* 2020
	4.0	Dornas *et al.* 2019
Paved road	0.31	Hubbard & Chalfoun 2012
	0.75	Hubbard & Chalfoun 2012
	1.0	Santos & Ascensão 2019
	2.7	Henry *et al.* 2021
Urban area	3.1	Riding & Loss 2018
	1.47	Kummer *et al.* 2016

Appendix S3

Vertebrate species roadkilled in the traffic routes of the Saracá-Taquera National Forest, Pará state, Brazil, between the years 2016 and 2018 and the feeding guilds identified in the literature. H = herbivorous, C = carnivorous, I = insectivorous, O = omnivorous, F = frugivorous, N = nectarivorous.

Taxonomic group	**Species**	**Records number**	**Feeding guild**	**Source(s)**
AMPHIBIANS	*Adenomera* sp.	4	I	Almeida *et al.* 2019
	Anura sp.	194	I	Lopes *et al.* 2017; Alves & Toledo 2017
	Boana boans	53	I	Torralvo *et al.* 2021; AmphibiaWeb 2022
	Boana cinerascens	16	I	Torralvo *et al.* 2021; AmphibiaWeb 2022
	Boana geographica	37	I	Torralvo *et al.* 2021; AmphibiaWeb 2022
	Boana raniceps	2	I	Thomassem & Ziade 2020
	Boana sp.	59	I	Moser *et al.* 2019; Torralvo *et al.* 2021
	Dendropsophus minutus	1	I	Thomassem & Ziade 2020; AmphibiaWeb 2022
	Dendropsophus sp.	4	I	Carvalho-e-Silva *et al.* 2015; Thomassem & Ziade 2020
	Hylidae sp.	83	I	Carvalho-e-Silva *et al.* 2015; Thomassem & Ziade 2020
	Leptodactylus fuscus	6	I	Carvalho-e-Silva *et al.* 2015; Thomassem & Ziade 2020
	Leptodactylus knudseni	1	I	do Couto *et al.* 2018
	Leptodactylus lineatus	1	I	do Couto *et al.* 2018
	Leptodactylus mystaceus	1	I	Thomassem & Ziade 2020
	Leptodactylus pentadactylus	15	I	do Couto *et al.* 2018; Torralvo *et al.* 2021
	Leptodactylus rhodomystax	1	I	do Couto *et al.* 2018
	Leptodactylus sp.	45	I	Carvalho-e-Silva *et al.* 2015; do Couto *et al.* 2018; Thomassem & Ziade 2020

	Leptodactylus stenodema	1	I	do Couto *et al.* 2018
	Osteocephalus oophagus	2	I	Torralvo *et al.* 2021; AmphibiaWeb 2022
	Osteocephalus sp.	35	I	Torralvo *et al.* 2021; AmphibiaWeb 2022
	Osteocephalus taurinus	2	I	Torralvo *et al.* 2021; AmphibiaWeb 2022
	Phyllomedusa bicolor	3	I	Lima *et al.* 2019
	Phyllomedusa sp.	4	I	Carvalho-e-Silva *et al.* 2015
	Rhinella granulosa	2	I	Carvalho-e-Silva *et al.* 2015
	Rhinella margaritifera	6	I	AmphibiaWeb 2022
	Rhinella marina	848	I	Carvalho-e-Silva *et al.* 2015
	Rhinella mirandaribeiroi	2	I	Carvalho-e-Silva *et al.* 2015
	Rhinella sp.	17	I	Carvalho-e-Silva *et al.* 2015; Thomassem & Ziade 2020
	Scinax ruber	7	I	Blanco-Torres *et al.* 2017
	Scinax sp.	13	I	Carvalho-e-Silva *et al.* 2015; Thomassem & Ziade 2020
	Sphaenorhynchus lacteus	3	I	AmphibiaWeb 2022
	Trachycephalus resinifictrix	1	I	Torralvo *et al.* 2021
	Trachycephalus sp.	1	I	Thomassem & Ziade 2020; Torralvo *et al.* 2021
	Trachycephalus typhonius	8	I	Thomassem & Ziade 2020
BIRDS	*Alcedinidae* sp.	1	I	WikiAves 2022
	Antrostomus rufus	5	I	WikiAves 2022
	Aramides cajaneus	1	O	WikiAves 2022
	Athene cunicularia	2	C	WikiAves 2022
	Cacicus cela	7	O	WikiAves 2022
	Cacicus haemorrhous	1	O	WikiAves 2022
	Caprimulgidae sp.	6	I	WikiAves 2022
	Cathartes burrovianus	1	C	WikiAves 2022
	Cathartes sp.	1	C	WikiAves 2022
	Cathartidae sp.	2	C	WikiAves 2022
	Ceratopipra erythrocephala	2	F	WikiAves 2022

Chelidoptera tenebrosa	1	I	WikiAves 2022
Columbina minuta	1	H	WikiAves 2022
Columbina passerina	2	H	WikiAves 2022
Columbina sp.	2	H	WikiAves 2022
Crax alector	1	H	WikiAves 2022
Crax fasciolata	1	H	WikiAves 2022
Crotophaga ani	5	O	WikiAves 2022
Dendrocygna autumnalis	4	H	WikiAves 2022
Elaenia sp.	2	O	WikiAves 2022
Ibycter americanus	1	F	WikiAves 2022
Laterallus exilis	1	I	WikiAves 2022
Legatus leucophaius	1	F	WikiAves 2022
Leptotila verreauxi	2	F	WikiAves 2022
Manacus manacus	4	F	WikiAves 2022
Megaceryle torquata	1	C	WikiAves 2022
Megascops choliba	1	I	WikiAves 2022
Micrastur ruficollis	1	C	WikiAves 2022
Mionectes macconnelli	1	I	WikiAves 2022
Mionectes sp.	1	I	WikiAves 2022
Molothrus bonariensis	1	O	WikiAves 2022
Monasa nigrifrons	1	I	WikiAves 2022
Myiozetetes similis	8	I	WikiAves 2022
Nyctibius griseus	1	I	WikiAves 2022
Nyctidromus albicollis	6	I	WikiAves 2022
Nyctidromus nigrescens	25	I	WikiAves 2022
Nyctidromus sp.	21	I	WikiAves 2022
Nyctiprogne leucopyga	1	I	WikiAves 2022
Ortalis guttata	5	F	WikiAves 2022

	Ortalis motmot	4	F	WikiAves 2022
	Patagioenas cayennensis	1	F	WikiAves 2022
	Phaethornis sp.	1	N	WikiAves 2022
	Piaya cayana	8	O	WikiAves 2022
	Pitangus sulphuratus	6	O	WikiAves 2022
	Psophia crepitans	1	F	WikiAves 2022
	Pteroglossus aracari	1	F	WikiAves 2022
	Pteroglossus viridis	2	F	WikiAves 2022
	Pulsatrix perspicillata	2	C	WikiAves 2022
	Ramphocelus carbo	5	I	WikiAves 2022
	Rupornis magnirostris	2	C	WikiAves 2022
	Selenidera piperivora	1	F	WikiAves 2022
	Tangara episcopus	3	F	WikiAves 2022
	Tangara palmarum	3	I	WikiAves 2022
	Tityra semifasciata	1	O	WikiAves 2022
	Tyrannidae sp.	1	I	WikiAves 2022
	Tyrannus melancholicus	4	F	WikiAves 2022
	Tyrannus savana	1	I	WikiAves 2022
MAMMALS	*Alouatta macconnelli*	2	F	Dunn *et al.* 2009
	Anoura geoffroyi	2	N	Caballero-Martinez *et al.* 2009
	Bradypus tridactylus	9	H	Carciofi *et al.* 1995
	Caluromys philander	1	O	Lessa & Geise 2010
	Carollia perspicillata	25	F	Novaes *et al.* 2018
	Carollia sp.	4	F	Lobova *et al.* 2009
	Choloepus didactylus	7	H	Mosquera *et al.* 2019
	Cingulata sp.	1	I	Serrano-Fochs *et al.* 2015
	Coendou prehensilis	2	F	Bonvicino *et al.* 2008
	Cricetidae sp.	1	O	Ramos & Facure 2009; Maestri *et al.* 2017

Cuniculus paca	6	F	Zucaratto *et al.* 2010
Cyclopes didactylus	2	I	Miranda *et al.* 2009
Dasyprocta leporina	13	F	Henry 1999
Dasypus kappleri	2	I	Serrano-Fochs *et al.* 2015
Dasypus novemcinctus	2	I	Serrano-Fochs *et al.* 2015
Didelphis marsupialis	124	O	Cordero & Nicolas 1987
Didelphis sp.	11	O	Lessa & Geise 2010
Echimys sp.	1	O	Mosquera *et al.* 2019
Eira barbara	4	O	Bisbal 1986
Glossophaga soricina	1	O	Dos Reis *et al.* 2007
Leopardus pardalis	3	C	Abreu *et al.* 2008
Marmosa murina	15	O	Lessa & Geise 2010
Mesomys sp.	3	O	Emmons & Feer 1997
Mesophylla sp.	1	F	Wilson & Reeder 2005
Micoureus demerarae	4	O	Lessa & Geise 2010
Myoprocta acouchy	2	F	Dubost & Henry 2006
Nectomys sp.	1	O	Ernest 1986
Phyllostomidae sp.	8	F	Arnone *et al.* 2016
Primates sp.	1	F	Chivers & Hladik 1980
Proechimys cuvieri	3	O	Emmons & Feer 1997
Proechimys sp.	3	O	Emmons & Feer 1997
Pteronotus gymnonotus	1	I	Pavan & Tavares 2020
Pteronotus parnellii	62	I	de Oliveira *et al.* 2015
Pteronotus sp.	3	I	Salinas-Ramos *et al.* 2015
Rodentia sp.	34	O	Landry 1970
Saccopteryx bilineata	1	I	Damásio *et al.* 2021
Saguinus martinsi	16	F	Silva *et al.* 2021
Saimiri sciureus	1	F	Pinheiro *et al.* 2013

