Non-volant mammals of Jaru Biological Reserve, Rondônia, Amazon, Brazil

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Keywords: Mastofauna; line transect; camera trap; Programa Monitora; biodiversity; Amazon rainforest.

ABSTRACT – The Amazon is recognized as the largest tropical forest worldwide, being the most biodiverse wildland. However, in several regions of this biome, there are gaps in knowledge about the geographic distribution of the species, described as a Wallacean shortfall. Here, we describe gathered data on the occurrence of mammals recorded in the Amazonian Jaru Biological Reserve, Rondônia, Brazil. Our data is based on the combination of two methodologies over a six-year period, from 2016 to 2022, amounting to 490 km of line-transect censuses and 270 days of camera-trap. The study reveals the significant importance of the reserve, harboring 43 taxa of non-flying mammals, representing over 20% of the species recorded for the state of Rondônia. We highlight the presence of endangered species and emphasize the relevance of the Jaru Biological Reserve as a crucial enclave for biodiversity conservation. Additionally, we discuss the complementarity of different sampling methodologies and address challenges and strategies for the ongoing biodiversity protection in the face of increasing anthropogenic pressures in this portion of the Amazon, which are causing significant reductions in diversity.

Mamíferos não voadores da Reserva Biológica do Jaru, Rondônia, Amazônia, Brasil

Palavras-chave: Mastofauna; transecto linear; armadilha fotográfica; Programa Monitora; biodiversidade; floresta Amazônica.

RESUMO – A Amazônia é reconhecida como a maior floresta tropical do mundo, sendo a área selvagem com maior biodiversidade. No entanto, em várias regiões deste bioma, existem lacunas no conhecimento sobre a distribuição geográfica das espécies, descrita como lacuna Wallaceana. Aqui, descrevemos dados sobre a ocorrência de mamíferos registrados na Reserva Biológica Amazônica de Jaru, Rondônia, Brasil. Nossos dados são baseados na combinação de duas metodologias ao longo de um período de seis anos, de 2016 a 2022, totalizando 490 km de censos de transecto linear e 270 dias de armadilha fotográfica. O estudo revela a importância significativa da reserva, abrigando 43 táxons de mamíferos não voadores, representando mais de 20% das espécies registradas para estado de Rondônia. Destacamos a presença de espécies ameaçadas de extinção e enfatizamos a relevância da Reserva Biológica do Jaru como um enclave crucial para a conservação da biodiversidade. Além disso, discutimos a complementaridade de diferentes metodologias de amostragem e abordamos desafios e estratégias para a proteção contínua da biodiversidade diante das crescentes pressões antrópicas nessa porção da Amazônia, que estão causando reduções significativas na diversidade.

Mamíferos no voladores de la Reserva Biológica Jaru, Rondônia, Amazonas, Brasil

Palabras clave: Mastofauna; transecto lineal; cámara trampa; programa de monitoreo; biodiversidad; selva amazónica.

RESUMEN – La Amazonía es reconocida como el bosque tropical más grande del mundo, siendo la zona silvestre con mayor biodiversidad. Sin embargo, en varias regiones de este bioma, existen lagunas en el conocimiento sobre la distribución geográfica de las especies, conocidas como la brecha de Wallace. Aquí describimos datos sobre la presencia de mamíferos registrados en la Reserva Biológica Amazónica Jaru, Rondônia, Brasil. Nuestros datos se basan en una combinación de dos metodologías durante un período de seis años, de 2016 a 2022, con un total de 490 km de censos de transectos lineales y 270 días de trampas cámaras. El estudio revela la importante importancia de la reserva, que alberga 43 taxones de mamíferos no voladores, que representan más del 20% de las especies registradas para el estado de Rondônia. Destacamos la presencia de especies en peligro de extinción y enfatizamos la relevancia de la Reserva Biológica Jaru como un enclave crucial para la conservación de la biodiversidad. Además, discutimos la complementariedad de diferentes metodologías de muestreo y abordamos desafíos y estrategias para la protección continua de la biodiversidad ante la creciente presión antropogénica en esta región de la Amazonía, que está causando reducciones significativas en la diversidad.

Introduction

The Amazon is recognized as the largest expanse of tropical forest globally and one of the most biodiverse [1]. Furthermore, it plays a pivotal role in maintaining global balance, with the capacity to sequester approximately 20% of the total carbon found in forests worldwide [2]. Its extension in Brazil encompasses approximately 49.5% of the entire national territory, spanning the states of Acre, Amapá, Amazonas, Pará, Rondônia, Roraima, Tocantins, and Mato Grosso [3].

