Universidade de Brasília
Instituto de Ciências Biológicas
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Impacto da Atividade Antrópica na Ecologia Temporal e Espacial do Tamanduá-bandeira em uma Unidade de Conservação Periurbana

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À minha família, a minha orientadora e aos meus amigos, cujo apoio inabalável e assistência tornaram esta jornada possível.

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“Eu cheguei de muito longe

E a viagem foi tão longa

E na minha caminhada

Obstáculos na estrada

Mas enfim aqui estou”

É preciso dar um jeito, meu amigo – Erasmo Carlos

SUMÁRIO

RESUMO GERAL

O tamanduá-bandeira (*Myrmecophaga tridactyla*) é uma espécie de mamífero vulnerável à extinção que desempenha papel ecológico no bioma Cerrado como supressor de populações de formigas e cupins, contribuindo para o equilíbrio do ecossistema. No entanto, a perda de habitat, a urbanização e os conflitos entre humanos e fauna têm colocado em risco sua sobrevivência, enfatizando a necessidade urgente de estratégias de conservação eficazes. Áreas protegidas, no Brasil chamadas de Unidades de Conservação, como o Parque Nacional de Brasília (PNB), oferecem refúgio para as populações, garantindo a persistência em longo prazo das espécies. Estudos sobre padrões de atividade, uso do habitat e estimativas populacionais são essenciais para compreender o estado das populações e elaborar ações de manejo mais eficientes. Esta tese examina a dinâmica ecológica da fauna no PNB, com um foco particular no tamanduá-bandeira, em um contexto periurbano. A pesquisa está estruturada em quatro capítulos: O primeiro estudo avalia a riqueza de mamíferos de médio e grande porte no PNB, destacando os respectivos serviços ecossistêmicos, como valor cultural, monitoramento de doenças e dispersão de sementes. O segundo estudo explora a dinâmica populacional e os comportamentos sociais dos tamanduás-bandeira, particularmente os padrões reprodutivos. O terceiro examina como as variáveis ambientais e antrópicas afetam a ocupação do tamanduá-bandeira, mostrando que a proximidade com cães domésticos e áreas agrícolas, impacta significativamente o tamanduá-bandeira no uso do espaço. O estudo destaca estratégias para reduzir conflitos, particularmente em áreas de conservação periurbanas, onde a expansão urbana representa séria ameaça às espécies nativas. O quarto estudo analisa o padrão de atividade do tamanduá-bandeira influenciado por condições ambientais e humanas, revelando uma mudança sazonal de comportamento com maior atividade crepuscular e diurna na estação chuvosa. Essa mudança indica um risco aumentado de encontros do tamanduá com as ameaças potenciais, enfatizando a importância de dados comportamentais nas estratégias de conservação. Esses estudos fornecem *insights* abrangentes sobre a ecologia e a conservação dos tamanduás-bandeira e de outros mamíferos no PNB, apoiando práticas de gestão informadas para salvaguardar a biodiversidade em ecossistemas periurbanos.

Palavras-chave: Áreas protegidas; Armadilhas fotográficas; Comportamento sazonal; Conflito humano-fauna; Ecologia espacial; Impacto antrópico; Modelos de ocupação.

GENERAL ABSTRACT

The giant anteater (*Myrmecophaga tridactyla*) is a vulnerable mammal species that plays an ecological role in the Cerrado biome by suppressing populations of ants and termites, contributing to ecosystem balance. However, habitat loss, urbanization, and human-wildlife conflicts have endangered its survival, underscoring the urgent need for effective conservation strategies. Protected areas, known as Conservation Units in Brazil, such as the Brasília National Park (PNB, Portuguese abbreviation), are vital as they offer refuge to wildlife populations, ensuring the long-term persistence of species. Studies of activity patterns, habitat use, and population estimates are essential for understanding the status of populations and devising more efficient conservation measures. This thesis examines the ecological dynamics of medium and large mammals in PNB, focusing on the giant anteater within a peri-urban context. It is structured around four chapters: The first study assesses the richness and seasonal occurrence of medium and large mammals in PNB, highlighting their essential ecosystem services, such as cultural value, disease monitoring, and seed dispersal. The second study explores giant anteaters' population dynamics and social behaviors, particularly their reproductive patterns. The third study examines how environmental and anthropogenic variables affect giant anteater occupancy, showing that proximity to domestic dogs and agricultural zones significantly impacts their space use. The study highlights the need for strategies to reduce human-wildlife conflicts, particularly in peri-urban conservation areas where urban expansion poses serious threats to native species. The fourth study analyzes giant anteater activity patterns influenced by environmental conditions and human presence, revealing a seasonal behavioral shift with increased crepuscular and diurnal activity during the rainy season. This shift indicates an increased risk of encounters with predators and potential threats, emphasizing the need for management to consider behavioral adaptations. These studies provide comprehensive insights into the ecology and conservation needs of giant anteaters and other mammals in PNB, supporting informed management practices to safeguard biodiversity in peri-urban ecosystems.
Keywords: Anthropogenic impact; Camera traps; Human-wildlife conflict; Occupancy models; Protected areas; Seasonal behavior; Spatial ecology

INTRODUÇÃO GERAL

O tamanduá-bandeira (*Myrmecophaga tridactyla* Linnaeus, 1758) é uma espécie emblemática da fauna neotropical, pertencente ao grupo dos xenartras. Suas adaptações morfológicas e fisiológicas incluem um crânio com focinho e língua alongados, garras robustas, visão reduzida e olfato apurado, características que facilitam a quebra de ninhos de formigas e cupinzeiros durante a busca por alimento (Eisenberg and Redford, 1999; Miranda, 2012). Essas adaptações refletem a especialização alimentar da espécie, que apresenta uma baixa taxa metabólica devido à sua dieta predominantemente composta de formigas e cupins (Eisenberg and Redford, 1999). O tamanduá pode consumir grandes quantidades de formigas de diferentes espécies por dia, desempenhando um papel essencial na supressão desses animais e, provavelmente, interferindo no tamanho dessas populações. Consequentemente, influenciando na manutenção do equilíbrio ecológico (Jiménez et al., 2018).

Uma característica marcante do tamanduá-bandeira é a ausência de dimorfismo sexual. Os indivíduos são em sua maioria solitários, sendo vistos em pares apenas durante o período reprodutivo, quando ocorrem interações entre casais (Júnior and Bertassoni, 2014; Kreutz et al., 2009; Shaw et al., 2016). Durante a amamentação, fêmeas são frequentemente avistadas carregando seus filhotes no dorso (Jerez and Halloy, 2003). Esses juvenis permanecem com as mães até atingirem um nível de desenvolvimento, aproximadamente aos seis meses, quando se tornam mais independentes (Junior e Bertassoni, 2014; Gaudin et al., 2018; Desbiez et al. 2020). A espécie possui um longo período de gestação, que dura entre 140-190 dias, resultando no nascimento de um único filhote por ciclo reprodutivo (Miranda et al., 2014). O tamanduá-bandeira atinge a maturidade sexual em torno de 24 a 48 meses de idade, embora haja relatos na literatura de casos de maturidade precoce, aos 16 meses (Gaudin et al., 2018). A reprodução é caracterizada por um sistema poligâmico, com a época reprodutiva divergindo entre estudos, permanecendo ainda uma lacuna no conhecimento sobre a espécie (Desbiez et al., 2020).

As adaptações fisiológicas do tamanduá-bandeira são fundamentais para sua sobrevivência. A espécie possui metabolismo relativamente baixo, com temperatura corporal fixa em torno de 32°C, que é inferior à de muitos mamíferos (Miranda, 2012). Essa adaptação está diretamente relacionada à dieta, predominantemente composta de formigas e cupins, que fornece um baixo valor energético, exigindo que o tamanduá conserve energia. Devido à sua baixa temperatura corporal e metabolismo, o uso do habitat e o padrão de atividade diária são influenciados pelas condições ambientais locais, permitindo que a espécie se mostre ativa tanto durante o dia quanto à noite (Giroux et al. 2021). Em geral, os tamanduás-bandeira são mais ativos nas horas mais quentes do dia, em campos abertos, e buscam abrigo em áreas de vegetação densa durante os períodos mais frios (Camilo-Alves and Mourão, 2006; Giroux et al. 2021). Para conservar a temperatura corporal e se camuflar, os tamanduás utilizam a cauda para cobrir o corpo durante os períodos de repouso (Medri and Mourão, 2005a; Shaw et al., 1985). Diversas espécies de animais, incluindo o tamanduá-bandeira, ajustam frequentemente seu comportamento de acordo com as condições ambientais para otimizar o uso de energia, considerando que suas atividades envolvem gastos energéticos (Caravaggi et al., 2018). Nesse contexto, as adaptações comportamentais também contribuem para a termorregulação da espécie (Camilo-Alves e Mourão, 2006).

A área de vida do tamanduá-bandeira pode variar entre 0,8 e 25 km² (Bertassoni and Ribeiro, 2019), dependendo da região e do método de análise utilizado, com registro de sobreposição na área de vida entre indivíduos e entre os sexos (Bertassoni et al., 2020; Medri and Mourão, 2005b; Miranda, 2004; Shaw et al., 2016). Alguns estudos investigaram a relação entre o tamanho da área de vida de fêmeas e machos, mas os resultados foram inconsistentes, evidenciando que essa relação ainda não está bem estabelecida e requer mais pesquisa (Bertassoni et al., 2020; Di Blanco et al., 2017; Miranda et al., 2014; Miranda, 2004). No entanto, Giroux et al. (2021) destacaram a importância de fatores que influenciam o uso do habitat, observando que tanto machos quanto fêmeas aumentaram o tamanho da área de vida

com o aumento da massa corporal. O tamanduá-bandeira é encontrado em uma ampla variedade de habitats, que vão desde campos abertos e florestas, até áreas agrícolas (Di Blanco et al., 2015; Margarido et al. 2023; Miranda, 2004; Vynne et al., 2011), sendo observado com mais frequência em áreas abertas (Gardner, 2007).

No Brasil, diversos estudos sobre o uso da paisagem por tamanduás foram realizados no Pantanal (Camilo-Alves and Mourão, 2006; Desbiez and Medri, 2010; Medri and Mourão, 2005b; Mourão and Medri, 2007; Souza et al., 2018) e no Cerrado (Bertassoni et al., 2020; Chhen et al., 2023; Petrazzini, 2019; Shaw et al., 1985; Versiani et al., 2021). Contudo, conforme observado em uma revisão recente (Bertassoni et al., 2019), poucos estudos foram realizados com indivíduos em áreas florestais nativas, visando entender a seleção de habitat por parte desses animais. Além disso, alguns estudos documentaram a utilização de ambientes alterados, como áreas de pastagens e plantações (Bertassoni et al., 2019; Bertassoni et al., 2020; Gouvea, 2020; Kreutz et al., 2012; Miranda, 2004), indicando a necessidade de mais investigações para elucidar a real plasticidade e tolerância da espécie a ambientes antrópicos. Alguns estudos sugerem que a espécie demonstra preferência por habitats próximos a cursos d'água, possivelmente em decorrência de suas características fisiológicas e da necessidade de termorregulação (Bertassoni et al., 2017).

Além de suas adaptações biológicas, o tamanduá-bandeira desempenha um papel crucial em seu ecossistema, oferecendo serviços ecossistêmicos significativos. Como predador de insetos sociais, ajuda a regular as populações de formigas e cupins, prevenindo desequilíbrios ecológicos que poderiam impactar negativamente o ambiente e a agricultura local (Braga, 2010). Além disso, por seu caráter carismático, a espécie presta serviços culturais/bem-estar, atuando como uma espécie "guarda-chuva", ou seja, os esforços para proteger seu habitat também beneficiam outras espécies que compartilham o mesmo ecossistema (Alonso Roldán, et al. 2022; Möcklinghoff et al., 2014). Essa relação destaca a importância da conservação do tamanduá, não apenas por seu valor intrínseco, mas também pela preservação da biodiversidade

Endêmico da região neotropical, o tamanduá-bandeira possui uma ampla distribuição, que se estende desde o sul de Belize até o sul da América do Sul, exceto na região dos Andes (Eisenberg and Redford, 1999; Gaudin et al, 2018). No entanto, a espécie já foi considerada extinta em Belize, Nicarágua, Guatemala e Uruguai (Miranda et al., 2014), e está quase extinta na Mata Atlântica no Brasil (Miranda et al., 2014). Atualmente, o tamanduá-bandeira é classificado como vulnerável na Lista de Espécies Brasileiras Ameaçadas de Extinção (ICMBIO, 2018) e na Red List of Threatened Species (IUCN, 2014). Estima-se que a população tenha reduzido cerca de 30% nas últimas três décadas (Miranda et al., 2014). As principais ameaças à espécie incluem a fragmentação e perda de habitat, atropelamentos, caça, incêndios e a presença de cães ferais (IUCN, 2014, Desbiez et al., 2020; Martins et al., 2023). O tempo de resposta da espécie a essas ameaças ainda não é bem compreendido, e apesar do aumento nas pesquisas sobre o tamanduá-bandeira (Diniz and Brito, 2012), há uma concentração de estudos em algumas regiões, principalmente no Pantanal (Bertassoni and Ribeiro, 2019; Diniz and Brito, 2012), enquanto poucos foram realizados em áreas com influências de paisagens modificadas (Bertassoni et al., 2019; Gouvea, 2020; Kreutz et al., 2012; Petrazzini, 2019; Versiani et al., 2021).

Embora o tamanduá-bandeira seja amplamente distribuído no bioma Cerrado, as populações estão em alto risco de extinção devido ao acelerado processo de mudança do uso da terra, especialmente pela conversão em áreas de construções urbanas e agropecuária (Diniz and Brito, 2013; Grecchi et al., 2014; Ribeiro et al., 2017). A expansão agrícola, por exemplo, tem resultado na fragmentação do habitat e no uso de pesticidas que reduzem a disponibilidade de suas presas naturais (Quandahor, et al, 2024). Além disso, a presença de contaminantes, como mercúrio, em tamanduás-bandeira, provavelmente oriundos de práticas agrícolas e industriais, representa um risco adicional à sua saúde e sobrevivência (Carvalho et al, 2021; Silva, 2020). Relata-se que o tamanduá-bandeira evita áreas de pastagem onde há presença de gado, sugerindo que práticas de uso da terra podem influenciar sua distribuição e comportamento (Di

Blanco et al., 2015). Alguns estudos observaram que a abundância de mamíferos pode ser afetada por efeitos de borda, presença de estradas, infraestrutura de turismo e a presença de cães domésticos (Lacerda et al., 2009; Monteiro and Lira, 2020).

A presença de cães domésticos nas proximidades de áreas protegidas agrava ainda mais a situação. Pesquisas realizadas em diversos países indicam que a presença de cães pode levar algumas espécies de fauna silvestre a modificar seus comportamentos habituais, resultando em uma maior vulnerabilidade a predadores naturais (Bassi et al., 2017; Zapata-Ríos and Branch, 2016**).** Cães também podem atacar espécies nativas, como a anta (*Tapirus terrestris*), representando um risco direto à biodiversidade **(**Gatti et al., 2018**).** Além disso, a presença de cães soltos em áreas protegidas está positivamente associada à densidade populacional humana nas proximidades, sugerindo uma correlação entre urbanização e o aumento dessa ameaça (Allemand et al., 2019).

Assim como os cães, o fogo representa uma ameaça significativa diretamente relacionada com a presença humana. O tamanduá-bandeira é afetado pela destruição de seu habitat, escassez de alimento e aumento nas taxas de mortalidade devido a incêndios (Silveira et al., 2009). No contexto do Distrito Federal, foram registradas quase 8.000 ocorrências de incêndios florestais em 2020, uma ameaça adicional que pode desestabilizar o ecossistema e afetar diretamente as espécies que dependem desse habitat (GPRAM, 2020). Entre 2004 e 2014, observou-se um aumento de 1% na área urbana e 2% na área rural na zona de amortecimento do Parque Nacional de Brasília (PNB), refletindo uma expansão que pode intensificar a pressão sobre os ecossistemas locais (Teixeira, I, 2015). Estudos indicam que as taxas de crescimento populacional humano em áreas próximas a áreas protegidas são quase o dobro das taxas médias observadas em regiões rurais, o que pode indicar um aumento na pressão antrópica sobre esses espaços (Wittemyer et al., 2008; Jones et al., 2018). Esses resultados alertam sobre uma possível redução populacional acarretada pela intensificação das ameaças à espécie, e consequentemente a probabilidade de persistência das populações locais de tamanduá-bandeira.

Estudos populacionais sobre o tamanduá-bandeira ainda são escassos. Populações reduzidas são mais vulneráveis à extinção devido à perda de diversidade genética (Barragán-Ruiz et al, 2021) e ao aumento da endogamia, como observado para a espécie no Parque Nacional das Emas (Collevatti et al., 2007). Um estudo da estrutura geográfica do tamanduá-bandeira, juntamente com a modelagem de nicho ecológico e análises filogeográficas integrativas, ressalta a importância das populações do Cerrado brasileiro como fonte, sendo este um bioma prioritário para a conservação da espécie (Coimbra et al. 2022). Clozato et al. (2017) conduziram o primeiro estudo genético sobre a estrutura populacional e diversidade genética de tamanduás no Brasil, amostrando 77 indivíduos e encontrando diferenciação genética entre as populações do Pantanal e da Mata Atlântica, além de alta diversidade genética dentro das subpopulações de duas grandes Unidades de Conservação do Cerrado brasileiro. No entanto, mais estudos abrangendo um número maior de amostras e diversidade de biomas e locais são necessários para garantir a conservação da espécie em longo prazo. Desbiez et al. (2020) destacaram que a porcentagem de fêmeas reproduzindo e as taxas de mortalidade são os parâmetros mais sensíveis para as análises de crescimento populacional, ressaltando a importância de programas de monitoramento de populações para fornecer dados locais e informações mais robustas que refinem previsões e aumentem a eficácia das ações de conservação.

Diante dessas crescentes ameaças à conservação do tamanduá-bandeira, esta tese busca investigar diversos aspectos de sua biologia e ecologia no Parque Nacional de Brasília (PNB). No Capítulo 1, apresento um levantamento das espécies de mamíferos de médio e grande porte detectadas no PNB, incluindo o tamanduá-bandeira, e uma análise dos serviços ecossistêmicos que essas espécies proporcionam. No Capítulo 2 examino os registros de filhotes e pares de adultos de tamanduás no parque, analisando a distância em relação à borda do parque e a periodicidade dos registros para entender padrões de reprodução. No Capítulo 3, os fatores ambientais e antrópicos que influenciam a detecção e ocupação do tamanduá-bandeira são

avaliados, com destaque para o impacto negativo da presença de cães domésticos. Por fim, no Capítulo 4 investigo como fatores ambientais e antrópicos afetam os padrões de atividade da espécie, abordando diferenças sazonais e sobreposições com predadores naturais, como pumas, e ameaças como cães e atividades humanas. Apresento como esses fatores podem alterar o comportamento diurno do tamanduá-bandeira no PNB. Os resultados obtidos com esta tese contribuirão para a conservação local da população e para preencher as lacunas de conhecimento. Este será o primeiro estudo focado no comportamento espaço/temporal com descrição do registro sazonal de filhotes, de tamanduá-bandeira de vida livre no Distrito Federal.

Área de estudo

Criado no dia 29 de novembro de 1961, no início da construção de Brasília, o Parque Nacional de Brasília (PNB) possui, além do objetivo de conservar a flora e fauna do Cerrado, a preservação de ecossistemas naturais de beleza cênica, a realização de pesquisas científicas e o desenvolvimento de atividades de educação ambiental e de turismo ecológico. Atualmente, faz parte da Reserva da Biosfera do Cerrado (Lei Nº 747, em julho de 1994), sendo uma das áreas mais importantes devido a sua extensão. Em 2006 foi aprovada a sua ampliação com a adição ao seu território da região conhecida como Chapada Imperial, passando de 30 mil para 41,8 mil hectares, sendo então, o maior fragmento de Cerrado do Distrito Federal (Figura 1). Atualmente, a sua área total equivale a 7,3% da área do Distrito Federal.

O Parque Nacional de Brasília está situado na porção noroeste do Distrito Federal, abrangendo os municípios de Sobradinho (DF), Brazlândia (DF), Brasília (DF) e Padre Bernardo (GO) e a 10 km do plano piloto (DF). O parque é limitado na região norte e oeste pela Estrada do Parque do Contorno (DF-001), na região leste pela EPIA (DF-003) e estrada do Parque do Contorno (DF001) e sul pelo córrego acampamento e DF-097. A área possui extrema importância na preservação dos córregos do Torto e Bananal, que contribuem com o lago Paranoá, além de garantir a qualidade do reservatório Santa Maria construído no centro da UC

com 858 ha, responsável pelo abastecimento de água de parte da região. Atualmente, uma das maiores ameaças para a fauna local é a crescente expansão urbana nas regiões vizinhas e sua limitação majoritária por rodovias de alta velocidade (FUNATURA/IBAMA, 1998). Estima-se que, entre 2004 e 2014, ocorreu um aumento de 1% de área urbana e 2% de área rural na região de amortecimento do PNB (Teixeira, I, 2015).

Conforme o Plano de Manejo (FUNATURA/IBAMA, 1998) vigente durante o período deste estudo, o PNB é dividido em cinco zonas de diferentes usos: Zona Intangível – áreas naturais sem interferência humana; Zona Primitiva – mínima intervenção humana; Zona de uso extensivo – áreas naturais, podendo apresentar algumas alterações humanas; Zona de uso intensivo – É aquela constituída por áreas naturais ou alteradas pelo homem; Zona de uso especial – áreas necessárias à administração; Zona de recuperação – Áreas alteradas em processo de recuperação. Essas áreas permitem a conservação de uma variedade de fisionomias vegetais, incluindo Mata de galeria pantanosa e não pantanosa, Cerrado Denso, Cerrado Sensu Stricto, Campo Sujo, Campo Limpo, Campo Úmido, Brejo, Campo de Murundus, Vereda, Campo Rupestre e áreas antropizadas. A região apresenta temperatura média do mês mais frio inferior a 18°C e a do mês mais quente variando em torno de 23°C e duas estações bem definidas. A precipitação média anual é da ordem de 1.600 mm, com uma concentração das chuvas nos meses de novembro a abril (médias mensais de até 300 mm). Os principais grupos de solos encontrados no parque são o Latossolo Vermelho-Escuro, Latossolo Vermelho-Amarelo e Cambissolo (FUNATURA/IBAMA, 1998).

O Parque Nacional de Brasília tem a importante função de abrigar espécies ameaçadas de extinção, como o lobo-guará (*Chrysocyon brachyurus*), o veado-campeiro (*Ozotoceros bezoarticus*), o tamanduá-bandeira (*Myrmecophaga tridactyla*) e o tatu-canastra (*Priodontes maximus*). Além da função de preservar a fauna e flora, o parque também possui uma área aberta à visitação pública com trilhas e duas piscinas de água mineral (FUNATURA/IBAMA, 1998). Em 2023, o Plano de Manejo foi atualizado (Brasil, 2023), aumentando as áreas de uso

público. No entanto, como essa alteração foi realizada após o encerramento das atividades de campo, manteremos as discussões com base nas classificações de zoneamento do Plano de Manejo anterior.

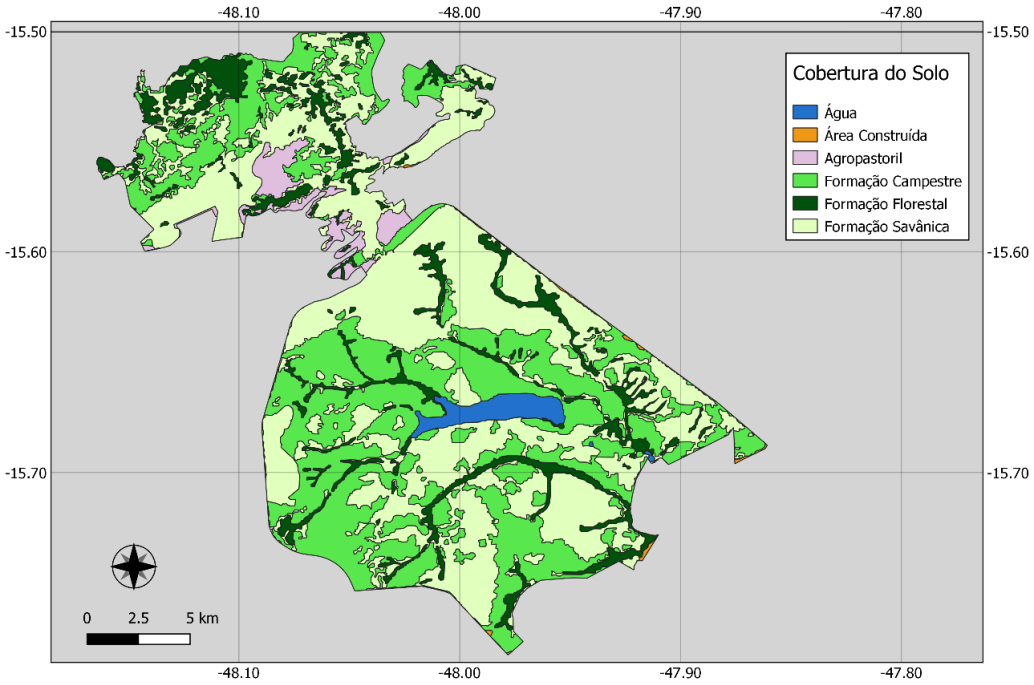

Figura 1: Mapa da cobertura da terra do Parque Nacional de Brasília (Codeplan – 2019).

REFERÊNCIA BIBLIOGRÁFICA

Allemand MM, Ferreguetti AC, Pereira-Ribeiro J, Duarte Rocha CF & Bergallo HG. 2019. Invasion by *Canis lupus familiaris* (Carnivora) in a protected area in the Atlantic Forest biome, Brazil: Spatial distribution and abundance. Mastozoología Neotropical, 26(2): 233–240.

Alonso Roldán V, Camino M, Argoitia MA, Campos CM, Caruso N et al. 2022. Potential contributions of mammals to human well-being in Argentina. *Mastozoología Neotropical* 29(2):1–27.

Barragán-Ruiz CE, Silva-Santos R, Saranholi BH, Desbiez AL. & Galetti Jr PM. 2021. Moderate genetic diversity and demographic reduction in the threatened giant anteater, *Myrmecophaga tridactyla*. Frontiers in Genetics 12:669350.

Bassi E, Canu A, Firmo I, Matiolli L, Scandura M & Apollonio M. 2017. Trophic overlap between wolves and free-ranging wolf × dog hybrids in the Apennine Mountains, Italy. Global Ecology and Conservation, 9: 39–49.

Bertassoni A & Ribeiro MC. 2019. Space use by the giant anteater (*Myrmecophaga tridactyla*): A review and key directions for future research. *European Journal of Wildlife Research*, 65:93.

Bertassoni A, Mourão G & Bianchi RDC. 2020. Space use by giant anteaters (*Myrmecophaga tridactyla*) in a protected area within a human-modified landscape. *Ecology and Evolution*, 10(15): 7981–7994.

Bertassoni A, Mourão G, Ribeiro RC, Cesário CS, Oliveira JPD & Bianchi RDC. 2017. Movement patterns and space use of the first giant anteater (*Myrmecophaga tridactyla*) monitored in São Paulo State, Brazil. *Studies on Neotropical Fauna and Environment*, 52(1): 68–74.

Brasil. Ministério do Meio Ambiente e Mudança do Clima (MMA). Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio). 2023. *Portaria ICMBio nº 3107, de 11 de setembro de 2023*. Aprova a revisão do Plano de Manejo do Parque Nacional de Brasília. Brasília, 2023.

Camilo-Alves CDSEP & Mourão GDM. 2006. Responses of a specialized insectivorous mammal (*Myrmecophaga tridactyla*) to variation in ambient temperature. Biotropica, 38(1): 52–56.

Caravaggi A, Gatta M, Vallely MC, Hogg K, Freeman M, Fadaei E & Tosh DG. 2018. Seasonal and predator-prey effects on circadian activity of free-ranging mammals revealed by camera traps. PeerJ, 6: e5827.

Carvalho GO, Meire RO, Lino AS, Yogui DR, Desbiez ALJ, Torres JPM & Malm O. 2021. Biomonitoring mercury contamination using fur from roadkilled giant anteaters. *Chemosphere* 270:128644.

Chhen A, Bertassoni A, Desbiez ALJ & Noonan MJ. 2024. The socio-spatial ecology of giant anteaters in the Brazilian Cerrado. *Journal of Zoology* 324:50–62.

Clozato CL, Miranda FR, Lara-Ruiz P, Collevatti RG & Santos FR. 2017. Population structure and genetic diversity of the giant anteater (*Myrmecophaga tridactyla*: Myrmecophagidae, Pilosa) in Brazil. Genetics and Molecular Biology 40(1):50–60.

Coimbra RT, Magalhães RF, Lemes P, Miranda FR & Santos FR. 2022. Integrative phylogeography reveals conservation priorities for the giant anteater *Myrmecophaga tridactyla* in Brazil. Diversity 14(7):542.

Collevatti RG, Leite KC, de Miranda GH & Rodrigues FH. 2007. Evidence of high inbreeding in a population of the endangered giant anteater, *Myrmecophaga tridactyla* (Myrmecophagidae), from Emas National Park, Brazil. Genetics and Molecular Biology 30:112–120.

Desbiez ALJ & Medri IM. 2010. Density and habitat use by giant anteaters (*Myrmecophaga tridactyla*) and southern tamanduas (*Tamandua tetradactyla*) in the Pantanal Wetland, Brazil. *Edentata*, 11, 4–10.:

Desbiez ALJ, Bertassoni A & Traylor-Holzer K. 2020. Population viability analysis as a tool for giant anteater conservation. *Perspectives in Ecology and Conservation*, 18(2): 124–131.

Di Blanco YE, Desbiez AL, Jiménez-Pérez I, Kluyber D, Massocato GF & Di Bitetti MS. 2017. Habitat selection and home-range use by resident and reintroduced giant anteaters in two South American wetlands. *Journal of Mammalogy* 98(4):1118–1128.

Di Blanco YE, Jiménez Pérez I & Di Bitetti MS. 2015. Habitat selection in reintroduced giant anteaters: the critical role of conservation areas. *Journal of Mammalogy*, 96(5): 1024–1035.

Diniz MF & Brito D. 2012. The charismatic giant anteater (*Myrmecophaga tridactyla*): a famous John Doe? *Edentata* 13(1):76–83.

Diniz MF & Brito D. 2013. Threats to and viability of the giant anteater, *Myrmecophaga tridactyla* (Pilosa: Myrmecophagidae), in a protected Cerrado remnant encroached by urban expansion in central Brazil. *Zoologia (Curitiba)* 30:151–156.

Eisenberg J & Redford K. 1999. *Mammals of the Neotropics*, Volume 3: Ecuador, Bolivia, Brazil. University of Chicago Press, Chicago.

FUNATURA/IBAMA (Fundação Pró-Natureza/Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis). 1998. Plano de manejo do Parque Nacional de Brasília (revisão). IBAMA. Volume I: S/n.

Gardner AL. 2007. *Mammals of South America volume 1: marsupials, xenarthrans, shrews, and bats*. Chicago: The University of Chicago Press.

Gatti A, Seibert JB & Moreira DD. 2018. A predation event by free-ranging dogs on the lowland tapir in the Brazilian Atlantic Forest. *Animal Biodiversity and Conservation*, 41(2): 311–314.

Gaudin TJ, Hicks P & Di Blanco Y. 2018. *Myrmecophaga tridactyla* (Pilosa: Myrmecophagidae). *Mammalian Species*, 50:1–13.

Giroux A, Ortega Z, Oliveira-Santos LGR, Attias N, Bertassoni A & Desbiez ALJ. 2021. Sexual, allometric and forest cover effects on giant anteaters' movement ecology. *PLOS ONE*, 16(8): e0253345.

Gouvea JA. 2020. How does the giant anteater *Myrmecophaga tridactyla* use a landscape featuring high human disturbance and free-ranging dogs? Dissertação de Mestrado, Universidade Estadual Paulista (UNESP).

GPRAM - Grupamento de Proteção Ambiental. 2020. Planilha de Registro Histórico das Operações Verde Vivo. Brasília: CBMDF.

Grecchi RC, Gwyn QHJ, Bénié GB, Formaggio AR & Fahl FC. 2014. Land use and land cover changes in the Brazilian Cerrado: a multidisciplinary approach to assess the impacts of agricultural expansion. *Applied Geography* 55:300–312.

ICMBio. 2018. Livro Vermelho da Fauna Brasileira Ameaçada de Extinção: v. 1, ed. 1. Brasília: ICMBio/MMA. 492 p.

International Union for Conservation of Nature. 2014. Red List of Threatened Species. In *Choice Reviews Online*, 49. Gland, Switzerland.

IPEDF - Instituto de Pesquisa e Estatística do Distrito Federal. 2022. Relatório Preliminar: Pesquisa Distrital por Amostra de Domicílios - PDAD Rural. 28 páginas.

IUCN. 2014. The IUCN Red List of Threatened Species. Version 2014. International Union for Conservation of Nature. Accessed: www.iucnredlist.org.

Jerez SV & Halloy M. 2003. El oso hormiguero, *Myrmecophaga tridactyla*: Crecimiento e independización de una cría. *Mastozoología Neotropical*, 10:323–330.

Jiménez NL, Di Blanco YE & Calcaterra LA. 2018. Ant diversity in the diet of giant anteaters (*Myrmecophaga tridactyla*) (Pilosa: Myrmecophagidae) in the Iberá Nature Reserve, Argentina. *Mastozoología Neotropical*, 25(2): 305–318.

Jones KR, Venter O, Fuller RA, Allan JR, Maxwell SL, Negret PJ & Watson JE. 2018. One-third of global protected land is under intense human pressure. *Science*, 360(6390), 788-791.

Júnior JFM & Bertassoni A. 2014. Potential agonistic courtship and mating behavior between two adult giant anteaters (*Myrmecophaga tridactyla*). *Edentata*, 15: 69–72.

Kreutz K, Fischer F & Linsenmair KE. 2009. Observations of intraspecific aggression in giant anteaters (*Myrmecophaga tridactyla*). *Edentata*, 8–10:6–7.

Lacerda ACR, Tomas WM & Marinho-Filho J (2009). Domestic dogs as an edge effect in the Brasília National Park, Brazil: Interactions with native mammals. Animal Conservation, 12, 477–487.

Margarido MP, Carvalho Jr EA, Endo W, Lopes AMC & Miranda FR. 2023. Xenarthra richness and activity pattern in the Brazilian Amazon. *Mammalian Biology*, 103(2): 215–225.

