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OTÁVIO AUGUSTO PEREIRA LEÃO VULCÃO

Integrando conhecimentos locais e armadilhas fotográficas para avaliar a detecção e as características ecológicas que afetam a presença e a abundância de vertebrados médios e grandes no Vale do Xingu, Amazônia Oriental.

Belém, 2024

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Dissertação apresentada ao Programa de Pós Graduação em Zoologia, do convênio da Universidade Federal do Pará e Museu Paraense Emílio Goeldi, como requisito parcial para obtenção do título de Mestre em Zoologia. Área de concentração: Biodiversidade e Conservação. Linha de Pesquisa: Zoologia aplicada.

Orientador(a): Prof. Dr. Juarez Carlos Brito Pezzuti

Co-orientador(a): Dr. Elildo Alves Ribeiro de Carvalho Jr.

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FOLHA DE APROVAÇÃO

OTÁVIO AUGUSTO PEREIRA LEÃO VULCÃO

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Aprovada em:

Local de defesa:

À Maria do Socorro Pereira – *In memoriam*

“Dreams save us. Dreams lift us up and transform us. And on my soul, I swear until my dream of a world where dignity, honor, and justice becomes the reality we all share — I'll never stop fighting. Ever.” – Superman (Action Comics 775)

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Integrating local knowledge and camera trapping to evaluate detection and the ecological traits affecting presence and abundance of medium and large vertebrates in the Xingu Valley, Eastern Amazonia

ABSTRACT: The choice of appropriate methods to observe population changes of species of interest in environmental monitoring is crucial to ensure the sustainability of long-term programs. This is a challenge in assessing medium and large vertebrates due to their ecological importance and relatively high costs for evaluation. In tropical regions, the methods commonly used are transect censuses or camera traps. However, both methods have limitations and can incur high costs and difficult maintenance, especially in megadiverse tropical countries. Including methods based on local ecological knowledge (LEK) can contribute to the sustainability of monitoring programs. We assessed the congruence between detection rates obtained from camera traps and sightings and traces detected through LEK in two protected areas of Eastern Amazonia, comparing detection probabilities and testing the influence of three ecological traits. We observed that, despite an overall positive relationship, the rates obtained by both methods show high variability. For 11 out of 20 species, the probability of detection was greater using the method that identified traces through LEK from local monitors. Among the selected traits, body mass, sociability, and trophic niche, only the last characteristic was significant within our models, indicating a detection capability primarily based on the behavioral patterns of the species. Our results demonstrate the significant ability of local monitors to detect the presence of species of interest, as well as the applicability of LEK in faunal monitoring. We recommend collaborative research strategies and the inclusion of the knowledge and experience of local populations in monitoring and conservation programs in the Amazon and other tropical systems, which are the regions richest in both biological diversity and sociocultural richness.

Key-Words: Local Ecological Knowledge; Amazon; Participatory monitoring

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RESUMO:

A escolha de métodos adequados para observar mudanças populacionais de espécies de interesse em monitoramento ambiental é crucial para garantir a sustentabilidade de programas a longo prazo. Este é um desafio na avaliação de vertebrados de médio e grande porte, pela sua importância ecológica e custos relativamente elevados para avaliação. Na região tropical é usual o método de censo em transectos ou armadilhas fotográficas. Porém ambos os métodos tem suas limitações e podem ter custos elevados e de dificil manutenção, sobretudo em países tropicais megadiversos. A inclusão de métodos baseados no conhecimento ecológico local (CEL) pode contribuir com a sustentabilidade de programas de monitoramento. Avaliamos a congruência entre taxas de detecção obtidas por armadilhas fotográficas e avistamentos e vestígios detectados através de LEK em duas áreas protegidas da Amazônia Oriental, comparamos a probabilidade de detecção e testamos a influência de três traços ecológicos. Observamos que, apesar de uma relação positiva geral, as taxas obtidas por ambos os métodos apresentam alta variabilidade. Para 11 das 20 espécies, a probabilidade de detecção foi maior pelo método utilizando vestígios identificados pelo LEK dos monitores locais. Dentre os traços selecionados, massa corporal, sociabilidade e nicho trófico, apenas a última característica foi significativa dentro dos nossos modelos, apontando para uma capacidade de detecção baseada principalmente pelos padrões de comportamentais das espécies. Nossos resultados demonstram a grande capacidade dos monitores locais em detectar a presença de espécies de interesse, e da aplicabilidade do CEL em monitoramentos faunísticos. Recomendamos estratégias de pesquisa colaborativa e a inclusão de seus saberes e experiência das populações locais em programas de monitoramento e conservação na Amazônia e em outros sistemas tropicais, que são as regiões mais ricas tanto em diversidade biológica como sóciocultural.

Palavras-Chave: Conhecimento Ecológico Local; Amazônia; Monitoramento Participativo

INTRODUÇÃO GERAL

A biodiversidade de vertebrados tem sido severamente impactada nos últimos 500 anos, com taxas de extinção estimadas em pelo menos 100 vezes maiores do que as taxas históricas (Ceballos et al. 2015). Essa crise é movida por vários fatores convergentes, como a fragmentação e perda de habitat (Benchimol & Peres, 2015), perda de adequabilidade ambiental (Diele-Viegas et al. 2020), caça excessiva (Wilkie et al. 2011), tráfico de animais silvestres (Phelps et al. 2016) e perda de cobertura florestal para monoculturas (Almeida-Maués et al. 2022) etc. Por exemplo, a Onça-Pintada (*Panthera onca*), principal predador terrestre sul-americano, teve redução de mais de 40% de sua distribuição histórica, resultando em várias subpopulações no continente (Torre et al. 2017). Declínios e fragmentações populacionais contribuem para o risco de extinção das espécies, incluindo perda de variabilidade genética (Roques et al. 2016), que dificultam a recuperação de populações viáveis.

Vertebrados de médio e grande porte são componentes fundamentais dos ecossistemas tropicais. Essas espécies geralmente apresentam maior predisposição a serem afetadas por fatores antropogênicos, como a superexploração para caça (Peres & Palacios, 2007) e fragmentação do hábitat (Peres, 2001). Desempenham funções importantes na manutenção da rede trófica, dispersão de frutas e sementes (Bodmer, 1991; Parolin et al. 2013), regulação populacional, manutenção de paisagem (Desbiez & Kluyber, 2013), fornecimento de carne para comunidades tradicionais (De Paula et al. 2022), regeneração florestal (Parolin et al. 2013) e até mesmo influência sobre captura de carbono da atmosfera (Sobral et al. 2017). Comunidades de mamíferos são particularmente afetadas, especialmente espécies de grande porte ou com hábitos arborícolas, como primatas, o que está ligado a traços ecológicos específicos desses grupos, como taxas reprodutivas mais lentas e preferência por caçadores (Bodmer, 1995; Peres, 2000; Mendes-Oliveira et al. 2017; Bogoni et al. 2018). Em outros casos, observa-se que algumas espécies são capazes de permanecer em áreas afetadas, a depender do grau de efeito da ação humana sobre o hábitat (Michalski & Peres, 2007; Sampaio et al. 2010).

Programas de monitoramento têm dado ênfase a vertebrados de médio e grande porte devido sua capacidade de influenciar os ecossistemas (Beck et al. 2015; Sobral et al. 2017) e responder às mudanças ambientais (Michalski & Peres, 2007). Compreende-se o monitoramento como coleta sistemática de dados ao longo de um período extenso de tempo, que permite a observação de padrões e tendências no objeto alvo do estudo (Lindenmeyer & Likens, 2010). Ele fornece informações que podem ser eficazes para ações de manejo, manutenção e recuperação dos recursos naturais (Gibbs et al. 1999). Para isso é fundamental a utilização de técnicas padronizadas, replicáveis e que possam ser usadas em grandes escalas espaço-temporais (Ahumada et al. 2013). Diferentes métodos de amostragem são utilizados para obter informações sobre vertebrados terrestres de médio e grande porte, como censo visual por transecções e armadilhas fotográficas (Munari et al. 2011). O uso e eficácia desses métodos variam conforme os traços comportamentais das espécies, como período de atividade (diurno, noturno, catemeral, crepuscular), substrato utilizado (terrestre, arborícola, fossorial), área de vida e padrões de movimento (Munari et al. 2011; Fragoso et al. 2016; Mendes-Oliveira et al. 2017; Ponce-Martins et al. 2022).

O emprego do método de contagem visual em transecções lineares para produção de estimativas de abundância e densidade foram predominantemente utilizados na região neotropical por cerca de duas décadas (Peres, 1996; 2000; Lopes & Ferrari, 2000; Benett et al. 2001; Peres & Lake, 2003; Jorge & Peres, 2005; Peres & Cunha, 2011). Contudo, espécies noturnas, raras, elusivas e crípticas raramente são registradas, além de características ambientais como a densidade da vegetação, que compromete a capacidade do método em fornecer indicadores bons e capazes de permitir avaliações temporais e espaciais (Silveira et al. 2003; Munari et al. 2011; Esbach & Patra, 2022). Trabalhos recentes também têm demonstrado que este protocolo também tende a produzir subestimativas, principalmente em estudos que procuram comparar de forma pareada o efeito de variáveis antrópicas, em especial a prática de caça (Fragoso et al. 2016, 2019).