Over the past five decades, a considerable portion of the original configuration of this forest has been modified due to elevated deforestation rates [4]. Various other chronic anthropogenic impacts,

such as habitat loss, overhunting, and forest fires, also pose threats to this tropical forest, affecting ecosystem processes and services [5][6]. Protected areas have been established as a mechanism to slow down biodiversity loss and the decline of ecological functions [7][8]. Historically, the state of Rondônia, situated within the Amazon, implemented the Rondônia Agricultural and Forestry Plan (Planafloro) in 1990, contributing to the creation of protected areas in its territory [9]. However, the effectiveness of a protected area relies on its legal status, as well as management and enforcement actions [10].

With the aim of generating qualified information about the biodiversity of protected areas, particularly conservation units (CUs), the Monitoring Program (Programa Monitora) was established. This program was instituted by Normative Instruction ICMBio n. 3/2017 and reformulated by Normative Instruction ICMBio n. 2/2022. Currently, over 100 CUs across different biomes in Brazil are included in the program. The program employs a standardized, cost-effective, and operationally efficient protocol, emphasizing the involvement of local stakeholders and facilitating the sharing of analyses and collective interpretation of results. One of the primaries focuses of the Monitora Program is the assessment of medium and large-sized mammalian fauna. Among the animal species, mammals play a crucial role as umbrella species in conservation, encompassing various taxonomic groups [11]. They are essential components for ecosystem functioning, contributing to herbivory, seed dispersal, predation on seeds, vertebrates, and invertebrates [12]. Additionally, they are identified as key elements in the carbon and nitrogen cycles [13][14].

In Rondônia, studies have identified the occurrence of 185 mammal species, with research conducted across the three hydrographic basins (Madeira, Mamoré, and Guaporé) [15][16]. Despite the growing empirical evidence, Linnean gaps (unknown species) and Wallacean gaps (unknown distributions and extinctions) persist in the region [17][18]. Concerning conservation units within this Northern Brazilian state, information regarding mammal species richness published in articles is absent, limited to grey literature, and constrained to their management plans, which are not available for all areas. The current state of knowledge about the mammalian fauna in the state has been primarily concentrated on surveys conducted on private properties [19][20][21]. Recent studies in Rondônia indicate that the distribution patterns of mammals are not yet fully elucidated, with continual expansions of distribution [22][23][24][25], the description of new species [26][27], and concentrated inventories with significant gaps in research [28][29][18]. Therefore, inventories are essential to contribute to our understanding of the distribution of the state's mammalian fauna.

The objective of this study is to compile and integrate data on the occurrence of mammals recorded in the Jaru Biological Reserve (REBIO Jaru) in Rondônia, Brazil. In addition, we conducted an assessment of the relevance of REBIO Jaru in the conservation of the primate *Mico nigriceps*, a species that is almost threatened with global extinction [41]. The analysis will focus on assessing their significance in the context of biodiversity conservation in the region and associated ecosystems. The aim is to aggregate information to support the development of strategies for the conservation of species in the area, particularly addressing extinction threats.

Material and Methods

The study was conducted in the REBIO Jaru, located in the municipality of Ji-Paraná, Rondônia, Brazil (Figure 1). This Federal Full Protection Reserve was established by Decree n. 83,716 on July 11, 1979. REBIO Jaru covers an area of 346,864.20 ha, preserving the virtually untouched Amazon biome. The reserve exhibits various phytophysiognomies, including open forest, Cerrado patches, rocky formations, and lacustrine areas [30]. The prevailing climate is classified as tropical rainforest, characterized as megathermal Aw, with two well-defined seasons: a dry season from May to October and a rainy season from November to April, with an annual precipitation of approximately 1,962 mm and an average annual temperature of 26°C [31]. The Ji-Paraná or Machado River extends along its Northeast and Southwest boundaries, while to the South, REBIO Jaru shares a border with the Indigenous Land Igarapé Lourdes.