	Sapajus apella	7	O	Ungar *et al.* 2017
	Tamandua tetradactyla	6	I	Sun *et al.* 2022
	Uroderma bilobatum	1	F	Damásio *et al.* 2021
	Vampyriscus bidens	1	F	Gomes *et al.* 2016
REPTILES	*Alligatoridae* sp.	2	C	Araújo 2017
	Ameiva ameiva	9	I	Cooper & Vitt 2002
	Amphisbaena alba	19	I	Colli & Zamboni 1999
	Amphisbaena amazonica	20	I	Avila-Pires *et al.* 2007
	Anilius scytale	27	C	Maschio *et al.* 2010
	Apostolepis nigrolineata	2	C	dos Santos-Costa *et al.* 2015
	Atractus major	1	I	dos Santos-Costa *et al.* 2015
	Atractus sp.	3	I	dos Santos-Costa *et al.* 2015
	Boa constrictor	33	C	dos Santos-Costa *et al.* 2015
	Bothrops atrox	61	C	dos Santos-Costa *et al.* 2015
	Caiman crocodilus	4	C	Thorbjarnarson 1993
	Chelonoidis carbonarius	5	H	de Castro *et al.* 2018
	Chelonoidis denticulatus	1	O	Tavares *et al.* 2019
	Chelonoidis sp.	3	H	de Castro *et al.* 2018
	Chironius carinatus	6	C	dos Santos-Costa *et al.* 2015
	Chironius fuscus	7	C	dos Santos-Costa *et al.* 2015
	Chironius multiventris	5	C	dos Santos-Costa *et al.* 2015
	Chironius scurrulus	1	C	dos Santos-Costa *et al.* 2015
	Chironius sp.	17	C	dos Santos-Costa *et al.* 2015
	Cnemidophorus cryptus	19	I	Mesquita *et al.* 2006
	Cnemidophorus lemniscatus	18	I	Magnusson *et al.* 1985
	Cnemidophorus sp.	13	I	Mesquita *et al.* 2006
	Colubridae sp.	6	C	dos Santos-Costa *et al.* 2015
	Corallus batesii	2	C	dos Santos-Costa *et al.* 2015

Corallus caninus	3	C	dos Santos-Costa *et al.* 2015
Corallus hortulanus	5	C	dos Santos-Costa *et al.* 2015
Corallus sp.	1	C	dos Santos-Costa *et al.* 2015
Dactyloa punctata	1	I	Vitt *et al.* 1999
Dactyloa sp.	1	I	Vitt *et al.* 1999
Dipsadidae sp.	2	C	dos Santos-Costa *et al.* 2015
Dipsas catesbyi	2	C	dos Santos-Costa *et al.* 2015
Dipsas indica	1	C	Ray *et al.* 2012
Drepanoides anomalus	4	C	dos Santos-Costa *et al.* 2015
Drymarchon corais	2	C	da Costa-Prudente *et al.* 2014
Drymoluber dichrous	1	C	dos Santos-Costa *et al.* 2015
Epicrates cenchria	12	C	dos Santos-Costa *et al.* 2015
Erythrolamprus aesculapii	2	C	dos Santos-Costa *et al.* 2015
Erythrolamprus reginae	2	C	dos Santos-Costa *et al.* 2015
Erythrolamprus sp.	6	C	dos Santos-Costa *et al.* 2015
Erythrolamprus taeniogaster	2	C	dos Santos-Costa *et al.* 2015
Erythrolamprus typhlus	2	C	Turci *et al.* 2021
Eunectes murinus	8	C	dos Santos-Costa *et al.* 2015
Hydrodynastes gigas	1	C	dos Santos-Costa *et al.* 2015
Iguana iguana	14	H	Govender *et al.* 2012
Imantodes cenchoa	13	C	dos Santos-Costa *et al.* 2015
Leptodeira annulata	17	C	dos Santos-Costa *et al.* 2015
Leptophis ahaetulla	19	C	dos Santos-Costa *et al.* 2015
Mastigodryas boddaerti	11	C	dos Santos-Costa *et al.* 2015
Mastigodryas sp.	1	C	Marques & Muriel 2007
Micrurus averyi	1	C	dos Santos-Costa *et al.* 2015
Micrurus hemprichii	1	C	dos Santos-Costa *et al.* 2015
Micrurus lemniscatus	3	C	dos Santos-Costa *et al.* 2015

Micrurus sp.	1	C	dos Santos-Costa *et al.* 2015
Micrurus spixii	2	C	Sanz *et al.* 2019
Oxybelis aeneus	12	C	dos Santos-Costa *et al.* 2015
Oxybelis fulgidus	28	C	dos Santos-Costa *et al.* 2015
Oxybelis sp.	3	C	dos Santos-Costa *et al.* 2015
Oxyrhopus melanogenys	8	C	dos Santos-Costa *et al.* 2015
Oxyrhopus petolarius	1	C	Dubeux *et al.* 2020
Paleosuchus palpebrosus	1	C	Araújo 2017
Paleosuchus sp.	6	C	Magnusson *et al.* 1987
Paleosuchus trigonatus	4	C	Magnusson *et al.* 1987
Philodryas viridissima	1	C	dos Santos-Costa *et al.* 2015
Phrynonax poecilonotus	1	C	dos Santos-Costa *et al.* 2015
Polychrus marmoratus	1	I	Sierra-Rueda 2021
Pseudoboa coronata	10	C	dos Santos-Costa *et al.* 2015
Pseudoboa neuwiedii	27	C	Torres-Bonilla *et al.* 2017
Pseudoboa sp.	5	C	dos Santos-Costa *et al.* 2015; Torres-Bonilla *et al.* 2017
Rhinoclemmys punctularia	1	O	Wariss *et al.* 2012
Rhinoclemmys sp.	1	O	Seguro 2021
Siphlophis cervinus	1	C	dos Santos-Costa *et al.* 2015
Siphlophis compressus	3	C	Turci *et al.* 2021
Spilotes pullatus	2	C	dos Santos-Costa *et al.* 2015
Spilotes sulphureus	2	C	dos Santos-Costa *et al.* 2015
Taeniophallus brevirostris	1	C	dos Santos-Costa *et al.* 2015
Taeniophallus sp.	1	C	dos Santos-Costa *et al.* 2015
Tantilla melanocephala	11	C	dos Santos-Costa *et al.* 2015
Tupinambis sp.	1	O	Monteiro & Abe 1997
Xenodon rabdocephalus	1	C	dos Santos-Costa *et al.* 2015

Appendix S4

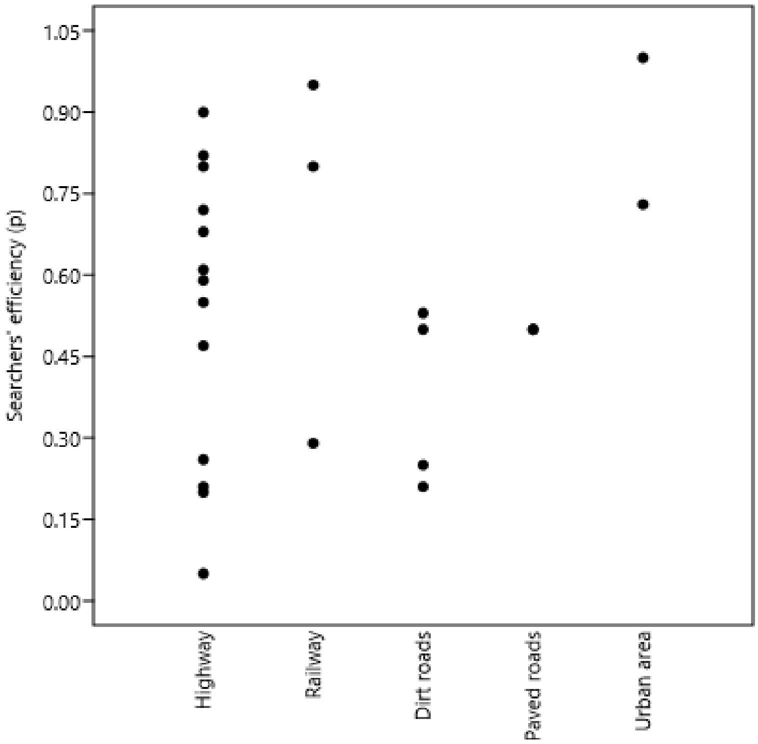


Figure S4. Observer efficiency values (p) found in the literature by road types. Each point represents an observer efficiency value found in the literature for each type of road.

Appendix S5

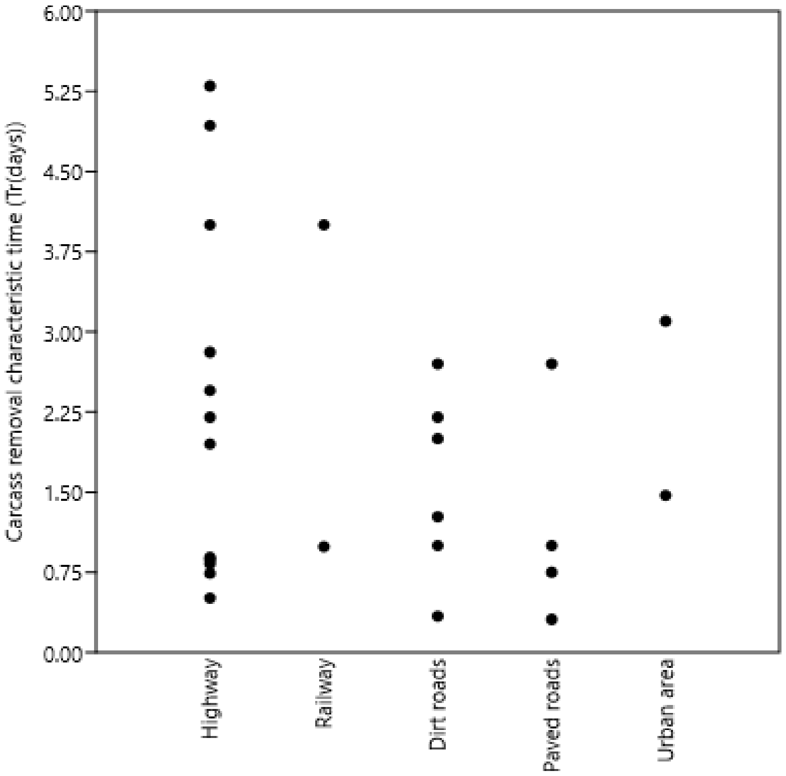


Figure S5. Characteristic carcass removal time (TR) values in days found in the literature road types. Each point represents a distinct carcass removal time value in days found in the literature for each type of road.