As armadilhas fotográficas têm se tornado um método amplamente utilizado por todo o mundo, por ser um método não-invasivo que permite obter informações sobre a riqueza de espécies, tamanho populacional (Karanth 1995; O'Brien et al. 2003; Silver et al. 2004), avaliação de impacto de uso de cobertura do solo em comunidades (Carvalho Jr. et al. 2020; 2021), efeito de fragmentação (Michalski & Peres, 2007), tendências em comunidades em escala espacial e temporal (Beaudrot et al. 2016), além de detectar espécies crípticas que raramente são avistadas por métodos de busca visual (Ponce-Martins et al. 2022). Entretanto, leva-se em consideração que o uso de armadilhas fotográficas tem um alto custo financeiro, tem durabilidade relativamente baixa, necessitando periódica reposição, e exigem grande esforço humano para instalação e retirada de câmeras (Zwerts et al. 2021). Também demandam considerável mão de obra qualificada para triagem, identificação dos animais fotografados, e organização final dos dados. Normalmente, em programas anuais de monitoramento, alguns meses são necessários para conclusão desta etapa (Zwerts et al. 2021).

A incorporação de diferentes métodos simultaneamente tem sido destacada como fundamental para alcançar organismos dificilmente acessados pelos métodos convencionais de detecção visual, como espécies noturnas ou com hábitos fossoriais (Munari et al. 2011; Benchimol & Peres, 2015; Fragoso et al. 2016; 2019; Seidlitz et al. 2021). Em um estudo na Costa Rica, Carrillo et al. (2008) usaram rastros para obter índices de abundância de mamíferos, observando que o método permitiu a detecção de espécies nunca vistas em buscas visuais. Rastros foram utilizados no sudeste indiano para obtenção de dados de ocupação da população de *Panthera tigris* (Hines et al. 2010) e na África do Sul para Hienas-Marrons (*Hyaena brunnea*) (Thorn et al. 2011). Estimativas de densidade também começaram a ser feitas a partir da contagem de rastros para diferentes espécies, a exemplo da fórmula Formozov-Malyshev-Pereleshin (FMP), desenvolvida por pesquisadores russos (Stephens et al. 2006). Estudos subsequentes têm, além de desenvolver estimativas, avaliado covariáveis como o movimento animal tem atuado para eficiência deste tipo de método (Keeping, 2014), com maior abordagem à mastofauna africana (Keeping & Pelletier, 2014; Keeping, 2018; Ahlswede et al. 2019). Esses estudos servem de exemplo da capacidade que sinais e vestígios deixados por animais têm na contribuição do monitoramento de espécies de médio e grande porte. Observa-se que para estudos que buscam obter índices usando rastros, a conciliação de diferentes métodos é fundamental (Esbach, 2023). Além dos fatores logísticos, como menor custo em comparação a obtenção e instalação de armadilhas fotográficas (Rovero & Marshall, 2009; Thorn et al. 2010), outro componente do uso de rastros e vestígios é a possibilidade de inclusão das comunidades locais nos programas de monitoramento (Keeping et al. 2018; Esbach, 2023), pelo uso do Conhecimento Ecológico Local (CEL).

O CEL pode ser definido como um conjunto de práticas, crenças e saberes que se acumula ao longo do tempo, transmitido através de gerações e que "evolui", no sentido de modificar-se ao decorrer das mudanças no ambiente (Berkes, 1999). A habilidade de rastrear pegadas de animais na savana africana, por exemplo, estava diretamente ligada à nossa sobrevivência e pode ter sido o princípio de pensamento que atualmente reconhecemos como científico (Liebenberg, 2013). Experiências do uso de CEL para conservação incluem levantamento e detecção de espécies (Camino et al. 2020; Ponce-Martins et al. 2022), modelos de ocupação (Brittain et al. 2022), mudanças na abundância e densidade de fauna (Gilchrist et al. 2005; Parry & Peres, 2015; Braga-Pereira et al. 2021), e avaliação de estado de conservação (Nash et al. 2016). Isso está ligado à capacidade que os moradores locais possuem de avaliar mudanças no ambiente e responder de modo adequado ao que acontece ao seu redor, graças a uma convivência constante com os recursos naturais (Berkes et al. 2000). Isso evidencia que a colaboração entre cientistas e moradores de comunidades tradicionais não é apenas possível, como promove resultados que nem sempre são viáveis pelas práticas científicas tradicionais.

A capacidade de detectar mudanças em padrões de distribuição ou abundância de espécies raras, como no caso do Pangolim (*Manis pentadactyla*) na China, é dificilmente alcançada por pesquisas pontuais devido aos hábitos elusivos da espécie (Nash et al. 2016). Em Camarões, a informação de moradores locais sobre a ocupação de *Loxodonta cyclotis* deram informações inéditas sobre a distribuição e abundância da espécie em áreas antes não mapeadas, que podem ser utilizadas para práticas de conservação e contra caça ilegal (Brittain et al. 2020). O monitoramento comunitário também pode fornecer informações sobre tópicos socialmente sensíveis, como caça de grandes felinos na Amazônia central (Valsecchi et al. 2022). A convivência diária dos moradores fornece uma fonte de informações valiosa para tomadas de decisão (Moller et al. 2004), as quais são prioritárias em áreas que o acesso é logisticamente difícil pelas características do ambiente e carecem de informações (Carvalho et al. 2023), ou devido a interrupção de investimento financeiro (Reis & Benchimol, 2023).

O bioma amazônico apresenta-se como alvo frequente de programas de monitoramento envolvendo comunidades locais (Reis & Benchimol, 2023), em especial por comportar um amplo conjunto de comunidades que utilizam os recursos naturais e assim constituem seu estilo de vida, dentro de um modelo de sustentabilidade ecológica de valores e práticas próprias (Lima & Pozzobon, 2005). Com mais da metade do bioma no território brasileiro, a chamada “Amazônia Legal” encara uma realidade de aumento recente no desmatamento na região, contribuindo para criar “fontes de carbono”, ao invés de sumidouros (Gatti et al. 2023). Áreas Protegidas (APs) têm sido importantes ferramentas no processo de contenção de desmatamento na Amazônia brasileira e conservação da biodiversidade (Qin et al. 2023). A região conhecida como “Terra do Meio”, na Amazônia Oriental, reproduz bem essa realidade, reunindo um conjunto de Terras Indígenas (TIs) e Unidades de Conservação (UCs), que comportam um amplo conjunto de comunidades ribeirinhas e etnias indígenas ao longo de sua extensão, com papel na contenção do avanço do arco do desmatamento (Schwartzman et al. 2013). Estudos sobre vertebrados de médio e grande porte no mosaico incluem questões sobre caça (Ramos et al. 2014; De Paula et al. 2022) e uso de hábitat e padrões de atividade de mamíferos (Wang et al. 2019; Margarido et al. 2023). Um trabalho recente demonstrou a habilidade de caçadores ribeirinhos das UCs em detectar espécies através de rastros e vestígios, e em produzir amostragens com composições faunísticas comparáveis com outros métodos usuais de amostragem aqui mencionados, em especial quando os levantamentos de vestígios indiretos são combinadas com as visualizações (Ponce-Martins et al. 2022) Contudo, o estudo não avaliou se o CEL era capaz de gerar índices de abundância congruentes aos obtidos por armadilhas fotográficas.

Tendo em consideração que trabalhos recentes na Amazônia têm evidenciado o potencial do conhecimento ecológico para detectar e obter informações sobre abundância, densidade e efeitos da caça sobre espécies de vertebrados de médio e grande porte (Parry & Peres, 2015; Fragoso et al. 2016; 2019; Braga-Pereira et al. 2021; Esbach, 2023), além da importância de se desenvolver métodos de baixo custo, aplicabilidade em escala e de fácil apropriação pelos moradores e manejadores dos recursos naturais, buscamos responder os seguintes questionamentos em nossa pesquisa: 1) Rastros e vestígios podem gerar índices de abundância congruentes a um método tradicional de monitoramento, como armadilhas fotográficas? 2) De que maneira características ecológicas, como a massa corporal, sociabilidade e nicho trófico, contribuem para geração desses índices? Avaliamos que programas de monitoramento, como o Programa Nacional de Monitoramento da Biodiversidade - Monitora, que já atuam em parceria com as comunidades em diversas UCs da Amazônia (Monitora et al. 2023), podem integrar o CEL para gerar respostas mais rápidas às mudanças ambientais (Moller et al. 2004), ao mesmo tempo que se gera um maior empoderamento dos atores locais para decisões de manejo e gestão de recursos naturais (Danielsen et al. 2021).

OBJETIVOS

Objetivo geral:

Avaliar o grau de congruência de índices de abundância (taxa de detecção) obtidos por armadilhas fotográficas para mamíferos de médio e grande porte e aves terrestres, em comparação às obtidas por sinais e vestígios identificas pelo CEL em estações amostrais pareadas.

Objetivos específicos:

- Estimar a taxa de detecção mamíferos de médio e grande porte e aves terrestres por armadilhas fotográficas;
- Estimar a taxa de detecção de mamíferos de médio e grande porte e aves terrestres por sinais e vestígios;
- Estimar a probabilidade de detecção de mamíferos de médio e grande porte e aves terrestres por ambos os métodos;
- Avaliar o grau de congruência das estimativas por espécie par a par;
- Analisar a influência da massa corporal, sociabilidade ou nicho trófico tem efeito sobre a relação entre os índices obtidos por sinais e vestígios.