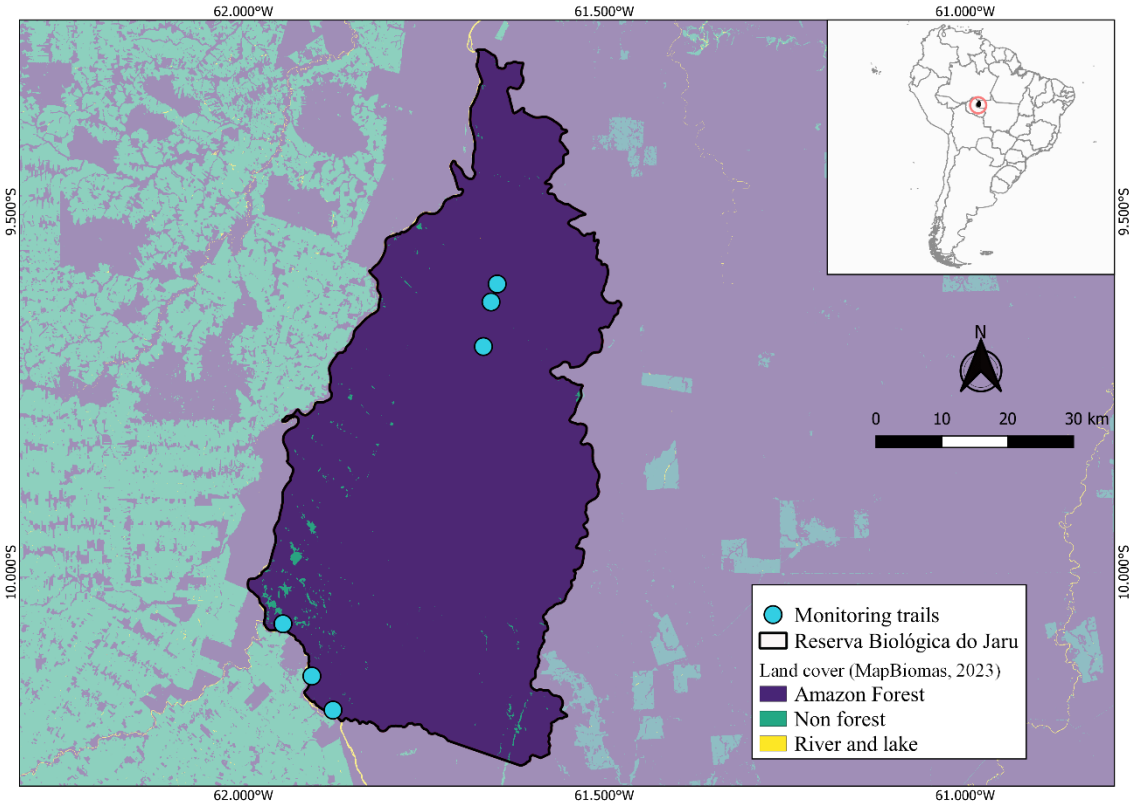

Figure 1 – Location of the Jaru Biological Reserve, Rondônia, Amazon, Brazil. The blue circles indicate the trails monitored to detect mammal species.

According to the management plan for REBIO Jaru, the presence of 31 mammal taxa is documented, including felids such as *Panthera onca*, *Puma concolor*, and *Leopardus pardalis*. Additionally, the plan highlights other species with varying degrees of threat and extinction risk, such as *Priodontes maximus*, *Pteronura brasiliensis*, and *Myrmecophaga tridactyla* [30]. However, the management plan does not present a consolidated list of all species occurring within the protected area's boundaries. The principal threats to REBIO Jaru include deforestation and habitat fragmentation in its surroundings, water pollution, the establishment of hydroelectric plants in the region, the presence of exotic species in its vicinity, hunting and predatory fishing, as well as mineral exploitation [30].

We conducted species monitoring over a six-year period (from 2016 to 2022) along six existing trails within the protected area, ranging from 1 to 5 km in length. Between 2016 and 2021, samplings were carried out by the National Biodiversity Monitoring Program (Programa Monitora) using the line-transect censuses [32]. In this method, two researchers traversed the trail during two distinct periods: from 06:00 to 11:00 hours and from 13:00 to 18:00 hours. A total of 98 sampling days were obtained on 5 km trails within REBIO Jaru, amounting to 490 km of line-transect censuses. As a complementary methodology, in June 2022, we installed nine camera traps (Bushnell low glow, 24 MP) along three trails, baited with salt to enhance mammal species detection. These were positioned approximately 50 cm above the ground, configured to record 10-second videos with a 5-second interval between detections. All cameras were placed at a minimum distance of 500 m from each other [33]. The camera traps were active for 30 days, totaling 270 camera-trap nights.