Martins NB, Pinto NNR, da Silva TSG & da Hora AS. 2023. Threats to the conservation of the vulnerable giant anteater (*Myrmecophaga tridactyla*) in the Cerrado biome: a retrospective survey. *Brazilian Journal of Veterinary Medicine*, 45.

Medri ÍM & Mourão G. 2005a. A brief note on the sleeping habits of the giant anteater (*Myrmecophaga tridactyla*) Linnaeus (Xenarthra, Myrmecophagidae). *Revista Brasileira de Zoologia*, 22: 1213–1215.

Medri ÍM & Mourão G. 2005b. Home range of giant anteaters (*Myrmecophaga tridactyla*) in the Pantanal wetland, Brazil. *Journal of Zoology*, 266(4): 365–375.

Miranda F. 2012. *Manutenção de tamanduás em cativeiro*. Editora Cubo, São Carlos. 302 p.

Miranda F, Bertassoni A & Abba AM. 2014. *Myrmecophaga tridactyla*. The IUCN Red List of Threatened Species. IUCN: Gland, Switzerland.

Miranda GHB. 2004. Ecologia e conservação do tamanduá-bandeira (*Myrmecophaga tridactyla*, Linnaeus, 1758) no Parque Nacional das Emas. Tese (Doutorado em Ecologia). Universidade de Brasília, Brasília.

Möcklinghoff L, Marques MI, Ganchev T, Jahn O, Figueiredo JM & Schuchmann KL. 2014. O tamanduá-bandeira, uma "flagship species" para conservação e ecoturismo no Pantanal. *Boletim Informativo Sociedade Brasileira de Zoologia* 111:7–9.

Monteiro MCM & Lira PK. 2020. Metropolitan mammals: understanding the threats inside an urban protected area. *Oecologia Australis*, 24(3): 661–675.

Mourão G & Medri ÍM. 2007. Activity of a specialized insectivorous mammal (*Myrmecophaga tridactyla*) in the Pantanal of Brazil. *Journal of Zoology*, 271(2): 187–192.

Petrazzini PB. 2019. Padrão de ocupação e atividade de tamanduá-bandeira em uma área de proteção no cerrado central. Dissertação de Mestrado, Universidade de Brasília, Brasília, Brasil.

Quandahor P, Kim L, Kim M, Lee K, Kusi F & Jeong IH. 2024. Effects of agricultural pesticides on decline in insect species and individual numbers. *Environments* 11(8):182.

Ribeiro P, Miranda JS & Araújo DR. 2017. The effect of roadkills on the persistence of xenarthran populations: the case of the Brazilian Cerrado. *Edentata* 18:51–61.

Shaw JH, Carter TS & Machado-Neto JC. 1985. Ecology of the giant anteater (*Myrmecophaga tridactyla*) in Serra da Canastra, Minas Gerais, Brazil: a pilot study. In: *The Evolution and Ecology of Armadillos, Sloths, and Vermilinguas*.

Shaw JH, Machado-Neto J & Carter TS. 2016. Behavior of free-living giant anteaters (*Myrmecophaga tridactyla*). *Biotropica* 19:255–259.

Silva MCD. 2020. Avaliação da exposição do tamanduá-bandeira (*Myrmecophaga tridactyla*) a agrotóxicos no Cerrado brasileiro. Dissertação de Mestrado, Universidade de Brasília.

Silveira L, Henrique F, Rodrigues G, Jácomo ATA & Diniz Filho JAF. 1999. Impact of wildfires on the megafauna of Emas National Park, central Brazil. *Oryx* 33(2), 108-114.

Souza JC, da Silva RM, Gonçalves MPR, Jardim RJD & Markwith SH. 2018. Habitat use, ranching, and human-wildlife conflict within a fragmented landscape in the Pantanal, Brazil. *Biological Conservation* 217:349–357.

Teixeira IIL. 2015. O uso da terra no entorno do Parque Nacional de Brasília. Brasília: Universidade de Brasília. 40 folhas. Trabalho Final de Conclusão de Curso. Departamento de Engenharia Florestal.

Versiani NF, Bailey LL, Pasqualotto N, Rodrigues TF, Paolino RM, Alberici V & Chiarello AG. 2021. Protected areas and unpaved roads mediate habitat use of the giant anteater in anthropogenic landscapes. *Journal of Mammalogy* 102(3):802–813.

Vynne C, Keim JL, Machado RB, Marinho-Filho J, Silveira L, Groom MJ & Wasser SK. 2011. Resource selection and its implications for wide-ranging mammals of the Brazilian Cerrado. *PLOS ONE* 6(12): e28939.

Wittemyer G, Elsen P, Bean WT, Coleman A, Burton O & Brashares JS. 2008. Accelerated human population growth at protected area edges. *Science* 321(5885): 123–126.

Zapata-Ríos G & Branch LC. 2019. Altered activity patterns and reduced abundance of native mammals in sites with feral dogs in the high Andes. *Biological Conservation* 193: 144–153.

CAPÍTULO 1

Artigo submetido para a *Studies on Neotropical Fauna and Environment*

Survey of medium and large mammals and their ecosystem services in a peri-urban park

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ABSTRACT

Medium and large mammals play a crucial role in maintaining ecosystem balance by providing essential ecological services. However, these species face significant threats due to human activities. This study, conducted in Brasília National Park (PNB), a peri-urban protected area within the Cerrado biome, aimed to evaluate the richness of medium and large mammal species, their seasonal occurrences, and the ecosystem services they provide. We monitored these mammals using camera traps across two seasons from 2020 to 2022. A total of 25 native species were recorded, five of which are classified as threatened. Additionally, three invasive species were detected, posing potential risks to the native fauna. Our analysis revealed no significant seasonal differences in species richness ($p = 0.4614$), indicating that these mammals persist throughout the year. The Tapirus terrestris was the most frequently recorded species, underscoring the park's importance for the conservation of threatened species. Furthermore, we identified ten ecosystem services provided by the recorded mammals, with cultural value, disease surveillance, and seed dispersal being the most frequently observed. This study underscores the urgent need for conservation efforts in PNB to safeguard its unique mammalian diversity and associated ecosystem services. Continued monitoring is essential for understanding and mitigating the threats faced by Cerrado biodiversity.

Keyword: anthropogenic impact, camera trap, fauna monitoring, habitat use and landscape ecology.

INTRODUCTION

Medium and large mammals play a crucial role in maintaining and balancing ecosystems, making them the central focus of our study. Their ecological functions and the ecosystem services they provide are invaluable (Lacher et al., 2019). These mammals contribute to various ecological processes, including relational services delivered by charismatic species, ecotourism, seed dispersal, pest and disease control, rodent regulation, carrion removal, nutrient transport, top-down regulation, and ecosystem engineering (Lacher et al., 2019; Vale et al., 2023). Consequently, they are considered keystone species in ecosystem restoration and conservation efforts (Davidson et al., 2012; Davidson et al., 2018), particularly in priority areas containing natural remnants. However, in the Neotropical region, the richness of medium and large mammals is primarily threatened by habitat loss and hunting pressure (Bogoni et al., 2020).

The Brazilian Cerrado, recognized as a biodiversity hotspot (Mittermeier et al., 2004; Myers et al., 2000), is a tropical savanna biome increasingly threatened by deforestation and land-use changes driven by human activities (Strassburg et al., 2017). The Cerrado has already lost between 40% and 55% of its original vegetation cover (Sano et al., 2010; Souza et al., 2020), with most remaining fragments being small, isolated, and poorly connected (Pompeu et al., 2024). In this context, larger fragments such as protected areas and Indigenous lands play a critical role in maintaining ecosystem services and conserving biodiversity in the Cerrado (Resende et al., 2021). These areas are essential for safeguarding mammalian richness (Ferreira et al., 2020). Understanding species richness and the ecosystem services they provide underscores the urgent need to protect natural areas, particularly those subjected to anthropogenic pressures or surrounded by urban landscapes.

Camera-trap surveys have proven effective in documenting the richness of medium and large mammals in protected Cerrado areas (Campos et al., 2013; Costa Estrela, 2015; Leite et al., 2016; Cabral et al., 2017; Pônzio et al., 2022). However, systematic studies on Cerrado

mammals remain limited, impeding robust comparisons, especially within protected areas. Consequently, the Cerrado's mammalian fauna is still poorly understood, with considerable knowledge gaps concerning species density, behavior, and ecological requirements (Cabral et al., 2017).

In Brazil, federal protected areas are legally designated reserves aimed at preserving natural environments. Brasília National Park (PNB, acronym in Portuguese) is a protected area in central Brazil located within a peri-urban matrix. Although relatively isolated from other protected areas, PNB serves as an important refuge for local fauna (Juarez, 2008; Brasil, 2023). Nevertheless, comprehensive studies on the park's mammalian fauna are scarce, particularly those encompassing its full extent, diverse vegetation types, and mammal habitat use. This research gap underscores the significance and novelty of our study.

In this study, we aim to investigate seasonal variations in species richness, distribution, and occurrence records of medium and large-sized mammals in Brasília National Park, located in the central Brazilian Cerrado. We hypothesize that species abundance will be higher during the rainy season, when resources such as food and water are more plentiful, reflecting seasonal patterns of habitat use and species activity. Additionally, we will assess potential seasonal differences in the spatial distribution of these mammals, focusing on how species occurrences vary between the dry and rainy seasons. Furthermore, we will categorize the ecosystem services provided by each recorded species to better understand their ecological roles within the park. By addressing these knowledge gaps, our research will contribute to a deeper understanding of the mammalian fauna in Brasília National Park, supporting the development of effective conservation strategies to protect the region's biodiversity.

MATERIALS AND METHODS

Study Area

This study was conducted in Brasília National Park (15°38′12″S, 48°02′21″W), located in central Brazil. The park has a tropical savanna climate (Aw) characterized by dry winters

and rainy summers, according to the Köppen-Geiger classification (Beck et al., 2023). Average temperatures range from below 18°C in the coldest month to around 23°C in the hottest month. The climate is marked by two distinct seasons: the dry season (May to October) and the rainy season (November to April).

Brasília National Park is the largest protected area in the Federal District and a key component of the Cerrado Biosphere Reserve. In 2006, the park's area was expanded from 30,000 to 41,800 hectares, making it the largest continuous natural reserve in the region (Brasil, 2023; Figure 1). The park encompasses a variety of Cerrado phytophysiognomies, including grasslands, savannas, and forests, reflecting the biome's ecological diversity.

Situated only 10 km from Brasília's city center, the park lies within a peri-urban matrix, surrounded by a mix of rural and urban settlements and bordered by major highways. It features areas open to visitors, including trails and natural swimming pools, but also faces challenges such as unauthorized human entry into restricted zones.

Data collection

We collected data on the mammalian fauna of Brasília National Park (PNB) using camera traps (Campark T80, Campark T86, and Meidase Trail). Sampling was conducted during both the rainy and dry seasons across three consecutive years (2020, 2021, and 2022), totaling six distinct field campaigns. Rainy season sampling occurred from January to April, while dry season sampling took place from June to October.

In 2020, we deployed 17 camera traps, increasing the number to 30 in 2021 and 2022. A total of 57 sampling points were strategically distributed across PNB, with a minimum distance of 1 km between points to ensure spatial independence (Figure 1). Cameras were relocated after each 30-day deployment, allowing complete coverage of all sampling points within each seasonal campaign.

Each camera trap was installed approximately 30 cm above the ground and set to operate continuously, recording occurrences 24 hours per day for 30 consecutive days per campaign. The devices were configured to capture three consecutive photos per detection event. This sampling design aimed to assess seasonal influences on species occurrence, distribution, and abundance, considering the marked seasonal variation in the Cerrado biome.

Given PNB's location within a peri-urban landscape and concerns over potential equipment theft, we avoided sampling areas close to urban boundaries. Our combined sampling effort across six field campaigns totaled 10,260 trap-days.

Data analysis

Animal identifications followed the taxonomy outlined by Quintela et al. (2020) in Mammals of Brazil. Medium and large-sized mammals were defined as those with a body mass greater than 1 kg, except for marsupials (Galetti et al., 2017). The conservation status of species was determined using the Biodiversity Extinction Risk Assessment System - SALVE (Instituto Chico Mendes de Conservação da Biodiversidade [ICMBio], 2024) and the IUCN Red List of Threatened Species (International Union for Conservation of Nature [IUCN], 2024).

We conducted statistical analyses to evaluate data normality using the Shapiro-Wilk test. Differences in species abundance between the dry and rainy seasons were assessed using a t-test to determine statistically significant variations in species detections between the two periods. To assess differences in species richness across years, we applied the Kruskal-Wallis test. Additionally, we analyzed species records' temporal distribution across years and seasons to detect potential variations in species occurrence and habitat use.

To evaluate species occurrence, we performed non-parametric analyses to detect seasonal differences in the frequency of mammal records. Relative abundance was calculated by totaling individual detections for each species across all sampling efforts. Statistical analyses were performed using R software (R Core Team, 2024).

To emphasize the ecological importance of PNB's mammalian fauna, we categorized the ecosystem services provided by the recorded medium and large mammals following the classification proposed by Vale et al. (2023) for Brazilian mammals. Based on their framework, we developed an order-level classification of ecosystem services to highlight key ecological roles played by the species detected.

RESULTS

Richness and Distribution

We recorded 25 species of native medium-sized and large mammals (Figure 2; Table 1). Additionally, we identified 236 occurrences of non-native species, such as dogs, horses, and humans (Figure 3). The order with the most representative species is Carnivora, which lists nine species. The *Tapirus terrestris* (tapir) was the most recorded species (39%), followed by *Myrmecophaga tridactyla* (giant anteater), with 199 records (20.90%) (Table 1). In contrast, *Panthera onca* (jaguar) and *Lontra longicaudis* (neotropical otter) were recorded with only one detection each.

We recorded one species categorized as endangered (*Sylvilagus brasiliensis* – Brazilian rabbit) and four as vulnerable (*Tayassu pecari* - white-lipped peccary, *Tapirus terrestris* - tapir, *Priodontes maximus* - giant armadillo and *Myrmecophaga tridactyla* - giant anteater) according to the Global List of Threatened Species (IUCN, 2024) and seven species categorized as vulnerable on national list (ICMBio, 2024) (Table 1). Additionally, we documented five species as near threatened according to the Global List of Threatened Species (IUCN, 2024), including *Chrysocyon brachyurus* (maned wolf), *Panthera onca* (jaguar), *Lontra longicaudis* (otter), *Ozotoceros bezoarticus* (marsh deer), and *Alouatta caraya* (howler monkey) (Table 1).

There was no significant difference ($t = 0.8$, $df = 2.9$, $p = 0.46$) in the number of medium and large mammals' records between the dry and rainy seasons (Figure 4). The non-parametric analyses of Kruskal-Wallis tests indicated no significant differences in richness between years (Kruskal-Wallis chi-squared = 4.3, $df = 2$, $p = 0.11$). These findings suggest that the measured

variables remained relatively stable over the three years, indicating a lack of variation in the data. The Shannon diversity analysis indicated an index of 1.93, and the Jackknife richness estimators showed a value of 34.82 (SE = 3.94).

We observed several species of mammals throughout the park, with the highest richness found in the northern part (indicated by red and dark red points in Figure 5). In contrast, a notable gap is evident in the southwestern portion, where the number of recorded species is lower (indicated by light pink points in Figure 5). The native species, including the threatened ones, exhibited different record patterns throughout the park (Figure 6). We observed that human records are concentrated notably in the southern part of the park, indicating higher human presence in this area, close to visitation areas and the park's perimeter with higher population density (Figure 6a). The giant anteater records are spread throughout the park, with a higher concentration in the southeastern part, where some locations record between 26-35 individuals (Figure 6b). Despite its distribution, there is a lower number of records observed in the southwestern region, with a population group at the park boundary and a significant number of human records.

The distribution of giant armadillo records, as depicted in Figure 6c, is notably sparse and scattered across the park. The fact that we managed to obtain 12 records, despite the species' rarity and the difficulties of camera trap studies, is a significant achievement. Similar to the giant armadillo, for which most locations report 1-5 records (Figure 6d), *Puma concolor* (puma) records, as shown in Figure 6e, are similarly sparse and distributed across the park, with most locations indicating 1-5 records, as expected, given the rarity and low population density of the species. Lastly, the tapir presents records spread throughout the park, with some areas showing higher concentrations (Figure 6f). The highest concentration of records (26-35) is located in the central part of the park, at the same location as the giant anteater. This suggests that this area might be a hotspot for tapir conservation. In this study, the points with the highest number of

native species records (from orange to dark red) are in areas beyond the fences that mark the end of the visitor-accessible area.

Ecosystem services

We identified ten ecosystem services provided by medium and large mammal species recorded by camera traps in the PNB (Figure 7). All recorded species showed potential and provided services for at least one type of ecosystem service (Figure 7). The most common service recorded is the cultural service of charismatic species. This service, which involves aesthetic appreciation and cultural connection of the people with the mammalian fauna, plays a significant role in the park's ecosystem. It is associated with all orders and species listed in our study. Following this, ecosystem services of seed dispersal, horizontal nutrient transport, and ecotourism are provided by 14, 8, and 7 species of medium and large mammals, respectively. Other ecosystem services were associated with a smaller number of mammal species (between 3 and 5 species).

DISCUSSION

Richness and Distribution

This study identified 25 mammal species in Brasília National Park (PNB), surpassing the 24 species recorded by Juarez (2008), who surveyed PNB alongside the Águas Emendadas Ecological Station (ESECAE) and the Gama-Cabeça-de-Veado Environmental Protection Area (APAGCV). Within PNB alone, Juarez documented 15 species, all of which were also recorded in this study. Similarly, Oliveira (2010) identified 13 species in PNB, with only Pecari tajacu (collared peccary) absent from our findings. In contrast, a survey in the nearby Brasília National Forest (FLONA) using indirect signs documented 27 species (Leite et al., 2016). Of these, six species—*Lycalopex vetulus* (hoary fox), *Leopardus guttulus* (small spotted cat), *Puma yagouaroundi* (jaguarundi), *Mazama gouazoubira* (brown brocket deer), *Euphractus sexcinctus*

(yellow armadillo), and *Coendou longicaudatus* (Brazilian porcupine)—were not detected in our study. Conversely, four species found in PNB — *Tayassu pecari* (white-lipped peccary), *Cavia aperea* (Brazilian guinea pig), *Panthera onca* (jaguar), and the otter — were absent from FLONA records.

The detection of five threatened species underscores PNB's critical role in regional biodiversity conservation. Among these, only the tapir, giant armadillo, and giant anteater were reported in APAGCV (Ribeiro et al., 2023), while only the giant anteater was detected in ESECAE (Juarez, 2008). Notably, the jaguar, a key top predator, has not been previously recorded in any published surveys from these areas (Juarez, 2008; Oliveira, 2010; Leite et al., 2016; Petrazzini & Aguiar, 2022), suggesting that PNB may serve as a crucial refuge for this and other sensitive species.

Species records within PNB displayed spatial patterns influenced by human activity, particularly near the park's southwest boundary adjacent to urban areas such as Estrutural. The central and northwest regions, including areas near the reservoir and along remote roads, emerged as potential biodiversity hotspots due to their isolation from human-disturbed zones. Similar patterns were observed for key species such as the giant armadillo and giant anteater, whose occurrences were concentrated in less accessible areas, suggesting that human pressure constrains their spatial distribution.

The presence of invasive species, particularly domestic dogs, poses a direct threat to native fauna. Dogs can compete with medium-sized carnivores (Vanak & Gompper, 2010), prey on vulnerable species such as the giant anteater and Brazilian rabbit (Guedes et al., 2021), and act as reservoirs for zoonotic pathogens transmissible to wildlife, including maned wolves and anteaters (Richini-Pereira et al., 2014; Campos et al., 2020; Heliodoro et al., 2020; Fiori et al., 2023). Galetti and Sazima (2006) estimated that dogs could kill up to 26.83 kg of native wildlife annually in similar environments.

Human intrusion into restricted park areas further compounds these threats. Mammals often perceive humans as predators, prompting avoidance behaviors that may incur survival costs (Frid & Dill, 2002). Behavioral shifts in response to human presence have been documented globally, including altered movement patterns, activity cycles, and habitat use (Blake et al., 2017; Gaynor et al., 2018; Barcelos et al., 2022). In PNB, records of humans in sensitive zones overlapped with threatened species detections, highlighting a concerning edge effect exacerbated by unauthorized human access. The presence of armed individuals likely involved in illegal hunting presents an additional conservation challenge.

The giant armadillo's records were concentrated in the north-central part of PNB, a remote area characterized by low human accessibility, suggesting that these regions are critical for the species' conservation. In contrast, maned wolves exhibited a more widespread distribution, with a notable concentration in less accessible central areas, possibly reflecting habitat preference and reduced disturbance levels. Species absences near the park’s urbanized edges reinforce the influence of anthropogenic pressures. The negative effects of human density and land-use change on wildlife are well-documented, including disruptions in predator-prey dynamics, increased disease transmission risks, and elevated extinction probabilities even within protected areas (Gorczynski et al., 2022).

The cumulative pressures on PNB's biodiversity, including habitat encroachment, invasive species, and human disturbance, mirror challenges faced by protected areas worldwide. Studies in analogous systems, such as Iguaçu and Cavernas do Peruaçu National Parks, have documented similar patterns of mammal avoidance in response to human activity (Silva et al., 2018; Barcelos et al., 2022). Globally, mammals adapt their behavior to minimize human encounters, often shifting activity patterns and reducing habitat use near roads and visitor areas (Rogala et al., 2011; Leblond et al., 2012; Searle et al., 2021; Tucker et al., 2023).

Given PNB's unique ecological significance, additional research on species-specific responses to human pressures is critical. Understanding how mammals adapt or fail to adapt to

anthropogenic disturbances will inform more effective conservation strategies aimed at preserving biodiversity in this key Cerrado refuge.

Ecosystem services

In our study, the cultural service of charismatic species and ecotourism appeared as ecosystem services provided by several medium and large mammal species. These ecosystem services are essential for protected areas, such as national parks that receive daily visits, as with PNB. Charismatic and flagship species are considered strategic conservation tools acting as the center of attention for an entire ecosystem and capturing the attention of the public to support conservation actions (Simberloff, 1998; Leader-Williams & Dublin, 2000; Jepson & Barua, 2015). Charismatic species, such as the jaguar, giant anteater, and other Brazilian species, are often seen as symbols of biodiversity (Mittermeier, 1986; Sergio et al., 2006). In this way, it is possible to raise awareness among people about conserving this peri-urban fragment of Cerrado and its importance in maintaining these mammalian populations, especially since many of them are threatened with extinction due to habitat loss and hunting.

Our study showed that the second most recorded ecosystem service was disease sentineling. Species that act as sentinels in an ecosystem can help in the early detection of diseases, allowing intervention before they spread to other populations or species, including humans (McCluskey, 2003; Reif, 2011). Furthermore, amidst so much climate change and the Anthropocene, these species can help manage changing ecosystems in the future (Hazen et al., 2024). Protecting sentinel species is essential for the conservation of biodiversity and for maintaining the health of ecosystems, as their conditions reflect the health of the environment (García-Fernández et al., 2020). Therefore, the sentinel mammal species of the PNB are essential to reflect the environmental conditions and health, as it is a peri-urban protected area of Cerrado in an anthropized matrix. The main species that perform this role are Carnivora, Primates, and Rodentia.

Seed dispersal was another ecosystem service provided by many mammal species in our study. Species such as the tapirs are important seed dispersers, helping to maintain vegetation structure and habitat regeneration (Fragoso et al., 2003; Aguiar et al., 2011; Donatti et al., 2011; Paglia et al., 2012). Medium and large mammals can disperse a large quantity of seed over long distances, just as they can ingest the seeds of larger fruits (Guimarães et al., 2008; Ong et al., 2022). The extinction of medium and large mammal species that act as seed dispersers can compromise plant regeneration and habitat integrity, especially in areas with threatened species (Lacher et al., 2019; Ong et al., 2022). Therefore, maintaining the seed-dispersing populations of medium and large mammals in the PNB is necessary for this peri-urban fragment of Cerrado. Urban fragments could serve as wildlife corridors and are more likely to be visited by peri-urban individuals than isolated habitat patches (Snep et al., 2006; Zellmer & Goto, 2022). Furthermore, peri-urban fragments provide numerous other ecosystem services, improving the quality of life for human urban populations (Li et al., 2017; Roeland et al., 2019).

Medium and large mammals also provide other essential ecosystem services, such as carrion control and pest and disease control, which are crucial to the ecosystem's overall health (Lacher et al., 2019). *Cerdocyon thous* (crab-eating fox), *Conepatus amazonicus* (striped hog-nosed skunk), and *Dasypus sp.* were the species recorded in our study that provide the ecosystem service carrion control. These species are opportunistic omnivores that feed on food carrion (Aguiar et al., 2011; Gallo et al., 2019; Cruz et al., 2022). Armadillos also provided ecosystem services of pest and disease control, acting as an ecosystem engineer and nutrient transportation service (bioturbators) (Rodrigues et al., 2019), along with white-lipped peccary and other suids. The loss of species that perform these services can lead to public health problems and ecological imbalances (Ostfeld & LoGiudice, 2003; Mace et al., 2012; Lacher et al., 2019).

Large carnivore predators are at the top of trophic webs. They can exert a top-down regulation on prey populations, maintaining ecological balance by controlling the biodiversity

and biomass at lower trophic levels (Ripple & Beschta, 2012; Wallach et al., 2015). In PNB, these predators are the jaguar, the puma, the maned wolf, and Leopardus pardalis (ocelot). Other medium carnivores of the PNB, such as the crab-eating fox, are also crucial in the ecosystem, controlling smaller prey such as herbivores and rodents (Juarez & Marinho-Filho, 2002; Dutra-Vieira et al., 2021). However, they cannot replace the role of large carnivores in the ecosystem (Su et al., 2022). Therefore, the presence of these medium and large mammals in the ecosystem is essential to maintain population regulation (Wallach et al., 2015; Su et al., 2022). The imbalance in the predator-prey relationship negatively affects the ecosystem and can lead species to become endangered (Ritchie & Johnson, 2009). The service not registered by any species is the ecosystem service of pollination since it is a service promoted especially by bats (Diniz et al., 2022; Diniz & Aguiar 2023 a,b), which were not considered in our study. The absence of this service could have implications for the park's ecosystem, highlighting the importance of considering all potential ecosystem services in conservation and management strategies.

Conclusion and Future Recommendations

This study demonstrates that Brasília National Park harbors a significant diversity of medium and large mammals, representing a substantial portion of the Cerrado's mammalian fauna and serving as a crucial refuge for these species, particularly those at risk of extinction, in an increasingly urbanized landscape. Nonetheless, there are notable concerns about mammal conservation in the park due to impacts from exotic and invasive species, edge effects, and pervasive human presence throughout both visitor and restricted areas. Large body size among mammals is linked to higher extinction risk in the tropical region (Fritz et al., 2009), implying that medium and large mammals in the park may be particularly vulnerable. Additionally, there is a general lack of data on the viability of these mammal populations, except for a study on the giant anteater, which highlighted roadkill as a significant threat to the species' survival in the

area (Diniz & Brito, 2013). Medium and large mammals offer essential ecosystem services, such as seed dispersal, nutrient cycling, habitat modification, and cultural benefits (Vale et al., 2023), crucial for biodiversity conservation and human well-being. Thus, effective management of tourism and human impacts, considering spatial distribution and activity intensity, is critical for conserving these species in protected areas (Barcelos et al., 2022). The lack of significant seasonal variation suggests that mammals are year-round residents of the protected area, even in the face of peri-urban pressures. The presence of threatened and large species, such as tapirs, collared peccaries, and jaguars, indicates the area's resilience in providing suitable habitat for sensitive fauna. Additionally, the identification of ten ecosystem services emphasizes the ecological significance of these species, particularly in seed dispersal and nutrient transport, both of which are crucial for maintaining ecosystem functionality. The presence of several threatened species accentuates the need for immediate conservation actions to safeguard this unique biodiversity.

This study reinforces that a protected area that hosts multiple species providing ecosystem services is essential for maintaining biodiversity and enhancing ecosystem resilience. Enhancing habitat connectivity and implementing effective management strategies are imperative to mitigate the risks associated with invasive species and human encroachment. Furthermore, continued monitoring and research are essential for understanding the dynamics of mammalian populations and their contributions to ecosystem health, thereby supporting the conservation of the unique biodiversity present in Brasília National Park. Engaging local communities in conservation efforts and promoting awareness about the ecological significance of these species will be essential for fostering a collective commitment to preserving the local biodiversity for the future.

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REFERENCES

Aguiar, L. M.; Moro-Rios, R. F.; Silvestre, T.; Silva-Pereira, J. E.; Bilski, D. R.; Passos, F. C.; Sekiama, M. L. & Rocha, V. L. 2011. Diet of brown-nosed coatis and crab-eating racoons from a mosaic landscape with exotic plantations in southern Brazil. Studies on Neotropical Fauna and Environment 46(3):153-161.

Barcelos, D., Vieira, E. M., Pinheiro, M. S., & Ferreira, G. B. (2022). A before− after assessment of the response of mammals to tourism in a Brazilian national park. Oryx. 56(6), 854-863.

Beck, H. E., McVicar, T. R., Vergopolan, N., Berg, A., Lutsko, N. J., Dufour, A., Zeng, Z., Jiang, X., van Dijk, A. I. & Miralles, D. G. (2023). High-resolution (1 km) Köppen-Geiger maps for 1901–2099 based on constrained CMIP6 projections. Scientific data. 10(1), 724.

Blake, J. G., Mosquera, D., Loiselle, B. A., Romo, D., & Swing, K. 2017. Effects of human traffic on use of trails by mammals in lowland forest of eastern Ecuador.Neotropical Biodiversity, 3(1), 57-64.

Brasil. Ministério do Meio Ambiente e Mudança do Clima (MMA). Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio). 2023. *Portaria ICMBio nº 3107, de 11 de setembro de 2023. Aprova a revisão do Plano de Manejo do Parque Nacional de Brasília*. Brasília, 2023.

Bogoni, J.A., Peres, C.A. & Ferraz, K.M.P.M.B. Extent, intensity and drivers of mammal defaunation: a continental-scale analysis across the Neotropics. Sci Rep 10, 14750 (2020). https://doi.org/10.1038/s41598-020-72010-w

Cabral, R., Zanin, M., Porfírio, G., & Brito, D. (2017). Medium-sized to large mammals of Serra do Tombador, Cerrado of Brazil. Check List, 13(3), 2129-2129.

Campos, F. S., Lage, A. R. B., & Ribeiro, P. H. P. (2013). Diversity of medium and large sized mammals in a Cerrado fragment of central Brazil. Journal of Threatened Taxa, 5(15), 4994-5001.

Campos, S. D. E., Cunha, N. C. D., Machado, C. D. S. C., Nadal, N. V., Seabra Junior, E. S., Telleria, E. L., Cordeiro, M. D., Toma, H. K. & Almosny, N. R. P. (2020). Spotted fever group rickettsial infection in dogs and their ticks from domestic–wildlife interface areas in southeastern Brazil. Revista Brasileira de Parasitologia Veterinária. 29, e020219. https://doi.org/10.1590/S1984-29612020012.

Cicero Diogo L. Oliveira , Keyla Juliana S. B. Café , Vandick S. Batista (2022). Management plans for Protected Areas in Brazil reveal similarity between specific objectives and mammals as the main focus of conservation. Nature Conservation Research. 7(3), 64-74.

Costa Estrela, D., de Souza, D. C., de Souza, J. M., & da Silva Castro, A. L. (2015). Medium and large-sized mammals in a Cerrado area of the state of Goiás, Brazil. Check List, 11(4), 1690-1690.

Cruz, L. R., Muylaert, R. L., Galetti, M., & Pires, M. M. (2022). The geography of diet variation in Neotropical Carnivora. Mammal Review, 52(1), 112-128.

Davidson, A. D., Detling, J. K., & Brown, J. H. (2012). Ecological roles and conservation challenges of social, burrowing, herbivorous mammals in the world's grasslands. Frontiers in Ecology and the Environment, 10(9), 477-486.

Davidson, A. D., Hunter, E. A., Erz, J., Lightfoot, D. C., McCarthy, A. M., Mueller, J. K., & Shoemaker, K. T. (2018). Reintroducing a keystone burrowing rodent to restore an arid

North American grassland: challenges and successes. Restoration Ecology, 26(5), 909-920.

Diniz, M. F., & Brito, D. (2013). Threats to and viability of the giant anteater, *Myrmecophaga tridactyla* (Pilosa: Myrmecophagidae), in a protected Cerrado remnant encroached by urban expansion in central Brazil. Zoologia (Curitiba), 30(2).

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

Donatti, C. I., Guimarães, P. R., Galetti, M., Pizo, M. A., Marquitti, F. M. D., & Dirzo, R. (2011). Analysis of a hyper-diverse seed dispersal network: Modularity and underlying mechanisms. Ecology Letters, 14(8), 773–781. https://doi.org/10.1111/j.1461-0248.2011.01639.x

Dutra-Vieira, F. M., Silva, M. S., Vieira, G. S., Carvalho, A. S., & Schimming, B. C. (2021). Diet of crab-eating fox (*Cerdocyon thous*) in two conservation units of the Amazon rainforest, Brazil. Brazilian Journal of Biology, 84, e252093.

Ferreira, G. B., Collen, B., Newbold, T., Oliveira, M. J. R., Pinheiro, M. S., de Pinho, F. F., ... & Carbone, C. (2020). Strict protected areas are essential for the conservation of larger and threatened mammals in a priority region of the Brazilian Cerrado. Biological Conservation, 251, 108762.

Fiori, F., Paula, R. C., Navas-Suárez, P. E., Boulhosa, R. L. P. & Dias, R. A. (2023). The sarcoptic mange in maned wolf (*Chrysocyon brachyurus*): Mapping an emerging disease in the largest South American Canid. Pathogens. 12(6), 830. https://doi.org/10.3390/pathogens12060830.

Fragoso JMV, Silvius KM, Correa JA (2003) Long-distance seed dispersal by tapirs increases seed survival and aggregates tropical trees. Ecology 84(8): 1998-2006.

Frid, A., & Dill, L. 2002. Human-caused disturbance stimuli as a form of predation risk. Conservation ecology, 6(1).

Fritz, S. A., Bininda-Emonds, O. R. P. & Purvis, A. (2009). Geographical variation in predictors of mammalian extinction risk: big is bad, but only in the tropics. Ecology Letters 12: 538-549. https://doi.org/10.1111/j.1461-0248.2009.01307.x

Galetti, M. & Sazima, I. (2006). Impacto de cães ferais em um fragmento urbano de Floresta Atlântica no sudeste do Brasil. Natureza & Conservação. 4(1), 58-63.