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Capítulo único

Integrating local knowledge and camera trapping to evaluate detection and the ecological traits affecting presence and abundance of medium and large vertebrates in the Xingu Valley, Eastern Amazonia

O capítulo desta Dissertação foi elaborado e formatado conforme as normas da publicação científica *Perspectives in Ecology and Conservation*, as quais se encontram em anexo (Anexo XX)

INTRODUCTION

Wildlife monitoring is a fundamental element for developing effective conservation measures for species facing environmental changes of anthropogenic origin (Di Marco et al. 2015). Monitoring the population's responses to ecological changes requires systematically collected data, with replicates that allow for observing trends over time and space (Lindenmayer & Likens, 2010). The choice of method is fundamental to respond adequately to the proposed objectives, taking into account that sampling techniques can have a different impact on the detectability of the species (Silveira et al. 2003; Taylor et al. 2007; Espartosa et al. 2011; Fragoso et al. 2016), as well as depending on the financial availability of the programs (Seidlitz et al. 2021).

The ability to detect trends in natural populations is critical for assessing the conservation status of medium and large vertebrates in Neotropical ecosystems. Terrestrial birds and mammals provide important ecosystem services, such as seed dispersal (Tobler et al. 2010; Parolin et al. 2013); landscape modification as “ecosystem engineers” (Desbiez & Kluyber, 2013), regulating natural populations (Ripple et al. 2014), food security in traditional communities through subsistence hunting (Peres, 2000; Michael et al. 2020) and generating income through ecotourism initiatives (Vale et al. 2018). The loss of this diversity implies modifications in ecosystems, including changes in tree community composition and diversity (Nuñez-Iturri & Howe, 2007), alterations in soil carbon stocks (Sobral et al. 2017), trophic cascades due to the loss of top predators or dispersers (Jorge et al. 2013), as well as other phenomena associated with the loss of taxonomic and functional diversity (Bogoni et al. 2020).

Visual census by transects is the most traditional method for sampling and producing indices to monitor these species in the Amazon region (de Thoisy et al. 2008). Linear transects are traversed at standardized distances multiple times, with species recorded by visual detection or vocalization (Peres, 1999). This method is ideal for recording arboreal and diurnal species, such as primates (Lopes & Ferrari, 2000; Almeida-Maués et al. 2022); however, it fails to record nocturnal or rare species and is susceptible to missing species that have altered their behavior patterns in response to human disturbance (Fragoso et al. 2016; 2019). Camera traps have innovated by allowing the recording of rare and nocturnal species as they remain active for 24 hours or longer in the field (Tobler et al. 2008; Munari et al. 2011), in addition to enabling systematic data collection. On the other hand, they require substantial upfront investment (Camino et al. 2020), as well as ongoing maintenance, replacement, and installation costs (Seidlitz et al. 2021; Zwerts et al. 2021), difficulty in identifying species, especially small ones (Potter et al. 2018), and biases associated with detectability, such as changes in animal behavior (Caravaggi et al. 2020) or limited capture areas due to movement patterns (Sollmann, 2018).

Another approach uses indirect signs (e.g., Footprints, dung, tracks, scratches, eggs, nests, scratchings, feathers, fur, bones, etc.). This method complements data collection from transects in visual censuses for ecological studies (e.g., Fragoso, 1998; Carrillo et al. 2000) and allows access to cryptic species or those that have changed their behavior patterns (Fragoso et al. 2016). These data can be used for various analyses, including presence-absence data for occupancy models (Seidlitz et al. 2021), density estimates through footprints, such as the Formozov-Malyshev-Pereleshin (FMP) formula (Stephens et al. 2006; Esbach, 2023), and individual identification for estimating population abundance (Jewell et al. 2016, Alibhai e al, 2017, Moreira et al. 2018). It also allows for incorporating local ecological knowledge (LEK) from traditional peoples and communities (Moreira et al. 2018; Ponce-Martins et al. 2022), based on experience acquired through oral transmission and observation of species behaviors. Recent studies have highlighted comparisons between traditional methods (transect censuses, camera traps) and LEK regarding species composition and richness, occupancy and abundance indices, ecological traits, temporal patterns, and species distribution (Camino et al. 2020; Braga-Pereira et al., 2021; Brittain et al. 2022; van Vliet et al. 2023). Involving participants in the monitoring process not only provides valuable information on a local scale but also empowers local communities in knowledge production and makes them active in conservation efforts (Danielsen et al. 2005; Benchimol et al. 2017; Camino et al. 2020).

The Brazilian Amazon contains most of the protected areas of the National Biodiversity Monitoring Programme (Programa Monitora), an integrated system that uses protocols based on transect sampling and camera trapping to assess the population status of medium and large mammals and terrestrial birds (Monitora, 2023). Most of these protected areas have historically been inhabited by traditional communities, who assist in data collection as monitors (Oliveira et al. 2024). However, despite their participation, the capacity of monitors to detect fauna through LEK isn't included in the protocol. The work of Ponce-Martins et al. (2022) demonstrated that local monitors in a protected area in the eastern Amazon were able to efficiently detect the program's target species through indirect signs, indicating the potential for integrating this knowledge into a comprehensive protocol.

In this study, we assessed the congruence between camera trap detection rates and LEK from local monitors in two protected areas in the eastern Amazon, and the influence of ecological traits on the probability of detecting these species. Finally, we discuss how integrated methods based on scientific and traditional knowledge are fundamental to understanding abundance patterns and detection of Amazonian species.

METHODOLOGY

2.1 Study Area

Our study was carried out at the Terra do Meio Ecological Station (ESECTM), a Protected Area (PA) covering 3,371,111 ha, and the Rio Iriri Extractive Reserve (RERI), a sustainable use PA covering 398,938 ha, located in the middle Xingu region of the eastern Amazon (Figure 01). Both are part of a larger block of PAs and Indigenous Lands (ILs) that forms the Xingu Sociobiodiversity Corridor, englobed over 27 million ha (Schwartzman et al. 2013; Balee et al. 2022), acting as a barrier to the expansion of forest cover loss from the so-called "arc of deforestation". The area is the continual scene of land conflicts for the implementation of mining, deforestation, and land grabbing, which violate the rights of local populations and cause damage to biodiversity (Schwartzman et al. 2010).

The resident riverine populations, known as 'Beiradeiros', arrived in the region in the 19th century to harvest rubber from the *Hevea brasiliensis* tree (da Cunha & de Almeida, 2000). Contact with the indigenous peoples, together with the local experiences of these communities, built up a universe of ecological knowledge of their own, based on hunting, fishing, management, and extraction of forest products, such as the Brazilian nut (*Bertholletia excelsa*) and the babassu coconut (*Attalea speciosa*) (Balee et al. 2022). Extractivism and fishing are vital income sources, primarily by developing sustainable production chains that value sociobiodiversity (Rezende et al. 2024).