For the current study, we adhered to the nomenclature proposed by [34], except for the genus *Plecturocebus*, for which we followed [35], *Leontocebus* as per [36], and *Passalites* as recently validated by [37]. To determine the species of *Dasyprocta* present in the area, we followed the distribution proposed by [38]. For the species within the genus *Dasypus*, we followed the taxonomic revision proposed by [39] and considered morphological aspects described by [40]. To assess the extinction threat level for each species, we referred to the IUCN

Red List of Threatened Species version 2025-1 [41] and the Biodiversity Extinction Risk Assessment System, known as SALVE (Sistema de Avaliação do Risco de Extinção da Biodiversidade) [42].

To quantify the role of the REBIO Jaru as a habitat of high biological diversity, we analyzed the proportion of documented species within the protected area in relation to the faunistic richness observed across the entire territory of the state of Rondônia. This assessment was based on information provided by the Biodiversity Conservation State Assessment System [42]. Additionally, we calculated the proportion of the protected area (346,729 ha) in relation to the total extent of the state of Rondônia (23,764,602.00 ha), considering specific habitat categories of Natural Areas (14,657,233 ha) and Forest Formation (13,829. 956 ha) based on information provided free of charge by the MapBiomas Initiative [43]. Furthermore, we conducted an assessment of the relevance of REBIO Jaru in the conservation of the species *Mico nigriceps*, whose geographical distribution spans an area of 6,560,166 ha, according to the geographic range provided by the Centro Nacional de Pesquisa e Conservação de Primatas Brasileiros [44].

Results

We sampled 44 non-volant mammal taxa, covering eight orders and 18 families (Table 1), representing 24.44% of the 180 described non-volant mammal species in the state of Rondônia. The most recorded orders were Carnivora (N = 13), Primates (N = 10), and Rodentia (N = 5). Concerning the 18 families, the number of detected species was distributed relatively evenly, however, Felidae stood out as the most expressive.

We recorded eleven species classified as threatened with extinction according to the Biodiversity Extinction Risk Assessment System [42] and nine globally threatened species according to the IUCN Red List [41]. A total of three species had insufficient data according to both national and global lists (Table 1).

Table 1 – List of mammal species recorded in the Jaru Biological Reserve, located in the municipality of Ji-Paraná, Rondônia, Brazil, and their respective conservation status according to the Biodiversity Extinction Risk Assessment System [42] and the International Union for Conservation of Nature Red List [41]. Abbreviations: DD = data deficient; EN = endangered; LC = least concern; NT = near threatened; VU = vulnerable.

Taxa	Popular name	Method	Threat status	
			ICMBio (2025)	IUCN (2025)
Didelphimorphia				
Didelphidae				
Didelphis marsupialis Linnaeus, 1758	Opossum	Cam trap	LC	LC
Marmosa sp. Gray, 1821	Opossum	Cam trap	-	-
Metachirus nudicaudatus (É. Geoffroy St.-Hilaire, 1803)	Opossum	Cam trap	LC	LC
Cingulata				
Dasypodidae				
Dasypus (Dasypus) novemcinctus Linnaeus, 1758	Nine-banded Armadillo	Cam trap	LC	LC
Dasypus (Hyperoambon) beniensis Lönnberg, 1942	Greater Long-nosed Armadillo	Cam trap	LC	-
Chlamyphoridae				
Cabassous unicinctus (Linnaeus, 1758)	Southern Naked-Tailed Armadillo	Line-transect	LC	LC
Priodontes maximus (Kerr, 1792)	Giant Armadillo	Cam trap	VU	VU

Pilosa				
Megalonychidae				
Choloepus sp. (Linnaeus, 1758)	Two-toed Sloth	Line-transect	-	-
Myrmecophagidae				
Myrmecophaga tridactyla Linnaeus, 1758	Giant Anteater	Line-transect	VU	VU
Tamandua tetradactyla (Linnaeus, 1758)	Southern Tamandua	Line-transect/Cam trap	LC	LC
Primates				
Atelidae				
Alouatta puruensis Lönnberg, 1941	Purús Red Howler Monkey	Line-transect	-	VU
Ateles chamek (Humboldt, 1812)	Black-faced Black Spider Monkey	Line-transect	VU	EN
Lagothrix lagotrhicha cana (Humboldt, 1812)	Common Woolly Monkey	Line-transect	-	EN
Cebidae				
Aotus nigriceps Dollman, 1909	Black-headed Night Monkey	Line-transect	LC	LC
Mico nigriceps (Ferrari & Lopes, 1992)	Black-headed Marmoset	Line-transect	LC	NT
Saimiri ustus (I. Geoffroy St.-Hilaire, 1843)	Golden-backed Squirrel Monkey	Line-transect	LC	NT
Sapajus apella (Linnaeus, 1758)	Black-capped Capuchin	Line-transect	LC	LC
Pitheciidae				
Chiropotes albinasus (I. Geoffroy St.-Hilaire & Deville, 1848)	White-nosed Saki	Line-transect	LC	VU
Pithecia irrorata Gray, 1842	Gray's Bald-faced Saki	Line-transect	LC	DD
Plecturocebus bernhardi M. Roomalen, T. Roosmalen & Mittermeier, 2002	Prince Bernhard's Titi Monkey	Line-transect	LC	LC
Rodentia				
Caviidae				
Hydrochoerus hydrochaeris Linnaeus, 1766	Capybara	Cam trap	LC	LC
Cuniculidae				
Cuniculus paca Linnaeus, 1766	Paca	Cam trap	LC	LC
Dasyproctidae				
Dasyprocta variegata Tschudi, 1845	Agouti	Line-transect/ Cam trap	-	DD
Erethizontidae				
Coendou (Coendou) longicaudatus Daudin, 1802	Porcupine	Line-transect	LC	-
Sciuridae				
Hadrosciurus spadiceus (Olfers, 1818)	Squirrel	Line-transect	LC	LC