Gallo, J. A., Fasola, L., & Abba, A. M. (2019). Armadillos as natural pests control? Food habits of five armadillo species in Argentina.

García-Fernández, A.J., Espín, S., Gómez-Ramírez, P., Martínez-López, E., Navas, I. (2020). Wildlife Sentinels for Human and Environmental Health Hazards in Ecotoxicological Risk Assessment. In: Roy, K. (eds) Ecotoxicological QSARs. Methods in Pharmacology and Toxicology. Humana, New York, NY. https://doi.org/10.1007/978-1-0716-0150-1_4

Gaynor, K. M., Hojnowksi, C. E., Carter, N. H., & Brashares, J. S. (2018). The influence of human disturbance on wildlife nocturnality. Science, 360, 1232-1235.

Gorczynski, D., Hsieh, C., Ahumada, J., Akampurira, E., Andrianarisoa, M. H., Espinosa, S., ... & Beaudrot, L. (2022). Human density modulates spatial associations among tropical forest terrestrial mammal species. Global Change Biology, 28(24), 7205-7216.

Guedes, J. J. M., Assis, C. L., Feio, R. N., & Quintela, F. M. (2021). The impacts of domestic dogs (Canis familiaris) on wildlife in two Brazilian hotspots and implications for conservation. Animal Biodiversity and Conservation, 44(1), 45–58.

Guimarães PR Jr, Galetti M, Jordano P (2008) Seed Dispersal Anachronisms: Rethinking the Fruits Extinct Megafauna Ate. PLoS ONE 3(3): e1745. https://doi.org/10.1371/journal.pone.0001745

Hazen, E. L., Savoca, M. S., Clark-Wolf, T. J., Czapanskiy, M., Rabinowitz, P. M., & Abrahms, B. (2024). Ecosystem Sentinels as Early-Warning Indicators in the Anthropocene. Annual Review of Environment and Resources, 49.

Heliodoro, G., Verona, C. E. & Henrique, R. (2020). Animais Domésticos e o Risco de

Zoonoses para a Fauna Silvestre na Área de Entorno do Parque Nacional da Tijuca. Biodiversidade brasileira. 10(2), 133-147.

IBRAM. 2011. Lista de Fauna do Distrito Federal:16.

ICMBio, 2024. Sistema de Avaliação do Risco de Extinção da Biodiversidade – SALVE. Available at: https://salve.icmbio.gov.br/. Accessed July 01, 2024.

IUCN. The IUCN Red List of Threatened Species. 2024. Available at: https://www.iucnredlist.org. Accessed July 01, 2024.

Jepson, P., & Barua, M. (2015). A theory of flagship species action. Conservation and Society, 13(1), 95-104.

Juarez, K. M. 2008. Mamíferos de médio e grande porte nas unidades de conservação do Distrito Federal. PhD thesis, Universidade de Brasília, Brasília, Brazil, 153 pp.

Juarez, K. M., & Marinho-Filho, J. (2002). Diet, habitat use, and home ranges of sympatric canids in central Brazil. Journal of Mammalogy, 83(4), 925-933.

Lacerda, A. C. R., Tomas, W. M., & Marinho-Filho, J. (2009). Domestic dogs as an edge effect in the Brasília National Park, Brazil: Interactions with native mammals. Animal Conservation, 12, 477–487.

Lacher Jr, T. E., Davidson, A. D., Fleming, T. H., Gómez-Ruiz, E. P., McCracken, G. F., Owen-Smith, N., ... & Vander Wall, S. B. (2019). The functional roles of mammals in ecosystems. Journal of Mammalogy, 100(3), 942-964.

Leader-Williams, N., & Dublin, H. T. (2000). Charismatic megafauna as flagship species's. Conservation Biology Series-Cambridge-, 53-84.

Leblond, M., Dussault, C., & Ouellet, J. P. (2012). Avoidance of roads by large herbivores and its relation to disturbance intensity. Journal of Zoology, 289, 32-40.

Leite, R. J. V., Lemos, J. L. F., Silva, F. W. M. D., Alencar, I. R. C. D., Bezerra, P. F., & Carregaro, J. B. (2016). Composition of medium and large mammals in forest reserve in the Cerrado of Brazil Central. Revista Árvore, 40(5), 825-832

Lemos, F. G., Facure, K. G., & Azevedo, F. C. (2011). A first approach to the comparative ecology of the hoary fox and the crab-eating fox in a fragmented human-altered landscape in the Cerrado biome at central Brazil. In L. M. Rosalino & C. Gheler-Costa (Eds.), Middle-sized carnivores in agricultural landscapes (pp. 143–160). Nova Science Publishers, Inc.

Li, F., Liu, X., Zhang, X., Zhao, D., Liu, H., Zhou, C., & Wang, R. (2017). Urban ecological infrastructure: an integrated network for ecosystem services and sustainable urban systems. Journal of Cleaner Production, 163, S12-S18.

Mace, G. M., Norris, K., & Fitter, A. H. (2012). Biodiversity and ecosystem services: a multilayered relationship. Trends in Ecology & Evolution, 27(1), 19–26.

Marion, S., Curveira Santos, G., Herdman, E., Hubbs, A., Kearney, S. P., & Burton, A. C. (2024). Mammal responses to human recreation depend on landscape context. Plos one, 19(7), e0300870.

Massara, R. L., de O. Paschoal, A. M., Bailey, L. L., Doherty, P. F., Hirsch, A., & Chiarello, A. G. (2018). Factors influencing ocelot occupancy in Brazilian Atlantic Forest reserves. Biotropica, 50, 125–134.

Maurer, A. S., Cove, M. V., Siegal, O. M., & Lashley, M. A. (2022). Urbanization affects the behavior of a predator-free ungulate in protected lands. Landscape and Urban Planning, 222, 104391.

McCluskey, B. J. 2003 Use of sentinel herds in monitoring and surveillance systems. In Animal disease surveillance and survey systems: methods applications (ed. M. D. Salman), pp. 119–133. Iowa, IA: Iowa State Press.

Mittermeier, R. A. (1986). Primate conservation priorities in the Neotropical region. In Primates: The road to self-sustaining populations (pp. 221-240). New York, NY: Springer New York.

Mittermeier, R. A., Myers, N., Gill, P. C., & Mittermeier, C. G. (2000). Hotspots: Earth's richest

and most endangered terrestrial ecoregions. Mexico City: CEMEX.

Myers, N., Mittermeier, R. A., Mittermeier, C. G., Da Fonseca, G. A., & Kent, J. (2000). Biodiversity hotspots for conservation priorities. Nature, 403(6772), 853-858.

Negret, P. J., Luskin, M. S., Gomez-Valencia, B., Diaz-Pulido, A., Romero, L. H., Restrepo, A., Zaehringer, J. G., Jones, K. R., Ochoa-Quintero, J. M., & Mendes, C. P. (2023). Neotropical understory birds and mammals show divergent behavioral responses to human pressure. Perspectives in Ecology and Conservation, 21(2), 180-188.

Oliveira, I. M. D. 2010. Riqueza, abundância de espécies e uso de habitat por mamíferos de médio e grande porte em cinco unidades de conservação no cerrado. Master's dissertation, Universidade de Brasília, Brasília, Brazil, 91 pp.

Ong, L., McConkey, K. R., & Campos-Arceiz, A. (2022). The ability to disperse large seeds, rather than body mass alone, defines the importance of animals in a hyper-diverse seed dispersal network. Journal of Ecology, 110(2), 313-326.

Ostfeld RS, LoGiudice K (2003) Community disassembly, biodiversity loss, and the erosion of an ecosystem service. Ecology 84(6): 142

Petrazzini, P. B., & de S. Aguiar, L. M. (2021). You say goodbye, and I say hello: The giant anteater (*Myrmecophaga tridactyla*) activity pattern in response to temperature and human presence. Mastozoología Neotropical, 28(1), e0469.

Petrazzini, P. B., & Aguiar, L. M. S. (2022). Completely caught off guard: a new record of Jaguar, *Panthera onca* (Linnaeus, 1758) (*Mammalia.* Felidae), from an urban park. Check List, 18(3), 463-467.

Pompeu, J., Assis, T. O., & Ometto, J. P. (2024). Landscape changes in the Cerrado: Challenges of land clearing, fragmentation and land tenure for biological conservation. Science of The Total Environment, 906, 167581.

Pônzio, M., Alberici, V., Pasqualotto, N., Paolino, R., Rodrigues, T., & Chiarello, A. (2022). Mammals of Cajuru State Forest and surroundings: a neglected but important Protected

Area for the Cerrado conservation in the São Paulo state, Brazil. Biota Neotropica, 22, e20211261.

Reif, J. S. (2011). Animal sentinels for environmental and public health. Public Health Reports, 126(1_suppl), 50-57.

Resende, F. M., Cimon-Morin, J., Poulin, M., Meyer, L., Joner, D. C., & Loyola, R. (2021). The importance of protected areas and Indigenous lands in securing ecosystem services and biodiversity in the Cerrado. Ecosystem Services, 49, 101282.

Ribeiro, M.C.; Zanatta, M.R.V.; Miranda, L.A.; Petrazzini, P.B.; Souza, E.N.F. & Sampaio, R.C. (2023) Subprograma Fauna. In: Brasília Ambiental (Ed.) Plano de Manejo da Estação Ecológica do Jardim Botânico de Brasília. Brasília, Distrito Federal. Volume 2 - Anexo.

Richini-Pereira, V. B., Marson, P. M., Hayasaka, E. Y., Victoria, C., Silva, R. C. & Langoni, H. (2014). Molecular detection of Leishmania spp. in road-killed wild mammals in the Central Western area of the State of São Paulo, Brazil. Journal of Venomous Animals and Toxins Including Tropical Diseases. 20, 01–07. https://doi.org/10.1186/1678-9199-20-27.

Ripple, W. J. & Beschta, R. L. Large predators limit herbivore densities in northern forest ecosystems. Eur. J. Wildl. Res. 58, 733–742 (2012).

Ritchie, E. G., & Johnson, C. N. (2009). Predator interactions, mesopredator release and biodiversity conservation. Ecology letters, 12(9), 982-998.

Rodrigues, T. F., Mantellatto, A. M., Superina, M., & Chiarello, A. G. (2020). Ecosystem services provided by armadillos. Biological Reviews, 95(1), 1-21.

Roeland, S., Moretti, M., Amorim, J. H., Branquinho, C., Fares, S., Morelli, F., ... & Calfapietra, C. (2019). Towards an integrative approach to evaluate the environmental ecosystem services provided by urban forest. Journal of Forestry Research, 30, 1981-1996.

Rogala, J. K., Hebblewhite, M., Whittington, J., White, C. A., Coleshill, J., & Musiani, M.

(2011). Human activity differentially redistributes large mammals in the Canadian Rockies National Parks. Ecology and Society, 16(3).

Sano, E. E., Rosa, R., Brito, J. L., & Ferreira, L. G. (2010). Land cover mapping of the tropical savanna region in Brazil. Environmental monitoring and assessment, 166, 113-124.

Searle, C. E., Smit, J. B., Cusack, J. J., Strampelli, P., Grau, A., Mkuburo, L., Macdonald, D. W., Loveridge, A. J., & Dickman, A. J. (2021). Temporal partitioning and spatiotemporal avoidance among large carnivores in a human-impacted African landscape. PLoS ONE, 16(9), e0256876.

Semper-Pascual, A., Sheil, D., Beaudrot, L., Dupont, P., Dey, S., Ahumada, J., Akampurira, E., Bitariho, R., Espinosa, S., Jansen, P. A. J., Lima, M. G. M., Martin, E. H., Mugerwa, B., Rovero, F., Santos, F., Uzabaho, E., & Bischof, R. (2023). Occurrence dynamics of mammals in protected tropical forests respond to human presence and activities. Nature Ecology & Evolution, 7, 1092-1103.

Sergio, F., Newton, I. A. N., Marchesi, L., & Pedrini, P. (2006). Ecologically justified charisma: preservation of top predators delivers biodiversity conservation. Journal of Applied Ecology, 43(6), 1049-1055.

Silva, M. X., Paviolo, A., Tambosi, L. R., & Pardini, R. (2018). Effectiveness of protected areas for biodiversity conservation: Mammal occupancy patterns in the Iguaçu National Park, Brazil. Journal of Nature Conservation, 41, 51-62.

Simberloff, D. (1998). Flagships, umbrellas, and keystones: is single-species management passé in the landscape era?. Biological conservation, 83(3), 247-257.

Snep, R. P. H., Opdam, P. F. M., Baveco, J. M., WallisDeVries, M. F., Timmermans, W., Kwak, R. G. M., & Kuypers, V. (2006). How peri-urban areas can strengthen animal populations within cities: a modeling approach. Biological conservation, 127(3), 345-355.

Souza Jr, C. M., Z. Shimbo, J., Rosa, M. R., Parente, L. L., A. Alencar, A., Rudorff, B. F., ... & Azevedo, T. (2020). Reconstructing three decades of land use and land cover changes in

brazilian biomes with landsat archive and earth engine. Remote Sensing, 12(17), 2735.

Strassburg, B. B., Brooks, T., Feltran-Barbieri, R., Iribarrem, A., Crouzeilles, R., Loyola, R., ... & Balmford, A. (2017). Moment of truth for the Cerrado hotspot. Nature Ecology & Evolution, 1(4), 0099.

Su, T., Li, Q., Wang, X., Cui, G., Man, Z., Li, W., & Zhao, M. (2022). The ecological roles of medium and small carnivores in the terrestrial animal community in Liancheng national nature reserve, China. Animals, 12(24), 3518.

Tucker, M. A., Schipper, A. M., Adams, T. S. F., Attias, N., Avgar, T., Babic, N. L., Barker, K. J., *et al.* (2023). Behavioral responses of terrestrial mammals to COVID-19 lockdowns. Science, 380, 1059-1064.

Vale, M. M., Vieira, M. V., Grelle, C. E. V., Manes, S., Pires, A. P. F., Tardin, R. H., Weber, M. M., Menezes, M. A., O'Connor, L., Thuiller, W., & Tourinho, L. (2023). Ecosystem services delivered by Brazilian mammals: Spatial and taxonomic patterns and a comprehensive list of species. Perspectives in Ecology and Conservation, 21, 302-310.

Wallach, A. D., W. J. Ripple, and S. P. Carroll. 2015. Novel trophic cascades: apex predators enable coexistence. Trends in Ecology and Evolution 30:146–153

Zellmer, A. J., & Goto, B. S. (2022). Urban wildlife corridors: Building bridges for wildlife and people. Frontiers in Sustainable Cities, 4, 954089.

TABLES

Table 1. List of medium and large mammals recorded in Brasília National Park from 2020 to 2022. Threat categories: CR (critically endangered), EN (endangered), VU (vulnerable), NT (near threatened), LC (least concern), DD (data deficient), blank (not evaluated). R: rainy season. D: dry season. RA: relative abundance. (%).

ORDER	SPECIES	IUCN	ICMBio	Records		RA
				R	D	
Cetartiodactyla	*Ozotoceros bezoarticus*	NT	VU	30	70	0.0098
	Tayassu pecari	VU	VU	0	4	0.0004
Carnivora	*Cerdocyon thous*	LC	LC	50	41	0.0089
	Chrysocyon brachyurus	NT	VU	33	28	0.0060
	Leopardus pardalis	LC	LC	2	8	0.0010
	Panthera onca	NT	VU	0	1	0.0001
	Puma concolor	LC	NT	14	21	0.0034
	Conepatus amazonicus	LC	LC	1	3	0.0004
	Eira barbara	LC	LC	4	7	0.0011
	Lontra longicaudis	NT	LC	0	1	0.0001
	Nasua nasua	LC	LC	4	11	0.0015
	Procyon cancrivorus	LC	LC	3	4	0.0007
Lagomorpha	*Sylvilagus brasiliensis*	EN	DD	0	3	0.0003
Perissodactyla	*Tapirus terrestris*	VU	VU	187	186	0.0363
Rodentia	*Cavia aperea*	LC	LC	0	1	0.0001
	Cuniculus paca	LC	LC	1	0	0.0001
	Dasyprocta azarae	DD	LC	1	0	0.0001
	Hydrochaeris hydrochaeris	LC	LC	5	4	0.0009
Cingulata	*Cabassous* sp.			0	1	0.0001
	Dasypus sp.			5	1	0.0006
	Priodontes maximus	VU	VU	9	3	0.0012
Pilosa	*Myrmecophaga tridactyla*	VU	VU	100	99	0.0194
	Tamandua tetradactyla	LC	LC	1	1	0.0002
Primates	*Alouatta caraya*	NT	NT	1	0	0.0001
	Callithrix sp.			0	3	0.0003
	Total native			**451**	**501**	**0.0928**

FIGURES

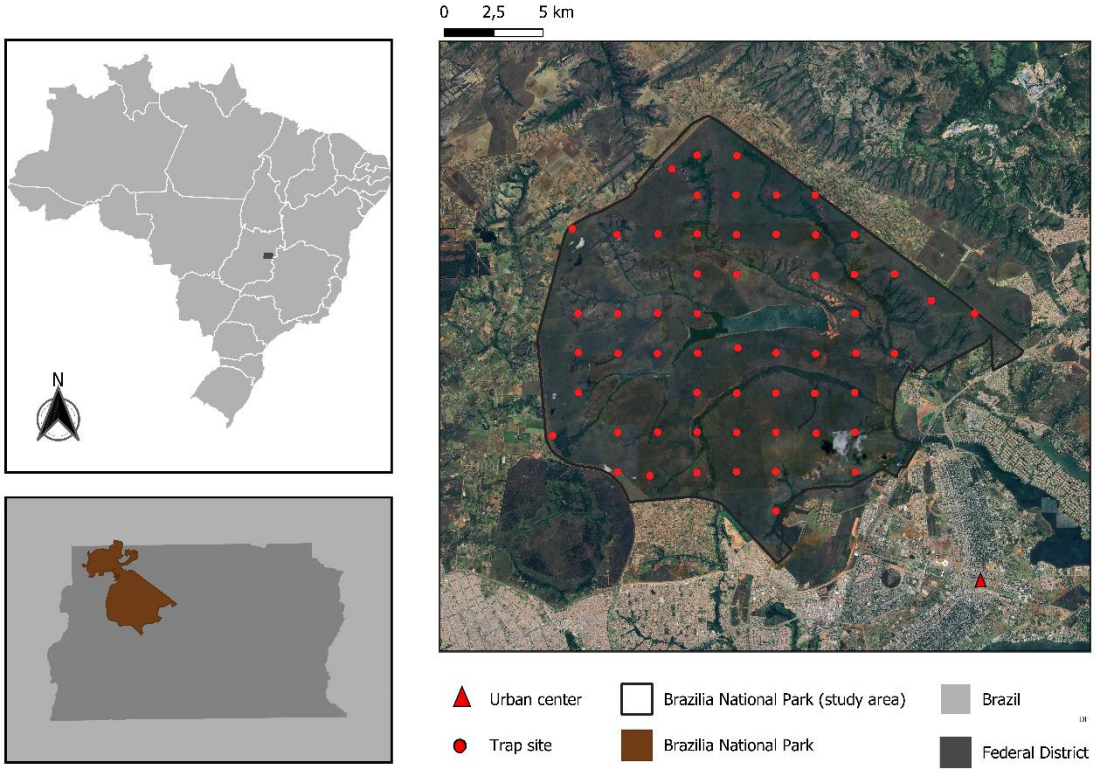

Figure 1. Map of the study area, Brasília National Park. Sampling conducted with camera traps from 2020 to 2022.

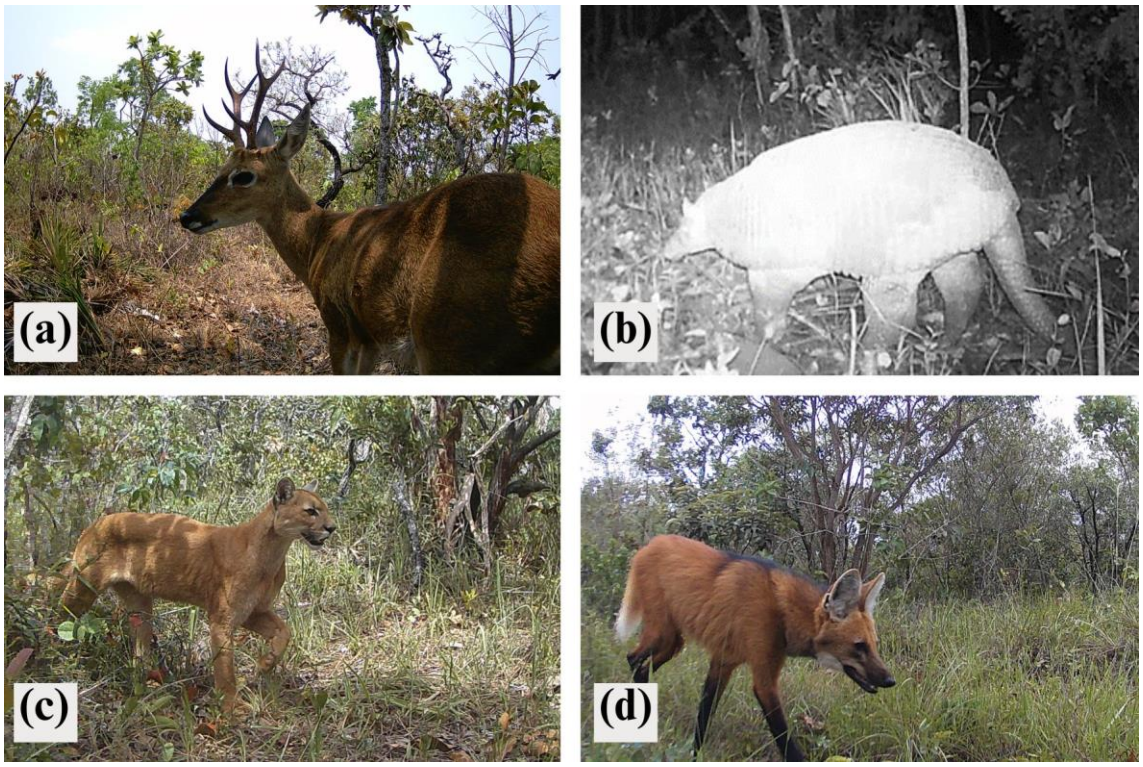

Figure 2. Native species recorded with camera traps in Brasília National Park during sampling in the dry and rainy seasons between 2020 and 2022. A: *Ozotoceros bezoarticus*; B: *Priodontes maximus*; C: *Puma concolor*; D: *Chrysocyon brachyurus*.

Figure 3. Non-native species recorded in Brasília National Park. A: Human possibly hunting (in area not allowed); B: Cyclist (in area not allowed); C: Horse; D: Dog.

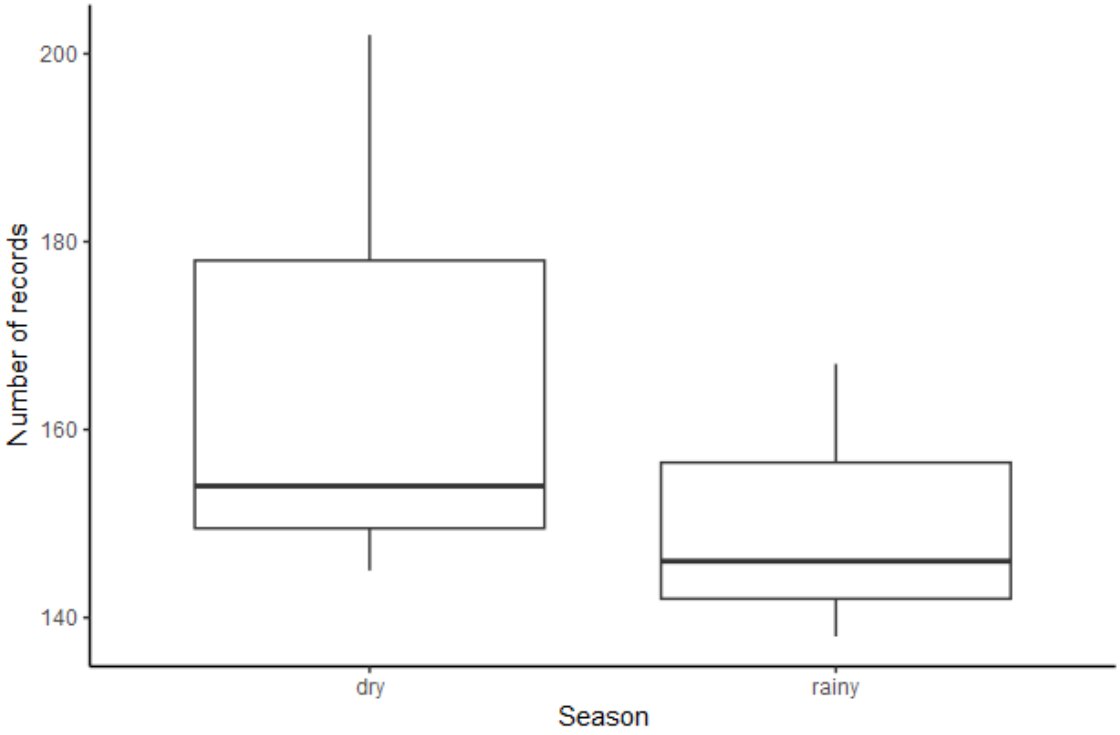

Figure 4. Seasonal effect in the relative abundance of medium and large mammals in Brasília National Park.

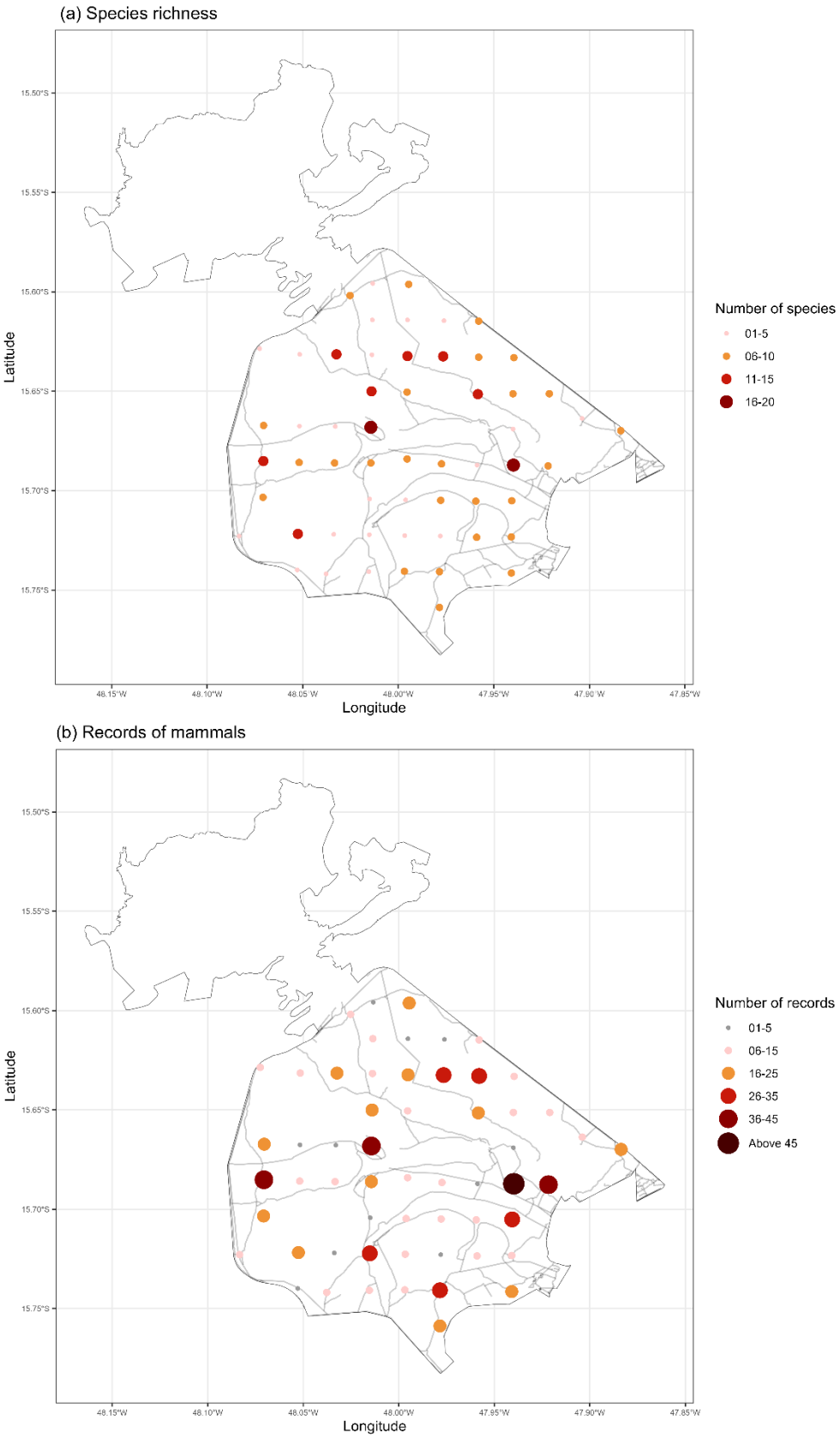

Figure 5. Distribution map showing richness (a) and frequency (b) of medium and large mammal records in Brasília National Park from 2020 to 2022.

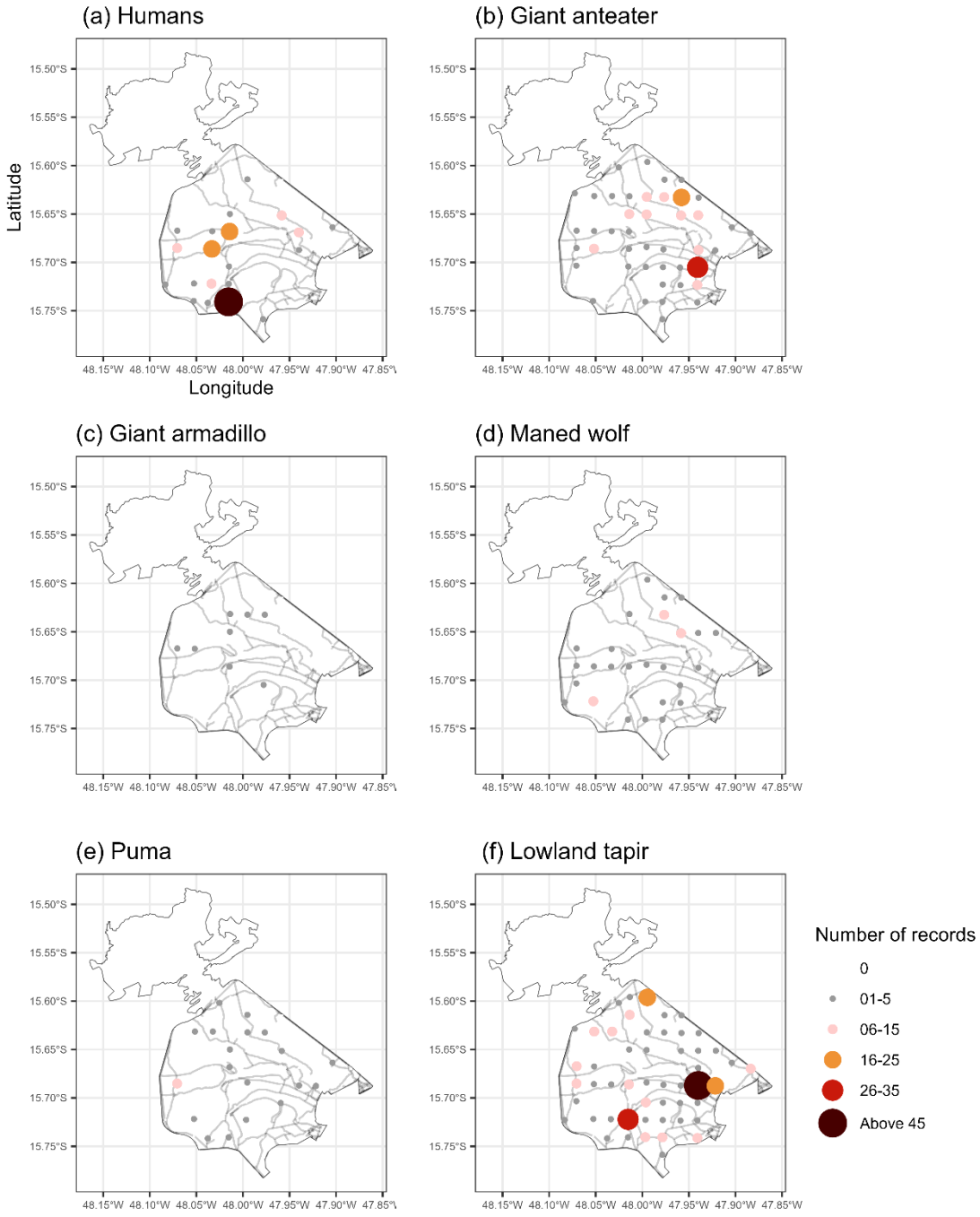

Figure 6. Distribution of the records of humans (a) and threatened native species: giant anteater (b), giant armadillo (c), maned wolf (d), puma (e) and tapir (f) sampled in Brasília National Park between 2020 and 2022.