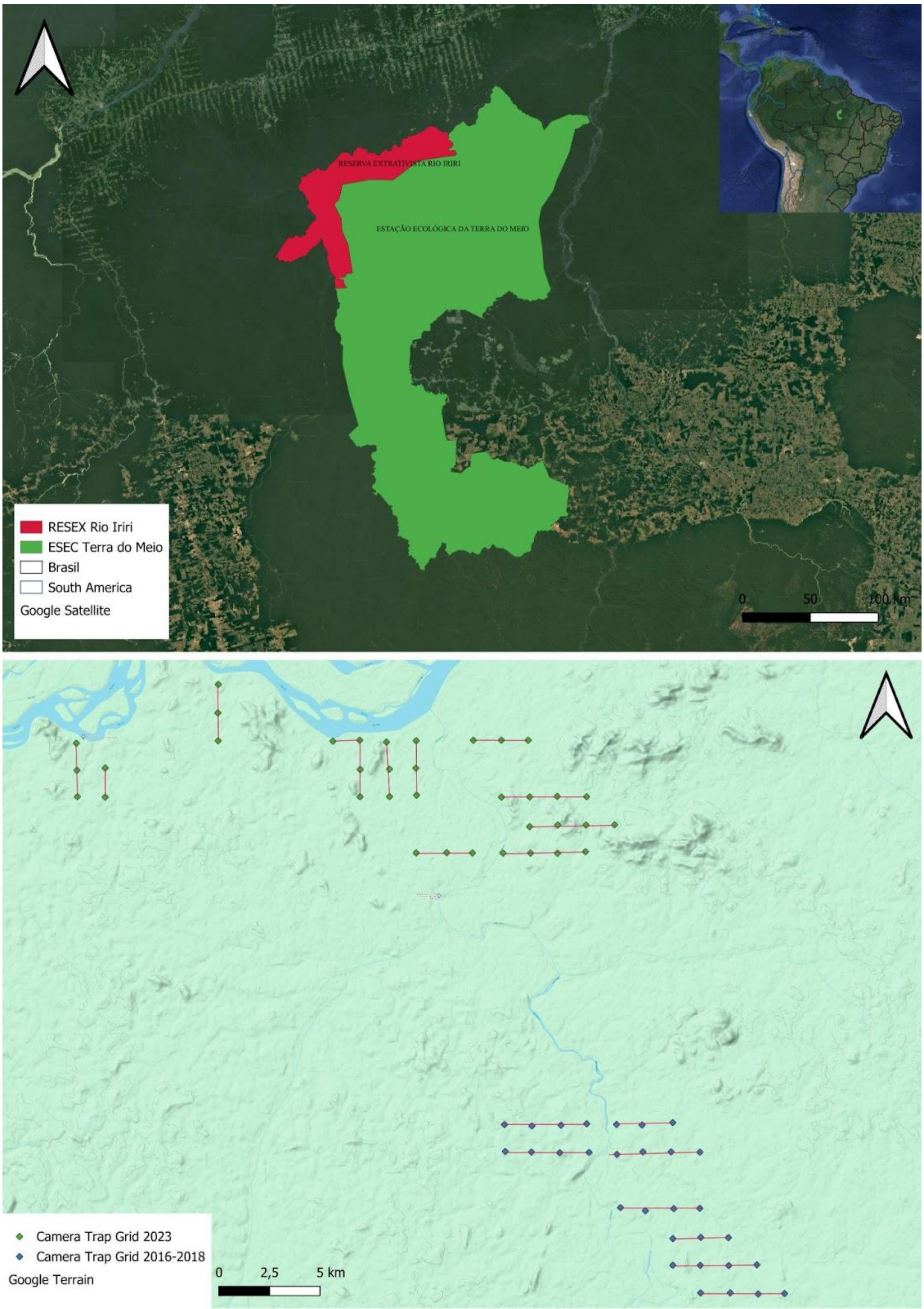

Figure 01: Above, a map of the two protected areas where the Monitora Program operates. Below, the transects made on the ICMBio camera trails. In blue are the cameras deployed between 2016 and 2018, and in green, those deployed in 2023.

2.2 Data collection

Camera trap data - The camera trap (CT) data was obtained through the advanced terrestrial vertebrates monitoring protocol implemented by the National Biodiversity Monitoring Program (Monitora Program), developed by the Chico Mendes Institute for Biodiversity Conservation (ICMBio), supported by the Amazon Protected Areas Program (ARPA) (ICMBio, 2018). The protocol is based on the TEAM (Tropical Ecology Assessment and Monitoring) network for monitoring terrestrial birds and medium-large mammals, with the deployment of camera trap grids at a distance of 1.4 km from each other, and a density of one camera per 2 km² (Rovero & Ahumada, 2017). On average, 60 camera traps (Bushnell Trophycam) with an infrared motion sensor and an interval between each photograph of 0.6 seconds, were deployed in 2016, 2017, 2018, and 2023, along transects 4.5 km long, between the end of the rainy season and the beginning of the dry season, with a minimum effort of 30 days in the field. The images were processed using the Wildlife Insights platform (Ahumada et al. 2020).

Transect data - We used an integrated version of the basic protocol of the Monitora program (see Carvalho Jr. et al. 2024), in which we collected data obtained through sightings/vocalizations and tracks left by wildlife, which we call the "sighting/track" (ST) protocol. We carried out the advanced protocol trails while installing or removing the cameras, at an average speed of 1.5 km/h. The signs and tracks were identified based on the local ecological knowledge of the riverine monitors, gained through personal experience, and transmitted orally. These include footprints, burrows, excavations left by the animals, feathers, nests, eggs, feces, fur, scrapes, animal trails, locally known as “carreiros”, fruits and leaves eaten, bones and marks on trunks. Only traces of up to seven days old were recorded, dating back to the monitor's identification. Data was recorded using the ODK and Cybertracker smartphone apps. In particular, Cybertracker is a tool that has been used for more than 20 years for monitoring mammals with the participation of local communities, including non-literate individuals (Liebenberg et al. 2016). In the case of cameras and signs, when it was not possible to define the species, we grouped them at the “ecospecies” level (such as *Crypturellus sp.* and Cervidae) (see Peres & Palacios, 2007).

2.3 Species traits

We selected three natural history traits of the species as predictor variables to assess their influence on detection: species body mass, sociability (solitary or gregariousness), and trophic guild (Animalivore, Omnivore, and Herbivore/Frugivore). We chose mass and sociability as a predictor because we expect that larger species and social species have a higher probability of detection (Tobler et al. 2008; Treves et al. 2010) and that the trophic guild is related to behavior patterns that leave traces, such as digging in the ground or gnawing on fruit (Ponce-Martins et al. 2022). The mass values were extracted from Peres & Palacios (2007). The trophic guild was extracted from the diet description of Emmons & Feer (1996), following the organization of Robinson & Redford (1986) for mammals, and Peres & Palacios (2007) for birds. Given the presence of ant-eater species (giant anteater and giant armadillo), we grouped them with carnivores in the "Animalivore" category (Voss et al. 2001).

2.4 Data analysis

We carried out paired analyses by transect and year to assess the degree of congruence between the rates obtained by CT and ST. Here we assume the detection rate (DR) as an abundance index, considering the number of independent records obtained by camera traps over seven days and the number of records per km traveled (Parsons et al. 2017; Kays et al. 2020). We calculate each rate per transect and total effort per method, respectively. Only data obtained from transects sampled simultaneously by CT and ST were analyzed. We defined buffers of 700 meters in diameter around each camera, considering the distance of 1.4 km between each camera trap unit. This decision was based on the assumption that sightings and tracks in this area were more likely to be detected by the corresponding camera. We then calculated the record rate/km traveled for each transect considering the sightings/tracks per species. We grouped the photographic trails by transect and calculated the number of independent records per one-hour interval for each species. Due to the difference in sampling effort between the two methods, we used the data from the first seven days for each camera. During four rounds of annual sampling conducted during the dry season each year, we had 33 transects, totaling 833 camera-days and 148.5 km walked. We calculated the percentage of sites where the species was detected by each method and its probability of detection (p) from a model of detection/non-detection (total number of registers/total number of transects), assuming constant detection (Munari et al. 2011).

We conducted a Spearman correlation (Rho, $p < 0.05$) to test the relationship between the relative abundance rates obtained by the two methods, evaluating the data in general and by species. Only species recorded at least once by both methods were considered. In the case of a transect where a species was observed by one method and not the other, we labeled it with a value of zero to perform the correlation. We fitted a series of Generalised Linear Mixed Models (GLMMs) to test the effect of ecological characteristics on detection, considering different combinations of predictor variables. We assumed that the model had only the predictor of the number of records per camera trap and the random variable as the null model. We use negative-binomial distribution for overdispersed data, using the number of records per km as the response variable, independent records obtained by camera trap, and species traits (session 2.3) as predictor variables. We converted the body mass values (in grams) into logarithmic values to reduce the discrepancy between the masses. We added the taxa's order level as a random variable to assess whether the difference in records between taxa influences the model's response. We used the “lme4” package (Bates et al. 2015) in the R Studio software. We selected the best models using the Akaike information criterion adjusted for small sample bias, with a delta value of less than 2.0 (Burnham & Andersons, 2002) from package “AICcmodavg” (Mazerolle, 2023). We used the “emmeans” package (Lenth, 2023) to evaluate the effect of each category within the categorical variables.

RESULTS

A total of 20 species (13 mammals and seven birds) were detected by both methods (Table 01 - Appendix A). The species with the highest detection rate (DR) for ST was Agouti (*Dasyprocta sp.*) (1.09 ± 0.014). The ecospecies Deer (*Mazama americana* and *Passilites nemorivaga*) were the second most frequently detected (0.801 ± 0.012), followed by the armadillo genus *Dasypus spp.* (0. 794 ± 0.127), White-lipped Peccary (*Tayassu pecari*) (0.424 ± 0.009), Tinamous (*Tinamus sp.*) (0.404 ± 0.009), Collared Peccary (*Dicotyles tajacu*) (0.403 ± 0.009) and Lowland Tapir (*Tapirus terrestris*) (0.350 ± 0.008). Agouti was also the most common species detected by camera traps (0.426, ± 0.003), followed by the Olive-winged trumpeter (*Psophia dextralis*) (0.112 ± 0.002), Deer (0.067 ± 0.001), Paca (*Cuniculus paca*) (0.091 ± 0.001) and Razor-Billed Curassow (*Pauxi tuberosa*) (0.066 ± 0.001) (figure 02).

The carnivore order had the lowest detection rates for both methods, with three species (*Nasua nasua, Panthera onca,* and *Puma concolor*) mostly detected by signs. Only one carnivore ecospecies, *Leopardus sp.*, had a similar detection rate for both methods (CT 0.027; ST 0.026). The giant anteater (*Myrmecophaga tridactyla*) was the rarest species for both methods, with only two records for each, resulting in a DR of 0.020 for ST and 0.002 for CT (figure 02).