Appendix S6

Minimum, maximum, and median values were calculated for the observation method efficiency (p) in different types of roads in the Saracá-Taquera National Forest, in Pará State, Brazil. Data was collected from the consulted literature (see text for details).

	Observation method efficiency (p)		
Roads types	**Minimum**	**Maximum**	**Median**
Urban area	0,73	1	0,865
Highway	0,05	0,9	0,59
Railway	0,29	0,95	0,8
Paved road	0,5	0,5	0,5
Unpaved road	0,21	0,53	0,375

Appendix S7

Minimum, maximum, and median values were calculated for the carcass removal characteristic time (TR) in days in different road types in the Saracá-Taquera National Forest, in Pará State, Brazil. Data was collected from the consulted literature (see text for details).

	Carcass removal characteristic time (TR)		
Roads types	**Minimum**	**Maximum**	**Median**
Urban area	1,47	3,1	2,285
Highway	0,51	5,3	2,075
Railway	0,99	4	2,495
Paved road	0,31	2,7	0,875
Unpaved road	0,34	2,7	1,635

References

Abreu K. C., Moro-Rios R. F., Silva-Pereira J. E., Miranda J., Jablonski E. F. & Passos F. C. (2008) Feeding habits of ocelot (*Leopardus pardalis*) in Southern Brazil. *Mammalian Biology*. *73*(5), 407- 411.

Almeida B. C., Santos R. S., Dos Santos T. F., de Souza M. B. & Menin M. (2019) Diet of five anuran species in a forest remnant in eastern Acre state, Brazilian Amazonia. *Herpetology Notes. 12*, 945- 952.

Alves G. A. & Toledo L. F. (2017) Food items in the rheophilic Torrent Frog *Megaelosia apuana* (Anura; Hylodidae). *Herpetology Notes. 10*, 535- 536.

AmphibiaWeb (2022) *Amphibia Web.* Universidade da Califórnia, Berkeley, CA, EUA. https://amphibiaweb.org (Accessed: 4 October 2022).

Araújo D. D. (2017) Snakes as prey of Cuvier's Dwarf Caiman (*Paleosuchus palpebrosus*: Alligatoridae), with a new observation from central Amazonia, Brazil. *Herpetology Notes*. *10*, 169- 171.

Arnone I. S., Trajano E., Pulchério-Leite A. & Passos F. D. C. (2016) Long-distance movement by a great fruit-eating bat, *Artibeus lituratus* (Olfers, 1818), in southeastern Brazil (Chiroptera, Phyllostomidae): evidence for migration in Neotropical bats?. *Biota Neotropica. 16*.

Ascensão F., Yogui D. R., Alves M. H., Alves A. C., Abra F. & Desbiez A. L. (2021) Preventing wildlife roadkill can offset mitigation investments in short-medium term. *Biological Conservation. 253*, 108902.

Avila-Pires T. C., Hoogmoed M. S. & Vitt L. J. (2007) Herpetofauna da Amazônia. *Herpetologia no Brasil II*. 13- 43.

Bisbal E. F. J. (1986) Food habits of some neotropical carnivores in Venezuela (Mammalia, Carnivora).

Blanco-Torres A., Duré M. & Bonilla M. A. (2017) Trophic ecology of *Scinax rostratus* (Peters, 1863) and *Scinax ruber* (Laurenti, 1768) (Anura: Hylidae) in tropical dry forests of northern Colombia. *Herpetology Notes.* 10, 405- 409.

Bonvicino C. E. A., Oliveira J. D. & D'Andrea P. S. (2008) Guia dos roedores do Brasil, com chaves para gêneros baseadas em caracteres externos. *Série de Manuais Técnicos. 11*.

Caballero-Martínez L. A., Rivas-Manzano I. V. & Aguilera-Gomez L. I. (2009) Feeding habits of *Anoura geoffroyi* (Chiroptera: Phyllostomidae) in Ixtapan del Oro, Mexico State. *Acta zoológica mexicana. 25*(1), 161- 175.

Carciofi A. C., Prada F. & Cassaro K. (1995) Alimentação do bicho preguiça (*Bradypus tridactylus*). Digestibilidade da embaúba (Cecropia sp.)-nota prévia. *Arquivos da Sociedade de Zoológicos do Brasil*. 13, 14- 16.

Carvalho-e-Silva S. P., Carvalho-e-Silva A. M. P. T. & Luna-Dias C. (2015) Anfíbios (Lissamphibia) da Reserva Biológica de Pedra Talhada. *Boissiera*. *68,* 334- 355.

Chivers D. J. & Hladik C. M. (1980) Morphology of the gastrointestinal tract in primates: comparisons with other mammals in relation to diet. *Journal of morphology*. *166*(3), 337- 386.

Colli G. R. & Zamboni D. S. (1999) Ecology of the worm-lizard *Amphisbaena alba* in the Cerrado of Central Brazil. *Copeia*. 733- 742.

Cooper Jr W. E. & Vitt L. J. (2002) Distribution, extent, and evolution of plant consumption by lizards. *Journal of Zoology*. *257*(4), 487- 517.

Cordero R. G. A. & Nicolas R. A. (1987) Feeding habits of the opossum (*Didelphis marsupialis*) in Northern Venezuela. *Fieldiana Zoology New Series*. 39: 125- 131.

da Costa-Prudente A. L., Costa-Menks A., da Silva F. M. & Maschio G. F. (2014) Diet and reproduction of the Western indigo snake *Drymarchon corais* (Serpentes: Colubridae) from the Brazilian Amazon. *Herpetological Notes*. *7,* 99- 108.

Damásio L., Ferreira L. A., Pimenta V. T., Paneto G. G., dos Santos A. R., Ditchfield A. D., ... & Banhos A. (2021) Diversity and abundance of roadkilled bats in the Brazilian Atlantic Forest. *Diversity*. *13*(7), 335.

Dasoler B. T., Kindel A., Beduschi J., Biasotto L. D., Dornas R. A., Gonçalves L. O., ... & Teixeira F. Z. (2020) The need to consider searcher efficiency and carcass persistence in railway wildlife fatality studies. *European Journal of Wildlife Research. 66*(5), 1- 6.

de Castro I. R. W., Testa C. A. E. P., Silva D. C., dos Santos G. J., Hippólito A. G. & Melchert A. (2018) Condição nutricional e sugestão de padrão alimentar para *Chelonoidis* sp. *Archives of Veterinary Science*. *23*(3Esp).

de Oliveira L. Q., Marciente R., Magnusson W. E. & Bobrowiec P. E. D. (2015) Activity of the insectivorous bat *Pteronotus parnellii* relative to insect resources and vegetation structure. *Journal of Mammalogy*. *96*(5), 1036- 1044.

do Couto A. P., Da Silveira R., Soares A. V. & Menin M. (2018) Diet of the Smoky Jungle Frog *Leptodactylus pentadactylus* (Anura, Leptodactylidae) in an urban forest fragment and in a pristine forest in Central Amazonia, Brazil. *Herpetology Notes. 11*, 519- 525.

Dornas R. A. P., Teixeira F. Z., Gonsioroski G. & Nóbrega R. A. (2019) Strain by the train: Patterns of toad fatalities on a Brazilian Amazonian railroad. *Science of the Total Environment*. 660, 493– 500.

Dos Reis N. R., Peracchi A. L., Pedro W. A. & de Lima I. P. (Eds.). (2007) *Morcegos do brasil*. Universidade Estadual de Londrina.

dos Santos-Costa M. C., Maschio G. F. & Ana L. (2015) Natural history of snakes from Floresta Nacional de Caxiuanã „, eastern Amazonia, Brazil. *Herpetology Notes*. *8,* 69- 98.

Dubeux M. J. M., Gonçalves U. & Mott T. (2020) Records of predation on *Ophiodes striatus* (Spix, 1824)(Squamata: Diploglossidae) by *Oxyrhopus petolarius* (Linnaeus, 1758)(Squamata: Dipsadidae) in the northern Atlantic Forest, Brazil. *Cuadernos de Herpetología*. *34*.

Dubost G. & Henry O. (2006) Comparison of diets of the acouchy, agouti and paca, the three largest terrestrial rodents of French Guianan forests. *Journal of Tropical Ecology*. *22*(6), 641- 651.

Dunn J. C., Cristóbal-Azkarate J. & Veà J. J. (2009) Differences in diet and activity pattern between two groups of Alouatta palliata associated with the availability of big trees and fruit of top food taxa. *American Journal of Primatology: Official Journal of the American Society of Primatologists. 71*(8), 654- 662.

Emmons L. H. & Feer F. (1997) Neotropical Rainforest Mammals, a Field Guide. University of Chicago Press, Chicago, 307 p.

Ernest K. A. (1986) *Nectomys squamipes*. *Mammalian species*. (265), 1- 5.

Franceschi I. C., Gonçalves L. O., Kindel A., & Trigo T. C. (2021) Mammalian fatalities on roads: how sampling errors affect road prioritization and dominant species influence spatiotemporal patterns. *European Journal of Wildlife Research. 67*(6), 1- 11.

Garcia de la Morena E. L., Malo J. E., Hervas I., Mata C., Gonzalez S., Morales R. & Herranz J. (2017) On-board video recording unravels bird behavior and mortality produced by high-speed trains. *Frontiers in Ecology and Evolution. 5*, 117.

Gomes A. J. B., Nagamachi C. Y., Rodrigues L. R. R., Benathar T. C. M., Ribas T. F. A., O'Brien P. C. M., ... & Pieczarka J. C. (2016) Chromosomal phylogeny of Vampyressine bats (Chiroptera, Phyllostomidae) with description of two new sex chromosome systems. *BMC Evolutionary Biology*. *16*(1), 1- 11.

Gonçalves L. O., Alvares D. J., Teixeira F. Z., Schuck G., Coelho I. P., Esperandio I. B. & Kindel A. (2018) Reptile road-kills in Southern Brazil: Composition, hot moments and hotspots. *Science of the Total Environment*. 615, 1438– 1445.