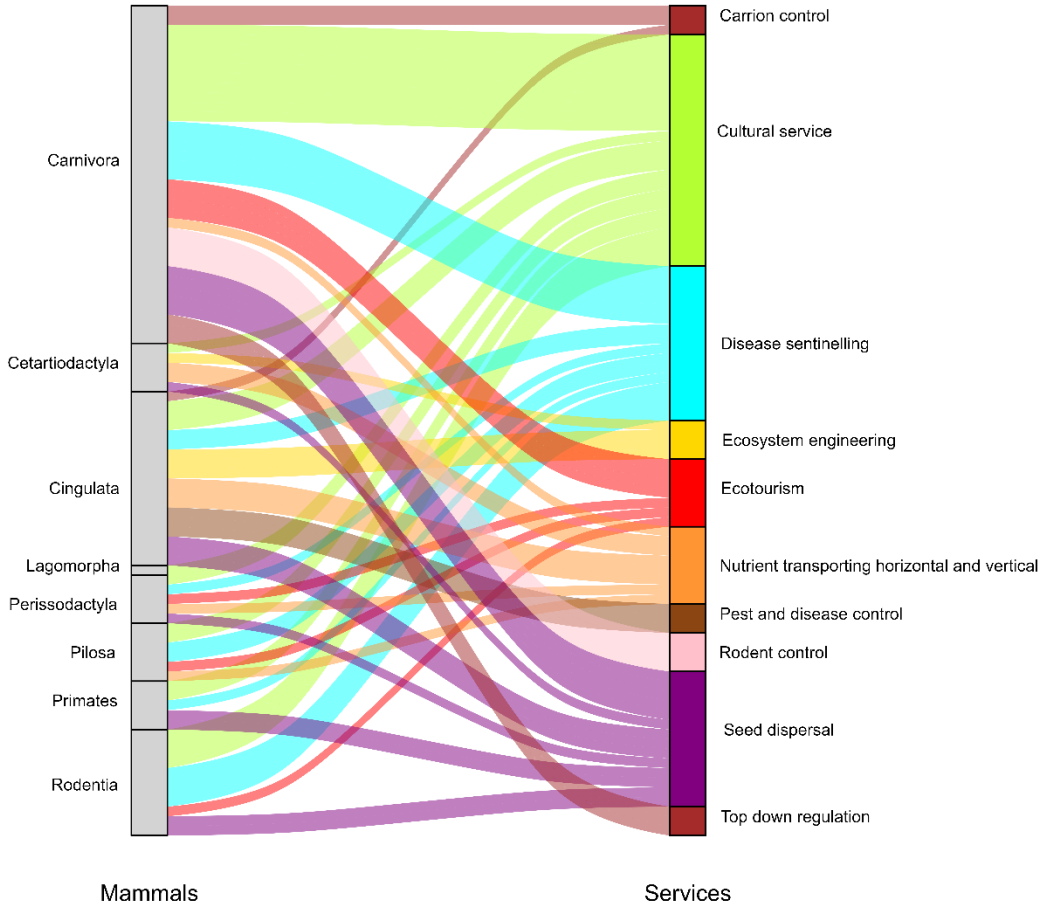

Figure 7. Ecosystem services provided by medium and large mammals sampled in Brasília National Park (2020-2022).

CAPÍTULO 2

From Rain to Offspring: Examining the Impact of Seasonality on Giant Anteater Behavior and Reproduction

ABSTRACT

The giant anteater (*Myrmecophaga tridactyla*) is a distinctive terrestrial mammal characterized by its elongated snout and specialized diet. Parental care involves females carrying their young on their backs for the first six months of life, providing essential protection and access to resources. Despite existing knowledge, significant gaps remain in understanding the species' reproductive and social patterns. This study aimed to assess the population dynamics and social behaviors of the giant anteater (*Myrmecophaga tridactyla*) throughout the year, focusing on observations of offspring presence and social interactions. Camera trap surveys were conducted during the dry and wet seasons at 57 sites over three years. The detection rate was 0.0194 records. The data revealed a predominance of solitary individual records (92%), with rare sightings of pairs (2%) and females with offspring (6%). Offspring records showed a peak in births in 2021, probably influenced by environmental changes and reduced human disturbance from the 2020 pandemic. Neonates were observed exclusively during the daytime and primarily during the rainy season, while cubs and juveniles were recorded throughout the year, with a notable increase in juveniles from August to October. The study's findings on the species' reproductive strategies underscore the importance of these critical habitats for conservation efforts. Future research should incorporate genetic analyses and advanced monitoring techniques to refine our understanding of giant anteater population dynamics and improve conservation strategies.

Keywords: Behavior, Camera Trap, Conservation, Population Structure, Seasonality.

INTRODUCTION

The giant anteater (*Myrmecophaga tridactyla* Linnaeus, 1758) is a charismatic terrestrial xenarthran species known for its elongated snout and long tongue. This mammal can reach up to 2 meters long and weigh between 22 and 45 kg. Since it has limited vision, the giant anteater relies primarily on its keen sense of smell, which is crucial for locating ants and termites, its primary food sources (Eisenberg and Redford, 1999; Miranda, 2012). These morphological traits reflect its specialized diet, supported by a low metabolic rate (Nowak, 1991; Eisenberg and Redford, 1999).

The species has thick, coarse fur ranging from dark gray to black coloration; the giant anteater features a distinctive long, triangular black stripe extending from below the ear and throat towards the hind limbs and a tail with long, flag-like hairs (Gaudin et al., 2018). Although pelage patterns and biometric traits are generally uniform, subtle variations can allow individual identification (Möcklinghoff et al., 2018). The species exhibits no sexual dimorphism and is predominantly solitary, with interactions occurring mainly during the breeding season (Kreutz et al., 2009; Miranda Júnior and Bertassoni, 2014; Shaw et al, 2016). The gestation period is about 120-190 days, and although births can occur year-round, seasonal peaks are observed, particularly during the rainy season (Bartmann, 1993; Shaw et al., 2016). Juveniles reach sexual maturity around two years (Nowak, 1991), and females carry their offspring on their backs until the cub is about six months old (Gaudin et al., 2018; Desbiez et al. 2020).

Giant anteaters are predominantly solitary animals, interacting socially, mainly during the mating season and while nursing their offspring. Each individual maintains their territory and generally avoids social interactions outside these periods. Although not fully understood, evidence suggests that home range overlap among giant anteaters can occur between individuals of different sexes and ages (Medri and Mourão, 2005; Macedo, Mourão, and Oliveira, 2010; Miranda, 2004; Shaw et al., 1987). Recent studies indicate that anteaters tolerate other individuals, particularly females with cubs (Bertassoni and Ribeiro, 2019; Catapani et al.,

2019). However, observations of marking behavior (Earl et al., 2024) and agonistic encounters are frequently documented, including conflicts between males and females with cubs (Kreutz et al., 2009; Miranda Júnior and Rocha, 2006; Miranda Júnior and Bertassoni, 2014).

The Brazilian government (VU A2C; ICMBio, 2014) and the IUCN (2014) recognize the giant anteater as vulnerable to extinction. Despite the valuable data available on the ecology of giant anteaters, a notable lack of specific information across various locations and biomes regarding population structure, reproduction, and seasonal patterns directly impacts management actions. Therefore, a thorough understanding of their population dynamics and behavioral patterns is essential for effective conservation efforts.

Nowadays, many natural areas are facing changes in land use at their surroundings, situated within a disturbed landscape matrix dominated by human activities such as agriculture, urban expansion, and infrastructure development. These changes pose significant anthropogenic threats to species, even in protected areas with restricted use (Jones et al. 2018; Burton et al. 2024). Human activities can alter habitat quality, disrupt feeding patterns, and increase the risk of human-animal conflicts (e.g., vehicle collisions and habitat encroachment) (Doherty et al. 2021; Storch et al. 2022; Burton et al. 2024). To effectively protect species, it is crucial to fill the gaps in our understanding of their basic biology, including behavior, social organization, and reproductive cycles. By comprehending the species' behavior and reproduction, we can better predict their responses to environmental changes and anthropogenic pressures. This knowledge enables better predictions of species' responses to environmental changes and anthropogenic pressures, especially for threatened species, which are often more susceptible during critical reproductive phases.

This study investigates the occurrence and behavior of giant anteaters within Brasília National Park. Our objectives are to assess species records' spatial and temporal distribution, report the proportions of solitary individuals, pairs, and females with offspring, and identify potential seasonal reproduction patterns related to the dry and rainy seasons during the study

period. We hypothesize a higher birth rate of giant anteaters during the rainy season (Shaw et al. 1987), as the environmental conditions are more favorable and food resources are more abundant, with a greater likelihood of survival (Jerez and Halloy, 2003). Consequently, we anticipate that the probability of detecting pairs may increase during the dry season, despite rare observations.

Monitoring the presence of offspring and potential breeding pairs of giant anteaters over several years is essential for understanding their reproductive patterns and social structure. Continuous observation, particularly in areas with significant human activity, can provide valuable insights into the factors influencing the species' behavior and help identify trends that indicate population persistence. This study represents a pioneering natural history analysis of the species and reproduction trends in the region, aiming to shed light on the patterns and challenges faced by anteaters in human-influenced protected areas. By examining these patterns, we seek to generate data to help targeted and effective management practices, ultimately contributing to broader conservation efforts for this vulnerable species.

MATERIALS AND METHODS

Study Area

Brasília National Park (PNB), located at coordinates 15°38′12″S and 48°02′21″W, plays a central role as an important conservation area in Brazil's Federal District. In 2006, the park was expanded to cover an area of 42,800 hectares. PNB is situated in a heavily urbanized matrix, approximately 10 kilometers from the center of Brasília, surrounded by high-speed highways, farms, rural residences, and dispersed settlements. Despite this urban and rural encroachment, the park has designated public access areas, including hiking trails and mineral water pools. The coldest month has average temperatures below 18°C, while the warmest month averages around 23°C. The area experiences two distinct seasons: a wet season from November to April, with monthly precipitation up to 300 mm, and a dry season (May to October) with

minimal rainfall. The park's vegetation is diverse, comprising different phytophysiognomies, from open fields to gallery forests and anthropized areas.

Data collection and analysis

To investigate the occurrence and behavior of the giant anteater within PNB, we employed a camera traps study (models Campark T80, Campark T86, and Meidase Trail). We determined sampling sites based in a grid with a minimum distance of 1 km between each point, totaling 57 sampling points distributed across the park. Surveys were conducted during the dry season (between June and October) and rainy season (between January and April) across three consecutive years (2020, 2021, and 2022). Due to the limited number of cameras (17 in the first year and 30 in subsequent ones), sites were not surveyed simultaneously but progressively as cameras were retrieved and, therefore, available to be deployed in other sites. After completing the rotation and sampling all 57 points, the campaign was concluded. The entire process of re-sampling was repeated only during the subsequent campaign (i.e., the following season). Camera traps were installed on trees at a height of approximately 25-30 cm and set to work continuously for 24 hours over 30 days per campaign. Each camera was configured to capture three photographs, followed by a 30-second video every time it was triggered. We checked camera traps approximately every 10-15 days for battery and memory card replacement. Sampling effort totaled 10,260 trap days.

To ensure independence of observations, photographs must have at least a 1-hour interval between consecutive images of the same species (Bowkett et al., 2007). The collected data were categorized by records of solitary individuals, pairs, and females with offspring of giant anteaters. For each photo, we noted the time and date of the record. The detection rate was calculated as the total number of records divided by the total number of trap days.

To assess seasonal patterns (dry versus rainy season) and potential spatial patterns associated with the location of these records, we identified areas with a high frequency of

records and thoroughly analyzed their characteristics regarding habitat features and proximity to visitation/isolated areas, providing a detailed understanding of the species' behavior. These data were available at the MapBiomas platform - collection 7 (Mapbiomas, 2023). To estimate daily activity patterns, we followed the approach developed by Ridout and Linkie (2009), using *circular* package. Our study documented the circadian and seasonal activity patterns for all social categories (e.g., female with neonate, female with cub, solitary adult, two adults) to understand daily activity and assess if behavior differences exist between solitary individuals and those in pairs or with offspring. Given that our study covered two seasons and did not involve individual monitoring, we created three distinct categories for the young to facilitate analysis of species behavior.

1. Neonate: Newborn giant anteaters, characterized by short fur, small body size, and limited mobility. They are fully dependent on the mother and are typically observed clinging closely to her back (Figure 1a).
2. Cub: Young giant anteaters that have reached a medium body size. They exhibit longer fur and greater freedom of movement but remain dependent on the mother for care and transportation. These cubs may begin to explore their environment but continue to rely on maternal support (Figure 1b).
3. Juvenile: Larger young giant anteaters, resembling adults in physical characteristics. They have long fur and nearly occupy the entire back of the mother, indicating they are nearing the stage of independence (Figure 1c).

Figure 1: Photos of giant anteaters (*Myrmecophaga tridactyla*) recorded during camera trap monitoring in Brasília National Park, Brazil, from 2020 to 2022. (A) Giant anteater carrying a

neonate offspring, (B) female carrying a cub, (C) female carrying a juvenile on her back and (D) a pair.

RESULTS

The detection rate was approximately 0.0194 records per day. In total, we recorded observations of giant anteaters during both seasons. According to our classification, we documented 92% of the images of solitary adults, 6% of females with offspring in the back, and 2% of paired anteaters.

Offspring records (seasonal, spatial and daily)

We recorded five females with neonates, four with cubs, and four with juveniles during both day and night. Approximately 54% of the records are during the day, and 46% are at night (Figure 2). Records categorized as neonates were obtained exclusively during the day.

For offspring, the observations range from February to October (Figure 3). The distribution of offspring records throughout the dry season indicates a relatively consistent presence of females with babies, with a significant concentration of events occurring in September and October. However, the variation in offspring body size across the months suggests a distinct pattern.

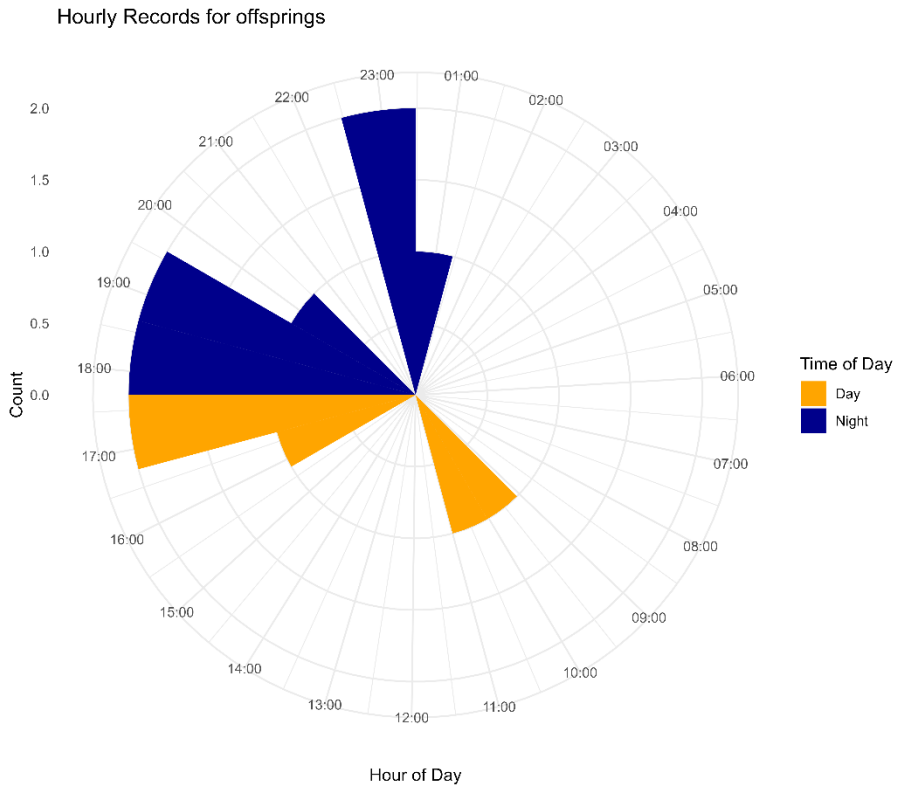

Figure 2: Circadian cycle of female giant anteaters *(Myrmecophaga tridactyla*) with offspring in Brasília National Park, Brazil, from 2020 to 2022.

In 2021, it was the year with the highest offspring records. Neonates were all observed during the rainy season, cubs in both seasons, and juveniles only during the dry season. Temporal analysis of the data indicates that the distribution of offspring types varied throughout the year, suggesting a pattern of physical growth: neonates were primarily observed from March to May, cubs appeared more frequently from June to September, and juveniles were present from August to October, with a notable peak in August (Figure 3).

The most frequent locations for these records were P13, P18 and P44, with 2 records. All three sampling sites are located in a savannah area in the middle of the park, with minimal human presence and close proximity to a water source (Figure 4). These sites suggest a possible sensitive area for the conservation and monitoring of anteaters' populations, especially for offspring protection.

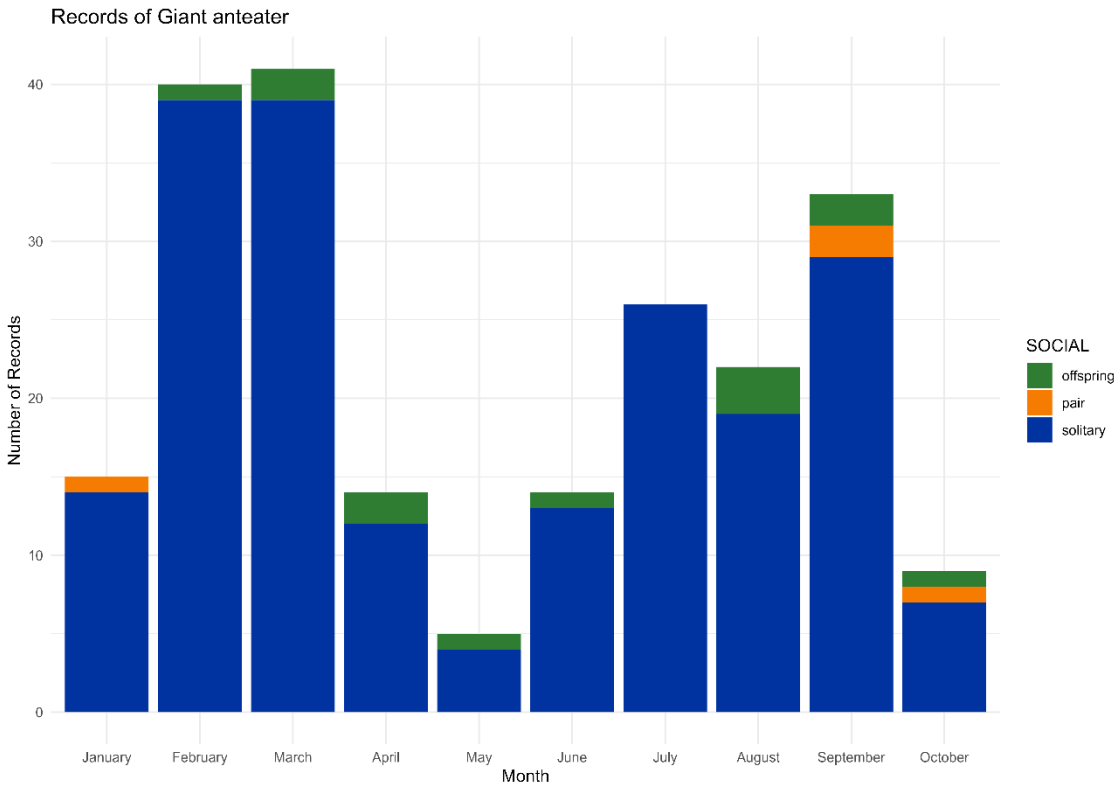

Figure 3: Records of Giant anteater (*Myrmecophaga tridactyla*) in Brasília National Park, Brazil, from 2020 to 2022. The bar chart displays the number of records per month, with colors representing different type of groups: dark blue for solitary anteaters, orange for pairs, and green for females with offspring.

Pairs records (seasonal, spatial and daily)

Only one pair was recorded during the rainy season, while three pairs were observed during the dry season, each at different locations. This pattern reflected a period of increased adult interaction or behaviors associated with possible reproduction in dry season. Two of the pair records (P19 and P46) were made on the same day but were approximately 17 hours apart, indicating that pairs may be active in the same area at different times of the day. The third record at P35 occurred more than a month after the earlier records. The locations were approximately 7 km apart (Euclidean distance), ignoring natural obstacles (Figure 4).

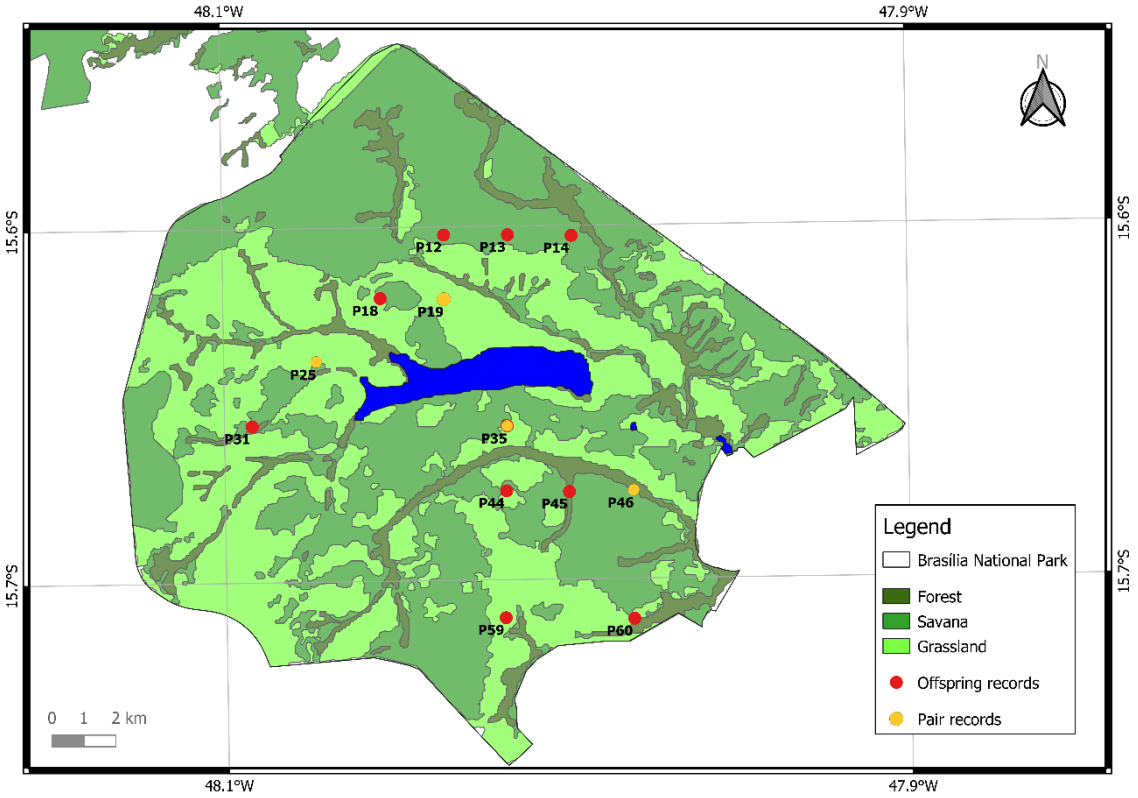

Figure 4: Locations of giant anteater (*Myrmecophaga tridactyla*) records in Brasília National Park, Brazil, from 2020 to 2022. Females with offspring records are indicated in red and pair records in yellow.

DISCUSSION

This study provides insights into the reproduction cycle and social behaviors of giant anteaters within a protected area based on observations over three years. Our findings contribute significantly to understanding giant anteater distribution, reproductive patterns, and social interactions, all of which hold implications for conservation strategies.

Detection Rates

Although our detection rate aligns with previous findings, it underscores the inherent challenges in monitoring elusive species and emphasizes the need for enhanced sampling efforts (Bertassoni et al., 2021; Desbiez and Medri, 2010; Rojano-Bolaño et al., 2015). Although techniques for individual identification of giant anteaters exist (Möcklinghoff et al.

2018), it was not possible to implement them in this study due to the lack of two cameras per location to capture both flanks and the poor quality of some images, which did not provide sufficient detail of the pelage. Future studies should consider deploying paired camera traps at each station and incorporating capture or genetic sampling to generate more robust and precise population estimates (Möcklinghoff et al., 2018; Bertassoni et al. 2021).

Seasonal Patterns of Social Behavior and Offspring Development

Notably, seeing adults together during September and October may indicate mating activities or increased social interactions in the dry season. A study conducted in the Cerrado region of southeastern Brazil estimated the mean distance traveled daily by giant anteaters at 1326 ± 451 m, ranging from 678 to 1956 m (Bertassoni et al., 2017). This information suggests that the pairs observed in our study were likely distinct individuals exhibiting a concentrated movement pattern within nearby areas. The close timing of pair records at locations P19 and P46 (17 h) indicates that these pairs may utilize common or adjacent areas for foraging, as all records were obtained from sites within the protected area characterized by prohibited public access and far from edge or visitor entry points. These areas likely provide a safer environment for reproduction and socialization due to reduced human interference, underscoring the importance of spatial analysis in understanding habitat use (Nickel et al. 2020; Milles et al. 2023; Gaynor et al. 2024). Studies have demonstrated that decreased human presence due to lockdown has led to environmental changes, such as fewer wildlife-vehicle collisions and reduced noise pollution, which can alter animal behavior (Terry et al., 2021; Tucker et al., 2023). For instance, during the lockdown, researchers observed increased detection rates of *Puma concolor* in protected areas, suggesting heightened movement due to reduced human activity (Procko et al., 2022). Similarly, a reserve in Costa Rica reported that enhanced staff patrolling and the absence of human activity resulted in higher nesting success rates for *Dermochelys coriacea* compared to previous years (Quesada-Rodríguez et al., 2021).

In our study, neonates were predominantly observed between March and May, with cubs recorded from February to September and juveniles noted from August to October. Notably, no large juveniles were documented in January. The timing of neonate observations aligns with other studies, which found that females with pups were most commonly observed from December to May in the southern savannahs of Guyana (Earl et al., 2024) and Brazil (Rodrigues et al., 2008). In contrast, a study in the Cerrado of Serra da Capivara documented only two births—one in October and another in April—suggesting potential year-round breeding (Shaw et al., 1987). Further studies are essential to understand wild giant anteaters' reproductive behavior and patterns, as observations of their reproduction are infrequent (Diniz and Brito, 2012; Fernandes et al. 2023). This scarcity can be attributed to their solitary and elusive nature and the complexities of their reproductive physiology. Research indicates that their reproductive cycle may involve delayed implantation, complicating our understanding of their reproductive timing and success in natural environments (Knott et al., 2013).

All neonate records occurred during daylight hours, particularly in the late afternoon and late morning during the rainy season, suggesting that they are more easily observed during milder temperatures, which likely helps prevent thermal dysregulation in newborns (Giroux et al., 2022). The seasonality of these observations indicates the potential birth period for offspring in PNB. The higher frequency of neonate sightings early in the year, extending into the second quarter, suggests that by September, juveniles are likely beginning to gain independence, typically remaining on their mother's back for about six months (Desbiez et al. 2020). Given the 120–190-day gestation period for giant anteaters (Bartmann, 1993; Shaw et al., 2016), with offspring born between March and May, conception likely occurred between late August and early October of the previous year. This timing aligns with observed pairings in our study and overlaps with the probable period during which juveniles walk beside their mothers before dispersal. Despite indications of a structured reproductive pattern, our data do not definitively

establish the reproductive period, as no direct mating interactions were observed. Further investigations are necessary to confirm the timing of the mating season.

Conservation Implications and Future Research Directions

Although giant anteaters are generally solitary, interactions between pairs may occur beyond the breeding seasons. Since observations of social interactions between individuals are less frequent (Desbiez et al., 2020; Giroux et al., 2021), recording paired individuals is a positive indicator of population health, suggesting either mating pairs or familial relationships. The literature indicates that the environment plays a crucial role in shaping reproductive strategies (Speakman, 2008; Dantas et al., 2021), highlighting the intricate link between the health of protected areas and reproductive outcomes (Plard et al., 2020; Dantas et al., 2021). For example, an inadequate diet could impact the quality of male semen in anteater (Mendonça et al., 2021), which could have implications for reproductive success. Also, female giant anteaters play a critical role in parental care, carrying their young on their backs during the initial months of life (Gaudin et al., 2018). We documented only 13 instances of mothers with offspring throughout our sampling period. While individual identification was not feasible, this limited number of observations raises concerns regarding the species' persistence and potential slow turnover in the population (Kiffner et al. 2020).

This research enhances our understanding of the reproduction and social behavior among giant anteaters in the wild. As the first study in the Federal District, it provides invaluable insights for conservation strategies and future research. By analyzing the frequency of records of mothers with offspring and pairs, we can infer aspects of reproduction, parental care, and habitat use—essential factors for species conservation. The lack of sexual dimorphism in giant anteaters complicates the reliable distinction between males and females in camera trap images, limiting our ability to analyze sex-related population structure and dynamics. This limitation underscores the necessity for complementary methods, such as genetic analysis, to better

understand the sexual composition of the studied population (Barragán-Ruiz et al. 2021). Future research incorporating these methods will be essential for comprehensively understanding the species' population dynamics and offers hope for further progress in the field.

Based on our findings, we advocate for the implementation of targeted management strategies to enhance the conservation of giant anteaters within the protected area. It is crucial to preserve key habitat features that support reproductive success and ensure connectivity between critical areas. Future research should explore the spatial and temporal patterns of giant anteater behavior and reproduction, emphasizing how environmental factors influence these patterns. Additionally, methodological improvements, such as genetic analyses and advanced camera trap configurations, could yield more precise data on individual identification and social interactions. However, it is the continuous monitoring that is truly essential to detect early signs of population decline or changes in reproductive behavior. Efforts should also focus on enforcing restrictions on human access in sensitive areas to maintain environmental stability, ensuring successful reproduction. The results of this study are crucial for effective management of the protected area, providing valuable insights into population dynamics and social behavior that will help formulate informed and effective conservation strategies.

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REFERENCES

Barragán-Ruiz, C. E., Silva-Santos, R., Saranholi, B. H., Desbiez, A. L., & Galetti Jr, P. M. 2021. Moderate genetic diversity and demographic reduction in the threatened giant anteater, *Myrmecophaga tridactyla*. *Frontiers in Genetics*, 12, 669350.

Bartmann, W. 1983. Haltung und Zucht von grossen Amiesenbären, *Myrmecophaga tridactyla*, im Dortmunder Tierpark. *Zoologischer Garten NF*, 53:1–31.

Bertassoni, A., & Ribeiro, M. C. 2019. Space use by the giant anteater (*Myrmecophaga tridactyla*): A review and key directions for future research. *European Journal of Wildlife Research*, 65:93.

Bertassoni, A., Bianchi, R. D. C., & Desbiez, A. L. J. 2021. Giant anteater population density estimation and viability analysis through motion-sensitive camera records. *The Journal of Wildlife Management*, 85(8), 1554–1562.

Bertassoni, A., Mourão, G., Ribeiro, R. C., Cesário, C. S., Oliveira, J. P. D., & Bianchi, R. de C. 2017. Movement patterns and space use of the first giant anteater (*Myrmecophaga tridactyla*) monitored in São Paulo State, Brazil. *Studies on Neotropical Fauna and Environment*, 52:68–74.

Burton, A. C., Beirne, C., Gaynor, K. M., Sun, C., Granados, A., Allen, M. L., ... & Oberosler, V. 2024. Mammal responses to global changes in human activity vary by trophic group and landscape. *Nature Ecology & Evolution*, 8:924–935.

Bowkett, A. E., Rovero, F., & Marshall, A. R. 2008. The use of camera-trap data to model habitat use by antelope species in the Udzungwa Mountain forests, Tanzania. African journal of ecology 46(4).

Catapani, M. L., Pires, J. S. R., & Vasconcellos, A. D. S. 2019. Single- or pair-housed: Which is better for captive southern tamanduas? *Journal of Applied Animal Welfare Science*, 22:289–297.

Chhen, A., Bertassoni, A., Desbiez, A. L. J., & Noonan, M. J. 2024. The socio-spatial ecology of giant anteaters in the Brazilian Cerrado. *Journal of Zoology*, 324:50–62.

Dantas, M. R. T., Souza-Junior, J. B. F., Castelo, T. D. S., Lago, A. E. D. A., & Silva, A. R. 2021. Understanding how environmental factors influence reproductive aspects of wild myomorphic and hystricomorphic rodents. *Animal Reproduction*, 18(1), e20200213.

Desbiez, A. L. J., & Medri, I. M. 2010. Density and habitat use by giant anteaters (*Myrmecophaga tridactyla*) and southern tamanduas (*Tamandua tetradactyla*) in the Pantanal Wetland, Brazil. *Edentata*, 11, 4–10. https://doi.org/10.1896/020.011.0102

Desbiez, A. L. J., Bertassoni, A., & Traylor-Holzer, K. 2020. Population viability analysis as a tool for giant anteater conservation. *Perspectives in Ecology and Conservation*, 18(2), 124–131.

Diniz, M. F., & Brito, D. 2012. The charismatic giant anteater (*Myrmecophaga tridactyla*): a famous John Doe?. *Edentata*, 13(1), 76–83.

Doherty, T. S., Hays, G. C., & Driscoll, D. A. 2021. Human disturbance causes widespread disruption of animal movement. *Nature Ecology & Evolution*, 5:513–519.

Earl, E., van Vliet, N., Braga-Pereira, F., Millar, N., & Wilson, N. 2024. Insights into marking behavior of giant anteaters: a camera trap study in the Rupununi savannahs, Guyana. *Mammali*a, 0.

Eisenberg, J., & Redford, K. 1999. *Mammals of the Neotropics*, Volume 3: Ecuador, Bolivia, Brazil. University of Chicago Press, Chicago.

Fernandes, D. P., Praxedes, É. A., Freitas, C. I. A., & Pereira, A. F. 2023. Ex situ approaches for the conservation of genetic resources in the superorder Xenarthra. *Biopreservation and Biobanking*, 21(3), 225–232.

Gaudin, T. J., Hicks, P., & Di Blanco, Y. 2018. *Myrmecophaga tridactyla* (Pilosa: Myrmecophagidae*). Mammalian Species*, 50:1–13.

Gaynor, K. M., Abrahms, B., Manlove, K. R., Oestreich, W. K., & Smith, J. A. 2024. Anthropogenic impacts at the interface of animal spatial and social behaviour. *Philosophical Transactions B*, 379(1912), 20220527.

Giroux, A., Ortega, Z., Bertassoni, A., Desbiez, A. L. J., Kluyber, D., Massocato, G. F., de Miranda, G., Mourão, G., Surita, L., Attias, N., Bianchi, R. de C., Gasparotto, V. P. de O.,

& Oliveira-Santos, L. G. R. 2022. The role of environmental temperature on movement patterns of giant anteaters. *Integrative Zoology*, 17(2), 285–296.

Giroux, A., Ortega, Z., Oliveira-Santos, L. G. R., Attias, N., Bertassoni, A., & Desbiez, A. L. J. 2021. Sexual, allometric and forest cover effects on giant anteaters' movement ecology. *PLOS ONE*, 16(8), e0253345.

ICMBio. 2014. Espécies ameaçadas de extinção: Lista de espécies da fauna brasileira ameaçadas de extinção. ICMBio, Brasília.

IUCN. 2014. The IUCN Red List of Threatened Species. Version 2014. International Union for Conservation of Nature. Accessed: www.iucnredlist.org.

Jones, K. R., Venter, O., Fuller, R. A., Allan, J. R., Maxwell, S. L., Negret, P. J., & Watson, J. E. 2018. One-third of global protected land is under intense human pressure. Science, 360(6390), 788-791.

Jerez, S. del V., & Halloy, M. 2003. El oso hormiguero, *Myrmecophaga tridactyla*: Crecimiento e independización de una cría. *Mastozoología Neotropical*, 10:323–330.