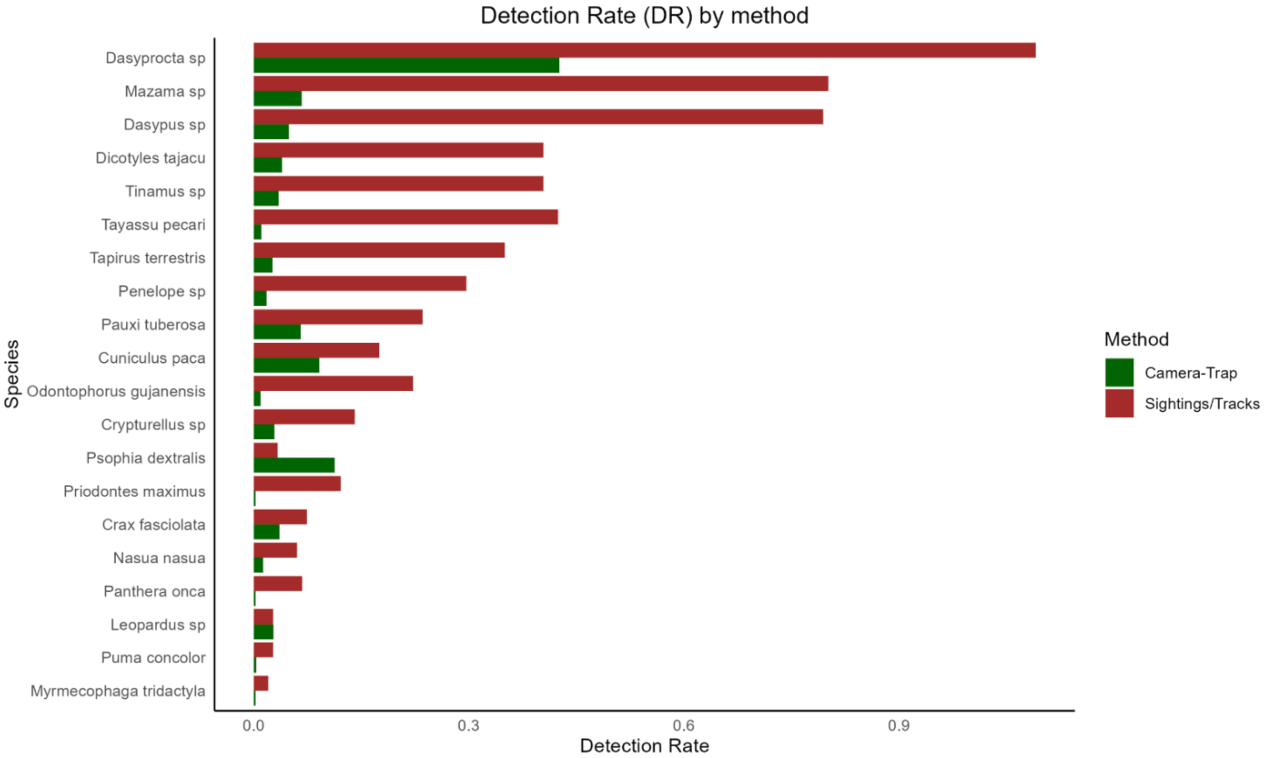

Figure 02: Detection rate by method (ST = Sighting/Track; CT = Camera Trap), considering the total effort per km traveled and the number of independent records, respectively.

The Agouti had the highest detection probability for Sighting/Tracks (*p* = 0.909), followed by Cervidae (*p* = 0.879), *Dasypus spp*. (*p* = 0.848), Lowland Tapir (*p* = 0.758), and Collared Peccary (*p* = 0.727). The Agouti also had the highest detection probability from camera traps (*p* = 0.939), followed by *P. dextralis* (*p* = 0.727), Cervidae (*p* = 0.697), *C. paca* (*p* = 0.606), and *P. tuberosa* (*p* = 0.636) (Figure 03). When we analyzed the relationship between the number of detections per transect depending on the method, we found that *Dasyprocta sp.* was the most common species, observed in all sites, with 84.4% of the sites detected by both methods (table 03 - Appendix A). Only 9.09% of the sites were detected exclusively by CT and 6.06% by ST. Along with Cervidae, these species were the only ones detected in more than 50% of the transects by both methods (63.6% for Deer). This contrasts with the 12 species detected in more than 50% of the transects regardless of the method used. Only five ecospecies (Cervidae, *Dasyprocta sp.*, *Dasypus spp.*, *Pauxi tuberosa*, and *Tinamus spp.*) were detected mainly by both methods. The Olived-Winged-Trumpeter (*P. dextralis*) was mostly detected by camera trap, with no site exclusively observed or recorded by sightings/tracks. The puma and the giant anteater were poorly detected species (Figure 03) and were not recorded on the same trails by either method (table 03 - Appendix A).

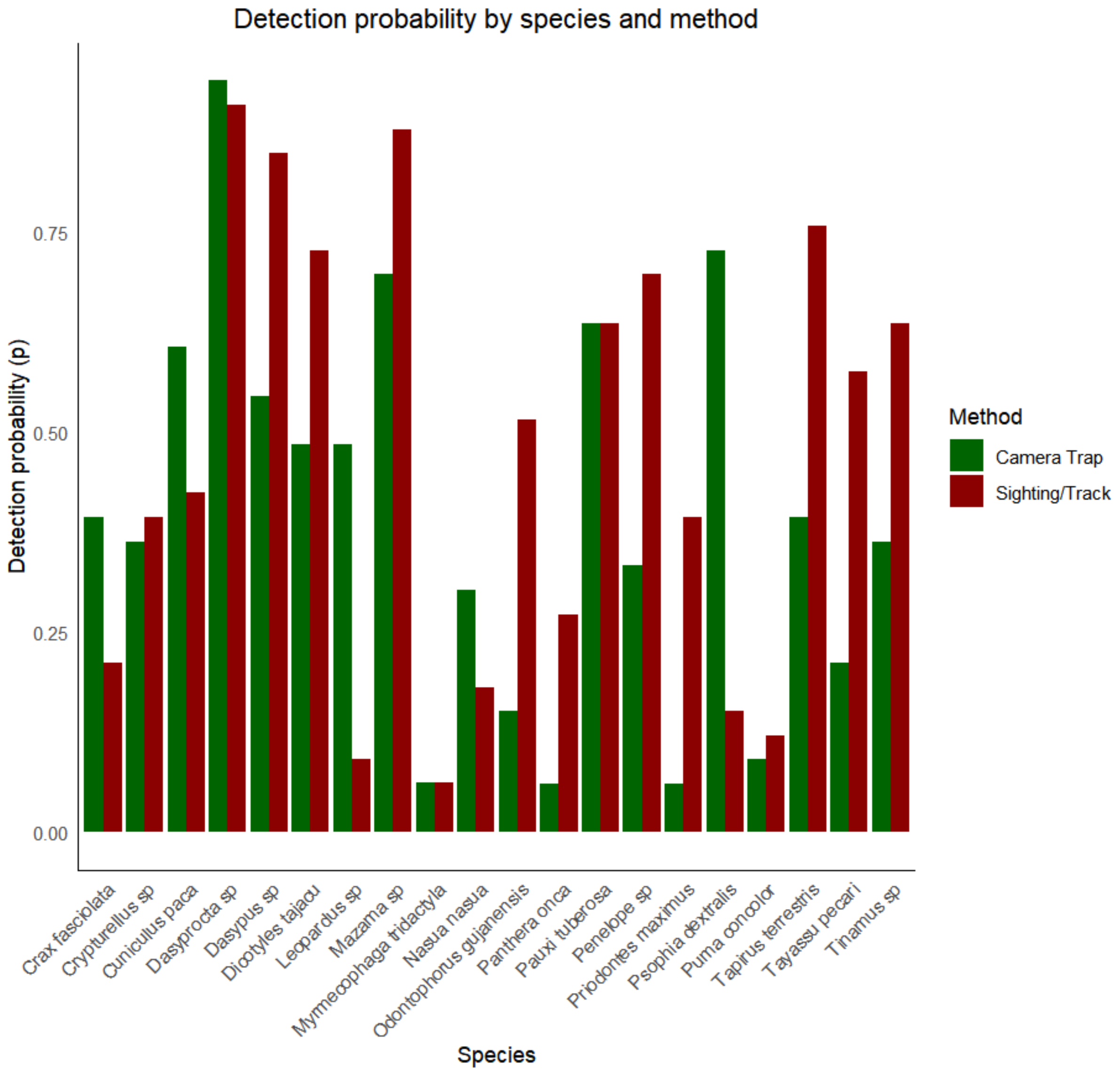

Figure 03: Detection probability (*p*) by method and species.

The result of Spearman's overall correlation showed moderate explanatory power (Rho = 0.51). It was significant ($p < 0.001$), indicating that there is a positive relationship between the number of sightings/tracks and camera trap records (Figure 04). However, when running the analysis for each species, a level of significance ($p < 0.05$) was observed only for *Odontophorus gujanensis* (Rho = 0.36, p = 0.03) and *Tinamus* genus (Rho = 0.41, p = 0.01).