Govender Y., Muñoz M. C., Camejo L. R., Puente-Rolón A. R., Cuevas E. & Sternberg L. (2012) An isotopic study of diet and muscles of the green iguana (*Iguana iguana*) in Puerto Rico. *Journal of Herpetology*. *46*(2), 167- 170.

Henry O. (1999) Frugivoria e a importância das sementes na dieta da cutia-da-serra (*Dasyprocta leporina*) na Guiana Francesa. *Journal of Tropical Ecology*. *15* (3), 291- 300.

Henry D. A., Collinson-Jonker W. J., Davies-Mostert H. T., Nicholson S. K., Roxburgh L. & Parker D. M. (2021) Optimising the cost of roadkill surveys based on an analysis of carcass persistence. *Journal of Environmental Management*. *291*, 112664.

Hubbard K. A., & Chalfoun A. D. (2012) An experimental evaluation of potential scavenger effects on snake road mortality detections. *Herpetological Conservation and Biology. 7*(2), 150- 156.

Kummer J., Nordell C., Berry T., Collins C., Tse C. & Bayne E. (2016) Use of bird carcass removals by urban scavengers to adjust bird-window collision estimates. *Avian Conservation and Ecology. 11*(2).

Landry Jr S. O. (1970) The Rodentia as omnivores. *The Quarterly Review of Biology*. *45*(4), 351- 372.

Lessa L. G. & Geise L. (2010) Hábitos alimentares de marsupiais didelfídeos brasileiros. *Oecologia Australis. 14*(4), 901- 910.

Lima L. L. C., Oliveira J. P. S., Silva L. E. B. & dos Santos C. B. (2019) Características gerais dos anfíbios anuros e sua biodiversidade. *Diversitas Journal*. *4*(3), 774- 789.

Lobova T. A., Geiselman C. K., Mori S. A. (2009) Seed dispersal by bats in the Neotropics. New York Botanical Garden Press. 465 p.

Lopes M. S., Bovendorp R. S., Moraes G. J. D., Percequillo A. R. & Bertoluci J. (2017) Diversity of ants and mites in the diet of the Brazilian frog *Chiasmocleis leucosticta* (Anura: Microhylidae). *Biota Neotropica. 17*.

Maestri R., Monteiro L. R., Fornel R., Upham N. S., Patterson B. D. & Freitas T. R. O. (2017) A ecologia de uma radiação evolutiva continental: a radiação de roedores sigmodontine é adaptativa? *Evolução*. 71- 3 , 610- 632.

Magnusson W. E., de Paiva L. J., da Rocha R. M., Franke C. R., Kasper L. A. & Lima A. P. (1985) The correlates of foraging mode in a community of Brazilian lizards. *Herpetologica*. 324- 332.

Magnusson W. E., da Silva E. V. & Lima A. P. (1987) Diets of Amazonian crocodilians. *Journal of Herpetology*. 85- 95.

Marques O. A. & Muriel A. P. (2007) Reproductive biology and food habits of the swamp racer *Mastigodryas bifossatus* from southeastern South America. *The Herpetological Journal*. *17*(2), 104- 109.

Maschio G. F., Prudente A. L. D. C., Rodrigues F. D. S. & Hoogmoed M. S. (2010) Food habits of *Anilius scytale* (Serpentes: Aniliidae) in the Brazilian Amazonia. *Zoologia (Curitiba)*. *27*, 184- 190.

Mesquita D. O., Costa G. C. & Colli G. R. (2006) Ecology of an Amazonian savanna lizard assemblage in Monte Alegre, Pará state, Brazil. *South American Journal of Herpetology*. *1*(1), 61- 71.

Miranda F., Veloso R., Superina M. & Zara F. J. (2009) Food habits of wild silky anteaters (*Cyclopes didactylus*) of São Luis do Maranhão, Brazil. *Edentata*. *2009*(10), 1- 5.

Monteiro L. R. & Abe A. S. (1997) Allometry and morphological integration in the skull of *Tupinambis merianae* (Lacertilia: Teiidae). *Amphibia-Reptilia*. *18*(4), 397- 405.

Moser C. F., Oliveira M. D., Avila F. R. D., Dutra-Araújo D., Farina R. K. & Tozetti A. M. (2019) Dieta e sobreposição de nicho trófico de *Boana bischoffi* e *Boana marginata* (Anura: Hylidae) no sul do Brasil. *Biota Neotropica. 19*(1).

Mosquera D., Vinueza-Hidalgo G. & Blake J. G. (2019) Patterns of mineral lick visitation by Linnaeus's two-toed sloth *Choloepus didactylus* (Pilosa, Megalonychidae) in eastern Ecuador. *Notas sobre Mamíferos Sudamericanos. 1*.

Novaes R. L. M., Laurindo R. S., Dornas R. A., Esbérard C. E. L. & Bueno C. (2018) On a collision course: the vulnerability of bats to roadkills in Brazil. *Mastozoología neotropical*. *25*(1), 115- 128.

Pacheco D. L. K., Coelho I., Anza R. & Teixeira F. Z. (2013) Distribuição espacial de mortalidade de fauna por atropelamento em um trecho da rodovia BR-101.

Pavan A. C. & da C. Tavares V. (2020) *Pteronotus gymnonotus* (Chiroptera: Mormoopidae). *Mammalian Species*. *52*(990), 40- 48.

Pinheiro P. F. (2016) Entendendo o viés de detecção nos atropelamentos de fauna: avaliação de método, variação entre os observadores e atributos das carcaças.

Pinheiro T., Ferrari S. F. & Lopes M. A. (2013) Activity budget, diet, and use of space by two groups of squirrel monkeys (*Saimiri sciureus*) in eastern Amazonia. *Primates*. *54*(3), 301- 308.

Plante J., Jaeger J. A. & Desrochers A. (2019) How do landscape context and fences influence roadkill locations of small and medium-sized mammals? *Journal of environmental management. 235*, 511- 520.

Ponce C., Alonso J. C., Argandoña G., García Fernández A. & Carrasco M. (2010) Carcass removal by scavengers and search accuracy affect bird mortality estimates at power lines. *Animal Conservation. 13*(6), 603- 612.

Ramos V. & Facure K. (2009) Ecologia alimentar de *Calomys tener* (Rodentia, Cricetidae) em áreas naturais de Cerrado. In *Anais do III Congresso Latino Americano de Ecologia, São Lourenço, MG*.

Ray J. M., Montgomery C. E., Mahon H. K., Savitzky A. H. & Lips K. R. (2012) Goo-eaters: diets of the neotropical snakes *Dipsas* and *Sibon* in Central Panama. *Copeia*. *2012*(2), 197- 202.

Riding C. S. & Loss S. R. (2018) Factors influencing experimental estimation of scavenger removal and observer detection in bird–window collision surveys. *Ecological Applications. 28*(8), 2119- 2129.

Salinas-Ramos V. B., Herrera Montalvo L. G., León-Regagnon V., Arrizabalaga-Escudero A., & Clare E. L. (2015) Dietary overlap and seasonality in three species of mormoopid bats from a tropical dry forest. *Molecular Ecology*. *24*(20), 5296- 5307.

Santos R. A. L., Santos S. M., Santos-Reis M., De Figueiredo A. P., Bager A., Aguiar L. M. S. & Ascensão F. (2016) Carcass Persistence and Detectability: Reducing the Uncertainty Surrounding Wildlife-Vehicle Collision Surveys. *PLoS ONE.* 11(11).

Santos R. A. L. & Ascensão F. (2019) Assessing the effects of road type and position on the road on small mammal carcass persistence time. *European Journal of Wildlife Research*. *65*(1), 1- 5.

Sanz L., de Freitas-Lima L. N., Quesada-Bernat S., Graça-de-Souza V. K., Soares A. M., Calderon L. D. A., ... & Caldeira C. A. (2019) Comparative venomics of Brazilian coral snakes: *Micrurus frontalis*, *Micrurus spixii spixii*, and *Micrurus surinamensis*. *Toxicon*. *166,* 39- 45.

Seguro A. M. S. (2021) O primeiro registro de alimentação onívora e necrófaga da Tartaruga do Rio Negro *Rhinoclemmys funerea* (Testudines: Geoemydidae) na Estação de Pesquisa La Selva na Costa Rica. *Herpetology Notes*. *14* , 1319- 1321.

Serrano-Fochs S., De Esteban-Trivigno S., Marce-Nogue J., Fortuny J. & Fariña R. A. (2015) Finite element analysis of the Cingulata jaw: an ecomorphological approach to armadillo's diets. *PloS one. 10*(4), e0120653.

Sierra-Rueda A. (2021) Common Bush-Anole (*Polychrus marmoratus*).

Silva L. P., Santana L. M. & de Melo F. R. (2021) Effect of Seasonality on the Feeding Behavior of Martins' Bare-faced Tamarin *Saguinus martinsi martinsi* (Primates: Callitrichidae) in the Brazilian Amazon. *Primate Conservation*. *35*, 37- 45.

Sun N. C. M., Lin C. C., Liang C. C. & Li H. F. (2022) Diet composition of an escaped captive-born southern tamandua (*Tamandua tetradactyla*) in a nonnative habitat in Asia. *Ecology and Evolution*. *12*(8), e9175.

Tavares A. S., Morcatty T. Q., Zuanon J. & Magnusson W. E. (2019) Influence of body size, topography, food availability and tree-fall gaps on space use by yellow-footed tortoises (*Chelonoidis denticulatus*) in Central Amazonia. *PloS one*. *14*(2), e0211869.

Teixeira F. Z., Coelho A. V. P., Esperandio I. B. & Kindel A. (2013) Vertebrate road mortality estimates: Effects of sampling methods and carcass removal. *Biological Conservation*. 157, 317– 323.

Thomassen H. & Ziade C. F. (2020) *Guia Ilustrado de Répteis e Anfíbios da Área de Influência da Usina Hidrelétrica de Emborcação.*

Thorbjarnarson J. B. (1993) Diet of the spectacled caiman (*Caiman crocodilus*) in the central Venezuelan llanos. *Herpetologica*. 108- 117.