Kiffner, C., Kioko, J., Baylis, J., Beckwith, C., Brunner, C., Burns, C., Chavez-Molina, V., Cotton, S., Glazik, L., Loftis, E., Moran, M., O'Neill, C., Theisinger, O., & Kissui, B. 2020. Long-term persistence of wildlife populations in a pastoral area. *Ecology and Evolution*, 10(18), 10000–10016.

Knott, K. K., Roberts, B. M., Maly, M. A., et al. 2013. Fecal estrogen, progestagen, and glucocorticoid metabolites during the estrous cycle and pregnancy in the giant anteater (*Myrmecophaga tridactyla*): evidence for delayed implantation. *Reproductive Biology and Endocrinology*, 11:83. https://doi.org/10.1186/1477-7827-11-83.

Kreutz, K., Fischer, F., & Linsenmair, K. E. 2009. Observations of intraspecific aggression in giant anteaters (*Myrmecophaga tridactyla*). *Edentata*, 8–10:6–7.

MapBiomas. 2023.Projeto MapBiomas – Coleção 7 da Série Anual de Mapas de Cobertura e Uso da Terra do Brasil.

Medri, Í. M., & Mourão, G. 2005a. A brief note on the sleeping habits of the giant anteater - *Myrmecophaga tridactyla* Linnaeus (Xenarthra, Myrmecophagidae). Revista Brasileira de Zoologia, 22:1213–1215.

Medri, Í. M., & Mourão, G. 2005b. Home range of giant anteaters (*Myrmecophaga tridactyla*) in the Pantanal wetland, Brazil. *Journal of Zoology*, 266:365–375.

Mendonça, M. A. C., Nichi, M., Teixeira, R. H. F., Braga, F. R., Simões, R., Losano, J. D. D. A., & Pizzutto, C. S. 2021. Spermatic profile of captive giant anteaters (*Myrmecophaga tridactyla*): Knowing more to preserve better. *Zoo Biology*, 40(3), 227–237.

Milles, A., Banitz, T., Bielcik, M., Frank, K., Gallagher, C. A., Jeltsch, F., Jepsen, J. U., Oro, D., Radchuk, V., & Grimm, V. 2023. Local buffer mechanisms for population persistence. *Trends in Ecology & Evolution*, 38(11), 1051–1059.

Miranda, F. 2012. *Manutenção de tamanduás em cativeiro*. Editora Cubo, São Carlos. 302 p.

Miranda, F. R., et al. 2015. Avaliação do risco de extinção de *Myrmecophaga tridactyla* Linnaeus, 1758. Pp. 89–105 in *Processo de avaliação do risco de extinção da fauna brasileira*. ICMBio. Instituto Chico Mendes de Conservação da Biodiversidade, Brasília, DF.

Miranda, F., Bertassoni, A., & Abba, A. M. 2014. *Myrmecophaga tridactyla*. The IUCN Red List of Threatened Species e.T14224A4:14. Downloaded on 20 August 2018.

Miranda, G. H. B. 2004. *Ecologia e conservação do tamanduá-bandeira (Myrmecophaga tridactyla, Linnaeus, 1758) no Parque Nacional das Emas*. Tese (Doutorado em Ecologia). Universidade de Brasília, Brasília.

Miranda, G. H. B. de, Tomás, W. M., Valladares-Pádua, C. B., & Rodrigues, F. H. G. 2006. Giant anteater (*Myrmecophaga tridactyla*) population survey in Emas National Park, Brazil – A proposed monitoring program. *Endangered Species Update*, 23:96–103.

Möcklinghoff, L., Schuchmann, K. L., & Marques, M. I. 2018. New non-invasive photo-identification technique for free-ranging giant anteaters (*Myrmecophaga tridactyla*) facilitates urgently needed field studies. *Journal of Natural History*, 52:2397–2411.

Nickel, B. A., Suraci, J. P., Allen, M. L., & Wilmers, C. C. 2020. Human presence and human footprint have non-equivalent effects on wildlife spatiotemporal habitat use. *Biological Conservation*, 241, 108383.

Nowak, R. 1991. *Walker's Mammals of the World*. 5th ed. Johns Hopkins University Press.

Nowak, R. 1991. *Walker's Mammals of the World*. 5th ed. Johns Hopkins University Press.

Plard, F., Chamiot-Clerc, B., & Cohas, A. 2021. Influences of climatic and social environment on variable maternal allocation among offspring in Alpine marmots. *Journal of Animal Ecology*, 90(2), 471–482.

Procko, M., Naidoo, R., LeMay, V., & Burton, A. C. 2022. Human impacts on mammals in and around a protected area before, during, and after COVID-19 lockdowns. *Conservation Science and Practice*, 4(7), e12743.

Quesada-Rodríguez, C., Orientale, C., Diaz-Orozco, J., & Sellés-Ríos, B. 2021. Impact of 2020 COVID-19 lockdown on environmental education and leatherback sea turtle (*Dermochelys coriacea*) nesting monitoring in Pacuare Reserve, Costa Rica. *Biological Conservation*, 255, 108981.

Ridout, M. S. & Linkie, M. (2009). Estimating overlap of daily activity patterns from camera trap data. Journal of Agricultural, Biological, and Environmental Statistics. 14, 322-337. https://doi.org/10.1198/jabes.2009.08038.

Rodrigues, F. H. G., Medri, I. M., Miranda, G. H. B., Camilo-Alves, C., & Mourão, G. (2008). Anteater behavior and ecology. In S. F. Vizcaíno & W. J. Loughry (Eds.), *The biology of the Xenarthra* (pp. 257-268). University Press of Florida.

Rojano-Bolaño, C., Giraldo, M. E. L., Miranda-Cortés, L., & Avilán, R. A. 2015. Área de vida y uso de hábitats de dos individuos de oso palmero (*Myrmecophaga tridactyla*) en Pore, Casanare, Colombia. *Edentata*, 16, 37–45.

Shaw, J. H., Carter, T. S., & Machado-Neto, J. C. 1985. Ecology of the giant anteater (*Myrmecophaga tridactyla*) in Serra da Canastra, Minas Gerais, Brazil: a pilot study. In: The Evolution and Ecology of Armadillos, Sloths, and Vermilinguas.

Shaw, J. H., Machado-Neto, J., & Carter, T. S. 1987. Behavior of free-living giant anteaters (*Myrmecophaga tridactyla*). *Biotropica*, 19:255–259.

Shaw, J. H., Machado-Neto, J., & Carter, T. S. 2016. Behavior of free-living giant anteaters (*Myrmecophaga tridactyla*). *Biotropica*, 19:255–259.

Speakman, J. R. 2008. The physiological costs of reproduction in small mammals. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 363(1490), 375–398.

Storch, D., Šímová, I., Smyčka, J., Bohdalková, E., Toszogyova, A., & Okie, J. G. 2022. Biodiversity dynamics in the Anthropocene: how human activities change equilibria of species richness. *Ecography*, 2022(4).

Terry, C., Rothendler, M., Zipf, L., Dietze, M. C., & Primack, R. B. 2021. Effects of the COVID-19 pandemic on noise pollution in three protected areas in metropolitan Boston (USA). *Biological Conservation*, 256, 109039.

Tucker, M. A., Schipper, A. M., Adams, T. S., Attias, N., Avgar, T., Babic, N. L., ... & Stacy-Dawes, J. 2023. Behavioral responses of terrestrial mammals to COVID-19 lockdowns. *Science*, 380(6649), 1059–1064.

CAPÍTULO 3

Under Pressure: Habitat Use by Giant Anteater in a Peri-urban Protected Area

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ABSTRACT

Urbanization around conservation areas poses significant threats to native fauna, including habitat loss, resource competition, noise and light pollution, and exotic species invasions. At Brasília National Park, we assessed the influence of biotic and abiotic variables on the occupancy of giant anteaters (*Myrmecophaga tridactyla*). We hypothesized that grassland and savanna habitats would increase occupancy while domestic dogs and proximity to urban areas would decrease it. Over three years, camera traps recorded data during rainy and dry seasons. Our analysis showed stable occupancy across the park, with domestic dogs significantly reducing detection rates, especially during the rainy season. Extinction rates were linked to agricultural proximity in the dry season, while forest cover and proximity to urban areas influenced colonization during the rainy season. These results underscore the need for targeted management strategies to minimize human-wildlife conflicts and ensure habitat protection, supporting long-term species persistence. Targeted management strategies are essential to ensure the long-term conservation of giant anteaters and other native species in peri-urban protected areas.

Keywords: Cerrado, Domestic Dogs, Human-wildlife conflict, Occupancy Models, Urbanization.

INTRODUCTION

The intensification of human activities continues to significantly diminish natural and preserved areas, directly affecting native fauna (Dirzo et al., 2014; Darlington et al., 2022). This poses an urgent concern for ecologists, conservation biologists, and environmental policymakers, whose aptitude is crucial in addressing this issue. Over 75% of the Earth's surface is now affected by anthropogenic activities, leading to habitat loss, fragmentation, and changes in ecosystem functions (Venter et al., 2016). Certain species are especially vulnerable to these changes due to their biological and ecological traits (Lino et al., 2019). Given these vulnerabilities, immediate and decisive conservation actions are critical to mitigate further declines and protect biodiversity. For instance, larger mammals that demand substantial food and extensive home ranges face higher extinction risks when confronted with human-induced habitat modifications (Chichorro et al., 2019). This vulnerability is further amplified for species with low population densities, slow reproductive rates, and limited dispersal abilities (Cardillo et al., 2004; Quesnelle et al., 2014).

Protected areas are fundamental for biodiversity conservation, providing refuge from human-induced pressures and preserving critical habitats for wildlife (Clements et al., 2019; Watson et al., 2014; Fornitano et al., 2024). In the Cerrado, these areas are vital in mitigating native vegetation loss (Colman et al., 2024). The authors emphasize the need to expand and maintain these protected areas as part of a comprehensive strategy to conserve biodiversity and reduce the impacts of agricultural expansion and other human-driven pressures in the biome. However, despite their importance, many of these areas face both internal and external threats, such as poaching, habitat encroachment, and invasive species, all of which can compromise their effectiveness (Bruner et al., 2001; Diniz & Brito, 2013). Although some studies in the Brazilian Cerrado have assessed how environmental and human factors influence species occupancy (e.g., Paolino et al., 2018; Rodrigues et al., 2017; Souza et al., 2018), there is still a

significant lack of long-term data on mammals in the region—particularly those affected by the surrounding altered landscapes. Not addressing this research gap could have severe consequences for biodiversity dynamics in the Cerrado biome, underscoring the urgency of this issue.

In its vast 1,983,017 km2, the Cerrado hosts more than 5% of the planet's known plant and vertebrate species, including the iconic giant anteater (*Myrmecophaga tridactyla*). The Cerrado encompasses ecosystems that vary from open grasslands and savannah shrublands to deciduous forests (Batalha, 2011), and its vast latitudinal and longitudinal extent (over 20° in both directions), combined with elevation ranging from sea level up to 1800 meters, gives a unique array of environmental conditions and ecosystems. The Cerrado is known as the 'cradle of the waters' because it holds the headwaters of eight of the twelve major South American river basins (Lahsen et al., 2016). However, this rich biodiversity is under a severe and endless threat due to extensive habitat loss caused by the agricultural monoculture expansion, resulting in the conversion of nearly half of Cerrado's natural vegetation (Grande et al., 2020; Pompeu et al., 2024). This rapid agricultural and urban expansion poses significant challenges for giant anteater populations in the Cerrado, leading to sharp declines and highlighting the urgent need for conservation measures to prevent further habitat loss and species declines. Immediate action is needed to avoid further losses and defend the remaining habitats and biodiversity of the Cerrado (Diniz & Brito, 2013; Grecchi et al., 2014; Machado et al., 2023).

The giant anteater, the largest of all anteater species, is characterized by its long, specialized tongue, adapted for feeding almost exclusively on ants and termites. Moreover, the giant anteater has a low basal metabolic rate and is slow and vulnerable to hunters, vehicle collisions, and dog attacks. The giant anteater is a mammal vulnerable to global- and regional-scale extinction. This species is distributed across various biomes from southern Central America to much of South America. Fossil records of giant anteaters in Brazil are limited, but

those found indicate the species' long-term presence in the Cerrado region. Even with this wide range, over half of its all natural habitat has been lost or severely altered due to human activities, such as agricultural expansion and habitat fragmentation (Pompeu et al., 2024). Despite its vulnerability and status as a flagship species for Cerrado conservation in Brazil, information about the giant anteater's ecology is still lacking (Diniz & Brito 2013; Miranda et al., 2022).

Habitat characteristics influence species distribution and detectability (Massara et al., 2018; Penido et al., 2017; Rodrigues et al., 2014), interspecific interactions (Veum, 2017), and anthropogenic threats (Lessa et al., 2016; Paschoal et al., 2018). It is essential to understand these factors to develop effective conservation strategies. For example, the giant anteater adjusts its habitat use based on vegetation type and temperature (Camilo-Alves & Mourão, 2006). Due to its low body temperature, this species has a limited ability to regulate its internal environment, making it more susceptible to fluctuations in environmental conditions. As a result, habitat loss and environmental changes, such as temperature variations and resource availability, can significantly affect its survival, increasing its risk of extinction (Bertassoni & Ribeiro, 2019; Miranda et al., 2014). While giant anteaters have shown some adaptability to altered landscapes, further research is needed to understand their resilience to urban encroachment and other anthropogenic influences (Bertassoni et al., 2020).

In this context, understanding the occupancy patterns of giant anteaters in peri-urban protected areas, is increasingly relevant. These studies are crucial for developing targeted conservation strategies that mitigate the impacts of habitat fragmentation. While previous research has primarily focused on the habitat use of giant anteaters in the Pantanal (Camilo-Alves & Mourão, 2006; Desbiez & Medri, 2010; Medri & Mourão, 2005; Mourão & Medri, 2007; Rosa, 2007; Di Blanco et al., 2017), more recent efforts have expanded to the Cerrado biome (Bertassoni et al., 2020; Bertassoni et al., 2017; Miranda et al., 2006; Petrazzini, 2019; Versiani, 2021). These studies highlight the urgent need to protect and manage remaining

habitat fragments to support the long-term persistence of this species in the face of rapid landscape change.

Brasília National Park (PNB) is a federal protected area surrounded by a dense urban matrix, including highways and residential zones, with sections open to public visitation. Despite its importance to local biodiversity, the impact of human activities on the spatial distribution of Xenarthra species within the park has not been fully addressed. This study aims to characterize the spatial patterns of habitat use by giant anteaters in PNB and identify the environmental and anthropogenic variables—such as human structures, domestic dogs, and vegetation cover—that affect their occupancy and pose potential threats during dry and rainy seasons.

We propose three hypotheses to guide this research: (1) Giant anteaters will preferentially use open areas, such as grasslands and savannas, due to their reliance on these habitats for thermoregulation and food resources (Miranda, 2004; Medri & Mourão, 2005; Quiroga et al., 2016). (2) Their occupancy is positively associated with natural landscapes, particularly open areas, where termite and ant populations are abundant and essential for their foraging (Miranda, 2004). (3) Anthropogenic factors, such as the presence of domestic dogs and proximity to human structures (including urban housing, farms, plantations, roads, and dirty trails), will negatively influence occupancy and detection, as these elements increase disturbance levels and pose direct threats to the species' survival (Lacerda et al., 2009; Koster, 2008; Quiroga et al., 2016). By investigating these variables, we aim to provide insights for management strategies that can ensure the persistence of giant anteaters in urban-proximate conservation areas like PNB.

MATERIALS AND METHODS

Study Area

Brasília National Park (PNB), is a federally protected area (15°38′12″S, 48°02′21″W) dedicated to conserving the flora and fauna of the Cerrado, preserving scenic ecosystems, and promoting scientific research, environmental education, and tourism. The park features various phytophysiognomies characteristic of the Cerrado biome, including gallery forests, cerrado *stricto sensu*, campo sujo, and rupestrian areas (Funatura/Ibama, 1998). The climate is tropical seasonal, with two distinct seasons: a rainy season from October to April and a dry season from May to September. Average annual temperatures range from 20°C to 25°C; however, afternoon temperatures can reach extreme levels during the dry season. Annual precipitation average ranges from 1200 to 1800 mm, with relative humidity generally low during the dry season (Köppen-Geiger classification, Beck et al., 2023).

The park encompasses four administrative areas in the northwestern portion of the Federal District (Sobradinho, Brazlândia, Brasília, and Padre Bernardo). Preserving local water sources, such as the Torto and Bananal creeks, which provide water to Brazil's capital, is crucial. Due to its peri-urban location, PNB is surrounded by high-speed highways and varying levels of human development (Horowitz, 1992). The park also includes two public swimming areas and various hiking trails distributed throughout its landscape (Figure 1).

Data Collection

To assess the environmental and anthropogenic factors influencing the occupancy and detection of giant anteaters in Brasília National Park (PNB), we conducted a three-year camera trap study (2020-2022), with sampling periods during both the dry (June to October) and rainy (January to April) seasons each year, resulting in a total of six field campaigns. Each campaign involved the sampling of 57 distinct sites, with a minimum distance of 1 km between, where cameras were deployed for 30 consecutive days to record species occurrences.

Due to the limited number of cameras available, it was not feasible to sample all sites simultaneously; thus, a rotating sampling design was implemented. After each 30-day period,

cameras were relocated to new sites, ensuring that all 57 points were sampled within each campaign. A field campaign was considered complete once all sites had been surveyed for 30 days. In 2020, we had a total of 17 cameras, and in 2021 and 2022, the number of cameras used simultaneously increased to 30 (Campark T80, Campark T86, and Meidase Trail models).

Each camera was programmed to operate continuously for 24 hours a day over the 30-day deployment period, recording occurrences of giant anteaters by capturing three sequential photographs with a 30-second interval between each trigger. Camera traps were checked every 10-15 days for battery and memory card replacement, ensuring consistent data collection throughout the sampling period. To minimize the risk of equipment theft, sampling was restricted to areas within the park, avoiding the surrounding regions.

Variables Measured

We measured several environmental and anthropogenic variables hypothesized to influence giant anteater occupancy and detection. All variables and their expected effects are detailed in Table 1. Meteorological variables were obtained from the nearest weather station to the protected area (INMET - Brazlândia). Land-use variables were extracted using the land cover map of the Cerrado biome (Mapbiomas, 2023). Vegetation structure was characterized by classifying it into three primary phytophysiognomic types (savanna, forest, and grassland). The proportion of each vegetation type within a 500-meter buffer around each sampling site was estimated. Distance-related variables, such as proximity to water sources, urban areas, and highways, were also derived from the land-use map. The minimum distance from each sampling point to these features was computed. The probability of dog occupancy at each sampling point was calculated a priori using through an occupancy model based on data recorded during the study period. The occupancy estimates obtained from this model were subsequently incorporated as covariates in the giant anteater occupancy model. All spatial and environmental analyses were performed using the *raster* package in R. Continuous covariates were log-

transformed for standardization, and correlations between covariates were assessed to mitigate multicollinearity.

Data analysis

We conducted a *t-test* to evaluate differences in giant anteater records between seasons. Additionally, we employed an *anova* to examine variations in anteater records across different years. To determine whether there was a significant difference in the number of anteater records at sites with dog sightings compared to those without, we performed a *Chi-square* test.

We used multi-season modeling (MacKenzie & Royle, 2005) to assess the influence of biotic and abiotic factors on giant anteater occupancy. The analysis was performed using the *Unmarked* package in R (R Core Team, 2017). To reduce the number of candidate models, we first modeled the detection parameter as a function of temporal variables (such as precipitation, temperature) and the presence of dogs. Subsequently, we modeled the probabilities of occupancy, colonization, and extinction while incorporating vegetation cover and anthropogenic factors, detailed in Table 1. This method allowed for the development of separate models for the rainy and dry seasons. We estimated four parameters from the model: (1) the probability of occupancy (ψ), the probability of colonization (γ), the probability of extinction (ε), and the probability of detecting (p). The *ad hoc* method was employed, where a sampling occasion was represented by 5 consecutive days of trapping. This approach allowed for a more flexible and efficient data collection process, maximizing the likelihood of detecting the target species during the designated sampling period. The best model was selected based on the Akaike Information Criterion (AIC), with the model exhibiting the lowest AIC being preferred (ΔAICc < 2). Model fit was further assessed using likelihood ratio tests (LRT) and goodness-of-fit tests. The final model was chosen for its balance between explanatory power and parsimony.

RESULTS

Sampling and Detection Rates

The sampling effort across the six field campaigns totaled 10,260 trap days. During this period, 199 independent records of giant anteaters were obtained (rainy season: 100; dry season: 99). The species was detected at least once at 43 out of the 57 study sites, resulting in a naïve occupancy rate of 75.4%. One camera trap recorded an agonistic interaction between a giant anteater and a domestic dog near the park's edge. Although the photograph quality was low, it clearly shows the dog in a defensive, fleeing position.

The heatmap (Figure 2) illustrates the distribution of giant anteater records, with red zones showing the highest concentration of detections. This pattern reveals a distribution of giant anteaters within the central part of the park, suggesting a preference for areas with minimal disturbance.

Effect of Domestic Dogs on Detection Rates

Domestic dogs near sampling sites significantly influenced detection rates. Specifically, detection rates were approximately 65% at sites with dogs, compared to 80% in areas without dog activity. Despite not reaching statistical significance ($\chi^2 = 0.79$, $p = 0.37$), the observed trend suggests that the dog's presence may influence giant anteater behavior and spatial distribution, reducing detection probability.

Seasonal and Temporal Effects

Statistical analysis revealed no significant differences in the number of giant anteater records between the rainy and dry seasons ($t = -0.03$, $p = 0.98$). Additionally, comparisons across the three years of data collection showed no significant differences in detection rates ($F = 0.59$, $p = 0.61$), suggesting that giant anteater presence remained consistent over time and across seasons.

Multi-Season Occupancy Models

The analysis of species detection revealed no significant influence from environmental variables such as rainfall and temperature; instead, detection rates were primarily affected by the presence of domestic dogs in both seasons (Figure 3). The results from the multi-season occupancy models showed that the presence of giant anteaters was best explained by a null model, suggesting stable occupancy across the park regardless of environmental predictors. However, specific factors influenced the tested parameters.

During the dry season (Table 2), the best model indicated that the extinction rate was negatively associated with distance to agricultural areas ($\beta = -2.06$, $p = 0.09$). In other words, as the distance to agricultural areas increases, the giant anteater probability of extinction reduces. The presence of domestic dogs significantly influenced detection probability negatively ($\beta = -7.81$, $p = 0.05$). None variables tested has influence from variables for initial occupancy ($\beta = -1.32$, $p < 0.001$) and colonization rate ($\beta = -0.48$, $p = 0.15$). During the rainy season, occupancy and extinction predictors did not significantly affect the parameters (Table 2). However, colonization was negatively associated with forest cover ($\beta = -16.11$, $p > 0.79$) and positively influenced by distance from urban areas ($\beta = 6.72$, $p = 0.73$). The domestic dog presence negatively affecting detection probability ($\beta = -5.31$, $p = 0.08$) (Figure 3).

The likelihood ratio test (LRT) has revealed differences between models for both seasons, with practical implications for ecological research. In the dry season, Model 1 ($\psi \sim 1$, $\gamma \sim 1$, $\epsilon \sim$agro, p~dog) was significantly superior to Model 2 (LRT value = 4.96), suggesting its potential for dry season predictions. In the rainy season, our analysis showed that Model 6 ($\psi \sim 1$, $\gamma \sim$p_flo+urb, $\epsilon \sim 1$, p~dog) did not significantly improve over Model 7 (LRT value = -0.36). These findings emphasize that while environmental variables did not significantly influence occupancy, anthropogenic disturbances, particularly domestic dog presence, impacted detection rates and may influence giant anteater spatial behavior within the park.

DISCUSSION

This study explores the occupancy patterns and detection of giant anteaters in a peri-urban protected area within the Cerrado, providing valuable insights into how these animals adapt to human activities and seasonal changes. Our findings indicate that giant anteaters consistently occupy the park throughout the year, with no significant seasonal shifts in their records. This habitat use throughout the year suggests that the variety of vegetation types and the balanced distribution of resources across the park offer giant anteaters the conditions they need to find suitable environments regardless of the season (Bertassoni & Ribeiro, 2019; Giroux et al., 2022). While giant anteaters can access different areas for their persistence, they may be primarily regulating their exposure to threats by altering their activity pattern by avoiding temporal overlap (Petrazzini, P.B., unpublished data). Some species could respond to threats first on a temporal scale, helping to maintain viable populations in the area (Tuomainen & Candolin, 2010). However, we visually observed a concentration of records in restricted-access areas, including a location above the reservoir along a single-access road.

Impact of Domestic Dogs

In our study, we identified the presence of domestic dogs as a significant factor influencing giant anteater detection probabilities. This finding agrees with other research showing that disturbances associated with human activity can substantially affect wildlife behavior and spatial patterns (Lacerda et al., 2009; Paschoal et al., 2018; Gouvea, 2020; Ewart et al., 2024). While the difference in ocorrence rates in areas with dogs was not statistically significant, the observed trend suggests that dogs may cause giant anteaters behavior changes. This behavior aligns with the concept of “fear ecology”, where real or perceived threats, like domestic dogs, act as a stressor that influences wildlife activity even in protected areas (Doherty et al., 2017; Vanak et al., 2009), changing species behavior (Lenth et al., 2008).

The influence of domestic dogs on native wildlife is not confined to a specific region but rather a global concern, particularly in protected and fragmented areas. For instance, a study in Asia has shown that species like the golden jackal (*Canis aureus*) adjust their activity patterns to minimize interactions with domestic dogs, demonstrating these animals' influence on the temporal dynamics of wildlife populations (Marshall et al., 2023). In Brazil, research on other Xenarthrans reveals that armadillos tend to avoid areas frequented by domestic dogs and ocelots over time, even without direct encounters (Costa et al., 2024). These findings confirm that domestic dogs create 'edge effects' within protected areas, reducing habitat quality and limiting the effectiveness of these regions as refuges for native species (Marshall et al., 2023; Costa et al., 2024).

In Brazilian protected areas, domestic dogs frequently interacted with at least 37 native species, often leading to population declines due to competition, predation, and disease transmission (Lessa et al., 2016). Such disruptions can force native species to alter their behavior and distribution, impacting local ecosystems. Notably, 55% of Brazil's 69 threatened animal species have been reported in studies involving dogs (Lessa et al., 2016). Effective management strategies are needed to mitigate these impacts, including controlling free-ranging dog populations and working intensively with local communities to reduce dog presence in conservation areas. This collaboration with local communities is beneficial and crucial in addressing the issue (Lessa et al., 2016; Marshall et al., 2023; Costa et al., 2024).

Our direct observation of an interaction between a giant anteater and a domestic dog underscores the urgent need for controlling dog populations within and around protected areas. These encounters pose disturbances and risks of behavioral changes, injuries, and even fatalities for giant anteaters. This evidence emphasizes our critical role in minimizing such conflicts to ensure the long-term conservation of wildlife populations. Additionally, it is important to remember that in peri-urban protected areas like the PNB, beyond the impacts already

described, dogs may also drive giant anteaters out of the protected area. This is particularly concerning as the surrounding landscape is a mix of urban and rural environments with numerous roads, increasing the risk of vehicle collisions and fatalities for giant anteaters.

Habitat Use and Seasonal Stability

Contrary to our initial expectations, we did not observe significant effects on giant anteater occupancy, nor did variables like rainfall or temperature significantly impact their detection. The high naïve occupancy, may stem from the park's diverse vegetation and habitat structures, which likely provide adequate thermal refuges and food resources year-round, allowing the species to use the entire parks area (Medri & Mourão, 2005; Giroux et al., 2023). This is reflected in the observed high naïve occupancy rate.

Despite the broad distribution of giant anteaters across the park, we found them in higher densities in areas with less human disturbance and fewer trails. This observation supports previous findings that wildlife presence decreases near human access points and trails (Lacerda et al., 2009). It suggests that, while giant anteaters are flexible in their habitat use, they may still prefer areas where human activity is minimal, likely as a strategy to avoid potential risks. In a recent study, Chhen et al. (2024) found that giant anteaters occupied stable home ranges with a mean area of 5.45 km2, with males having significantly larger home ranges than females. They also observed that giant anteaters are a solitary and largely asocial species that readily share space with conspecifics. Despite their capacity to share space, the combined pressures of being condensed into smaller areas and decreased food availability due to increased pesticide use may cause behavioral changes throughout the population (Chhen et al. 2024).

Effect of Agricultural Areas

Our analysis revealed that proximity to agricultural areas affects negatively the giant anteater's extinction probability during the dry season. Di Blanco et al. (2017) and Semper-Pascual et al. (2020) observed that giant anteater avoidance from settlements and agriculture in Argentina, similarly to our study. This association presumably reflects the wider impacts of agricultural expansion, including habitat fragmentation, pesticide exposure, and the loss of thermal refuges, all of which can pose severe threats to giant anteaters (Di Blanco et al., 2017; Semper-Pascual et al., 2020; Chhen et al., 2024). During the dry season, when water and shade are scarce, these impacts become particularly dangerous, creating ecological traps that increase the species' vulnerability (Nawrocki et al., 2019). As previously mentioned, the combined pressures of being confined to isolated areas and reduced food availability may lead to behavioral changes across the population. Additionally, these conditions may facilitate inbreeding or cause a genetic bottleneck, ultimately reducing genetic diversity (Barragan-Ruiz et al., 2021; Clozato et al., 2017; Collevatti et al., 2007), despite the species' ability to share space (Chhen et al., 2024). These findings underscore the importance of effective protected area management, particularly through establishing buffer zones around these areas, to minimize the influence of nearby agricultural activities, and also mitigate the impacts of domestic dogs, preventing that the reduction of home range by the influence of agriculture, promoting an avoidance of borders and creating a higher use of the core area (Lima & Ranieri, 2018; Xu et al., 2022). Unfortunately, this approach has not been implemented effectively for the Brasília National Park (Silva et al. 2024), putting the long-term survival of the giant anteater at extreme risk.

Effect of Forest and Urban Areas

During the rainy season, the selected model show that colonization rates decreased with higher forest cover and increased with distance from urban areas. One possible explanation is

that, with resources more abundant and conditions less restrictive, giant anteaters can be more selective in habitat use, avoiding areas with greater human disturbance. Although they are known to use diverse habitats (Kreutz et al. 2012; Di Blanco et al., 2017; Bertassoni et al., 2020; Giroux et al., 2023), in the rainy season, when food availability is higher (Queiroz et al., 2022), the species may prefer open areas where foraging is more efficient than in dense forests.

The positive correlation between colonization and distance from urban areas suggests that giant anteaters favor habitats farther from human disturbances. Urban environments introduce noise, pollution, and increased human activity, which can deter wildlife (Marion et al., 2024). The resources abundance during this period could give to anteater greater flexibility to avoid urbanized areas and select undisturbed habitats, likely as a strategy to minimize risks associated with human presence (Paolino et al., 2016). Research has shown that human structures, such as settlements and roads, negatively impact giant anteater occupancy (Semper-Pascual et al., 2020; Versiani et al., 2021), with linear features linked to broader wildlife impacts (Trombulak & Frissell, 2000; Laurance et al., 2009; de Jonge et al., 2022), including the presence of domestic dogs in natural areas (Sepúlveda et al., 2015; Doherty et al., 2017; Paschoal et al., 2018; Felizardo et al., 2023). These findings emphasize the need to balancing conservation, tourism and urban developing, a critical challenge for park managers.

Management Implications

The results of our study emphasize the need for targeted management strategies to reduce human-wildlife conflicts and minimize disturbances in and around Brasília National Park. To mitigate human-wildlife conflicts, park managers must monitor recreational trails, manage domestic dog presence, and establish buffer zones. Implementing buffer zones and improving public education about the impact of dogs and human activity on wildlife can help mitigate these interactions and strengthen conservation efforts (Marion et al., 2024; Sepúlveda et al.,

2015). These strategies not only protect giant anteaters but also enhance the resilience of the Cerrado biome against the pressures of urban and agricultural development.

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REFERENCES

Barragán-Ruiz, C. E., Silva-Santos, R., Saranholi, B. H., Desbiez, A. L., & Galetti Jr, P. M. (2021). Moderate genetic diversity and demographic reduction in the threatened giant anteater, *Myrmecophaga tridactyla*. *Frontiers in Genetics, 12*, 669350.

Batalha, M. A. (2011). The Brazilian Cerrado is not a biome. *Biota Neotropica, 11*(1), 21-24.

Beck, H. E., McVicar, T. R., Vergopolan, N., Berg, A., Lutsko, N. J., Dufour, A., Zeng, Z., Jiang, X., van Dijk, A. I. & Miralles, D. G. (2023). High-resolution (1 km) Köppen-Geiger maps for 1901–2099 based on constrained CMIP6 projections. Scientific data. 10(1), 724.

Bertassoni, A., & Ribeiro, M. C. (2019). Space use by the giant anteater (*Myrmecophaga tridactyla*): A review and key directions for future research. *European Journal of Wildlife Research, 65*, 93.

Bertassoni, A., Mourão, G., & de C. Bianchi, R. (2020). Space use by giant anteaters (*Myrmecophaga tridactyla*) in a protected area within a human-modified landscape. *Ecology and Evolution, 10*(1), 1–14.

Bertassoni, A., Mourão, G., Ribeiro, R. C., Cesário, C. S., de Oliveira, J. P. D., & de C. Bianchi, R. (2017). Movement patterns and space use of the first giant anteater (*Myrmecophaga tridactyla*) monitored in São Paulo State, Brazil. *Studies on Neotropical Fauna and Environment, 52*(1), 68–74.

Bruner, A. G., Gullison, R. E., Rice, R. E., & da Fonseca, G. A. B. (2001). Effectiveness of parks in protecting tropical biodiversity. *Science, 291*(5501), 125–128.

Camilo-Alves, C. de S. E. P., & Mourão, G. de M. (2006). Responses of a specialized insectivorous mammal (*Myrmecophaga tridactyla*). *Biotropica, 38*(1), 52–56.

Cardillo, M., Purvis, A., Sechrest, W., Gittleman, J. L., Bielby, J., & Mace, G. M. (2004). Human population density and extinction risk in the world's carnivores. *PLoS Biology, 2*(7), 909–914.

Chhen, A., Bertassoni, A., Desbiez, A. L. J., & Noonan, M. J. 2024. The socio-spatial ecology of giant anteaters in the Brazilian Cerrado. *Journal of Zoology, 324*(1), 50-62. https://doi.org/10.1111/jzo.13195

Chichorro, F., Juslén, A., & Cardoso, P. (2019). A review of the relation between species traits and extinction risk. *Biological Conservation, 237*, 220–229.

Clements, H. S., Kerley, G. I. H., Cumming, G. S., de Vos, A., & Cook, C. N. (2019). Privately protected areas provide key opportunities for the regional persistence of large- and medium-sized mammals. *Journal of Applied Ecology, 56*(3), 537–546.