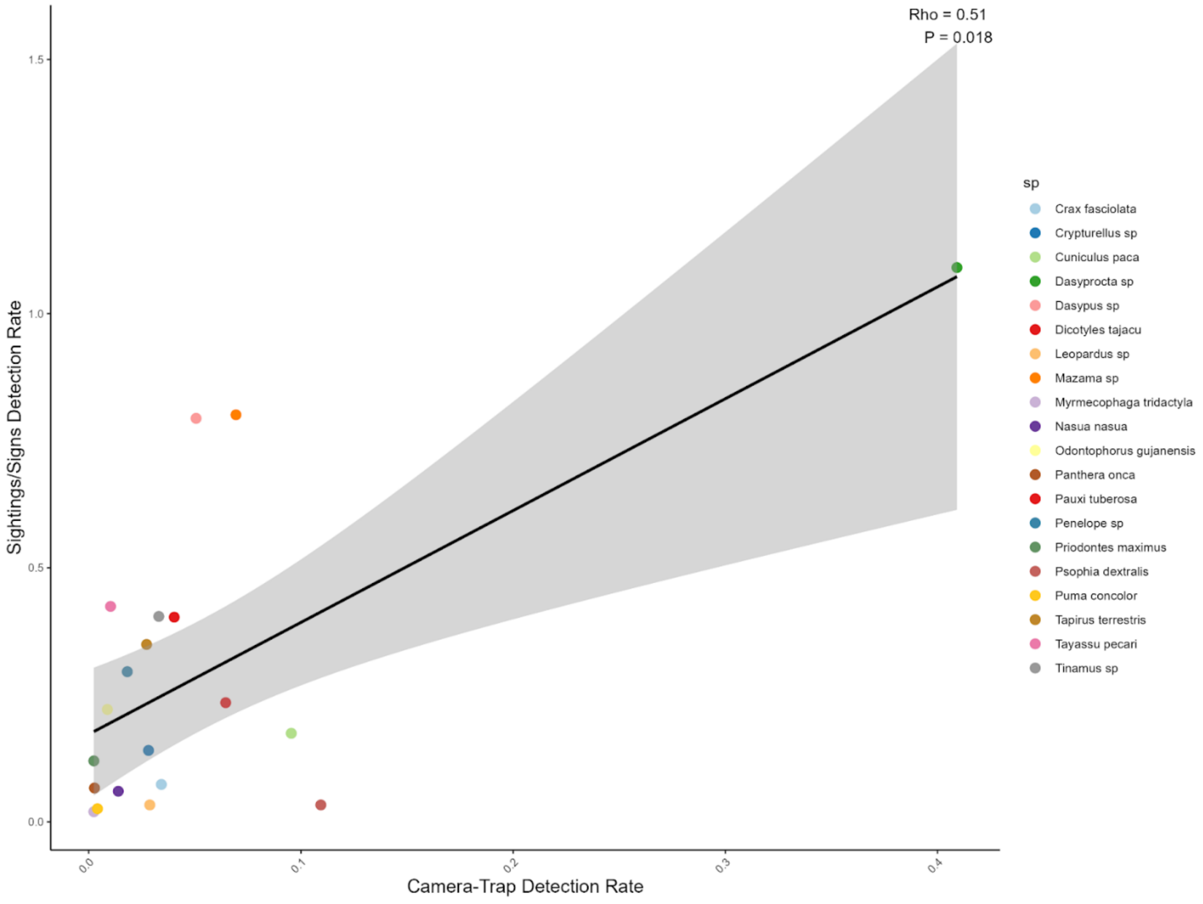

Figure 04: Correlation between species for both methods.

According to Akaike's information criterion, the best model (ΔAICc ≤ 2.00; weight 0.52) considered one explanatory variable, trophic guild, using the “animalivore” guild as reference values in the intercept (Figure 1 and Table 04 - Appendix A). The result of the estimated mean for the trophic guilds shows that the herbivore/frugivore guild contributes the most to the number of detections using the sighting/track method (0.747) compared to animalivores (-1.692) and omnivores (-0.422). However, both herbivores/frugivores (-0.0782, 1.572) and omnivores (-1.0853, 0.240) have confidence intervals (0.95) that include zero, indicating that this difference is not significant on average for these two guilds.

DISCUSSION

We identified six orders of mammals and three of birds, totaling 20 species detected by both methods in our study area. A previous study in the same area detected 33 species (see Ponce-Martins et al. 2022), of which five were primates detected almost exclusively by visual records/vocalizations. Simultaneously incorporating different methods is useful for approaching species with distinct characteristics, such as stratification or activity time (Ñunez et al. 2019). We did not include arboreal species in our study because camera traps do not detect them, but it has been observed that traces of *A. speciosa* consumption by capuchin monkeys (*Sapajus apella*) are easily detected by local communities (Ponce-Martins et al. 2022). Other taxa, such as canids (*Atelocynus microtis* and *Speothos venaticus*), are naturally rare regardless of the method used, with low densities observed in the Amazon (Michalski, 2010). Specifically in our study area, few residents claim to have personally seen these species (personal observation), and even camera trap detections are rare (Ponce-Martins et al. 2022).

Our results show a relationship between detection for both methods, with similarity between species detectability for other upland forest sites in the Amazon (Munari et al. 2011; Michalski et al. 2015; Benchimol et al. 2017). The high density of *Dasyprocta*, the most frequent and detected species considering both methods, is associated with the aggregation of fruit trees and phenological patterns of these species (Silvius & Fragoso, 2003; Ferregueti et al. 2018), such as the Brazil nut (*B. excelsa*) (Jorge & Peres, 2005). In our study, most of the records of this species are obtained by identifying eaten babassu coconuts, the same technique used to detect *C. paca*, with the difference being determined by the shape of the teeth left by the animal. Managing these extractive tree species by communities in the region (Balee et al. 2020) may favor high densities of agouti, with further studies focusing on the relationship between frugivores and the spatial distribution of fruit trees.

Large carnivores generally exhibit low detection rates in the Amazon biome (Munari et al. 2011; Michalski et al. 2015; Mena et al. 2020). Our results showed the same trend for both methods, with low detection rates and probabilities for Jaguar and Puma. These two species have large home ranges and territorial behavior, which decreases the likelihood of their being observed in diurnal censuses (Hill et al. 1997; Carrilo et al. 2000; Munari et al. 2011; Fragoso et al. 2019) and even through camera traps (van Kuijik et al. 2022), which implies in the need a considerable sampling effort to produce reliable metrics on their population status (Tobler & Powell, 2013). Almost all records obtained through Sighting/Track were derived from indirect signs (footprints, feces, clawing trees, and scrapes), which exhibited a higher probability of detection using this method. While footprints are influenced by substrate quality and other environmental variables (Hill et al. 1997), scrapes are signals associated with marking behavior (Harmsen et al. 2010), differentiated by monitors based on their shape. This underscores the necessity of using indirect signs to detect these species and the capability of local monitors to observe these traces (Fragoso et al. 2019).

Ungulates are one of the most important food sources for traditional and Indigenous communities, accounting for a significant portion of the accumulated biomass throughout the Amazon basin (Peres, 2000) and in Xingu Valley in particular (De Paula et al. 2022). They are sensitive to high hunting pressure and tend to have depleted populations near large settlements or urban centers (Scabin & Peres, 2021; Sampaio et al. 2023), thus monitoring target populations is essential. We observed a high detection rate and probability for Cervidae (Figure 02-03), recorded in over 90% of the transects, with an overlap of 21 sites (63.3%) where both methodologies detected the species. This indicates a high capacity of local monitors to detect the presence of this eco-species, particularly *M. americana*, as *Passilites nemorivaga* naturally occurs at low densities (Rossi et al. 2010).

Three other ungulates (*D. tajacu, T. terrestris, and T. pecari*) were also detected in more than 50% of the transects when considering both methodologies, predominantly through traces, in which the first two species had a high probability of being detected using sighting/track method (Figure 03). This phenomenon has been noted in the literature during visual census protocols (Hill et al. 1997; Munari et al. 2011; Fragoso et al. 2016; Benchimol et al. 2017), highlighting the effectiveness of both methods for assessing these species of high hunting importance. The high detection of these species through the sighting/track method supports that hunting in the region is sustainable due to the low human population density present in the protected areas (de Paula et al. 2022).

T. pecari showed a low rate and probability of being detected by camera traps. Peccaries can form groups of over 100 individuals (Peres, 1996), requiring large home ranges and exhibiting high mobility in search of resources (Fragoso, 1998; Keuroghlian et al. 2004). Our sampling effort for camera traps utilized only the first seven available days, making it plausible to consider that peccary populations may be elsewhere (Michalski et al. 2015). This is consistent with the findings by Kays et al. (2020), which evaluated high variability in mammal detection rates during the first two weeks of sampling. Thus, the use of ST along trails with a wider coverage may be a suitable and cost-effective tool for monitoring the population of this species, whereas sightings alone would be ineffective and CT potentially prohibitive in terms of long-term costs for a large area. In contrast, for another gregarious species, the Olive-Winged Trumpeter, detection was predominantly achieved through camera traps. Species of the genus *Psophia* require large home ranges and are abundant in upland forest areas, frequently detected through sightings and camera traps (Haugaasen et al. 2008; Michalski et al. 2015; Roncal et al. 2019). It is possible that these birds do not leave physical evidence like other game species in our study (e.g., *Tinamus spp.*), such as "bathrooms" or scratches on the ground, which makes them less detectable by indirect signs, due to a movement pattern that covers a large home range.

Multiple intrinsic environmental factors can affect detectability: the type of substrate for tracks, seasonality, availability of food resources, and proximity to water bodies, which can lead to understate or overstate the target species' abundance (Srbek-Araujo & Chiarello, 2007; Munari et al. 2011; Michalski et al. 2015; Moreira et al. 2018). We observed a lack of species-specific correlation between the methods employed for most species, except for two birds (*O. gujanensis* and *Tinamus sp.*). Two factors help to explain this result: 1) differences in the presence/absence of species across sampled transects; 2) the rates obtained per species per transect. In the case of three species (*Leopardus spp., N. nasua* and *P. tuberosa*) there are discrepant relationships between the indices, where the sighting/track rates are similar to or higher than those of camera traps (table 1 - Appendix A), but the probability of detection does not show the same trend (table 2 - Appendix A).