Torralvo K., Lima A. P., Fraga R. D. & Magnusson W. E. (2021) *Guia de sapos da Floresta Nacional do Tapajós.*

Torres-Bonilla K. A., Floriano R. S., Schezaro-Ramos R., Rodrigues-Simioni L. & da Cruz-Höfling M. A. (2017) A survey on some biochemical and pharmacological activities of venom from two Colombian colubrid snakes, *Erythrolamprus bizona* (Double-banded coral snake mimic) and *Pseudoboa neuwiedii* (Neuwied's false boa). *Toxicon*. *131*, 29- 36.

Turci L. C. B., Machado R. A. & Bernarde P. S. (2021) Snake assemblage in an unflooded forest in western Brazilian amazon.

Ungar P. S., Hartgrove C. L., Wimberly A. N. & Teaford M. F. (2017) Dental topography and microwear texture in *Sapajus apella*. *Biosurface and Biotribology*. *3*(4), 124- 134.

Vitt L. J., Zani P. A. & Espósito M. C. (1999) Historical ecology of Amazonian lizards: implications for community ecology. *Oikos*. 286- 294.

Wariss M., Isaac V. J. & Brito Pezzuti J. C. (2012) Habitat use, size structure and sex ratio of the spot-legged turtle, *Rhinoclemmys punctularia punctularia* (Testudines: Geoemydidae), in Algodoal-Maiandeua Island, Pará, Brazil. *Revista de Biología Tropical*. *60*(1), 413- 424.

WikiAves (2022) *WikiAves, a Enciclopédia das Aves do Brasil*. http://www.wikiaves.com.br/ (Accessed: 4 October 2022).

Wilson D. E. & Reeder D. M. (Eds.). (2005) *Mammal species of the world: a taxonomic and geographic reference* (Vol. 1). JHU press.

Zucaratto R., Carrara R. & Franco B. K. S. (2010) Dieta da paca (*Cuniculus paca*) usando métodos indiretos numa área de cultura agrícola na Floresta Atlântica brasileira. *Biotemas*. *23*(1), 235- 239.

Acadêmicas.

Comentários à coordenação do PPGBEES:
Parabenizo a aluna de mestrado ANDRÉA COELI GOMES DE LUCENA COSTA pelo seu trabalho. O estudo realizado é importante e contribui com o conhecimento na área da ecologia de estradas, especialmente para uma região onde há poucos estudos. Os dados obtidos e apresentados são interessantes, e foram bem explorados analiticamente visando descrever o padrão de fatalidades em diferentes tipos de estradas. A dissertação está adequada à obtenção do grau de mestre e, visando a qualificação do trabalho, fiz uma série de comentários e sugestões ao longo do texto que envio em arquivo anexo.

Avaliação final do projeto de dissertação de mestrado
I - Aprovada (X) Aprovada: indica que o revisor aprova a dissertação sem ou com correções. Na existência de correções, estas devem ser indicadas nos comentários à coordenação e/ou no próprio documento da dissertação. **IV - Reprovada (   )** Reprovada: indica que a dissertação não é adequada.

Nome do membro da banca: Fernanda Zimmermann Teixeira

Data: 04/12/2022

Assinatura:

gov.br Documento assinado digitalmente
FERNANDA ZIMMERMANN TEIXEIRA
Data: 04/12/2022 16:41:47-0300
Verifique em https://verificador.iti.br

conforme artigo 60 deste regimento, sob pena de não diplomação até que a versão final seja devidamente submetida no Sistema de Gestão de Atividades Acadêmicas.

Comentários à coordenação do PPGBEES:
A dissertação está muito boa e a altura de um trabalho de mestrado. É possível observar que o trabalho foi conduzido com atenção e cuidado. Porém, ainda existem pontos a serem melhorados, alguns para a entrega da dissertação final em si e outros mais voltados para publicação de artigo científico.
Na introdução geral senti falta de falar sobre a importância do trabalho.
No capítulo da dissertação em si, tanto introdução como discussão precisam de reestruturação da ordem das informações. A introdução como um todo está satisfatória de conteúdo, porém a discussão ainda está um pouco confusa e sem uma direção clara e, essa ultima, precisa ser melhorada tanto para entrega da dissertação como para o artigo.
Na metodologia e resultados algumas coisas não estão claras, como se, por exemplo, as taxas de atropelamento foram testadas de forma separada para cada rota de transporte e a análise das guildas, se foi feita separadamente para cada grupo. No meu ver a análise de guildas é um dos diferencias do trabalho, mas também é a análise/discussão que precisa ainda de muitas melhorias, sobretudo para publicação de um artigo de nível internacional.
Mais detalhes podem ser vistos direto no arquivo da dissertação revisado e enviado anexo.
Apesar das críticas aqui pontuadas, gostaria de reiterar que a discente se propôs a fazer um trabalho bem ambicioso para um trabalho de mestrado e mesmo está de fato muito bom e tanto a discente, como seu orientador, estão de parabéns pelo excelente trabalho desenvolvido.

Avaliação final do projeto de dissertação de mestrado

I - Aprovada (X)

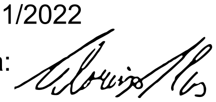
Aprovada: indica que o revisor aprova a dissertação sem ou com correções. Na existência de correções, estas devem ser indicadas nos comentários à coordenação e/ou no próprio documento da dissertação.

IV - Reprovada (   )

Reprovada: indica que a dissertação não é adequada.

Nome do membro da banca: Clarissa Alves da Rosa

Data: 08/11/2022

Assinatura: 

Comentários à coordenação do PPGBEES:
A dissertação aborda um importante efeito das estradas (as colisões entre veículos e fauna), em uma região mega diversa, inserida em um contexto de impactos gerados por uma mineração. Achei bastante interessante a proposta de publicação da introdução geral e por se tratar de um público jovem, sugiro algumas inclusões de parágrafos mais gerais (estão no documento). Sobre o primeiro capítulo achei bem interessante as relações exploradas e também a discussão sobre valores observados e valores estimados de número de animais mortos em estruturas viárias. Entretanto, recomendo fortemente que as sugestões sejam consideradas, pois faltam informações importantes para entender os métodos tanto de coleta quanto de análise mais claramente. Além disso, há algumas limitações metodológicas, principalmente em relação ao uso dos dados secundários dos erros amostrais. Houve um confundimento entre os dados obtidos, pois cada artigo compilado obteve a informação com um tipo de método e não necessariamente os valores utilizados referem-se ao tempo característico de remoção descrito e nem estão na unidade utilizada (dias). Ainda, recomendo fortemente que haja uma revisão do inglês por profissional da área, pois há muitos erros de tradução e concordância.
Como sugestão final acho que o capítulo único da dissertação poderia se tornar dois:

1- um poderia ser explorar os padrões temporais, espaciais e as relações com variáveis climáticas, dos tipos de via e das espécies. Utilizando os valores observados de atropelamentos.
2- E outro poderia compilar os erros amostrais de dados secundários e fazer as estimativas, utilizando as variações dos valores (mínimo, máximo e média) para tentar chegar a um número de animais mortos mais próximo do real. Trabalhos que salientem a importância de considerarmos os erros amostrais são muito importantes e precisam cada vez mais de visibilidade.

Parabenizo à aluna pelo importante trabalho gerado em uma região tão importante do nosso país.
Agradeço o convite e fico à disposição para qualquer dúvida.

Avaliação final do projeto de dissertação de mestrado

I - Aprovada (X) com correções importantes indicadas no documento da dissertação revisado e enviado.

Aprovada: indica que o revisor aprova a dissertação sem ou com correções. Na existência de correções, estas devem ser indicadas nos comentários à coordenação e/ou no próprio documento da dissertação.

IV - Reprovada ( )

Reprovada: indica que a dissertação não é adequada.

Nome do membro da banca: Larissa Oliveira Gonçalves

Data: 29/11/2022

Assinatura:

gov.br
Documento assinado digitalmente
LARISSA OLIVEIRA GONCALVES
Data: 29/11/2022 11:49:45-0300
Verifique em https://verificador.iti.br

Comentários à coordenação do PPGBEES:

Parabéns à autora e orientador pela dissertação. Ainda há muito que trabalhar para reduzir a quantidade de informações apresentadas e focar no que realmente é importante: as questões científicas. Muitas figuras e tabelas podem e devem ser mantidas como material suplementar. É importante checar novamente as normas da revista. Importante, também, enviar a versão final e mais enxuta para uma nova revisão do inglês por uma empresa profissional, especializada em artigos científicos. Vejam diversos outros comentários no texto.

Avaliação final do projeto de dissertação de mestrado

I - Aprovada (x)

Aprovada: indica que o revisor aprova a dissertação sem ou com correções. Na existência de correções, estas devem ser indicadas nos comentários à coordenação e/ou no próprio documento da dissertação.

IV - Reprovada ( )

Reprovada: indica que a dissertação não é adequada.

Nome do membro da banca: Rodrigo Ferreira Fadini

Data: 04/12/2022

Assinatura:

Austral Ecology
A Journal of ecology in the Southern Hemisphere
Ecological Society of Australia

Your Open Access fees might be covered

Effective with the 2019 volume, this journal will be published in an online-only format.

There is no charge to publish your research in *Austral Ecology*. The journal offers authors an open access option to have their article immediately freely available to everyone, including those who don't subscribe. To cover the cost of publishing Open Access, authors pay an article publication charge (APC). For more information about this journal's APC's, please visit the Open Access Page.

Print subscription and single issue sales are available from Wiley's Print-on-Demand Partner. To order online click through to the ordering portal from the journal's subscribe and renew page on WOL.

Contents

1. SUBMISSION

Thank you for your interest in *Austral Ecology*. Please read the complete Author Guidelines carefully prior to submission. Note that submission implies that the content has not been published or submitted for publication elsewhere except as a brief abstract in the proceedings of a scientific meeting or symposium.

Austral Ecology now offers Free Format submission for a simplified and streamlined submission process allowing researchers to submit their manuscript in their preferred formatting style at original submission. See details in Section 4. PREPARING YOUR MANUSCRIPT FOR SUBMISSION.

Manuscripts should be submitted online at https://mc.manuscriptcentral.com/aec.