Carnivora				
Canidae				
Atelocynus microtis (Sclater, 1883)	Short-eared Dog	Line-transect/ Cam trap	VU	NT
Cerdocyon thous (Linnaeus, 1766)	Crab-eating Fox	Line-transect	LC	LC
Speothos venaticus (Lund, 1842)	Bush Dog	Line-transect	VU	NT
Mustelidae				
Eira barbara (Linnaeus, 1758)	Tayra	Line-transect	LC	LC
Lontra longicaudis (Olfers, 1818)	Neotropical Otter	Line-transect	LC	NT
Pteronura brasiliensis (Zimmermann, 1780)	Giant Otter	Line-transect	VU	EN
Procyonidae				
Nasua nasua (Linnaeus, 1766)	South American Coati	Line-transect	LC	LC
Procyon cancrivorus Cuvier, 1798	Crab-eating Raccoon	Line-transect/ Cam trap	LC	LC
Felidae				
Herpailurus yagouaroundi (É. Geoffroy Saint-Hilaire, 1803)	Jaguarundi	Line-transect	VU	LC
Leopardus pardalis (Linnaeus, 1758)	Ocelot	Cam trap	LC	LC
Leopardus wiedii (Schinz, 1821)	Margay	Line-transect	VU	NT
Puma concolor (Linnaeus, 1771)	Puma	Cam trap	NT	LC
Panthera onca (Linnaeus, 1758)	Jaguar	Line-transect/ Cam trap	VU	NT
Perissodactyla				
Tapiriidae				
Tapirus terrestris (Linnaeus, 1758)	Tapir	Line-transect/ Cam trap	VU	VU
Cetartiodactyla				
Cervidae				
Mazama americana (Erxleben, 1777)	Red Brocket	Cam trap	DD	DD
Passalites nemorivagus (Cuvier, 1817)	Amazonian Brown Brocket	Cam trap	DD	LC
Tayassuidae				
Dicotyles tajacu (Linnaeus, 1758)	Collared Peccary	Line-transect/ Cam trap	LC	LC
Tayassu pecari (Link, 1795)	White-lipped Peccary	Line-transect/ Cam trap	VU	VU

We observed that 23 species (53.48%) were exclusively detected using the line-transect censuses (Figure 2), twelve species (27.90%) only through camera traps (Figure 3), and eight species (18.60%) using both methodologies. The REBIO Jaru accounts for 1.45% of the territory of the state of Rondônia. This protected area represents 2.36% of Natural Areas habitats and 2.50% of Forest Formation in the state of Rondônia. Additionally, we identified that the reserve encompasses 5.28% of the occurrence area of the primate species *Mico nigriceps*.

Figure 2 – Some primates' species recorded in current study by line-transect censuses: A = *Pithecia irrorata* Gray, 1842; B = *Chiropotes albinasus* (I. Geoffroy St.-Hilaire & Deville, 1848); C = *Ateles chamek* (Humboldt, 1812); D = *Lagothrix lagotricha cana* (Humboldt, 1812); E = *Plecturocebus bernhardi* M. Roomalen, T. Roosmalen & Mittermeier, 2002; F= *Alouatta seniculus puruensis* Lönnberg, 1941.