Ecological traits, like body mass and sociability, can affect detection rates using different methods (Tobler et al. 2008; Treves et al. 2010). However, the best-supported model did not consider these variables. The trophic guild was the only significant predictor variable, with the herbivore/frugivore group showing the highest detection rates. Large species are generally detected more frequently by camera traps compared to smaller species (Lyra-Jorge et al. 2008; Tobler et al. 2008; Rowcliff et al. 2011), which is also true in some cases where tracks are used (Silveira et al. 2003). However, our result here is supported by other studies (e.g Wong et al. 2019; Ñunez-Iturri et al. 2019), which assessed that detectability can be equally variable for gregarious or solitary species, as shown by the different responses of two gregarious species (*P. dextralis* and *T. pecari*). Body mass influences the type of sampling methods used, such as dung production that can be detected in transects (Ñunez-Iturri et al. 2019) and by underestimating footprints left on different types of substrates (Espartosa et al. 2011).

Robinson & Redford (1986) observed that smaller species at the base of the trophic web are more abundant than larger species in the same position; therefore, we expected that body mass would influence detectability through indirect signs. The results found here may be explained by the skills of the monitors, which are primarily based on various traces left by animals, associated with behaviors involving movement, foraging, territorial marking, or burrowing, which are not directly linked to body mass or sociability traits. Moreover, the detectability using indirect signs may reflect the ability of local experts to detect wildlife tracks and vestiges regardless of the animal size, based on their skills as experienced hunters, and knowledge of local fauna natural history and behavior.

Consequently, nocturnal species, such as armadillos (*Dasypus spp.* and *P. maximus*), showed a high detection probability (p = 0.8, p = 0.3, respectively) and detection rate (0.794, 0.121, respectively) using the sightings/tracks method in relation to camera traps, despite their nocturnal habits. The genus *Dasypus spp.* tend to be the most common compared to other armadillos in the Amazon biome (Margarido et al. 2023) and studies in the biome have obtained relatively high detection rates by camera traps (Mena et al. 2020; Van Kuijik et al. 2022). Although we did not observe the same pattern in our results, we did observe a high probability of detecting the genus by CT (p = 0.54), which may indicate the low rate for CT results from the limited sample period we used in our study.

These results raise important questions for future applications of this methodology. Firstly, rates vary significantly between methods for each species, decreasing the effectiveness of conventional correlation analyses to observe congruence in this index. Detection/non-detection can be used in occupancy models to estimate abundance and reduce biases in behavior and environmental conditions that can increase detection rates by sites (Sollmann, 2018; Kays et al. 2020). Secondly, our results show that the probability of detection by monitors is higher than that of camera traps for 11 of the 20 species, four of which are of great importance for the food security of local communities (Cervidae, *D. tajacu, T. terrestris,* and *T. pecari*). This difference indicates that rapid sampling by local monitors can generate reliable histories for a larger area than currently sampled. This is fundamental for the context of Terra do Meio, where the camera grid covers only 0.4% of the mosaic of PAs. Thirdly, the LEK of the monitors can help with systematic collection at different times of the year, providing more information about differences in the detection of species in various environmental conditions. Community-based monitoring programs increase empowerment, promote governance, and result in faster responses at the local level than when conducted by government institutions alone (Danielsen et al. 2005; 2010). Incorporating methods using LEK values local participants and can be more cost-effective, a limiting factor for long-term monitoring (Reis & Benchimol, 2023). It is therefore essential to integrate different methods to sample target species more efficiently and produce rapid responses to anthropogenic impacts.

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Apendix A, Table 01: Detection Rate by method and correlation of spearman value (Rho)

Taxa	Sightings/Tracking DR (SE)	Camera-Trap DR (SE)	R^2 (p-value)
BIRDS			
GALLIFORMES			
Cracidae			
Crax fasciolata	0.073 (0.003)	0.036 (0.001)	0.14 (0.41)
Pauxi tuberosa	0.235 (0.006)	0.066 (0.001)	-0.001 (0.99)
Penelope spp.	0.295 (0.007)	0.018 (0.000)	-0.010 (0.95)
Odontophoridae			
Odontophorus gujanensis	0.211 (0.006)	0.009 (0.000)	0.36 (0.03)
GRUIFORMES			
Psophiidae			
Psophia dextralis	0.033 (0.002)	0.112 (0.002)	0.09 (0.60)
TINAMIFORMES			
Tinamidae			
Crypturellus spp.	0.141 (0.005)	0.028 (0.001)	-0.32 (0.06)
Tinamus spp.	0.404 (0.009)	0.034 (0.001)	0.40 (0.01)
MAMMALIA			
ARTIODACTYLA			
Cervidae (Deer)	0.801 (0.012)	0.067 (0.001)	0.25 (0.14)
Tayassuidae			
Dicotyles tajacu	0.404 (0.009)	0.039 (0.001)	-0.070 (0.69)
Tayassu pecari	0.424 (0.009)	0.010 (0.000)	0.007 (0.96)
CARNIVORA			
Felidae			
Leopardus sp.	0.026 (0.002)	0.027 (0.001)	0.06 (0.73)
Panthera onca	0.067 (0.003)	0.002 (0.000)	0.11 (0.53)
Puma concolor	0.026 (0.002)	0.003 (0.000)	-0.11 (0.52)
Procyonidae			
Nasua nasua	0.060 (0.003)	0.013 (0.000)	0.01 (0.95)
CINGULATA			
Chlamoyphoridae			
Priodontes maximus	0.121 (0.004)	0.002 (0.000)	0.22 (0.19)
Dasypodidae			
Dasypus spp.	0.794 (0.127)	0.049 (0.001)	-0.24 (0.16)
PERISSODACTYLA			
Tapiridae			
Tapirus terrestris	0.350 (0.008)	0.026 (0.000)	0.05 (0.75)
PILOSA			
Myrmecophagidae			
Myrmecophaga tridactyla	0.020 (0.002)	0.002 (0.000)	-0.06 (0.72)
RODENTIA			
Cuniculidae			
Cuniculus paca	0.175 (0.005)	0.091 (0.001)	-0.01 (0.92)
Dasyproctidae			
Dasyprocta sp.	1.090 (0.014)	0.426 (0.003)	0.25 (0.15)

Appendix A, Table 02: Detection probability

Taxa	***P* (Sightings/Tracking)**	***P* (Camera-Trap)**
BIRDS		
GALLIFORMES		
Cracidae		
Crax fasciolata	0.212	0.394
Pauxi tuberosa	0.636	0.636
Penelope spp.	0.697	0.333
Odontophoridae		
Odontophorus gujanensis	0.515	0.152
GRUIFORMES		
Psophiidae		
Psophia dextralis	0.152	0.727
TINAMIFORMES		
Tinamidae		
Crypturellus spp.	0.394	0.364
Tinamus spp.	0.636	0.364
MAMMALIA		
ARTIODACTYLA		
Cervidae (Deer)	0.879	0.697
Tayassuidae		
Dicotyles tajacu	0.727	0.485
Tayassu pecari	0.576	0.212
CARNIVORA		
Felidae		
Leopardus sp.	0.0909	0.485
Panthera onca	0.273	0.0606
Puma concolor	0.121	0.0909
Procyonidae		
Nasua nasua	0.182	0.303
CINGULATA		
Chlamoyphoridae		
Priodontes maximus	0.394	0.0606
Dasypodidae		
Dasypus spp.	0.848	0.545
PERISSODACTYLA		
Tapiridae		
Tapirus terrestris	0.576	0.394
PILOSA		
Myrmecophagidae		
Myrmecophaga tridactyla	0.0625	0.0625
RODENTIA		
Cuniculidae		
Cuniculus paca	0.424	0.606
Dasyproctidae		
Dasyprocta sp.	0.909	0.939

Appendix A, Table 03: Number of sites where each species was detected exclusively by one or both methods.