The submission system will prompt you to use an ORCiD (a unique author identifier) to help distinguish your work from that of other researchers. Click here to find out more.

Click here for more details on how to use ScholarOne.

For help with submissions, please contact: AECEditor@wiley.com

If you are considering sending your Article to *Austral Ecology*, but are unsure of the quality of your manuscript, you can send a preprint to Peer Community in Ecology for an initial assessment. Peer Community in Ecology is a community of recommenders playing the role of editors who recommend unpublished articles based on peer-reviews to make them complete, reliable and citable articles. Evaluation and recommendation by PCI Ecology are free of charge.

https://ecology.peercommunityin.org/

We look forward to your submission.

2. AIMS AND SCOPE

Austral Ecology is the premier journal for fundamental and applied ecology in the Southern Hemisphere. *Austral Ecology* publishes original papers describing experimental, observational or theoretical studies on terrestrial, marine or freshwater systems, which are considered without taxonomic bias. We welcome ecologically relevant studies that incorporate physiological, genetics, life-history, and behavioural perspectives for organismal studies; through to community and biogeochemical studies when addressing ecosystem- and landscape-scale questions.

Special thematic issues are published regularly, including those resulting from symposia and workshops.

The editorial board of *Austral Ecology* involves an international group of representatives from Africa, Oceania, and South America. These representatives provide expert opinions, access to qualified reviewers and act as a focus for attracting a wide range of contributions.

As the official Journal of **The Ecological Society of Australia (ESA)**, *Austral Ecology* addresses the commonality among ecosystems across the globe, with a special focus in ecosystems in the southern hemisphere. ESA's aim is to publish innovative research to encourage the sharing of information and experiences that enrich the understanding of the ecology of the Southern Hemisphere.

Objetivos e Escopo

Austral Ecology é a principal revista de ecologia básica e aplicada do hemisfério sul. *Austral Ecology* publica artigos originais descrevendo estudos experimentais, observacionais ou teóricos em sistemas terrestres, marinhos ou dulcícolas, os quais são considerados sem viés taxonômico ou regional. Aceitamos submissões de estudos ecologicamente relevantes que incorporem perspectivas fisiológicas, genéticas, de história de vida e comportamentais para estudos sobre organismos, comunidades e biogeoquímica que abordem questões em escala de ecossistema e paisagem.

Edições temáticas especiais são publicadas regularmente, incluindo aquelas resultantes de simpósios e workshops.

O corpo editorial da *Austral Ecology* é representado por pesquisadores da África, América do Sul e Oceania. Os editores fornecem avaliações especializadas, acesso a revisores qualificados e são pontos focais para atração de uma ampla gama de contribuições de diferentes países na região.

Como a revista oficial da Sociedade de Ecologia da Austrália (ESA), *Austral Ecology* trata das semelhanças entre ecossistemas ao redor do planeta, com foco especial em ecossistemas do hemisfério sul. O objetivo da ESA é publicar pesquisas inovadoras para encorajar o compartilhamento de informação e experiências que enriquecem o entendimento da ecologia do hemisfério sul.

Objetivos y Alcances

Austral Ecology es una revista de primera línea en ecología básica y aplicada del hemisferio sur. *Austral Ecology* publica artículos originales que describen estudios experimentales, observacionales o teóricos sobre sistemas terrestres, marinos o de agua dulce, de cualquier grupo taxonómico. Recibimos con agrado, siempre que sean ecológicamente relevantes, trabajos que incorporen perspectivas fisiológicas, biogeoquímicas, genéticas, de historia de vida y de comportamiento, al estudio de organismos, comunidades, ecosistemas y paisajes. También se publican periódicamente números temáticos especiales, incluidos los resultantes de simposios y talleres.

El comité editorial de *Austral Ecology* incluye representantes de Australia, Sudáfrica, Nueva Zelanda, Brasil y Argentina. Esos representantes brindan sus opiniones expertas, convocan revisores calificados y actúan como núcleo para atraer un amplio rango de contribuciones. Como revista oficial de la **Ecological Society of Australia (ESA)**, *Austral Ecology* apunta a identificar patrones y procesos comunes en los ecosistemas de todo el mundo, con un enfoque especial en los ecosistemas del hemisferio sur. La ESA tiene como objetivo publicar investigación innovadora para estimular la integración de información y experiencias que enriquezcan nuestra comprensión de la ecología del hemisferio sur.

3. MANUSCRIPT CATEGORIES AND REQUIREMENTS

Papers routinely are rejected from *Austral Ecology* for not following the guidelines presented below. Please read them carefully; and also read the following editorial: Andrew N. R. (2020) Design flaws and poor language: Two key reasons why manuscripts get rejected from *Austral Ecology* across all countries between 2017 and 2020. *Austral Ecology.* **45**, 505-9.

Word limits do NOT include abstracts, references, tables, figures, acknowledgements and declarations of interest.

Research Article

Original papers describing experimental, observational or theoretical studies on terrestrial, marine or freshwater systems, which are considered without taxonomic bias. Papers are expected to outline a single aim, and then be developed through a series of objectives/questions, which are back up by well-grounded hypotheses.

Abstract: 300 words unstructured

Main text: 7,000 words, not including the abstract, references, tables or figures.

Please see the **Parts of the Manuscript** below for more details

Review Article

Review articles that are brief, synthetic and/or provocative will be considered. Please contact the Editor-in-Chief if you would like to write a review with a pre-submission enquiry - a 300-word proposal identifying the key areas/topics for discussion.

Abstract: 300 words unstructured

Main text: 7,000 words, not including the abstract, references, tables or figures.

Research Note

Shorter research articles with a focussed question and hypothesis. Null results from well-conceived experiments encouraged. Data to be supplied as supplementary material.

Abstract: 200 words, unstructured

Main text word limit: 2,000 words (not including abstract, references, tables and figures)

References: 20 references max.

Figures/tables: Maximum 3 items tables or figures (no more 1 page in total length for both).

Invited Reviews

Review articles that are brief, synthetic and/or provocative are occasionally commissioned by the Editors. These submissions are reviewed under the journal's usual standards. It is normal for there to be some negotiation between the invited author and the commissioning Editor about the content and timing of any invited submission.

Forum

Abstract: N/A

Word limit: 1,000 words, not incl. references, figures or tables

Figures and tables: 2 of each max.

These are short communications presenting opinions on, or responses to, material published in the journal, or hot topics in ecology requiring a rapid response and turnaround.

If relating to a previously published article: Re-analysis of the original data presented in the focal article is encouraged; however new data should not generally be presented. Forums should be submitted promptly, ideally within 12 months of publication of the original article. Forum articles will be assessed by the *Austral Ecology* Editorial Board and, if deemed to be of sufficient broad interest to our readership, will usually be sent for external peer review. If accepted, they will be held from publication while the authors of the original article are invited to respond. Authors of the original article are not required to write a forum response and are given a set time frame if they choose to do so. If accepted, both Forum articles will then be published together in an issue. If factual errors with the data or analyses presented in the original article come to light, these will be investigated before publication of the Forum article(s) and a correction notice will be published either instead of or as well as the Forum article(s).

- Designed to facilitate debate
- Short communications presenting opinions on, or responses to, material published in the journal, or hot topics in ecology requiring a rapid response and turnaround.
- Submitted within 12 months of publication of the original article.
- Will be peer-reviewed if considered to be of sufficiently broad interest to the readership.

Ecological Toolkit

Abstract: 300 words

Main text: 7,000-word limit, not including references, tables and figures.

* Supplementary material (datasets, codes, field notes etc.) expected.

'Ecological Toolkit' articles are instructional papers that aim to serve as a practical guide for ecologists in applying a specific method (e.g. analysis, experimental system or modelling approach) to their research. The aim is not to provide a comprehensive review of the uses of specific models or techniques, nor to review the empirical results of their application to ecological data sets.

Important sections and areas to cover:

<u>Introduction</u>

As with all articles, the introduction should provide ecological context, and in this case setting out the ecological questions and problems that have motivated the use of this method.

<u>Explanation of the method</u>

A very brief historical background. Why is the method useful for investigating or analysing the topic in question? Provide some details on the method's applications.

<u>How to use</u>

Outline the requirements for framing hypotheses, data and computing, experimental constraints and statistical power.

<u>Worked examples</u>

Papers should include at least one tutorial (two ideal), with a step-by step demonstration of the method. Figures and mathematical formulations are particularly useful here. If a new coding package where possible, tutorials and examples should include those using the R statistical package or other freeware with appropriate commentary at major steps throughout the code.

<u>Tools</u>

Describe the available tools (e.g. software) and where they can be obtained. It can be helpful to provide a table giving an overview.

Hands on

You should provide some sample data in the supporting information for readers to try the method for themselves.

Other possibilities and developments

How else may this method be utilised and developed?

Caveats and pitfalls

Limitations and common examples of misuse or misunderstanding of the method, and how to deal with or avoid these in ones' research.

Additional resources

It is helpful to include a section at the end providing links to relevant tutorials, notes, etc.

Natural History Notes

Abstract: 300 words

Main document: 1,500 words (not including abstract or references).

Submissions about animals, plants, fungi, or microorganisms are all welcome. Submissions should consist of at least one striking, high-quality photo/ drawing documenting some interesting or previously unknown aspect of an organism's life cycle or ecology, accompanied by an essay of no more than 1500 words total, explaining why it is scientifically interesting or significant.

• Should be accessible to both scientific and non-scientific communities.

• accompanied by an illustrative photo/ line drawing.

• Illustrate a rare, unusual, or fascinating organism, behaviour, process, or other natural phenomenon that will inspire and engage us in natural history

• Describe something new or important in southern hemisphere ecology that challenges existing theories and points in new directions

• Raise open questions or generate new hypotheses

Hot Topics (by invitation)

Hot Topics in Ecology are timely, evidence-based syntheses of topics that are relevant to environmental policy development and public discourse, land management and more broadly, aimed at increasing an understanding of ecology and its applications in society. Submission is by invitation and full author guidelines can be found **here.**

Acceptance Criteria

1. Normally the paper should relate to ecosystems in the Southern Hemisphere, although general theoretical papers are acceptable, as are those with a Northern Hemisphere basis, but that have implications for Southern Hemisphere ecosystems.