Figure 3 – Some mammal species recorded during camera trap sampling: A = *Tapirus terrestris* (Linnaeus, 1758); B = *Dicotyles tajacu* (Linnaeus, 1758); C = *Dasyprocta variegata* Tschudi, 1845; D = *Cuniculus paca* Linnaeus, 1766; E = *Panthera onca* (Linnaeus, 1758); F = *Atelocynus microtis* (Sclater, 1883).

Discussion

With 43 mammal taxa, this study highlights the significance of the REBIO Jaru as a crucial enclave for the conservation of non-volant mammal biodiversity. The protected area harbors over one-fifth of the mammal species recorded for the state of Rondônia. The high diversity in REBIO Jaru may be explained by its proximity to other protected areas, such as the Igarapé Lourdes Indigenous Land, which borders it to the south. Eleven species were classified as endangered by the Brazilian Red List [42], and eight globally threatened species [41] were documented. Among these species, we emphasize the notable role of REBIO Jaru in the conservation of *M. nigriceps*, considering that the protected area is one of the few existing within the geographical distribution of this Amazonian primate [23]. Rare and elusive species were also recorded, such as *Atelocynus microtis*, one of the least studied canid species globally [45].

The diverse distribution of species among different orders and families demonstrates the complexity of ecological niches within the REBIO Jaru. The prevalence of well-represented orders, such as Carnivora, Primates, and Rodentia, suggests a wide variety of behaviours and ecological functions. In general, protected areas with lower anthropogenic pressures maintain more diverse mammal assemblages, while unprotected areas tend to be depauperate and defaunated [12], as is the case with REBIO Jaru [16]. In this portion of the Amazon, vertebrate diversity has been reduced due to the combined effects of landscape and habitat variables, while REBIO Jaru acts as an important remnant [16]. Large mammals, especially carnivores, require extensive areas to seek prey [46]. The availability of prey, such as rodents and Tayassuidae, plays a crucial role in the ecology of top predator chains [47], potentially reducing the likelihood of predation on livestock near the protected area [48]. Larger remnants exhibit more complex interaction networks and retain greater functionality than smaller fragments [49]. Therefore, they are crucial for maintaining ecosystem health, preventing the collapse of essential ecological processes such as herbivory, seed dispersal, and predation [50][51][52].

The use of different sampling methodologies has revealed valuable insights into the occurrence of mammal species in a significant remnant. Monitoring projects, such as the Program Monitora, provide useful information to address these biogeographic sampling gaps [54]. The exclusive detection of many species by different methodologies (Table 1) underscores the importance of methodological complementarity in tropical forests, aiming for a more comprehensive understanding of the non-volant mammal community in the protected area. Primate species were exclusively detected using the line-transect censuses, which is expected as this method is efficient in detecting this group but may also occasionally provide data on terrestrial species [16][55][33]. In contrast, camera traps provided detections of terrestrial species rarely observed during on-foot surveys along line-transect census, such as felids [56]. Thus, the combination of these methods represents potential tools to enhance our knowledge of species and promote biodiversity conservation goals (e.g., [16][33][57]).

In the context of biodiversity conservation, the results also underscore the importance of REBIO Jaru in relation to its relative size compared to the state of Rondônia and its contribution to the protection of Natural Habitats and Forest Formation areas. A growing body of evidence has demonstrated high rates of biological depletion in Amazonian regions [5][16], triggering detrimental effects on ecosystem functioning [50]. In this regard, based on this extensive dataset of mammal assemblages, we highlight the value of REBIO Jaru in harbouring high levels of species, especially carnivores and ungulates, which have historically faced extinction [58]. However, challenges persist in ensuring species protection and preventing the collapse of ecological processes in the face of chronic anthropogenic impacts [54]. Greater efforts should be directed toward biodiversity monitoring using diverse methodologies to investigate new biological processes. Additionally, effective control of illegal anthropogenic activities (such as fires and deforestation), observable through satellite imagery, is crucial to prevent biodiversity impoverishment and improve conservation prospects.

Conclusion

The REBIO Jaru plays a crucial role in mammal conservation in Rondônia, harbouring approximately one-third of the species described for the state. This protected area stands out as a vital refuge for the preservation of Amazonian mammals in the face of increasing anthropogenic pressures in its surrounding areas. The high species richness recorded highlights this area as a priority for the conservation species, especially medium and large mammals. We recommend the continuation of monitoring and ecological studies to unveil more substantial information about the area's effectiveness and its importance in a macroecological

context, involving the landscape as a modulator of occurrence. Through the efforts revealed in this study, we have revealed information that can support more effective conservation strategies aimed at protecting biodiversity, especially those threatened with extinction.

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