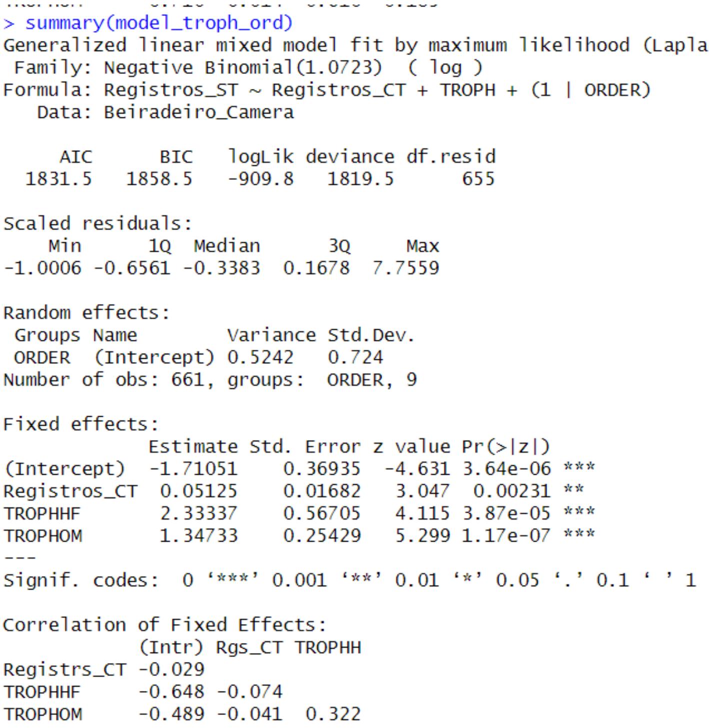
Taxa	**Number of sites detected by ST (%)**	**Number of sites detected by CT (%)**	**Number of sites detected by both methods (%)**	**Total number of sites detected (%)**
BIRDS				
GALLIFORMES				
Cracidae				
Crax fasciolata	03 (9.09)	09 (27.2)	04 (12.1)	16 (48.4)
Pauxi tuberosa	07 (21.2)	07 (21.2)	14 (42.4)	28 (84.8)
Penelope spp.	13 (39.3)	01 (3.03)	10 (30.3)	24 (72.7)
Odontophoridae				
Odontophorus gujanensis	13 (39.3)	01 (3.03)	04 (12.2)	18 (54.5)
GRUIFORMES				
Psophiidae				
Psophia dextralis	0	19 (57.5)	05 (15.5)	24 (72.7)
TINAMIFORMES				
Tinamidae				
Crypturellus spp.	10 (30.3)	09 (27.2)	03 (9.09)	22 (66.6)
Tinamus spp.	10 (30.3)	01 (3.03)	11 (33.3)	22 (66.6)
MAMMALIA				
ARTIODACTYLA				
Cervidae (Deer)	08 (24.4)	02 (6.06)	21 (63.6)	31 (93.9)
Tayassuidae				
Dicotyles tajacu	13 (39.3)	05 (15.1)	11 (33.3)	29 (87.7)
Tayassu pecari	15 (45.4)	03 (9.09)	04 (12.1)	22 (66.6)
CARNIVORA				
Felidae				
Leopardus sp.	01 (3.03)	13 (39.3)	03 (9.09)	17 (51.5)
Panthera onca	08 (24.2)	01 (3.03)	01 (3.03)	10 (30.3)
Puma concolor	03 (9.09)	03 (9.09)	0	06 (18.1)
Procyonidae				
Nasua nasua	04 (12.1)	08 (24.2)	02 (6.06)	14 (42.4)
CINGULATA				
Chlamoyphoridae				
Priodontes maximus	11 (33.3)	0	02 (6.06)	13 (39.3)
Dasypodidae				
Dasypus spp.	13 (39.3)	03 (9.09)	15 (45.4)	31 (93.9)
PERISSODACTYLA				
Tapiridae				
Tapirus terrestris	15 (45.4)	03 (9.09)	10 (30.3)	28 (84.8)
PILOSA				
Myrmecophagidae				
Myrmecophaga tridactyla	02 (6.06)	02 (6.06)	0	04 (12.1)
RODENTIA				
Cuniculidae				
Cuniculus paca	04 (12.1)	10 (30.3)	10 (30.3)	24 (72.7)
Dasyproctidae				
Dasyprocta sp.	02 (6.06)	03 (9.09)	28 (84.8)	33 (100)

Appendix A, Table 04: Models ranked according to Akaike's information criterion corrected for small samples.

Model	AICc	ΔAICc	ωi
TG + Order	1831.64	0.00	0.52
Soc. + BM + TG + Order	1832.91	1.27	0.28
BM + TG + Order	1833.60	1.96	0.20
Soc + BM + Order	1852.60	20.96	0.00
BM + Order	1852.59	20.98	0.00
Order	1858.59	26.95	0.00
Soc. + Order	1860.62	28.98	0.00

Predictors: TG = trophic guild (Herbivore/Frugivore, Omnivore and Annimalivore); Order = order taxa level; Soc. = sociability (Gregariousness or Solitary); BM = body mass value log-transformed. AICc = Akaike information criterion adjusted for small sample bias; ΔAICc = difference between a given model and the best model; ωi = Akaike weights.

Appendix A, Figure 01: Result of the best model according to Akaike's information criterion.



```
> summary(model_troph_ord)
Generalized linear mixed model fit by maximum likelihood (Laplace Approximation) ['glmerMod']
 Family: Negative Binomial(1.0723)  ( log )
Formula: Registros_ST ~ Registros_CT + TROPH + (1 | ORDER)
   Data: Beiradeiro_Camera

     AIC      BIC   logLik deviance df.resid 
  1831.5   1858.5   -909.8   1819.5      655 

Scaled residuals: 
    Min      1Q  Median      3Q     Max 
-1.0006 -0.6561 -0.3383  0.1678  7.7559 

Random effects:
 Groups Name        Variance Std.Dev.
 ORDER  (Intercept) 0.5242   0.724   
Number of obs: 661, groups:  ORDER, 9

Fixed effects:
             Estimate Std. Error z value Pr(>|z|)    
(Intercept)  -1.71051    0.36935  -4.631 3.64e-06 ***
Registros_CT  0.05125    0.01682   3.047  0.00231 ** 
TROPHHF       2.33337    0.56705   4.115 3.87e-05 ***
TROPHOM       1.34733    0.25429   5.299 1.17e-07 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Correlation of Fixed Effects:
            (Intr) Rgs_CT TROPHH
Registrs_CT -0.029              
TROPHHF     -0.648 -0.074       
TROPHOM     -0.489 -0.041  0.322
```

ANEXOS

Anexo 1: Normas da revista *Perspective in Ecology and Conservation onde o artigo foi submetido.*

Introduction

Perspectives in Ecology and Conservation (PECON) is a scientific journal devoted to improving theoretical and conceptual aspects of conservation science. It has the main purpose of communicating new research and advances to different actors of society, including researchers, conservationists, practitioners, and policymakers. Perspectives in Ecology and Conservation publishes original papers on biodiversity conservation and restoration, on the main drivers affecting native ecosystems, and on nature?s benefits to people and human wellbeing. This scope includes studies on biodiversity patterns, the effects of habitat loss, fragmentation, biological invasion and climate change on biodiversity, conservation genetics, spatial conservation planning, ecosystem management, ecosystem services, sustainability and resilience of socio-ecological systems, conservation policy, among others.

We are mostly interested in articles that deal with tropical and subtropical systems, but without any bias towards particular organisms or ecosystems. Scientific papers must focus on new conceptual or methodological developments with practical implications. Case studies will be considered only if inserted in these more general contexts. Authors are encouraged to submit reviews and essays that provide new perspectives on arising ecological and conservation issues. Purely descriptive papers and studies without a clear link with conservation theory and practice will not be considered.

Perspectives in Ecology and Conservation is the official scientific journal of the "Brazilian Association for Ecological Science and Conservation". It is an open access journal, supported by the Boticário Group Foundation for Nature Protection, and thus without any charge for authors. Perspectives in Ecology and Conservation was previously published, between 2003 and 2016, as ?Natureza & Conservac?o?.

Audience

Researchers working with biodiversity and ecosystem services, conservationists and practitioners, government, decision and policymakers.

Types of article

Perspectives in Ecology and Conservation publishes peer-reviewed original papers in English, following six main formats:

Essays & Perspectives/ Trends deal with longer essays and reviews updating recent topics of interest in conservation science. These articles provide an opportunity to propose new conceptual frameworks or personal viewpoints, supported by evidences, but still not completely explored. They should stimulate new cutting-edge research or applied perspectives. Those articles are usually up to 4000 words (excluding text in boxes, figures, tables and references), with 300-words abstract, graphical abstract (because it draws more attention to the online article), up to 1 to 2 boxes (maximum 400 words per box), 4 figures or tables, 50 references and highlights (a short collection of bullet points that convey the core findings of the article and should be submitted in a separate editable file in the online submission system).

Research Letters/ Research Paper are original scientific research presented in a more concise manuscript with up to 3000 words in length (excluding text in boxes, figures, tables and references), abstract with up to 200 words, graphical abstract (because it draws more attention to the online article), and up to 1 box (400 words) and 4 figures or tables, 40 references and highlights (a short collection of bullet points that convey the core findings of the article and should be submitted in a separate editable file in the online submission system).

Policy Forums / Reflective Practive are brief essays (1000 to 2000 words, short abstracts with up to 150 words, graphical abstract, plus 1 to 2 figures and highlights - a short collection of bullet points that convey the core findings of the article and should be submitted in a separate editable file in the online submission system) for a general audience on issues related to conservation and society. Contributions to this section should clearly articulate the significance of the ideas for conservation policy and practice.

Correspondences are letters commenting papers published in one of the three previous issues of the journal. Letters should be short (less than 1000 words, plus 1 figure), written in a polite and constructive way, with references kept to a minimum.

Book reviews (up to 2,000 words) consider relevant and internationally available publications that are not more than two years old. Books can cover a wide range of topics related to conservation science that should be of interest for a broad audience (scientists, policy makers, managers, graduate students). Submissions should be discussed with the editor-in-chief in advance.

Society Position Statement/White papers will be restricted to provide a state-of-the-art on topical and conflicting environmental issues, including a political positioning of a scientific association. Those articles will be usually invited, but suggestions of topics are welcomed and will be discussed with the editors. Those articles can be long (e.g. 5,000 words, plus 300-words abstract, graphical abstract, 5 figures/tables/boxes, 50 references) and should present highlights (a short collection of bullet points that convey the core findings of the article and should be submitted in a separate editable file in the online submission system). These papers may be published as supplementary issue in a bilingual version (when necessary).

Opinion Papers The aim of this type of manuscript is to combine a brief review of the literature of a research topic (setting the scene) with the personal author?s opinion (based on scientific evidences), stimulating new research ideas, conceptual models or presenting innovative challenges. Manuscripts should be short (~2000 words, abstract with up to 150 words, plus 2-3 figure/table/box, max. 40 references, box with maximum 400 words) and accessible to a wide readership. Those articles will be invited only.

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