2. The paper can describe studies in terrestrial, aquatic or marine habitats. They can be at a local, regional or global scale but should be set in a broad ecological context, and contribute new information towards some general question. Specifically, we do not publish papers that simply describe an ecosystem or a local ecological pattern. Nor do we publish papers that ask ecological questions that are only relevant to some local region (e.g. how does fire affect plant communities in the Mount Lofty Ranges, South Australia), although local studies that can make new contributions to broader generalisations can be accepted.

3. A review paper should not just list all of the relevant publications but should provide insights, by some novel synthesis or analysis, of trends that can be revealed from previously published research.

4. The paper should ask questions relating to the patterns observed in ecosystems, at the level of the individual organism, the population, the ecological community or the landscape. The study might be motivated by either basic or applied research questions. Sometimes those questions and the derived explanations will have relevance to ecosystem management issues, but the papers in *Austral Ecology* should focus on the science in the study. The results of the study might form the basis for management or policy recommendations, which should be submitted to alternative publishing outlets, such as *Ecological Management and Restoration*.

5. Papers can cover a broad range of ecological topics from landscape ecology and ecosystem dynamics to individual population dynamics and behavioural ecology.

6. The paper needs a logical structure with explicit questions and hypotheses that are addressed by the methods and analysis.

7. Conclusions need to be supported by the results presented.

8. Studies need to be well supported by appropriate statistical analyses that are reported in sufficient detail to allow readers to assess the rigour of the conclusions. Where replication is impractical, the implications for interpretation should be acknowledged.

9. Figures should be well presented and appropriate for the data you are presenting. We will not accept bar charts with error bars – such figures representing distributions are best presented as violin plots/ boxplots, or mean-error plots. Visualising raw data within these plots (e.g. violin and box plots) is highly recommended. Bar charts are appropriate for count data.

10. We encourage raw data, coding for statistical analysis and for graphical presentation to be housed and referenced to on a public data repository such as FigShare.

4. PREPARING YOUR SUBMISSION

Free Format submission

Before you submit, you will need:

- Your manuscript can be a single file including text, figures, and tables, or separate files – whichever you prefer.
  - All required sections relevant to the chosen manuscript type should be contained in your manuscript (eg: abstract, introduction, methods, results, and conclusions etc).
  - Figures and tables should have legends.
  - References may be submitted in any style or format, as long as it is consistent throughout the manuscript, but it is recommended that the journal's style is followed.
  - It is strongly recommended that you follow the guidelines of *Austral Ecology* manuscripts when submitting your first draft. Please do pay close attention to having your references correctly formatted. If references are poorly formatted it can be perceived as a poor reflection on your eye to detail; and a disservice to the reviewers that will be spending a substantive amount of time giving you constructive feedback.
- The title page of the manuscript should include the following, where relevant:
  - data availability statement
  - funding statement
  - conflict of interest disclosure
  - permission to reproduce material from other sources
  - Your co-author details, including affiliation and email address. *(Why is this important? We need to keep all co-authors informed of the outcome of the peer review process.)*

If the manuscript, figures or tables are difficult for you to read, they will also be difficult for the editors and reviewers. If your manuscript is difficult to read, the editorial office may send it back to you for revision.

If you are invited to revise your manuscript after peer review, the journal will also request the revised manuscript to be formatted according to journal requirements as described below.

General Style Points

• Manuscripts should be double-spaced.
• The journal uses UK spelling.
• Before you submit, please make sure that your paper has been edited by a competent English speaker that has a good grasp of scientific English and its nuances. Papers with poor grammar are more likely to be rejected – so to reduce the burden on our reviewers. This enables reviewers to focus on the research primarily presented and not be detracted into fixing grammar and style issues. If you are worried about this, please contact the Editor-in-Chief before submission.
• All measurements must be given in SI units
• Abbreviations should be used sparingly. Initially use the word in full, followed by the abbreviation in parentheses. Thereafter use the abbreviation.
• At the first mention of a chemical substance, give the generic name only.
• Trade names should not be used.
• Continuous line numbering must be enabled in the main document.

Cover letter

Austral Ecology requires all submissions to include a cover letter which contains the following (where applicable):

- manuscript type and title
- confirm that this work is original and has not been published elsewhere, nor is it currently under consideration for publication elsewhere.
- why this manuscript is appropriate for consideration to publish in *Austral Ecology.*
- please explain in your own words: the significance and novelty of the work and the problem that is being addressed. Briefly describe the research you are reporting in your paper, why it is important, and why you think the readership of the journal would be interested in it.
- If the paper has been submitted elsewhere previously, please state the publication(s) it was submitted to. You are also welcome to include the reviewers comments and your response to these. This can speed up the review process substantially.
- Acknowledgment that all authors have contributed to the work.

Parts of the Manuscript

The manuscript should be submitted in separate files: title page; main text file; figures.

Title page

The title page should contain:
(i) a short informative title (ideally no more than 15 words) that contains the major key words. The title should not contain abbreviations nor a question (see Wiley's best practice SEO tips);
(ii) the full names of the authors;
(iii) the author's institutional affiliations at which the work was carried out;
(iv) the full postal and email address, plus telephone number, of the author to whom correspondence about the manuscript should be sent;
(v) acknowledgements.

The present address of any author, if different from that where the work was carried out, should be supplied in a footnote.

Acknowledgements: The source of financial grants and other funding should be acknowledged, including a frank declaration of the authors' industrial links and affiliations. The contribution of colleagues or institutions should also be acknowledged.

Main text

The main text file should be presented in the following order: (i) title, abstract and key words, (ii) main text, (iii) references, (iv) tables (each table complete with title and footnotes) (v) figure legends, (vi) appendices (if relevant). Figures and supporting information should be supplied as separate files.

Footnotes to the text are not allowed and any such material should be incorporated into the text as parenthetical matter.

Abstract
Articles must have an abstract that states in 300 words or less the purpose, basic procedures, main findings and principal conclusions of the study. The abstract should not contain abbreviations or references. The names of organisms used should be given.

Non-English Language Abstracts
Austral Ecology is pleased to incorporate abstracts in other languages and authors are invited to include a version of the abstract, translated into a second language. Translated abstracts will be published online, alongside the English-language version. There are no restrictions on which languages the translation appears in, however the author is responsible for ensuring that the translated text is correct and meets the journal's publishing and ethical requirements.

- Authors are responsible for supplying the translated abstract.
- Include translated abstracts in the main document, under the English-language version.
- Please also indicate the language to which the abstract has been translated.

Keywords
Five key words should be supplied below the abstract for the purposes of indexing.

Text
Authors should use the following subheadings to divide the sections of their manuscript: Introduction, Methods, Results, Discussion, Species Nomenclature, Acknowledgements, References. These sections of the text should be less than 7,000 words (not including references, tables and figures).

Introduction: This section should include sufficient background information to set the work in context. The aims of the manuscript, and why this aim of broad ecological interest, should be clearly stated. The aim should then be partitioned into the objectives/ questions that were carried out in order to achieve your aim. Each objective/ question should then be backed up by a hypothesis clearly indicating the scientific motives behind your research.

Methods: This should be concise but provide sufficient detail to allow the work to be repeated by others.

Standard reporting guidelines should be followed where appropriate (examples include ROSES reporting standards for evidence synthesis and a checklist compiled by Ecology Letters for reporting standards in experimental studies). All data, program code, methods and research materials should be appropriately cited, see Reference section below for examples. Where specific equipment and materials are named, the manufacturer's details (name, city and country) should be given so that readers can trace specifications by contacting the manufacturer. Where commercially available software has been used, details of the supplier should be given in brackets or the reference given in full in the reference list.

Results: Results should be presented in a logical sequence in the text, tables and figures; repetitive presentation of the same data in different forms should be avoided. The results should not contain material appropriate to the Discussion, such as citation of published research papers.

Discussion: This should consider the results in relation to any hypotheses advanced in the Introduction and place the study in the context of other work. Only in exceptional cases should the Results and Discussion sections be combined.

Species nomenclature: When the generic or specific name of the major study organism(s) is first used, the taxonomic family or affiliation should also be mentioned, both in the abstract and in the body of the text.

Upon its first use in the title, abstract and text, the common name of a species should be followed by the scientific name (genus and species) in parentheses. However, for well-known species, the scientific name may be omitted from the article title. If no common name exists in English, the scientific name should be used only.

References

The Harvard (author, date) system of referencing is used. Consult a recent issue of the journal for the referencing format.

Personal communications, unpublished data and publications from informal meetings are not to be listed in the reference list but should be listed in full in the text with a year date (e.g. A. Smith, unpublished data, 2000).

References in articles: We recommend the use of a tool such as EndNote or Reference Manager for reference management and formatting.

EndNote styles can be searched for here: http://www.endnote.com/support/enstyles.asp

Reference Manager styles can be searched for here: http://www.refman.com/support/rmstyles.asp

Tables

Tables should be self-contained and complement, but not duplicate, information contained in the text. Tables should be numbered consecutively in Arabic numerals. Column headings should be brief, with units of measurement in parentheses; all abbreviations should be defined in footnotes. Footnote symbols: †, ‡, §, , should be used (in that order) and *, **, *** should be reserved for P values. The table and its legend/footnotes should be understandable without reference to the text.

Figure Legends

Legends should be concise but comprehensive – the figure and its legend must be understandable without reference to the text. Include definitions of any symbols used and define/explain all abbreviations and units of measurement.

Preparing Figures

Although we encourage authors to send us the highest-quality figures possible, for peer-review purposes we are happy to accept a wide variety of formats, sizes, and resolutions. Figures should be well presented and appropriate for the data you are presenting. We will not accept bar charts with error bars – such figures representing distributions are best presented as violin plots/ boxplots, or mean-error plots. Visualising raw data within these plots (e.g. violin and box plots) is highly recommended. Bar charts are appropriate for count data.

Click here for the basic figure requirements for figures submitted with manuscripts for initial peer review, as well as the more detailed post-acceptance figure requirements.

Colour figures: Figures submitted in colour will be reproduced in colour online free of charge. Please note, however, that it is preferable that line figures (e.g. graphs and charts) are checked in black and white so that they are legible if printed by a reader in black and white.