Clozato, C. L., Miranda, F. R., Lara-Ruiz, P., Collevatti, R. G., & Santos, F. R. (2017). Population structure and genetic diversity of the giant anteater (*Myrmecophaga tridactyla*: Myrmecophagidae, Pilosa) in Brazil. *Genetics and Molecular Biology, 40*(1), 50–60.

Collevatti, R. G., Leite, K. C., de Miranda, G. H., & Rodrigues, F. H. (2007). Evidence of high inbreeding in a population of the endangered giant anteater (*Myrmecophaga tridactyla*) (Myrmecophagidae) from Emas National Park, Brazil. *Genetics and Molecular Biology, 30*, 112–120.

Colman, C. B., Guerra, A., Almagro, A., de Oliveira Roque, F., Rosa, I. M., Fernandes, G. W., & Oliveira, P. T. S. (2024). Modeling the Brazilian Cerrado land use change highlights the need to account for private property sizes for biodiversity conservation. *Scientific Reports, 14*(1), 4559.

Costa, R. T., Fornitano, L., & de Cassia Bianchi, R. (2024). Nine-banded armadillos temporally avoid sites visited by domestic dogs and native carnivores. *Wildlife Research, 51*.

Darlington, S., Ladle, A., Burton, A. C., Volpe, J. P., & Fisher, J. T. (2022). Cumulative effects of human footprint, natural features and predation risk best predict seasonal resource selection by white-tailed deer. *Scientific Reports*, *12*, 1072.

de Jonge, M. M. J., Gallego-Zamorano, J., Huijbregts, M. A. J., Schipper, A. M., & Benítez-López, A. (2022). The impacts of linear infrastructure on terrestrial vertebrate populations: A trait-based approach. *Global Change Biology*, *28*(24), 7217–7233. https://doi.org/10.1111/gcb.16450

Desbiez, A. L. J., & Medri, Í. M. (2010). Density and habitat use by giant anteaters (*Myrmecophaga tridactyla*) and southern tamanduas (Tamandua tetradactyla) in the Pantanal Wetland, Brazil. *Edentata*, 11, 4–10.

Di Blanco, Y. E., Desbiez, A. L., Jiménez-Pérez, I., Kluyber, D., Massocato, G. F., & Di Bitetti, M. S. (2017). Habitat selection and home-range use by resident and reintroduced giant anteaters in two South American wetlands. *Journal of Mammalogy*, 98, 1118–1128.

Diniz, M. F., & Brito, D. (2013). Threats to and viability of the giant anteater, *Myrmecophaga tridactyla* (Pilosa: Myrmecophagidae), in a protected Cerrado remnant encroached by urban expansion in central Brazil. *Zoologia* (Curitiba), 30, 151–156.

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

Doherty, T. S., Dickman, C. R., Glen, A. S., Newsome, T. M., Nimmo, D. G., Ritchie, E. G., Vanak, A. T., & Wirsing, A. J. (2017). The global impacts of domestic dogs on threatened vertebrates. *Biological Conservation*, 210, 56–59. http://dx.doi.org/10.1016/j.biocon.2017.04.007

Ewart, H. E., Pasqualotto, N., Paolino, R. M., Jensen, K., & Chiarello, A. G. (2024). Effects of anthropogenic disturbance and land cover protection on the behavioural patterns and abundance of Brazilian mammals. *Global Ecology and Conservation*, e02839. https://doi.org/10.1016/j.gecco.2024.e02839

Felizardo, L. V., Marciniak, B., & Dechoum, M. S. (2023). A ocorrência de cães domésticos invasores é positivamente influenciada por um maior potencial de uso público em trilha. *Oecologia Australis*, 27(4), 375–388. https://doi.org/10.4257/oeco.2023.2704.03

Fornitano, L., Gouvea, J. A., Costa, R. T., Magioli, M., & Bianchi, R. (2024). Large protected areas safeguard mammalian functional diversity in human-modified landscapes. *Sustainability, 16(13)*, 5419.

Funatura/Ibama. (1998). *Plano de Manejo do Parque Nacional de Brasília - Revisão*.

Giroux, A., Ortega, Z., Attias, N., Desbiez, A. L. J., Valle, D., Börger, L., & Oliveira-Santos, L. G. R. (2023). Activity modulation and selection for forests help giant anteaters to cope with temperature changes. *Animal Behaviour*, *201*, 191–209.

Giroux, A., Ortega, Z., Bertassoni, A., Desbiez, A. L. J., Kluyber, D., Massocato, G. F., & Oliveira-Santos, L. G. R. (2022). The role of environmental temperature on movement patterns of giant anteaters. *Integrative Zoology*, *17*(2), 285–296.

Gouvea, J. A. (2020). *How does the giant anteater Myrmecophaga tridactyla use a landscape featuring high human disturbance and free-ranging dogs?* (Master's thesis, 60 pages). Universidade Estadual Paulista. http://hdl.handle.net/11449/193076

Grande, T. O., Aguiar, L. M., & Machado, R. B. (2020). Heating a biodiversity hotspot: Connectivity is more important than remaining habitat. *Landscape Ecology, 35***,** 639–657.

Grecchi, R. C., Gwyn, Q. H. J., Bénié, G. B., Formaggio, A. R., & Fahl, F. C. (2014). Land use and land cover changes in the Brazilian Cerrado: A multidisciplinary approach to assess the impacts of agricultural expansion. *Applied Geography, 55*, 300–312.

Horowitz, C. (1992). *Plano de manejo do Parque Nacional de Brasília: Avaliação da metodologia de planejamento adotada, execução e resultados alcançados no decênio 79/89*. Universidade de Brasília.

Koster, J. (2008). The impact of hunting with dogs on wildlife harvests in the Bosawas Reserve, Nicaragua. *Environmental Conservation, 35*, 211–220.

Kreutz, K., Fischer, F., & Linsenmair, K. E. (2012). Timber plantations as favourite habitat for giant anteaters. *Mammalia, 76*(2), 137–142. https://doi.org/10.1515/mammalia-2011-0049

Lacerda, A. C. R., Tomas, W. M., & Marinho-Filho, J. (2009). Domestic dogs as an edge effect in the Brasília National Park, Brazil: Interactions with native mammals. *Animal Conservation, 12*, 477–487.

Lahsen, M., Bustamante, M. M., & Dalla-Nora, E. L. (2016). Undervaluing and overexploiting the Brazilian Cerrado at our peril. *Environment: Science and Policy for Sustainable Development, 58*(6), 4–15.

Laurance, W. F., Goosem, M., & Laurance, S. G. (2009). Impacts of roads and linear clearings on tropical forests. *Trends in Ecology and Evolution, 24*, 659–669. https://doi.org/10.1016/j.tree.2009.06.009

Lenth, B. E., Knight, R. L., & Brennan, M. E. (2008). The effects of dogs on wildlife communities. *Natural Areas Journal, 28*, 218–227.

Lessa, I., Guimarães, T. C. S., Bergallo, H. de G., Cunha, A., & Vieira, E. M. (2016). Domestic dogs in protected areas: A threat to Brazilian mammals? *Natureza e Conservação, 14*(2), 46–56.

Lima, E. A. C. F., & Ranieri, V. E. L. (2018). Land use planning around protected areas: Case studies in four state parks in the Atlantic forest region of southeastern Brazil. *Land Use Policy, 71*, 453–466.

Lino, A., Fonseca, C., Rojas, D., Fischer, E., & Ramos Pereira, M. J. (2019). A meta-analysis of the effects of habitat loss and fragmentation on genetic diversity in mammals. *Mammalian Biology, 94*, 69–76.

Machado, R. B., Aguiar, L. M. S., & Silva, J. M. C. (2023). Brazil: Plan for zero vegetation loss in the Cerrado. *Nature, 615*, 216.

Mackenzie, D. I., & Royle, J. A. (2005). Designing occupancy studies: General advice and allocating survey effort. *Journal of Applied Ecology, 42*, 1105–1114.

Marion, S., Curveira Santos, G., Herdman, E., Hubbs, A., Kearney, S. P., & Burton, A. C. (2024). Mammal responses to human recreation depend on landscape context. *PLOS ONE, 19*(7), e0300870.

Marshall, H. E., Sukumal, N., Ngoprasert, D., & Savini, T. (2023). The spatial and temporal displacement of native species by domestic dogs. *Global Ecology and Conservation, 44*, e02504.

Massara, R. L., Paschoal, A. M. de O., Bailey, L. L., Doherty, P. F., Hirsch, A. H., & Chiarello, A. G. (2018). Factors influencing ocelot occupancy in Brazilian Atlantic Forest reserves. *Biotropica, 50*, 125–134.

Medri, Í. M., & Mourão, G. (2005). Home range of giant anteaters (*Myrmecophaga tridactyla*) in the Pantanal wetland, Brazil. *Journal of Zoology*, 266, 365–375.

Miranda, F., Bertassoni, A., & Abba, A. M. (2014). *Myrmecophaga tridactyla*. The IUCN Red List of Threatened Species, e.T14224A4.

Miranda, G. H. B. (2004). *Ecologia e conservação do tamanduá-bandeira (Myrmecophaga tridactyla, Linnaeus, 1758) no Parque Nacional das Emas* (Doctoral dissertation, 81 pages). Universidade de Brasília.

Miranda, G. H. B., Tomás, W. M., Valladares-Pádua, C. B., & Rodrigues, F. H. G. (2006). Giant anteater (*Myrmecophaga tridactyla*) population survey in Emas National Park, Brazil – A proposed monitoring program. *Endangered Species Update*, 23(3), 96–103.

Mourão, G., & Medri, Í. M. (2007). Activity of a specialized insectivorous mammal (*Myrmecophaga tridactyla*) in the Pantanal of Brazil. *Journal of Zoology*, 271, 187–192.

Nawrocki, J. A., Schooley, R. L., & Ward, M. P. (2019). When good animals love restored habitat in bad neighborhoods: Ecological traps for eastern cottontails in agricultural landscapes. *Biodiversity and Conservation*, 28, 953–973. https://doi.org/10.1007/s10531-019-01704-0

Paolino, R. M., Royle, J. A., Versiani, N. F., Rodrigues, T. F., Pasqualotto, N., Krepschi, V. G., & Chiarello, A. G. (2018). Importance of riparian forest corridors for the ocelot in agricultural landscapes. *Journal of Mammalogy*, 99, 874–884.

Paolino, R. M., Versiani, N. F., Pasqualotto, N., Rodrigues, T. F., Krepschi, V. G., & Chiarello, A. G. (2016). Buffer zone use by mammals in a Cerrado protected area. *Biota Neotropica*, *16*(2), e20140117. https://doi.org/10.1590/1676-0611-BN-2014-0117

Paschoal, A. M., Massara, R. L., Bailey, L. L., Doherty Jr, P. F., Santos, P. M., Paglia, A. P., & Chiarello, A. G. (2018). Anthropogenic disturbances drive domestic dog use of Atlantic Forest protected areas. *Tropical Conservation Science*, 11, 194008291878983.

Penido, G., da Silva, R. R., Guimarães, J. P., Dechoum, M. S., & Rusch, V. (2017). Mesocarnivore activity patterns in the semiarid Caatinga: Limited by the harsh environment or affected by interspecific interactions? *Journal of Mammalogy*, 98, 1732–1740.

Petrazzini, P. B. (2019). Occupancy patterns and activity of giant anteaters in a protected area in the Central Cerrado (Master's thesis, 83 pages). Universidade de Brasília.

Pompeu, J., Assis, T. O., & Ometto, J. P. (2024). Landscape changes in the Cerrado: Challenges of land clearing, fragmentation, and land tenure for biological conservation. *Science of The Total Environment*, 906, 167581.

Queiroz, A. C., Marques, T. G., Ribas, C. R., Cornelissen, T. G., Nogueira, A., Schmidt, F. A., Feitosa, R. M., Sobrinho, T. G., Quinet, Y., Baccaro, F. B., & Ulyssea, M. A. (2023). Ant diversity decreases during the dry season: A meta-analysis of the effects of seasonality on ant richness and abundance. *Biotropica*, 55(1), 29–39.

Quesnelle, P. E., Lindsay, K. E., & Fahrig, L. (2014). Low reproductive rate predicts species sensitivity to habitat loss: A meta-analysis of wetland vertebrates. *PLoS ONE*, 9 (3), e90926.

Quiroga, V. A., Noss, A. J., Boaglio, G. I., & Di Bitetti, M. S. (2016). Local and continental determinants of giant anteater (*Myrmecophaga tridactyla*) abundance: Biome, human, and jaguar roles in population regulation. *Mammalian Biology*, 81, 274–280.

Rodrigues, T. F., Kays, R., Parsons, A., Versiani, N. F., Paolino, R. M., Pasqualotto, N., Krepschi, V. G., & Chiarello, A. G. (2017). Managed forest as habitat for gray brocket deer (*Mazama gouazoubira*) in agricultural landscapes of southeastern Brazil. *Journal of Mammalogy*, 98(5), 1301–1309.

Rodrigues, T. F., Paolino, R. M., Versiani, N. F., Salvador, N. A. P., de Oliveira, E. D., & Chiarello, A. G. (2014). The lowland tapir (*Tapirus terrestris*) is back to the largest protected area of Cerrado in the state of São Paulo, Brazil. *Tapir Conservation Newsletter*, 23(32), 5–9.

Rosa, A. L. M. (2007). *Effect of environmental temperature on the activity, habitat use, and body temperature of the giant anteater (Myrmecophaga tridactyla) at Nhumirim Farm, Pantanal* (Master's thesis,32 pages). Universidade Federal de Mato Grosso do Sul.

Semper-Pascual, A., Decarre, J., Baumann, M., Camino, M., Di Blanco, Y., Gómez-Valencia, B., & Kuemmerle, T. (2020). Using occupancy models to assess the direct and indirect impacts of agricultural expansion on species' populations. *Biodiversity and Conservation, 29*(11), 3669–3688. https://doi.org/10.1007/s10531-020-02042-1

Sepúlveda, M., Pelican, K., Cross, P., & et al. (2015). Fine-scale movements of rural free-ranging dogs in conservation areas in the temperate rainforest of the coastal range of southern Chile. *Mammalian Biology, 80*, 290-297. https://doi.org/10.1016/j.mambio.2015.03.001

Silva, M. S. F., Magnani, E., & Araújo Sobrinho, F. L. (2024). Usos, impactos e entraves para a conservação no Parque Nacional de Brasília. *Revista Cerrados, 22*(1), 99–131. https://doi.org/10.46551/rc24482692202405

Souza, J. C. de, da Silva, R. M., Gonçalves, M. P. R. e, Jardim, R. J. D., & Markwith, S. H. (2018). Habitat use, ranching, and human-wildlife conflict within a fragmented landscape in the Pantanal, Brazil. *Biological Conservation, 217*, 349–357.

Trombulak, S. C., & Frissell, C. A. (2000). Review of ecological effects of roads on terrestrial and aquatic communities. *Conservation Biology, 14*(1), 18–30. https://doi.org/10.1046/j.1523-1739.2000.99084.x

Tuomainen, U., & Candolin, U. (2011). Behavioural responses to human-induced environmental change. *Biological Reviews, 86*(3), 640–657. https://doi.org/10.1111/j.1469-185x.2010.00164.x

Vanak, A. T., Thaker, M., & Gompper, M. E. (2009). Experimental examination of behavioural interactions between free-ranging wild and domestic canids. *Behavioral Ecology and Sociobiology, 64*, 279–287.

Venter, O., Sanderson, E. W., Magrach, A., Allan, J. R., Beher, J., Jones, K. R., Possingham, H. P., Laurance, W. F., Wood, P., Fekete, B. M., Levy, M. A., & Watson, J. E. M. (2016). Sixteen years of change in the global terrestrial human footprint and implications for biodiversity conservation. *Nature Communications, 7*, 12558. https://doi.org/10.1038/ncomms12558

Versiani, N. F., Bailey, L. L., & Pasqualotto, N. (2021). Protected areas and unpaved roads mediate habitat use of the giant anteater in anthropogenic landscapes. *Journal of Mammalogy, 102*(3), 802–812.

Veum, S. A. (2017). *Using occupancy estimates to assess habitat use and interspecific interactions of bats in forested communities* (Master's thesis, 24 pages). Mississippi State University.

Watson, J. E. M., Dudley, N., Segan, D. B., & Hockings, M. (2014). The performance and potential of protected areas. *Nature, 515*, 67–73.

Xu, X., Huang, A., Belle, E., De Frenne, P., & Jia, G. (2022). Protected areas provide thermal buffer against climate change. *Science Advances, 8*(44), eabo0119. https://doi.org/10.1126/sciadv.abo0119

TABLES AND FIGURES

Table 1 – Variables and their effects on corresponding occupancy (Ψ) and detection (p) probabilities. NA: no expected effect, (+): positive effect, (-): negative effect.

Variable	Description	Expected Effect	
		Ψ	*p*
Distance from Highway	Minimum distance from the camera trap to the nearest highway, used as a proxy for edge effects. Highways can create barriers to movement and increase roadkill risk.	(+) Positive effect, as greater distance reduce disturbance.	NA
Trails	Proportion of trail sections within a 500m buffer of the sampling site, indicating human accessibility.	(-) Negative effect, as higher trail density increases disturbance.	(-) Negative effect, trails may increase human and dog presence, reducing detectability.
Grassland Vegetation	Proportion of grassland within a 500m buffer around the sampling site. Grasslands are suitable habitats for foraging and thermoregulation.	(+) Positive effect, as they provide essential resources.	NA
Savanna Vegetation	Proportion of savanna vegetation within a 500m buffer around the sampling site, another preferred habitat for giant anteaters.	(+) Positive effect, providing foraging and thermoregulatory benefits.	NA
Forest Vegetation	Proportion of forested areas within a 500m buffer around the sampling site. Forests are important for termoregulation, but less suitable.	NA	NA
Distance from Water	Minimum distance from the camera trap to water bodies, a critical resource, particularly in the dry season.	(-) Negative effect, as greater distance may reduce access to hydration.	(-) Negative effect, animals may be less detectable farther fr water sources.
Distance from Constructions	Minimum distance from the camera trap to human structures such as dwellings and other built environments.	(-) Negative effect, as proximity increases disturbance levels.	(+) Positive effect, a distance may enha detection probabili reducing disturban
Distance from agricultural	Minimum distance from the camera trap to agricultural areas, such as farms or plantations.	(-) Negative effect, as proximity may increas conflict with agricultu activities.	NA
Domestic Dog	Probability of domestic dog presence at the sampling site, indicating predator and competitor presence.	(-) Negative effect, as dogs disturb and pose threats to giant anteate	(-) Negative effect, dog presence may reduce detection rat
Temperature	Temperature recorded at the time of detection, influencing animal activity patterns.	NA	(-) Negative effect, higher temperatures may reduce detectio during peak heat.
Precipitation	Amount of rainfall recorded during the time of detection, affecting movement and behavior.	NA	(-) Negative effect, increased precipitati may reduce detectability.

Table 2 – Rankings of species occupancy best models based on Akaike Information Criterion (AIC) for giant anteaters from multi-season occupancy modeling for the Brasília National Park. Psi = occupancy covariate, p = detection covariate, gamma = colonization covariate, epsilon = extinction covariate, (~1) = constant probability, p_sav = proportion of savanna, flo = proportion of forest, dog = presence of domestic dogs, urb = distance to urban areas, agro = distance to agricultural areas and trail_500 = number of trails in a buffer of 500m.

Season		Model	K	AICc	ΔAICc	AICcWt	LL
Dry	**1***	**a) ψ~1, γ~1, ϵ~agro, p~dog**	**6**	**513.64**	**0.00**	**0.70**	**-249.98**
	2	b) ψ~1, γ~1, ϵ~1, p~dog	5	516.10	2.46	0.20	-252.46
	3	c) ψ~1, γ~trail_500, ϵ~1, p~dog	6	517.99	4.36	0.08	-252.16
	4	d) ψ~1, γ~1, ϵ~1, p~1	4	521.64	8.00	0.01	-256.44
	5	e) ψ~p_sav, γ~1, ϵ~agro, p~dog	7	525.95	12.32	0.00	-254.83
Rainy	**6***	**(ψ~1,γ~p_flo+urb,ϵ~1,p~dog)**	**7**	**553.36**	**0.00**	**0.76**	**-268.54**
	7	(ψ~dog,γ~p_flo+urb,ϵ~1,p~dog)	8	555.71	2.36	0.23	-268.36
	8	(ψ~1,γ~1,ϵ~1,p~dog)	6	563.50	10.14	0.00	-274.91
	9	(ψ~dog,γ~1,ϵ~1,p~dog)	6	565.54	12.18	0.00	-275.93
	10	(ψ~urb,γ~1,ϵ~1,p~dog)	5	566.31	12.95	0.00	-277.57

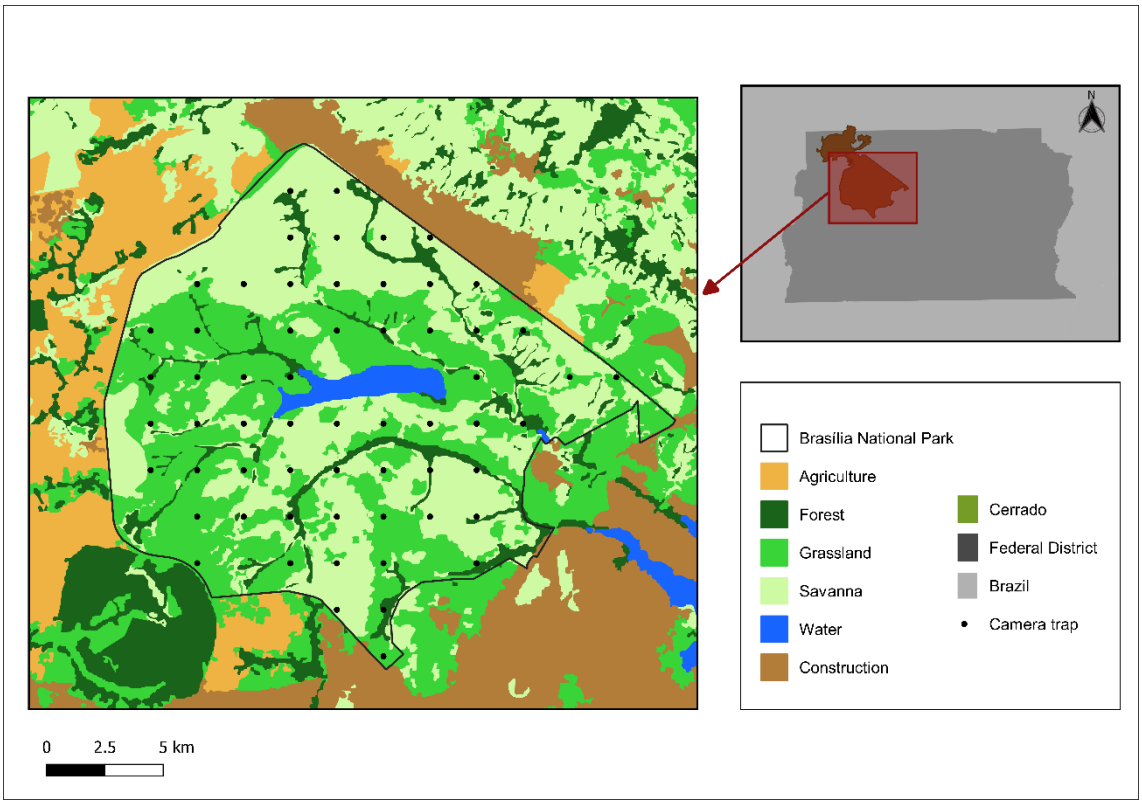

Figure 1 – The map illustrates the location of Brasília National Park in the Federal District, Brazil, and shows the distribution of land use within and surrounding the park. A black line marks the protected area's boundaries, while black dots indicate camera trap sites.

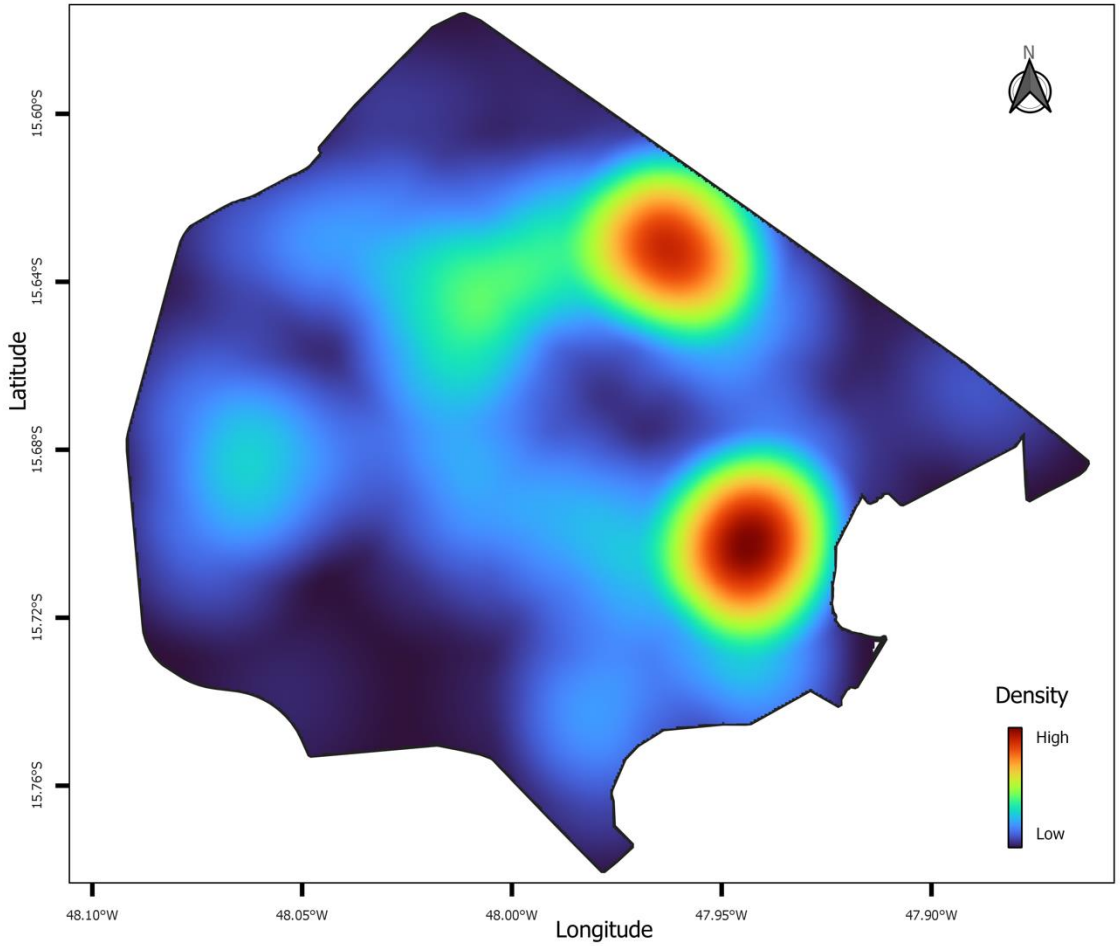

Figure 2 – The heatmap displays the distribution of giant anteater records across Brasília National Park, with red zones indicating the highest density of observations from camera traps. The central pattern reflects a concentration of habitat use and preferences across the park during the study period (2020–2023).

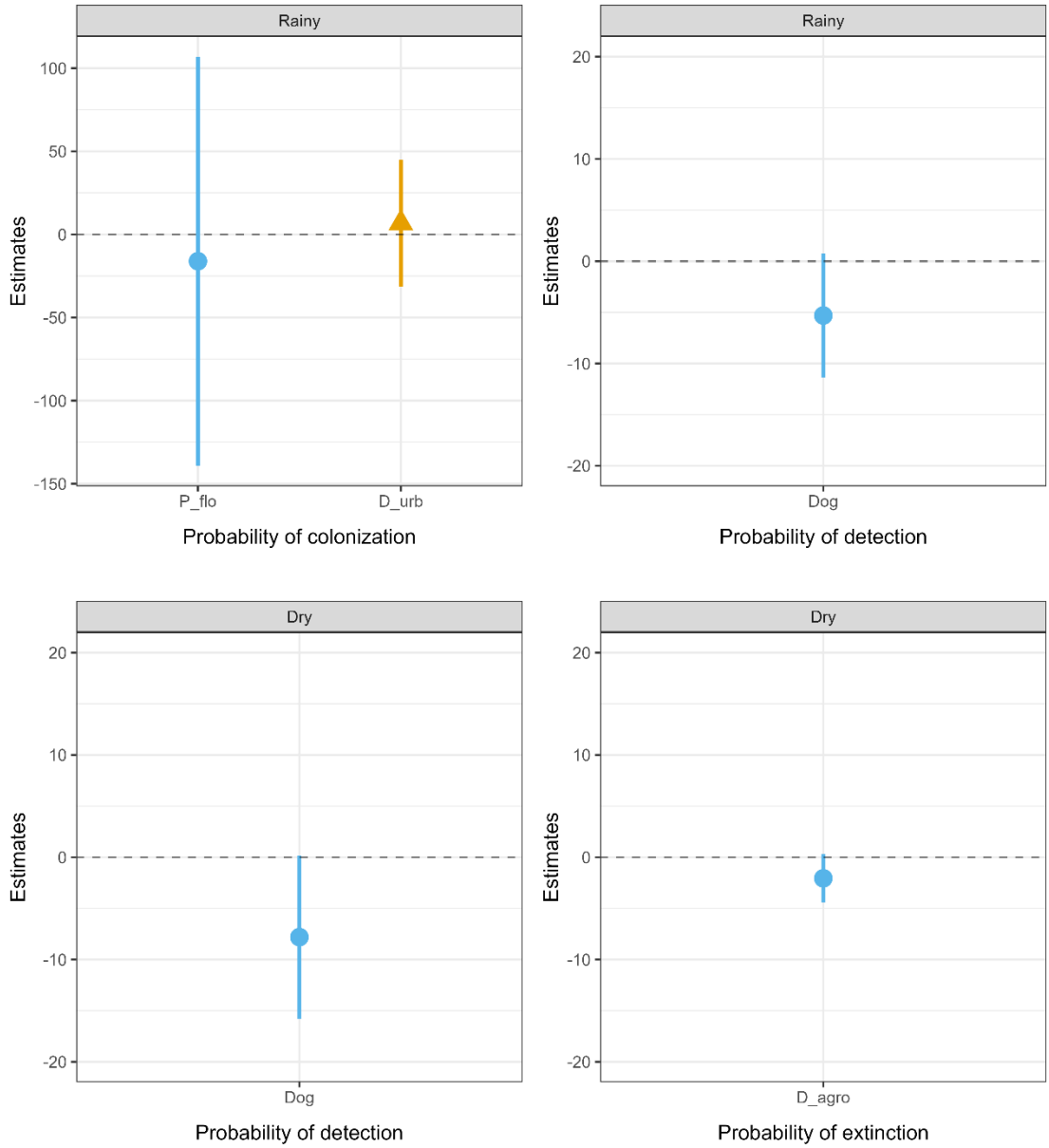

Figure 3 – Parameter estimates from multi-season occupancy best models for giant anteaters in Brasília National Park (2020–2023). The top row represents estimates for the rainy season, while the bottom row represents the dry season. Colonization is influenced by the proportion of forest cover (P_flo) and the distance to urban areas (D_urb). Detection probability is affected by the presence of domestic dogs (Dog), and extinction probability is influenced by distance to agricultural areas (D_agro).

CAPÍTULO 4

Artigo submetido para a *Animal Conservation*

Behind the Veil of Protection: Uncovering the Threats to Giant Anteaters in a Protected Area

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ABSTRACT

The giant anteater (*Myrmecophaga tridactyla*) is classified as a vulnerable mammal species, facing a significant risk of extinction. This study investigates the activity patterns of the giant anteater in Brasília National Park, a critical urban protected area. Using camera traps installed at 57 sites over 30 days, we collected data to analyze activity intervals exceeding one hour between consecutive photos for accuracy. We recorded 199 giant anteater, 174 humans, 59 domestic dogs, and 35 pumas sightings. The results indicated that giant anteaters were primarily nocturnal during the dry season but shifted to crepuscular and nocturnal activity in the rainy season, starting their activities earlier and increasing overlap with other species. Although overlap with potential threats was relatively low, this shift suggests a higher risk of encounters with predators. Additionally, human presence influenced anteater behavior, with more diurnal activity in areas farther from agricultural zones. These findings highlight the need for conservation strategies that consider the species' behavioral patterns and interactions with potential threats, especially during the evening. The data from this study are essential for effective conservation measures, emphasizing the importance of preserving giant anteaters in Brasília National Park, an isolated fragment of the Cerrado ecosystem immersed in an urban matrix, crucial for biodiversity conservation.

Keywords: Activity patterns; Anthropogenic impact; Biodiversity conservation; Human-wildlife interactions; Seasonal behavior; Urban protected areas

INTRODUCTION

Analyses of species' activity patterns based on observational records are essential for understanding seasonal and daily variations in species' behavior. These analyses also provide insights into temporal overlaps between individuals of different sexes (Azevedo et al., 2018), predator-prey relationships (Foster et al., 2013), human presence (Días-Ruiz et al., 2016), temperature (Giroux et al., 2023), and activity periods (Zapata-Ríos & Branch, 2016). Such analyses are vital in understanding how animals adjust their behavior in response to environmental conditions, balancing rest and activity periods to optimize energy expenditure during activities such as foraging and thermoregulation while avoiding unfavorable conditions (Sih, 2013; Acosta-Rodríguez et al., 2021). Recent reviews indicate that mammals exhibit divergent responses to anthropogenic activities, affecting their movements (Tucker et al., 2018; Tucker et al., 2023) and potentially increasing nocturnality to avoid encounters with humans (Gaynor et al., 2018; Nickel et al., 2020).

Several studies demonstrate the influence of anthropogenic activities on wildlife behavior, particularly affecting foraging, spatial use, reproduction, and activity patterns of native species. Such activities also intensify the invasion of dogs into protected areas, contributing to disturbances in native fauna populations (Lemos et al., 2011; Massara et al., 2018; Bertassoni et al., 2019). The presence of domesticated or feral dogs is linked to changes in the distribution of native fauna, reductions in local populations (Koster, 2008; Soto & Palomares, 2015; Dias et al., 2019), and even the facilitation of zoonotic disease spread, such as mange (Fiori et al., 2003). In response to anthropogenic stimuli, native species may exhibit cautious behavior, leading to adaptive modifications of their habits (Tucker et al., 2023), which can have non-lethal effects on fitness (Cresswell, 2008; Bennie et al., 2014). Such adjustments can negatively impact long-term survival and reproduction, as prey species must allocate significant time and energy away from resource acquisition (Frid & Dill, 2002). This alteration

of activity patterns, particularly due to human activities, has been documented in the giant anteater (Bertassoni et al., 2019; Cox et al., 2023; Giroux et al., 2023; Ewart et al., 2024).