When developing your figure please refer to these two comprehensive, online resources
https://www.data-to-viz.com/
https://serialmentor.com/dataviz/

to see what your figures will look like to a colour-blind person.
https://colororacle.org/

Also read
Editorial. (2014) Kick the bar chart habit. Nature Methods 11, 113.
Streit M. & Gehlenborg N. (2014) Bar charts and box plots. Nature Methods 11, 117.
Krzywinski M. & Altman N. (2014) Visualizing samples with box plots. Nature Methods 11, 119.

Appendices

Appendices will be published after the references. For submission they should be supplied as separate files but referred to in the text.

Embedded Rich Media

Austral Ecology now has the option for authors to embed rich media (i.e. video and audio) within their final article. These files should be submitted with the manuscript files online, using either the "Embedded Video" or "Embedded Audio" file designation. If the video/audio includes dialogue, a transcript should be included as a separate file. **The combined manuscript files, including video, audio, tables, figures, and text must not exceed 350 MB.** For full guidance on accepted file types and resolution please see here.

Ensure each file is numbered (e.g. Video 1, Video 2, etc.) Legends for the rich media files should be placed at the end of the article.

The content of the video should not display overt product advertising. Educational presentations are encouraged.

Any narration should be in English, if possible. A typed transcript of any speech within the video/audio should be provided. An English translation of any non-English speech should be provided in the transcript.

All embedded rich media will be subject to peer review. Editors reserve the right to request edits to rich media files as a condition of acceptance. Contributors are asked to be succinct, and the Editors reserve the right to require shorter video/audio duration. The video/audio should be high quality (both in content and visibility/audibility). The video/audio should make a specific point; particularly, it should demonstrate the features described in the text of the manuscript.

Participant Consent: It is the responsibility of the corresponding author to seek informed consent from any identifiable participant in the rich media files. Masking a participant's eyes, or excluded head and shoulders is not sufficient. Please ensure that a consent form (https://authorservices.wiley.com/author-resources/Journal-Authors/licensing/licensing-info-faqs.html) is provided for each participant.

Supporting Information

Supporting information is information that is not essential to the article but that provides greater depth and background. Figures, supporting information, and appendices should be supplied as separate files. You should review the basic figure requirements for manuscripts for peer review, as well as the more detailed post-acceptance figure requirements. Click here for Wiley's FAQs on supporting information.

Note, if data, scripts or other artefacts used to generate the analyses presented in the paper are available via a publicly available data repository, authors should include a reference to the location of the material within their paper. *Austral Ecology* strongly supports open access of data and code. We strongly encourage authors to make their data and relevant coding/ analysis methods etc. available either as supporting Information, or on an online repository such as Github or FigShare.

Supporting figures, tables and files should be labelled consecutively as Appendix S1, Appendix S2, etc. Authors should refer to this material in the text of their papers using those titles. Authors are also requested to provide abbreviated headings of no more than 100 characters including spaces for each of their figures and tables of Supporting Information and include a list of these abbreviated headings after the reference list.

Wiley Author Resources

Wiley Editing Services offers expert help with English Language Editing, as well as translation, manuscript formatting, figure illustration, figure formatting, and graphical abstract design – so you can submit your manuscript with confidence. Also, check out our resources for Preparing Your Article for general guidance about writing and preparing your manuscript. In particular, authors may benefit from referring to Wiley's best practice tips on Writing for Search Engine Optimization.

5. EDITORIAL POLICIES AND ETHICAL CONSIDERATIONS

Editorial Review and Acceptance

Austral Ecology is single-blind peer reviewed unless otherwise stated.

Authorship

Authorship requirements - All persons listed as authors should qualify for authorship as defined by the ICMJE, i.e. authorship requires- (i) substantial contributions to: the conception or design of the work, the acquisition, analysis or interpretation of data for the work; (ii) drafting the work or revising it critically for important intellectual content; and (iii) final approval of the version to be published. All persons qualifying for these requirements should be listed as authors.

Joint Authorship - Joint authorship cannot be shared by more than two authors. These authors will need to be in first and second position of the author line.

Corresponding Author - There can only be one corresponding author and this person is solely responsible for (i) communicating with the journal and managing communication between co-authors; (ii) including all qualifying authors in the author list and getting their approval for submission of the manuscript and the order in which the authors are listed; (iii) distributing the proofs to all co-authors and returning all proof corrections to the journal office; (iv) responding to any queries regarding the published paper.

Author Contributions - At submission of a manuscript, the corresponding author is required to indicate the contribution role and degree of contribution for each author using the CRediT Contributor Role Taxonomy. This information will be included in the publication as the author contribution statement.

Group Authorship - *Austral Ecology* follows the ICMJE recommendations for group authorship. For studies performed on behalf of or in collaboration with a group, the group name should be included in the list of authors and the names of the group members should be listed in the *Acknowledgements*. *Austral Ecology* reserves the right to move extensive lists of group member names to a *Supplementary Information* file. Only group members that meet the criteria for authorship outlined above should be listed as individual authors in the byline and will be indexed by PubMed as authors. Group members listed in the *Acknowledgements* or *Supplementary Information* will be indexed by PubMed as collaborators.

Research Ethics

Papers describing experiments that involve procedures that could impact on the welfare of vertebrate animals must include a statement that the research has been approved by an appropriate animal welfare or ethics committee, and that it conforms to the national guidelines for animal usage in research.

Publication Ethics

This journal is a member of the Committee on Publication Ethics (COPE). Read our Top 10 Publishing Ethics Tips for Authors here. Wiley's Publication Ethics Guidelines can be found at https://authorservices.wiley.com/ethics-guidelines/index.html

Data Sharing and Data Availability

Austral Ecology expects data sharing. Review Wiley's Data Sharing policy where you will be able to see and select the data availability statement that is right for your submission. Authors may consult the global registry of research data repositories www.re3data.org to help them identify registered and certified repositories relevant to their subject areas.

6. COPYRIGHT AND LICENSING

If your paper is accepted, the author identified as the formal corresponding author will receive an email prompting them to log in to Author Services, where via the Wiley Author Licensing Service (WALS) they will be required to complete a copyright license agreement on behalf of all authors of the paper.

You may choose to publish under the terms of the journal's standard copyright agreement, or Open Access under the terms of a Creative Commons License.

Standard re-use and licensing rights vary by journal. Note that certain funders mandate a particular type of CC license be used. This journal uses the CC-BY/CC-BY-NC/CC-BY-NC-ND Creative Commons License.

Self-Archiving Definitions and Policies: Note that the journal's standard copyright agreement allows for self-archiving of different versions of the article under specific conditions.

Open Access fees: If you choose to publish using open access you will be charged a fee. A list of Article Publication Charges for Wiley journals is available here.

Funder Open Access: Please click here for more information on Wiley's compliance with specific Funder Open Access Policies.

7. PUBLICATION PROCESS AFTER ACCEPTANCE

Accepted article received in production

When your accepted article is received by Wiley's production team, you (corresponding authors) will receive an email asking you to login or register with Author Services. You will be asked to sign a publication licence at this point.

Proofs

Authors will receive an e-mail notification with a link and instructions for accessing HTML page proofs online. Page proofs should be carefully proofread for any copyediting or typesetting errors. Online guidelines are provided within the system. No special software is required, all common browsers are supported. Authors should also make sure that any renumbered tables, figures, or references match text citations and that figure legends correspond with text citations and actual figures. Proofs must be returned within 48 hours of receipt of the email. Return of proofs via e-mail is possible in the event that the online system cannot be used or accessed.

Early View

The journal offers rapid speed to publication via Wiley's Early View service. Early View (Online Version of Record) articles are published on Wiley Online Library before inclusion in an issue. Note there may be a delay after corrections are received before your article appears online, as Editors also need to review proofs. Once your article is published on Early View no further changes to your article are possible. Your Early View article is fully citable and carries an online publication date and DOI for citations.

8. POST PUBLICATION

Article Promotion Support

Wiley Editing Services offers professional video, design, and writing services to create shareable video abstracts, infographics, conference posters, lay summaries, and research news stories for your research – so you can help your research get the attention it deserves.

Access and sharing

When your article is published online:
• You receive an email alert (if requested).
• You can share your published article through social media.
• As the author, you retain free access (after accepting the Terms & Conditions of use, you can view your article).
• The corresponding author and co-authors can nominate up to ten colleagues to receive a publication alert and free online access to your article.

You can now order print copies of your article (instructions are sent at proofing stage).

Now is the time to start promoting your article. Find out how to do that here.

Measuring the impact of your work

Wiley also helps you measure the impact of your research through our specialist partnerships with Kudos and Altmetric.

Author Guidelines Updated 10 October 2022

Tools

Submit an Article

Browse free sample issue

Get content alerts

Subscribe to this journal

Published on behalf of The Ecological Society of Australia (ESA)

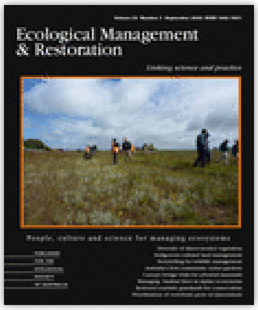
ESA

Listen to the ESA Podcast

More from this journal

- Virtual Issues
- Upcoming Special Issues
- Jobs
- Video Abstracts Gallery

Related Title



ISSUE

Volume 23, Issue 3

Pages: 203-285

September 2022

Tweets from @AustralEcology

#AustralEcology
@AustralEcology · 12h

Este estudo de #AustralEcology encontrou o impacto negativo dos besouros endofíticos no sucesso reprodutivo de duas espécies de Banisteriopsis, nas quais as formigas ofereciam pouca proteção. @WileyEcolEvol @EcolSocAus. bit.ly/3VbPBki

1

#AustralEcology

Tweets from @EcolSocAus

Follow

Ecological Society of Australia Retweeted

RZS NSW @rzsnsw · 10h

The Ethel Mary Read Research Grant supports young

The Ethel Mary Read Research Grant supports young zoologists in short-term research projects in zoology within Australasia.

Applications for 2023 are currently open, and close on 30 April.
rzsnsw.org.au/grants-awards/...

Please share this opportunity with your networks!

3

Wiley Press Room