The giant anteater (*Myrmecophaga tridactyla*), the largest extant Xenarthran (Gaudin et al., 2018), faces several threats, including habitat degradation and fragmentation, wildfires, road mortality, hunting, and illicit trade (Miranda, Bertassoni & Abba, 2014; Desbiez, Bertassoni, & Traylor-Holzer, 2020). This species is particularly vulnerable due to its unique biology, including an elongated snout to accommodate its long (45 cm) tongue, specialized diet, solitary habits, low fecundity, long gestation periods, and high generation time (Eisenberg & Redford, 1999), making it more vulnerable to anthropogenic threats (Desbiez et al., 2020). The giant anteater is classified as threatened in the Brazilian Cerrado (ICMBio, 2024) and globally by the IUCN Red List. It is also listed in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), reflecting its status as a species at risk.

Evaluating the environment and adjusting behavior is crucial for the survival of the giant anteater. This Xenarthran species exhibits a low metabolic rate and body temperature (Miranda et al., 2015), which makes it particularly sensitive to temperature extremes. As a result, the giant anteater is more active during milder temperatures (Di Blanco, Spørring & Di Bitetti, 2017), using open areas for foraging and retreating to closed areas during periods of extreme temperatures to avoid unfavorable conditions and the risk of hypothermia (Camilo-Alves & Mourão, 2006; Petrazzini & Aguiar, 2021). Therefore, understanding the species' spatial and temporal habitat use is essential for informing management decisions and identifying potential threats, such as increasing human activity and the expansion of urban structures.

Natural areas are crucial in preserving species and maintaining ecosystem balance (Gallardo et al., 2017; Duncanson et al., 2023; Sousa et al., 2023). However, the rapid pace of globalization and increasing human resource demands have led to escalating anthropogenic pressures, significantly threatening protected areas worldwide (Ward et al., 2020; Shrestha et

al., 2021). These pressures persist even within protected areas, where anthropogenic forest loss for agriculture is particularly prevalent in tropical regions (Wade et al., 2020). Current land use changes and the expansion of human activities are significant drivers of mammal species extinction (Dirzo et al., 2014; Ceballos et al., 2015; Baisero et al., 2020). Therefore, urgent measures and concerted efforts are needed to mitigate these threats and ensure the long-term sustainability of natural environments. This research aims to evaluate the activity patterns of the giant anteater and investigate the effects of seasonality and potential predators on the temporal overlap of their activity in Brasília National Park (PNB), a protected area in the Cerrado.

In this study, we hypothesize that seasonal differences will influence activity patterns due to temperature variations: 1) During the rainy season, we expect giant anteaters to exhibit more diurnal activity patterns, starting their activities earlier and resting at night, consistent with the findings of Camilo-Alves and Mourão (2006) and Miranda et al. (2014); 2) During the dry season, we anticipate more nocturnal activity due to high daytime temperatures, similar to the seasonal effects reported by Di Blanco et al. (2017). We also predict a greater temporal overlap between pumas and giant anteaters during the night. Considering the species' thermoregulatory behavior, we expect proximity to water sources to influence daytime activity during the hotter, dry season. Given that tourists visit PNB mostly during the day, we anticipate that giant anteaters will exhibit increased nocturnal activity in areas closer to urban structures to avoid human encounters.

MATERIAIS AND METHODS

Study area

Brasília National Park (PNB), part of the Cerrado Biosphere Reserve (Law No. 747, July 1994), is one of the most significant protected areas in the Federal District of Brazil. Covering 42,800 hectares, PNB (15°38′12″S, 48°02′21″W) is located about 10 kilometers from Brasília's

city center within a highly urbanized matrix. The park is bordered by highways and surrounded by rural farms and settlements, with urbanization posing significant threats to its biodiversity. PNB offers public access to hiking trails and mineral water pools (Funatura/IBAMA, 1998). The establishment of Brasília National Park is directly related to the construction of Brasília itself, created by the federal government in 1961 (Decree 241/1961) and expanded in 2006 (Federal Law 11.285). The park is classified as a "Strict Protection Conservation Unit," according to the National System of Conservation Units (SNUC). It primarily aims to preserve ecosystems and the associated fauna and flora.

The park protects typical Cerrado phytophysiognomies, including gallery forest, dry forest, grassland, and murundus field. It also safeguards watersheds supplying 25% of the Federal District's potable water. PNB is home to rare or vulnerable species such as giant armadillo (*Priodontes maximus*), lowland tapir (*Tapirus terrestris*), and the giant anteater (*Myrmecophaga tridactyla*), the focus of this study. The region's climate is Aw, with a tropical climate featuring dry winters and rainy summers (Köppen-Geiger classification, Beck et al., 2023). Average temperatures range from below 18°C in the coldest month to around 23°C in the warmest, with annual precipitation averaging 1,600 mm, concentrated from November to April. The main soil types are dark Red Latosol, Red-Yellow Latosol, and Cambisol.

PNB faces significant challenges from historical human activities and invasive species despite its protected status. The park is home to approximately 28 species of invasive grasses (Martins et al., 2007), feral dogs, cats, and cattle, which seriously threaten native species and conservation efforts (Funatura/IBAMA, 1998).

Data collection

We used camera trap data to study the activity patterns of the giant anteater and identify environmental and anthropogenic factors influencing its behavior within PNB. Sampling sites were strategically selected by overlaying a grid onto the park map, with each quadrant centroid

designated as a potential sampling point to ensure camera independence. Considering the park's proximity to urban areas, we excluded surrounding regions to mitigate the risk of equipment theft, although some incidents still occurred within the park (Fig. 1).

A total of 57 sampling sites were established across the park, ensuring a minimum distance of 1 km between each point to avoid pseudoreplication. Quadrant sizes were based on the species' average home range in Brazil, which spans approximately 1 km² (Bertassoni & Ribeiro, 2019; Miranda *et al*., 2014; Miranda *et al*., 2015). At each site, camera traps (Campark T80, Campark T86, and Meidase Trail models) were installed on trees at a height of approximately 25-30 cm. The traps were set to operate continuously for 24 hours a day over 30 consecutive days, capturing three photographs at 30-second intervals when triggered.

In the first year of the study, a total of 17 cameras trap were used. In the subsequent years, the number of cameras used simultaneously increased to 30. Due to limited number of camera traps available, a rotational sampling scheme was used, ensuring continuous monitoring throughout each campaign. Each campaign was defined by a completed rotation, in which all 57 sites were sampled for continuous 30 days (i.e., one full season). Data were collected for rainy season (January - April) and dry season (June - October) from 2020 to 2022, resulting in a total of six sampling campaigns. Camera traps were inspected every 10 to 15 days for battery replacements and memory card swaps. No bait was used to attract animals. The total sampling effort amounted to 10,260 trap-days.

Data analysis

Human presence impact was assessed by calculating a human capture rate, dividing the number of individuals captured by total trap days, and multiplying by 100 (Oberosler et al. 2017; Cruz et al., 2018). Capture rates above the mean indicated high human presence, while rates below indicated low presence. Differences in activity patterns were evaluated using the Watson-Wheeler test, and the Rayleigh test was used to determine if daily activity was

uniformly distributed across the 24-hour cycle using the package *circular* (Agostinelli & Lund, 2022). Test of Uniformity ($p < 0.05$) indicates non-uniform distribution, where records are concentrated in a certain time interval.

Overlap between giant anteater and pumas, humans, and dog's activity was estimated using the *overlap* package in R (Ridout & Linkie, 2009). In this method, the activity periods of species are estimated using the circular Kernel probability density function, through the coefficient of overlap. This coefficient ranges from 0, indicating no overlap (when the activity patterns are entirely distinct), to 1, representing complete overlap (i.e., identical activity patterns) (Meredith & Ridout, 2014). Following the premise of the analysis, to account for potential sample size bias, a smoothing parameter of Δ_1 was used for species with fewer than 50 records, and Δ_4 was applied to species with more 50 records (Ridout and Linkie 2009). An independent record was considered with a one-hour interval between pictures (following Bowkett et al., 2007).

To investigate the influence of anthropogenic and environmental variables on diurnal/nocturnal behavior, a binomial generalized linear model (GLM) test was employed using the program R (Ferreira et al., 2022). Variables included distance to water sources, agricultural areas, urban areas, highways, dirt trails, and the frequency of human records, allowing us to identify significant factors shaping nocturnal behavior. For each sampling site, we calculated the minimum distance to environmental and anthropogenic features, such as water sources, roads, and urban areas. These measurements were derived from land-use data based on the Cerrado biome's land cover map (Mapbiomas, 2023). All spatial analyses were conducted in R using the raster package. Continuous covariates were log-transformed for standardization. We also assessed the correlation between covariates to avoid multicollinearity issues. For model selection and averaging we used the package 'MuMIn' (Barton, 2023). We selected the model with the lowest AIC.

RESULTS

We collected 199 records of giant anteaters and 35 pumas. We obtained 174 independent records of humans (solitary and in groups) and 59 records of domestic dogs within the park. Human presence included authorized and unauthorized individuals, cyclists, hunters, residents, researchers, and park staff. Domestic dogs were photographed in pairs or trios, with groups of up to five individuals observed twice during equipment installations.

Activity pattern

Circular statistics indicated non-uniform temporal activity for the giant anteater ($U = 322.82$, $p < 0.001$), humans ($U = 324.83$, $p < 0.001$), and dogs ($U = 262.37$, $p < 0.001$). Only pumas exhibited a uniform activity distribution in both seasons ($U_{rainy} = 94.2857$, $U_{dry} = 143.57$, $p > 0.10$). The giant anteater showed significant seasonal differences in activity ($W = 8.39$, $p < 0.05$), as did pumas ($W = 6.47$, $p < 0.05$), humans ($W = 145.68$, $p < 0.01$), and dogs ($W = 65.91$, $p < 0.01$). During the dry season, the giant anteater exhibited a cathemeral temporal pattern, with nocturnal and crepuscular activity peaking at 8:00 pm and no morning activity (Fig. 2a). In the rainy season, activity increased in the afternoon, with more evenly distributed activity throughout the day and a smoother nocturnal peak (Fig. 2a). Pumas were active from 12:00 am to 12:00 pm during the dry season, with the rainy season peaks at 2:00 pm and 9:00 pm. Domestic dogs (Fig. 2b) and humans (Fig. 2c) were primarily diurnal in both seasons

During the rainy season, the giant anteater started activity earlier at dusk, increasing overlap with pumas ($\Delta = 0.73$), dogs ($\Delta = 0.45$), and humans ($\Delta = 0.39$) (Fig. 3). In areas with higher human activity, the anteater's activity peaked narrowly around 9:00 pm and ceased by morning. The giant anteater's daytime activity varied with human presence. Predominant activity records (89.6%) were in sites with low human use, showing higher crepuscular activity than in sites with high human use (Fig. 4). No morning activity was recorded in high human activity areas. Despite differences in activity distribution, the overlap estimate between low and

high human presence was high ($\Delta = 0.80$) without a significant pattern difference ($t = 0.1343$, $p > 0.10$).

Anthropic influence on nocturnality

We identified evidence of anthropogenic activities influencing the behavior of the species within the protected area (Fig. 5). The giant anteater exhibited a higher probability of diurnal activity far from agricultural areas during rainy season. In the dry season, distance to water sources negatively affected activity, showing increased nocturnal activity far from water and daytime activity closer to water sources. Other indicators of human pressure (urbanization, human presence, and roads) showed no significant influence on the species' behavior (Fig. 5).

DISCUSSION

This study aimed to evaluate the giant anteater's activity patterns and the effects of seasonality and anthropogenic factors within Brasília National Park (PNB). Our findings indicate that the giant anteater exhibits distinct temporal activity patterns between the dry and rainy seasons, influenced by environmental conditions and human presence.

During the rainy season, the giant anteater begins its activity earlier, starting at dusk, in contrast to the dry season. The dry season in this area is characterized by significantly higher daytime temperatures and lower relative humidity levels (Hofmann et al., 2021), dropping to 20% in the afternoons (Codeplan, 2020; Petrazzini & Aguiar, 2021). These extreme conditions likely explain the concentration of nocturnal activity during the dry season. In the rainy season, warmer temperatures allow for increased daytime activity, particularly in the late afternoon, as the species becomes more active in search of food. This behavior shift, influenced by environmental conditions, aligns with other studies indicating more nocturnal activity under higher temperatures to evade solar radiation (Di Blanco, et al. 2017; Giroux et al.,2023).

The observed pattern increases the overlap of the giant anteater's activity with pumas, a potential natural predator in the study area. Studies report that pumas adjust their activity timing according to prey availability (Paviolo et al., 2009; Di Bitetti et al., 2010; Foster et al., 2013; Azevedo et al., 2018; Alberti et al., 2023), which may explain the observed seasonal fluctuation. Although jaguars (*Panthera onca*) are the main natural predators of giant anteaters, their rarity in the study area prevented evaluation of their overlap (Petrazzini & Aguiar, 2022). With reduced competition in Brasília National Park, pumas can be considered the main native threat, potentially preying on anteater cubs.

An invasive species in the park, domestic dogs show an increased overlap with giant anteaters during the rainy season. Although the overlap values are relatively low (<70%), they pose substantial risks. During the rainy season, the overlap between the two species increased by 55% compared to the dry season. During the dry season, dogs may seek shelter and food in surrounding farms and residential areas (manuscript in preparation). Increased overlap during the rainy season indicates a higher probability of encounters, heightening the vulnerability of giant anteaters to dog attacks. This was observed during our study's first campaign and in recent research where a female giant anteater with a cub was seen fleeing from dogs (Brasília é o Bicho, 2024). Due to the park's surrounding area being highly anthropogenic, with residences, farms, and zones of human encroachment, these dogs are domesticated and have not become feral, probably just exploring the park and depending of humans housing, but still pose a considerable threat.

The presence of domestic and feral dogs in protected areas is a significant threat to wildlife (Lacerda et al., 2009; Gatti, Seibert & Moreira, 2018; Silva et al., 2018; Guedes et al., 2021), impacting the long-term persistence of native species (Zapata-Ríos & Branch, 2016). Dogs can prey on substantial amounts of native species annually (Galetti & Sazima, 2006; Pereira et al., 2019), and dog attacks are a leading cause of giant anteater mortality and disease

transmission (Miranda et al., 2014; Bianchi et al., 2020). Dogs carry various pathogens harmful to wildlife, including *Leishmania* (Batista et al., 2022), highlighting the need to monitor the health of these animals interacting with native fauna (Campos et al., 2020; Heliodoro, Verona & Henrique, 2020). Several studies have identified common pathogens found in domestic animals that contaminate wildlife, such as anteaters (Richini-Pereira et al., 2014; Arenales et al., 2020; Granjeiro et al., 2020; Pena et al., 2020; Souza et al., 2022). Free-range dogs' economic and conservation impact on wildlife is insufficiently studied, particularly in South America. This research enhances our understanding of these effects, providing insights into the impact of these animals on local ecosystems and addressing existing knowledge gaps.

Despite low overlap values with invaders (e.g., dogs and humans), we observed an increase in the giant anteater frequency of records during the late afternoon increasing the probability of disturbances. Although much remains unknown about the impacts of intensive human use on peri-urban protected areas' fauna, some studies report behavioral changes. For example, the European hedgehog (*Erinaceus europaeus*) exhibited extended daytime activity in locations with lower visitation rates (Beasley et al., 2023). In a Brazilian national park in the Cerrado, the ocelot (*Leopardus pardalis*) showed reduced diurnal activity on trails after tourism began, indicating temporal adjustment (Barcelos et al., 2022). Human presence, even for tourism, affects mammal behavior (Bennie et al., 2014; Gaynor et al., 2018; Barcelos et al., 2022). Animals can perceive humans as potential predators, altering their activities and locations and negatively impacting individual fitness (Frid & Dill, 2002). This result serves as a warning for local managers and assists in decision-making to avoid conflicts, considering the behavior of the species and invaders, especially during the afternoon.

Human presence (capture rate) did not strongly influence the giant anteater's nocturnality but did affect the distribution of this activity throughout the day, as observed in the overlap. Specifically, areas with higher human presence showed concentration of activity at certain

times, suggesting the species may be beginning to adapt to these conditions. These findings align with those of Pardo et al. (2021), who observed reduction in the natural crepuscular activity of giant anteaters in the Colombian Llanos. Similarly, Ferreira et al. (2022) found that diurnal activity in the lesser anteater increased with distance from households, also indicating a potential shift in behavior to avoid areas of high human activity.

The increase in nocturnality in mammals due to anthropogenic pressures has been widely documented (Blake et al., 2012; Bennie et al., 2014; Massara et al., 2018; Ferreira et al., 2022; Teixeira et al., 2023). In the tropics, while nocturnal species find some refuge at night, day-active and cathemeral species face significant population declines (Cox, Gardner & Gaston, 2023) due to anthropogenic pressures such as habitat loss, harvesting, and human-wildlife conflict. Notably, diurnal species, which account for 52.1% of species, face the highest risks when compared to nocturnal (40.1%), crepuscular (39.1%), and cathemeral species (43.0%) (Cox et al., 2023). In more developed regions, animals increasingly shift to nocturnal behaviors in response to elevated levels of human activity, reflecting a broader trend observed across worldwide (Burton et al., 2024).

As PNB is a federally protected area near urban areas and situated within a matrix of intense human activity, the negative impacts of increased nocturnality are likely to intensify. However, with strategic conservation efforts, we can mitigate these impacts. Agricultural areas border the park, and with ongoing land conversion, the giant anteater may decrease its daytime activities. This effect was observed by Pardo *et al*. (2021) in an oil palm plantation in the Colombian Llanos, noting reduced cathemeral activity and decreased activity after 6:00 AM, contrasting with forested areas. The increase in nocturnality in some species is reported as a possible strategy to use high human-pressure areas (Díaz-Ruiz *et al*., 2016).

Our hypothesis regarding the importance of water proximity, especially during the dry season, was corroborated. Temperatures rise during the afternoon in the Cerrado's dry season

and areas near water, with better vegetation coverage, exhibit milder temperatures, providing thermal refuges that allow for increased daytime activity without the risk of hyperthermia (Giroux et al., 2023). Increasing the giant anteater's diurnality near these water sources may be a strategy for maintaining body temperature, a behavior observed in other studies (Bertassoni et al., 2017; Giroux et al., 2023). Researchs in the Brazilian Amazon (Margarido et al, 2023) and Ecuador (Blake et al., 2012), in larger and more preserved areas with extensive forest cover, demonstrated that the giant anteater exhibits more diurnal behavior, highlighting how thermal conditions and human presence influence the species' behavior. This result also indicates the importance of protecting these wet areas from human access to prevent the species from losing these refuges, where they can safely remain active during the daytime.

However, our findings contrast with those of Ferreira et al. (2022), who observed a higher probability of diurnal activity in giant anteaters farther from water sources. This highlights distinct patterns of activity in different regions and emphasizes the need to consider geographic and environmental factors, as the same species may respond differently across its range.

Conservation Implications

Our study underscores the complex interplay between seasonal environmental conditions, human activity, and the behavior of giant anteaters. The plasticity of giant anteaters to altered habitats needs to be better understood, requiring further research to comprehend their varied responses (Bertassoni & Ribeiro, 2019). This study contributes to filling this gap by highlighting the importance of seasonality in modulating the species' behavior in the Cerrado and the influence of human activities. Our findings provide insights into the temporal behavioral adaptations of anteaters. The observed seasonal variations and the impact of anthropogenic pressures suggest potential long-term shifts towards increased nocturnality, particularly in response to escalating human activities near protected areas. This research serves as a critical case study for the future of other protected areas facing similar pressures from agriculture and

urban development. Therefore, the results of this research offer valuable insights for management actions in other protected areas surrounded by anthropogenic influences and urban perimeters.

We recommend conducting further studies on the behavior of invasive species to gain a detailed understanding of their habitat use, the seasonal differences observed, and the long-term effects on native fauna. Continuous monitoring of native species is essential, as mammals often exhibit a temporal lag in their behavioral responses. This suggests that species may be gradually adjusting to these pressures, and over the long term, more consistent behavioral responses may be observed, particularly if these pressures intensify. Managers and decision-makers must understand the actual, often severe, effects of anthropization on species, especially those vulnerable to extinction, such as the giant anteater, and take actions to mitigate and prevent new impacts, ensuring the continued presence of these species in the region.

Effective management strategies should account for these behavioral adaptations and aim to mitigate the impacts of human presence and invasive species. Protecting thermal refuges, managing human access, and controlling invasive species are critical to ensure the persistence of giant anteaters and other vulnerable species in disturbed landscapes. Implementing these strategies makes creating a more sustainable coexistence between wildlife and human activities in protected areas possible.

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AUTHOR CONTRIBUTIONS

PBP and LMSA conceived the idea and designed the methodology; PBP collected and analyzed the data; All authors contributed to the writing of the manuscript and gave final approval for publication.

REFERENCES

Acosta-Rodríguez, V. A., Rijo-Ferreira, F., Green, C. B., & Takahashi, J. S. (2021). Importance of circadian timing for aging and longevity. *Nature communications*, 12(1), 2862.

Agostinelli, C., & Lund, U. (2022). *R package 'circular': Circular Statistics (version 0.4-95)*. https://r-forge.r-project.org/projects/circular/

Alberti, M. E. S., Tirelli, F. P., Prestes, N. P. & Martinez, J. (2023). Daily and seasonal activity patterns of a felid assemblage in a forest-grassland mosaic in southern Brazil. *Iheringia*. 113, e2023006. https://doi.org/10.1590/1678-4766e2023006.

Arenales, A., Gardiner, C. H., Miranda, F. R., Dutra, K. S., Oliveira, A. R., Mol, J. P., Costa, M. E. L. T., Tinoco, H. P., Coelho, C. M., Silva, R. O. S., Pinto, H. A., Hoppe, E. G. L., Werther, K. & Santos, R. L. (2020). Pathology of free-ranging and captive Brazilian anteaters. *Journal of Comparative Pathology*. 180, 55-68. https://doi.org/10.1016/j.jcpa.2020.08.007.

Azevedo, F. C., Lemos, F. G., Freitas-Junior, M. C., Rocha, D. G. & Azevedo, F. C. C. (2018). Puma activity patterns and temporal overlap with prey in a human-modified landscape at Southeastern Brazil. *Journal of Zoology*. 305(4), 246-255. https://doi.org/10.1111/jzo.12558.

Baisero, D., Visconti, P., Pacifici, M., Cimatti, M. & Rondinini, C. (2020). Projected global loss of mammal habitat due to land-use and climate change. One Earth. 2(6), 578-585. https://doi.org/10.1016/j.oneear.2020.05.015.

Barcelos, D., Vieira, E. M., Pinheiro, M. S., & Ferreira, G. B. (2022). A before− after assessment of the response of mammals to tourism in a Brazilian national park. *Oryx*. 56(6), 854-863. https://doi.org/10.1017/S0030605321001472.

Barragán-Ruiz, C. E., Paviotti-Fischer, E., Rodríguez-Castro, K.G., Desbiez, A. L. & Galetti Jr, P. M. (2021). Molecular sexing of Xenarthra: a tool for genetic and ecological studies. *Conservation Genetics Resources*. 13, 41-45. https://doi.org/10.1007/s12686-020-01168-2.

Barton, K. (2023) *MuMin:Multi-Model Inference*. R package version 1.42.4. https://cran.r-project.org/web/packages/MuMIn/MuMIn.pdf

Batista, A. I. V., Andrade, W. W. A., Nascimento, J. D. O., Silva, W. S. I. D., Oliveira, M. R., Santos, I. G. D., Oliveira Neto, M. B., Ramos, R. A. N., Alves, L. C. & Lima, V. F. S. (2022). Leishmaniasis in wild, synanthropic and domestic animals on the Island of Itamaracá, Pernambuco, Northeastern Brazil. *Research, Society and Development*. 11(4), e28511426659. https://doi.org/10.33448/rsd-v11i4.26659.

Beasley, R., Carbone, C., Brooker, A. Rowcliffe, M. & Waage, J. (2023). Investigating the impacts of humans and dogs on the spatial and temporal activity of wildlife in urban woodlands. *Urban Ecosystems*. 26, 1843–1852. https://doi.org/10.1007/s11252-023-01414-z.

Beck, H. E., McVicar, T. R., Vergopolan, N., Berg, A., Lutsko, N. J., Dufour, A., Zeng, Z., Jiang, X., van Dijk, A. I. & Miralles, D. G. (2023). High-resolution (1 km) Köppen-Geiger maps for 1901–2099 based on constrained CMIP6 projections. *Scientific data*. 10(1), 724. https://doi.org/10.1038/s41597-023-02549-6.

Bennie, J. J., Duffy, J. P., Inger, R. & Gaston, K. J. (2014). Biogeography of time partitioning in mammals. *Proceedings of the National Academy of Sciences. 111*(38), 13727-13732. https://doi.org/10.1073/pnas.1216063110.

Bertassoni, A. (2010). *Avaliação da relação entre área de vida, distância média diária percorrida e disponibilidade de energia para tamanduás-bandeira (Myrmecophaga tridactyla) em savanas neotropicais*. Dissertation, Universidade Federal de Mato Grosso do Sul, Campo Grande, Brazil

Bertassoni, A. & Ribeiro, M. C. (2019). Space use by the giant anteater (*Myrmecophaga tridactyla*): a review and key directions for future research. *European Journal of Wildlife Research*. 65(6), 93. https://doi.org/10.1007/s10344-019-1334-y.

Bertassoni, A., Costa, R. T., Gouvea, J. A., Bianchi, R. D. C., Ribeiro, J. W., Vancine, M. H., & Ribeiro, M. C. (2019). Land-use changes and the expansion of biofuel crops threaten the giant anteater in southeastern Brazil. *Journal of Mammalogy*. 100(2), 435-444.

Bertassoni, A., Mourão, G., & Bianchi, R. D. C. (2020). Space use by giant anteaters (*Myrmecophaga tridactyla*) in a protected area within human-modified landscape. *Ecology and Evolution*. 10(15), 7981-7994. https://doi.org/10.1002/ece3.5911.

Bertassoni, A., Mourão, G., Ribeiro, R. C., Cesário, C. S., Oliveira, J. P. D. & Bianchi, R. D. C. (2017). Movement patterns and space use of the first giant anteater (*Myrmecophaga*

tridactyla) monitored in São Paulo State, Brazil. *Studies on Neotropical Fauna and Environment*. 52(1), 68-74. https://doi.org/10.1080/01650521.2016.1272167.

Bianchi, R. C., Olifiers, N., Riski, L. L., Gouvea, J. A., Cesário, C. S., Fornitano, L., Zanirato, G. L., Oliveira, M. Y., Morais, K. D. R., Ribeiro, R. L. A., D'Andrea, P. S. & Gompper, M. E. (2020). Dog activity in protected areas: behavioral effects on mesocarnivores and the impacts of a top predator. *Eur J Wildl Res*. 66, 36. https://www.arca.fiocruz.br/handle/icict/43157.

Blake, J. G., Mosquera, D., Loiselle, B. A., Swing, K., Guerra, J. & Romo, D. (2012). Temporal activity patterns of terrestrial mammals in lowland rainforest of eastern Ecuador. *Ecotropica*. 18(2), 137-146.

Brasília é o Bicho. 2024. "Imagens fortes, uma mãe em desespero". Instagram, 28 April 2024. Available at: www.instagram.com/reel/C6TbN44uU-y. Accessed: 1 July 2024.

Burton, A. C., Beirne, C., Gaynor, K. M., Sun, C., Granados, A., Allen, M. L., ... & Oberosler, V. (2024). Mammal responses to global changes in human activity vary by trophic group and landscape. *Nature ecology & evolution*. 8(5), 924-935. https://doi.org/10.1038/s41559-024-02363-2.

Camilo-Alves, C. S. P., & Mourao, G. M. (2005). Responses of a specialized insectivorous mammal (*Myrmecophaga tridactyla*) to variation in ambient temperature. *Biotropica*. 38(1), 52e56. https://doi.org/10.1111/j.1744-7429.2006.00106.x.

Campolina, B. (2019). Population growth and urbanization in the brazilian cerrado. In: *Innovation with spatial impact: sustainable development of the brazilian cerrado*. Hosono, A., Hamaguchi, N., Bojanic, A. (Eds.). Springer, Singapore. https://doi.org/10.1007/978-981-13-6182-1_6.

Campos, S. D. E., Cunha, N. C. D., Machado, C. D. S. C., Nadal, N. V., Seabra Junior, E. S., Telleria, E. L., Cordeiro, M. D., Toma, H. K. & Almosny, N. R. P. (2020). Spotted fever

group rickettsial infection in dogs and their ticks from domestic–wildlife interface areas in southeastern Brazil. *Revista Brasileira de Parasitologia Veterinária*. 29, e020219. https://doi.org/10.1590/S1984-29612020012.

Ceballos, G., Ehrlich, P. R., Barnosky, A. D., García, A., Pringle, R. M. & Palmer, T. M. (2015). Accelerated modern human–induced species losses: Entering the sixth mass extinction. *Science advances*. 1(5), e1400253.

Companhia de Planejamento do Distrito Federal - CODEPLAN. (2020). Atlas do Distrito Federal, Capítulo 2. Brasília. Available at: https://www.codeplan.df.gov.br/atlas-do-distrito-federal-2020. Accessed: 1 July 2024.

Cox, D. T., Gardner, A. S. & Gaston, K. J. (2023). Diel niche variation in mammalian declines in the Anthropocene. *Scientific Reports*. 13(1), 1031. https://doi.org/10.1038/s41598-023-28104-2.

Cresswell, W. (2008). Non-lethal effects of predation in birds. *Ibis.* 150(1), 3-17.

Desbiez, A. L. J., Bertassoni, A., & Traylor-Holzer, K. (2020). Population viability analysis as a tool for giant anteater conservation. *Perspectives in Ecology and Conservation*. 18(2), 124-131. https://doi.org/10.1016/j.pecon.2020.04.004.

Di Bitetti, M. S., De Angelo, C. D., Di Blanco, Y. E. & Paviolo, A. (2010). Niche partitioning and species coexistence in a Neotropical felid assemblage. *Acta Oecologica*. 36, 403-412. https://doi.org/10.1016/j.actao.2010.04.00.

Di Blanco, Y. E., Spørring, K. L. & Di Bitetti, M. S. (2017). Daily activity pattern of reintroduced giant anteaters (*Myrmecophaga tridactyla*): Effects of seasonality and experience. *Mammalia.* 81(1),11e21.

Dias, D. D. M., Massara, R. L., Campos, C. B., & Rodrigues, F. H. G. (2019). Human activities influence the occupancy probability of mammalian carnivores in the Brazilian Caatinga. *Biotropica. 51*(2), 253-265. https://doi.org/10.1111/btp.12628.

Díaz-Ruiz, F., Caro, J., Delibes-Mateos, M., Arroyo, B. & Ferreras, P. (2016). Drivers of red fox (*Vulpes vulpes*) daily activity: prey availability, human disturbance or habitat structure?. *Journal of Zoology*. 298(2), 128-138.

Dirzo, R., Young, H. S., Galetti, M., Ceballos, G., Isaac, N. J. & Collen, B. (2014). Defaunation in the Anthropocene. *Science.* 345(6195), 401-406. https://doi.org/10.1126/science.1251817.

Duncanson, L., Liang, M., Leitold, V., Armston, J., Krishna Moorthy, S. M., Dubayah, R., Costedoat, S., Enquist, B. J., Fatoyinbo, L., Goetz, S. J., Gonzalez-Roglich, M., Merow, C., Roehrdanz, P. R., Tabor, K. & Zvoleff, A. (2023). The effectiveness of global protected areas for climate change mitigation. *Nature Communications*. 14(1), 2908. https://doi.org/10.1038/s41467-023-38073-9.

Eisenberg, J. F. & Redford, K. H. (1999). *Mammals of the Neotropics: the central Neotropics: Ecuador, Peru, Bolivia, Brazil*, Vol. 3. Chicago and London: University of Chicago Press.

Ewart, H. E., Pasqualotto, N., Paolino, R. M., Jensen, K., & Chiarello, A. G. (2024). Effects of anthropogenic disturbance and land cover protection on the behavioural patterns and abundance of Brazilian mammals. *Global Ecology and Conservation*, 50, e02839.

Ferreira, G. B., Newbold, T., Oliveira, M. J. R., Pringle, H., Pinheiro, M. S., de Pinho, F. F., Carbone, C. & Rowcliffe, M. (2022). Limited temporal response of Cerrado mammals to anthropogenic pressure in areas under distinct levels of protection. *Journal of Zoology*. 317(1), 43-55. https://doi.org/10.1111/jzo.12958.

Fiori, F., Paula, R. C., Navas-Suárez, P. E., Boulhosa, R. L. P. & Dias, R. A. (2023). The sarcoptic mange in maned wolf (*Chrysocyon brachyurus*): Mapping an emerging disease in the largest South American Canid. *Pathogens*. 12(6), 830. https://doi.org/10.3390/pathogens12060830.

Foster, V. C., Sarmento, P., Sollmann, R., Tôrres, N., Jácomo, A. T., Negrões, N., Fonseca, C. & Silveira, L. (2013). Jaguar and puma activity patterns and predator-prey interactions in four Brazilian biomes. *Biotropica.* 45(3), 373-379.

Françoso, R. D., Brandão, R., Nogueira, C. C., Salmona, Y. B., Machado, R. B. & Colli, G. R. (2015). Habitat loss and the effectiveness of protected areas in the Cerrado Biodiversity Hotspot. *Natureza & Conservação*. 13(1), 35-40. https://doi.org/10.1016/j.ncon.2015.04.001.

Frid, A. & Dill., L. (2002). Human-caused disturbance stimuli as a form of predation risk. Ecology and Society 6:11.

FUNATURA - Fundação Pró-Natureza/IBAMA - Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis. (1998). *Plano de Manejo do Parque Nacional de Brasília - Revisão*. Volume 1. Brasília.

Galetti, M. & Sazima, I. (2006). Impacto de cães ferais em um fragmento urbano de Floresta Atlântica no sudeste do Brasil. *Natureza & Conservação.* 4(1), 58-63.

Gallardo, B., Aldridge, D. C., González-Moreno, P., Pergl, J., Pizarro, M., Pyšek, P., Thuiller, W., Yesson, C. & Vilà, M. (2017). Protected areas offer refuge from invasive species spreading under climate change. *Global change biology*. 23(12), 5331-5343. https://doi.org/10.1111/gcb.13798.

Gatti, A., Seibert, J. B. & Moreira, D. D. (2018). A predation event by free–ranging dogs on the lowland tapir in the Brazilian Atlantic Forest. *Animal Biodiversity and Conservation*. 41(2), 311-314. https://doi.org/10.32800/abc.2018.41.0311.

Gaudin, T. J. & Nyakatura, J. A. (2018). Epaxial musculature in armadillos, sloths, and opossums: functional significance and implications for the evolution of back muscles in the Xenarthra. *Journal of Mammalian Evolution*. 25, 565-572. https://doi.org/10.1007/s10914-017-9402-0.

Gaynor, K. M., Hojnowski, C. E., Carter, N. H. & Brashares, J. S. (2018). The influence of human disturbance on wildlife nocturnality. *Science.* 360(6394), 1232-1235.

Giroux, A., Ortega, Z., Attias, N., Desbiez, A. L. J., Valle, D., Börger, L. & Oliveira-Santos, L. G. R. (2023). Activity modulation and selection for forests help giant anteaters to cope with temperature changes. *Animal Behaviour.* 201, 191-209. https://doi.org/10.1016/j.anbehav.2023.04.008.

Granjeiro, M. D. B., Kavasaki, M. L., Morgado, T. O., Pavelegini, L. A. D., Barros, M. A., Fontana, C., Bianchini, M. A., Souza, A. O., Santos, A. R. G. L. O., Lunardi, M., Colodel, E. M., de Aguiar, D. M. & Mendonça, A. J. (2020). First report of a canine morbillivirus infection in a giant anteater (*Myrmecophaga tridactyla*) in Brazil. *Veterinary Medicine and Science*. 6(3), 606-611. https://doi.org/10.1002/vms3.246.

Guedes, J. J. M., Assis, C. L., Feio, R. N. & Quintela, F. M. (2021). The impacts of domestic dogs (*Canis familiaris*) on wildlife in two Brazilian hotspots and implications for conservation. *Animal Biodiversity and Conservation*. 44(1), 45-58.

Heliodoro, G., Verona, C. E. & Henrique, R. (2020). Animais Domésticos e o Risco de Zoonoses para a Fauna Silvestre na Área de Entorno do Parque Nacional da Tijuca. *Biodiversidade brasileira*. 10(2), 133-147. https://doi.org/10.37002/biodiversidadebrasileira.v10i2.1463.

Hofmann, G. S., Cardoso, M. F., Alves, R. J. V., Weber, E. J., Barbosa, A. A., Toledo, P. M., Pontual, F.B, Salles, L. O., Hasenack, H., Cordeiro, J. L. P., Aquino, F. E. & Oliveira, L. F. B. (2021). The Brazilian Cerrado is becoming hotter and drier. *Global Change Biology*. 27(17), 4060–4073. https://doi.org/10.1111/gcb.15712.

ICMBio, Instituto Chico Mendes de Conservação da Biodiversidade. (2024). Sistema de Avaliação do Risco de Extinção da Biodiversidade – SALVE. Available at: https://salve.icmbio.gov.br/. Accessed: 20 June 2024.

Koster, J. (2008). The impact of hunting with dogs on wildlife harvests in the Bosawas Reserve, Nicaragua. *Environmental Conservation*. 35(3), 211-220. https://doi.org/10.1017/S0376892908005055.

Lacerda, A. C., Tomas, W. M. & Marinho-Filho, J. (2009). Domestic dogs as an edge effect in the Brasília National Park, Brazil: interactions with native mammals. *Animal Conservation*. 12(5), 477-487. https://doi.org/10.1111/j.1469-1795.2009.00277.x.

Lemos, F. G., Azevedo, F. C., Costa, H. C. & May Junior, J. A. (2011). Human threats to hoary and crab-eating foxes in central. *Brazil. Canid News. 14(2), 1*-6.

Margarido, M. P., Carvalho Jr, E. A., Endo, W., Lopes, A. M. C. & Miranda, F. R. (2023). Xenarthra richness and activity pattern in the Brazilian Amazon. *Mammalian Biology.* 103(2), 215-225. https://doi.org/10.1007/s42991-022-00342-3.

Marshall, S. K., Spainhower, K. B., Sinn, B. T., Diggins, T.P. & Butcher, M.T. (2021). Hind limb bone proportions reveal unexpected morphofunctional diversification in xenarthrans. *Journal of Mammalian Evolution.* 28, 599-619. https://doi.org/10.1007/s10914-021-09537-w.

Martins, C. R., Hay, J. D. V., Valls, J. F., Leite, L. L. & Henriques, R. P. B. (2007). Study on alien gramineous of the brasilia national park, federal district, Brazil. *Natureza & Conservação.* 5, 93-100.

Massara, R. L., de Oliveira Paschoal, A. M., Bailey, L. L., Doherty Jr, P. F., de Frias Barreto, M., & Chiarello, A. G. (2018). Effect of humans and pumas on the temporal activity

of ocelots in protected areas of Atlantic Forest. *Mammalian Biology*. 92, 86-93. https://doi.org/10.1016/j.mambio.2018.04.009.

Miranda, F. R., Chiarello, A. G., Röhe, F., Braga, F. G., Mourão, G. D. M., Miranda, G. D., Silva, K. F. M., Faria-Corrêa, M. A., Vaz, S. M. & Belentani, S. D. S. (2015). Avaliação do Risco de Extinção de *Myrmecophaga tridactyla* Linnaeus. In *Processo de avaliação do risco de extinção da fauna brasileira:*89–105. (Ed.) ICMBIO - Instituto Chico Mendes de Conservação da Biodiversidade, Brasília, DF.

Miranda, F., Bertassoni, A. & Abba, A. M. (2014). *Myrmecophaga tridactyla*. The IUCN Red List of Threatened Species e.T14224A4:14. Accessed: 20 May 2024.

Naples, V. L. (1999). Morphology, evolution and function of feeding in the giant anteater (*Myrmecophaga tridactyla*). *Journal of Zoology*. 249(1), 19-41.

Nickel, B. A., Suraci, J. P., Allen, M. L. & Wilmers, C. C. (2020). Human presence and human footprint have non-equivalent effects on wildlife spatiotemporal habitat use. *Biological Conservation.* 241, 108383. https://doi.org/10.1016/j.biocon.2019.108383.

Oliveira, E., Nascente, E. D. P., Oliveira, L. P., Neto, J. M. S., de Lima, B. S. G., Cardoso, J. R. & de Moura, V. M. B. D. (2023). Macroscopic and histological aspects of the pharynx and larynx of the giant anteater (*Myrmecophaga tridactyla* Linnaeus, 1758). *Anatomia, Histologia, Embryologia*. 52(5), 709-722. https://doi.org/10.1590/1678-5150-PVB-6608.

Pardo, L. E., Edwards, W., Campbell, M. J., Gómez-Valencia, B., Clements, G. R. & Laurance, W. F. (2021). Effects of oil palm and human presence on activity patterns of terrestrial mammals in the Colombian Llanos. *Mammalian Biology*. 101(6), 775-789. https://doi.org/10.1007/s42991-021-00153-y.

Paviolo, A., Di Blanco, Y. E., De Angelo, C. D. & Di Bitetti, M. S. (2009). Protection affects the abundance and activity patterns of pumas in the Atlantic Forest. *Journal of Mammalogy*. 90(4), 926-934. https://doi.org/10.1644/08-MAMM-A-128.1.

Pena, H. F. J., Ferrari, V. M., Aires, L. P. N., Soares, H. S., Oliveira, S., Alves, B. F., Gennari, S. M., Dubey, J. P., Mattos, L. C., Mattos, C. C. B. & Castiglioni, L. (2020). First isolation and genotyping of *Toxoplasma gondii* in a free-living giant anteater (*Myrmecophaga tridactyla*) revealed a unique non-archetypal genotype. *Acta tropica*. 204, 105335. https://doi.org/10.1016/j.actatropica.2020.105335.

Pereira, A. D., Antoniazzi, M. H., Magnoni, A. P. V. & Orsi, M. L. (2019). Mamíferos silvestres predados por cães domésticos em fragmentos de Mata Atlântica no sul do Brasil. *Biotemas*. 32(2), 107-113. https://doi.org/10.5007/2175-7925.2019v32n2p107.

Petrazzini, P. B., & Aguiar, L. M. (2021). You say goodbye, and I say hello: the giant anteater (*Myrmecophaga tridactyla*) activity pattern in response to temperature and human presence. *Mastozoología Neotropical*. 28(1), 469-469. https://doi.org/10.31687/saremMN.21.28.1.0.33.

Petrazzini, P. B., & Aguiar, L. M. S. (2022). Completely caught off guard: a new record of Jaguar, *Panthera onca* (Linnaeus, 1758) (*Mammalia.* Felidae), from an urban park. Check List, 18(3), 463-467. https://doi.org/10.15560/18.3.463.

Pompeu, J., Assis, T. O. & Ometto, J. P. (2024). Landscape changes in the Cerrado: Challenges of land clearing, fragmentation and land tenure for Biological Conservation. *Science of The Total Environment*. 906, 167581. https://doi.org/10.1016/j.scitotenv.2023.167581.

Richini-Pereira, V. B., Marson, P. M., Hayasaka, E. Y., Victoria, C., Silva, R. C. & Langoni, H. (2014). Molecular detection of *Leishmania* spp. in road-killed wild mammals in

the Central Western area of the State of São Paulo, Brazil. *Journal of Venomous Animals and Toxins Including Tropical Diseases*. 20, 01–07. https://doi.org/10.1186/1678-9199-20-27.

Ridout, M. S. & Linkie, M. (2009). Estimating overlap of daily activity patterns from camera trap data. *Journal of Agricultural, Biological, and Environmental Statistics.* 14, 322-337. https://doi.org/10.1198/jabes.2009.08038.

Shrestha, N., Xu, X., Meng, J. & Wang, Z. (2021). Vulnerabilities of protected lands in the face of climate and human footprint changes. *Nature Communications*. 12(1), 1632. https://doi.org/10.1038/s41467-021-21914-w.

Sih, A. (2013). Understanding variation in behavioural responses to human-induced rapid environmental change: a conceptual overview. *Animal Behaviour*, 85(5), 1077-1088.

Silva, K. V. K. A., Kenup, C. F., Kreischer, C., Fernandez, F. A., & Pires, A. S. (2018). Who let the dogs out? Occurrence, population size and daily activity of domestic dogs in an urban Atlantic Forest reserve. *Perspectives in Ecology and Conservation*. 16(4), 228-233. https://doi.org/10.1016/j.pecon.2018.09.001.

Soto, C. A. & Palomares, F. (2015). Human-related factors regulate the presence of domestic dogs in protected areas. *Oryx*. 49(2), 254-260.

Sousa, M. V., Melo, S. N., Souza, J. C., Silva, C. F., Feitosa, Y. & Matias, L. F. (2023). Importance of protected areas by brazilian states to reduce deforestation in the Amazon. *ISPRS International Journal of Geo-Information*. 12(5), 190. https://doi.org/10.3390/ijgi12050190.

Souza, L. R., Carvalho, M. P., Lopes, C. E., Lopes, M. C., Campos, B. H., Teixeira, É. P., Mendes, E. J., Santos, L. P., Caixeta, E. A., Costa, E. A., Cunha, J. L. R., Fraiha, A. L. S., Silva, R. O. S., Ramos, C. P., Varaschin, M. S. & Ecco, R. (2022). Outbreak of canine distemper and coinfections in a maned wolf (*Chrysocyon brachyurus*) and in three giant anteaters

(*Myrmecophaga tridactyla*). Brazilian *Journal of Microbiology*. *53*(3), 1731-1741. https://doi.org/10.1007/s42770-022-00783-5.

Superina, M. & Loughry, W. J. (2015). Why do Xenarthrans matter? *Journal of Mammalogy*. *96*(4), 617–621. https://doi.org/10.1093/jmammal/gyv099.

Teixeira, D. F., Ares-Pereira, G., Camarinha, C., Lima, C., Magalhães, A., Castro, G., Fonseca, C. & Rosalino, L. M. (2023). Effect of anthropic disturbances on the activity pattern of two generalist mesocarnivores inhabiting Mediterranean forestry plantations. *Biodiversity and Conservation*. 32(4), 1251-1270. https://doi.org/10.1007/s10531-023-02548-4.

Tucker, M. A., Böhning-Gaese, K., Fagan, W. F., Fryxell, J. M., Van Moorter, B., Alberts, S. C., ... & Mueller, T. (2018). Moving in the anthropocene: global reductions in terrestrial mammalian movements. *Science*. 359(6374), 466-469. https://doi.org/10.1126/science.aam9712.

Tucker, M. A., Schipper, A. M., Adams, T. S., Attias, N., Avgar, T., Babic, N. L., ... & Stacy-Dawes, J. (2023). Behavioral responses of terrestrial mammals to COVID-19 lockdowns. *Science*. 380(6649), 1059-1064. https://doi.org/10.1126/science.abo6499.

Wade, C. M., Austin, K. G., Cajka, J., Lapidus, D., Everett, K. H., Galperin, D., Maynard, R., & Sobel, A. (2020). What is threatening forests in protected areas? A global assessment of deforestation in protected areas, 2001–2018. *Forests*. 11(5), 539.

Ward, M., Saura, S., Williams, B., Ramírez-Delgado, J. P., Arafeh-Dalmau, N., Allan, J. R., Venter, O., Dubois, G. & Watson, J. E. (2020). Just ten percent of the global terrestrial protected area network is structurally connected via intact land. *Nature communications*. 11(1), 4563.

Zapata-Ríos, G. & Branch, L. C. (2016). Altered activity patterns and reduced abundance of native mammals in sites with feral dogs in the high Andes. *Biological Conservation*. 193, 9-16. https://doi.org/10.1016/j.biocon.2015.10.016.

FIGURES

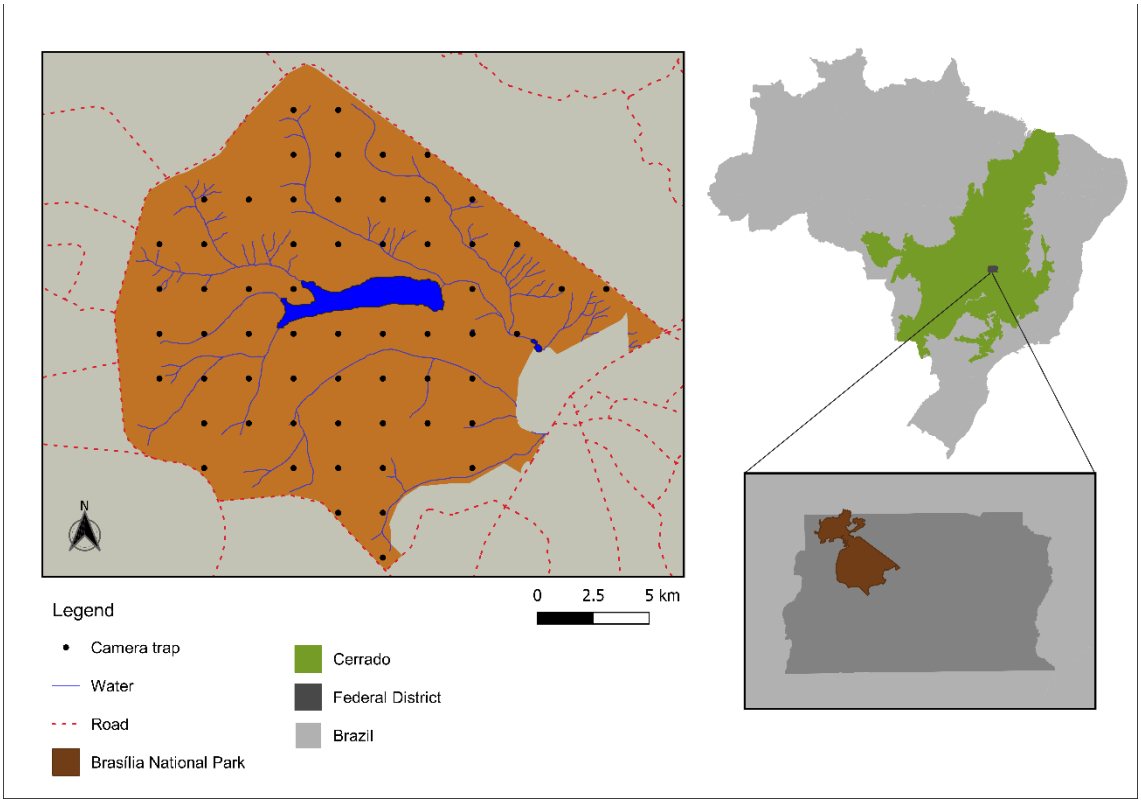

Figure 1. Map of the study area in Brasília National Park, Federal District, Brazil. Black dots indicate the locations of the camera trap stations (each at least 1 km apart), sampled between 2020 and 2022.

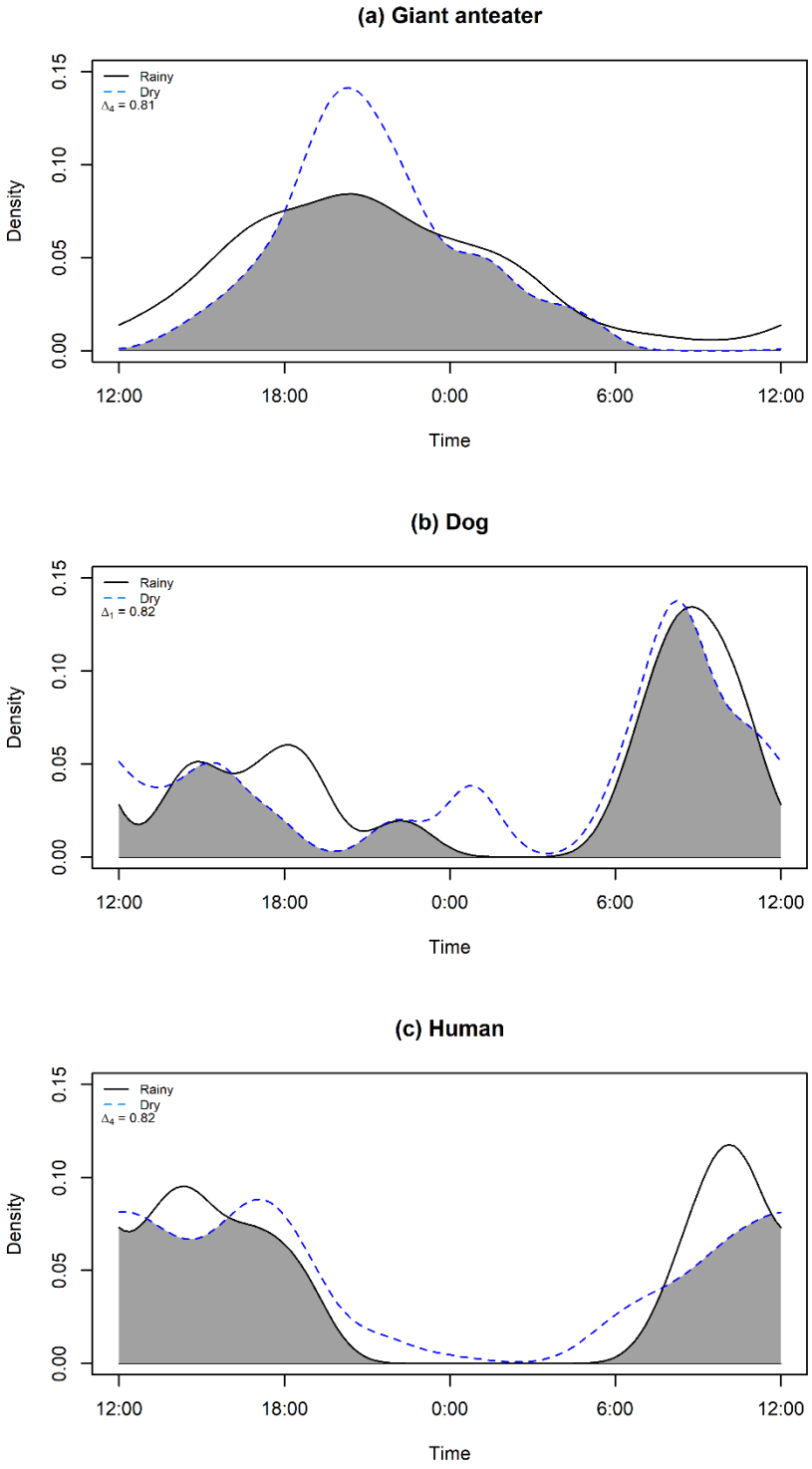

Figure 2. Comparison of activity pattern overlap between the rainy season (black line) and dry season (dashed blue line) over a 24-hour period for the (a) giant anteater, (b) dog, and (c) human. The gray area represents the overlap between seasons. Δ = overlap estimation. Data collected in Brasília National Park, Federal District, Brazil, between 2020 and 2022.

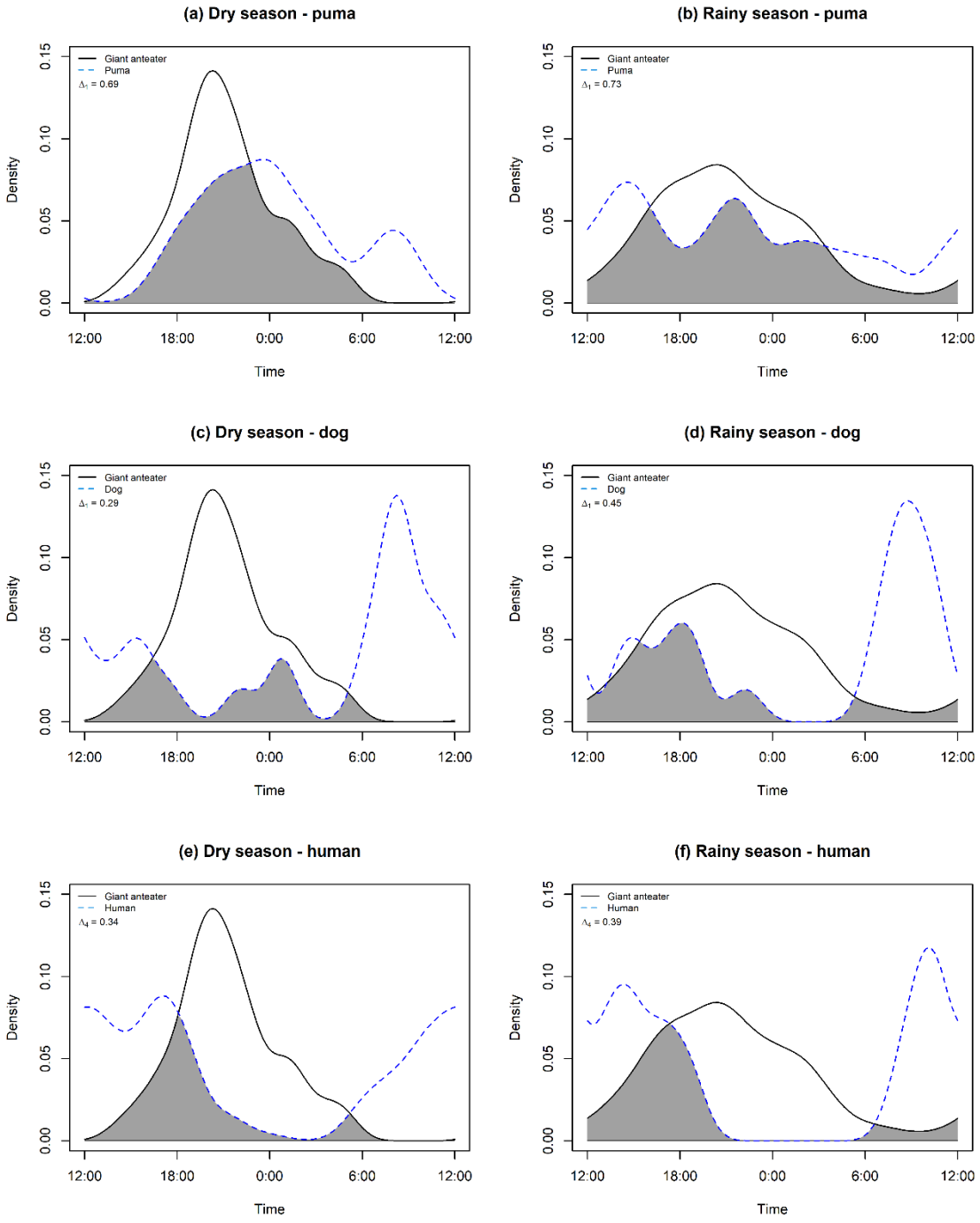

Figure 3. Overlap of daily activity between the giant anteater (black) and potential predators (blue) in Brasília National Park from 2020 to 2022. The gray area represents the overlap with pumas (a, b), dogs (c, d), and humans (e, f) during the dry and rainy seasons. Δ = overlap estimation.

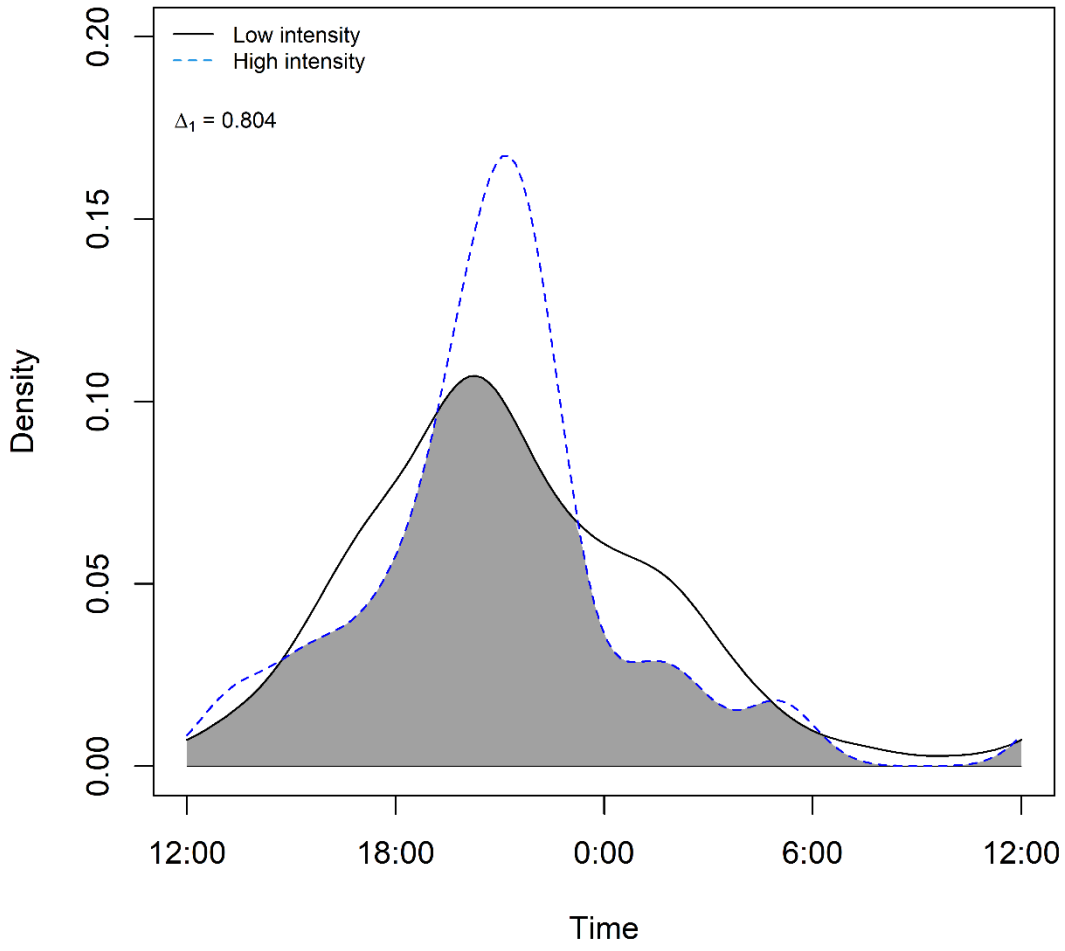

Figure 4. Activity pattern of the giant anteater across sites with low (black line) and high (blue dashed line) human activity. The intensity of human activity was calculated based on the capture rate of humans recorded by camera traps in Brasília National Park, Federal District, Brazil, between 2020 and 2022.

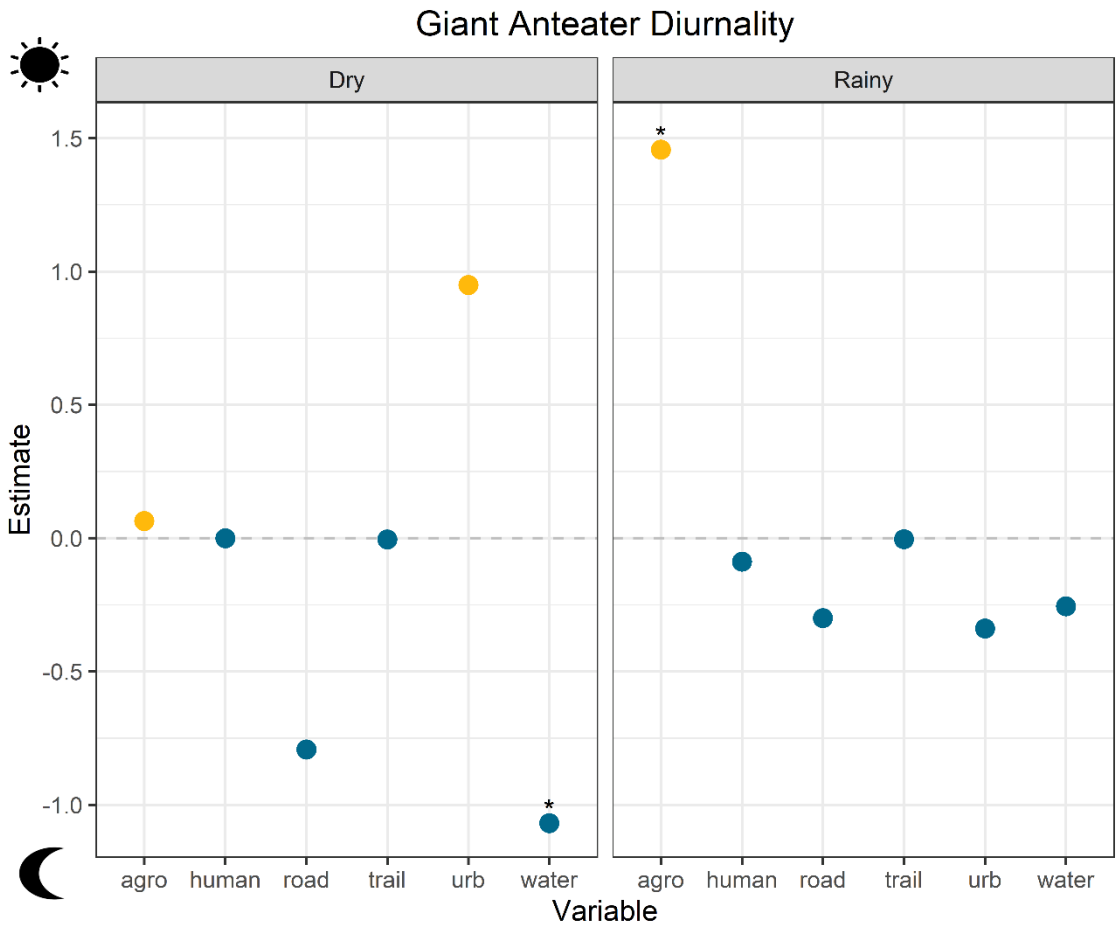

Figure 5. Estimates of anthropogenic and natural variable effects on the diurnality of the giant anteater in Brasília National Park, Brazil, from 2020 to 2022. The variables agriculture, road, trail, urbanization, and water are measured by distance from the site of record. The variable "human" represents the number of people recorded at the evaluated site. Positive values (yellow dots) indicate a higher probability of diurnal activity, while negative values (blue dots) indicate a higher probability of nocturnal activity. Asterisks indicate significant results.

CONCLUSÃO GERAL

Os resultados obtidos nesta tese destacam a importância do Parque Nacional de Brasília (PNB) como um refúgio crucial para a diversidade de mamíferos de médio e grande porte, incluindo cinco espécies vulneráveis a extinção, como o tamanduá-bandeira (*Myrmecophaga tridactyla*). A análise das dinâmicas populacionais e comportamentais do tamanduá-bandeira indicou uma baixa densidade populacional – de acordo com a literatura – e uma baixa taxa de detecção de indivíduos com filhotes. Os registros indicaram que 92% das observações foram de indivíduos solitários, com raras ocorrências de pares (2%) e de fêmeas com filhotes (6%). Os filhotes nasceram predominantemente durante a estação chuvosa, e todos os recém-nascidos foram registrados durante o dia.

A ocupação dos tamanduás no PNB foi constante ao longo do ano; no entanto, a presença de cães domésticos afetou significativamente as taxas de detecção, especialmente na estação chuvosa. A proximidade com áreas agrícolas influenciou as taxas de extinção na estação seca, enquanto a cobertura florestal e a distância de áreas urbanas impactaram a colonização durante a estação chuvosa. Além disso, a atividade dos tamanduás foi afetada pela presença humana, com um aumento da atividade diurna em áreas distantes de zonas agrícolas. A proximidade de corpos d'água durante a estação seca foi um fator importante para a diurnalidade, indicando que o acesso a fontes hídricas influencia a distribuição e o comportamento dos tamanduás, devido às suas características fisiológicas.

As mudanças nos padrões de atividade dos tamanduás, influenciadas pela sazonalidade e pela presença humana, sublinham a necessidade de estratégias de manejo voltadas para mitigar conflitos e proteger habitats críticos. Este estudo serve como um caso para outras unidades de conservação que enfrentam desafios semelhantes, visto que muitas áreas protegidas estão cercadas por matrizes urbanizadas, cenário provável para a maioria das unidades de conservação no futuro. Esses dados ressaltam a interconexão entre a conservação das espécies

e a saúde dos ecossistemas, evidenciando que a implementação de zonas de amortecimento, a educação pública e o monitoramento contínuo são essenciais para a preservação da biodiversidade no PNB.

Portanto, é imperativo adotar práticas de manejo eficazes que garantam a resiliência das populações de mamíferos e a manutenção dos serviços ecossistêmicos, contribuindo para a saúde ambiental e o bem-estar humano em áreas urbanas e periurbanas. Este estudo contribui para o aumento do conhecimento sobre a biologia da espécie, sua plasticidade comportamental e o desenvolvimento de abordagens de conservação que podem ser replicadas e ajustadas para proteger a fauna em outros parques e reservas ao redor do mundo, assegurando a preservação da biodiversidade em um cenário de urbanização crescente.