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Thematic Review

Understanding distribution and survey gaps of Mammals from the Atlantic Forest and Cerrado Biomes

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Abstract: The Atlantic Forest and Cerrado (Brazilian Savannah) contain a large number of endemic species and high species diversity, particularly for medium and large-bodied mammals. However, there is no large-scale assessment of these animals and their spatial distribution. Our study synthesises the literature on medium and large-bodied mammal surveys in the Cerrado and Atlantic Forest to provide insights into their distributions across large spatial scales and identify knowledge gaps to guide future research. We synthesised papers published in three databases, focusing on mammals weighing more than 1kg. Of the 84 papers we found, the majority (57.14%) were on mammals in the Atlantic Forest, while 42.85% were on mammals found in the Cerrado. We gathered records for 116 species, the most common of which were *Cerdocyon thous* (Linnaeus, 1766), *Procyon cancrivorus* (Cuvier, 1798) and *Chrysocyon brachyurus* (Illiger, 1815) (Cerrado); *Dasypus novemcinctus* (Linnaeus, 1758), *Cerdocyon thous* (Linnaeus, 1766) and *Nasua nasua* (Linnaeus, 1766; Atlantic Forest). Our study allowed us to access, for the first time in the Atlantic Forest and Cerrado, the information available about medium and large-bodied mammals. We also highlight important sampling gaps, especially concerning the northern parts of both biomes that we need to address, as well as the differences in density of sampling points that are caused by a smaller concentration of sampling efforts in the Atlantic Forest than what we found in Cerrado. As a consequence, larger extensions of Cerrado present knowledge gaps concerning mammal surveys that need to be investigated in future research.
***Keywords*:** *Conservation Biology; Mammals field sampling; Knowledge synthesis; literature review; secondary data.*

Compreendendo Lacunas na Distribuição e Amostragem de Mamíferos dos Biomas da Mata Atlântica e Cerrado

Resumo: A Mata Atlântica e o Cerrado brasileiro abrigam uma enorme quantidade de espécies endêmicas e alta diversidade de espécies, especialmente de mamíferos de médio e grande porte. No entanto, não há uma avaliação em larga escala desses animais e de sua distribuição espacial. Nosso estudo sintetiza a literatura sobre levantamentos de mamíferos de médio e grande porte no Cerrado e na Mata Atlântica, com o objetivo de fornecer informações sobre suas distribuições em larga escala e identificar lacunas no conhecimento para guiar futuras pesquisas. Sintetizamos artigos publicados em três bases de dados, com foco em mamíferos com peso superior a 1 kg. Dos 84 artigos encontrados, a maioria (57,14%) tratava de mamíferos na Mata Atlântica, enquanto 42,85% abordavam mamíferos encontrados no Cerrado. Coletamos registros para 116 espécies, sendo as mais comuns *Cerdocyon thous* (Linnaeus, 1766), *Procyon cancrivorus* (Cuvier, 1798) e *Chrysocyon brachyurus* (Illiger, 1815) (Cerrado); *Dasypus novemcinctus* (Linnaeus, 1758), *Cerdocyon thous* (Linnaeus, 1766) e *Nasua nasua (Linnaeus, 1766;* Mata Atlântica). Nosso estudo também mostra as lacunas no levantamento especialmente em relação às

distribuições ao norte dos biomas, que precisam ser resolvidas, assim como a diferença na densidade de pontos que é causada pela menor concentração de amostragens na Mata Atlântica do que o que encontramos no Cerrado. Como consequência, existem largas extensões do Cerrado que apresentam lacunas no levantamento de mamíferos que precisam ser investigados em pesquisas futuras.

Palavras-chave: *Levantamento de mamíferos; síntese do conhecimento; biologia da conservação; revisão de literature; dados secundários.*

Introduction

Human activities are triggering a cascade of intense modifications in natural habitats, mostly due to selective suppression and the exploratory pressure on natural habitats during the development and expansion of the agricultural frontiers. Agricultural expansion and anthropogenic climate changes are the main factors affecting the terrestrial biota in the XXI century (Cowie et al. 2022). The long-term effects of human expansion are drastic, and directly impact biodiversity, contributing to species loss. These impacts are so extreme that they are being called "Anthropocene defaunation" (Bogoni et al. 2016), as they lead to local extinctions and the fragmentation of natural environments . Some biodiversity groups, such as mammal communities, are more sensitive to those changes, which impact directly on their size, species richness, and viability of natural communities (Galetti et al. 2017). On the other hand, drastic climatic changes has persistent effects on mammal communities such as increased viral transmission risks (Carlson et al., 2022), loss of the ability to maintain their metabolic needs under hot climate (da Silva et al., 2023) and ultimately death due to temperatures rising above mammal's physiological limits (Sherwood & Huber, 2010). This scenario will lead to changes in mammal distribution, switching to areas where they are less vulnerable (e.g. upper montane, higher latitudes; Lenoir & Svenning, 2015).

Medium and large-bodied mammals are an example of natural communities that are suffering drastic consequences due to the suppression of their natural habitats, including reduced genetic diversity (Lino et al. 2019), decreases in species richness (Bogoni et al. 2016), limitations in species interactions (*e.g.* predator-prey; Teckentrup et al. 2019), and restrictions in foraging areas (Buchmann et al. 2012). Mammals' species loss also triggers the depletion of ecosystem services that are essential to the environment (Estes et al. 2011) , disrupting seed dispersal and predation mechanisms, which in turn affects the regeneration of degraded areas and trophic control of herbivory (Galetti et al. 2015, Norbury et al. 2013, Wilkie et al. 2011). To limit these impacts, we need accurate information about the spatial distribution patterns of medium and large-bodied mammals, but our current knowledge of mammal distributions in Brazil is fragmentary and concentrated in local surveys based on samplings carried out at smaller scale, which tends to be incomplete (Costa et al. 2005). Without knowing which species inhabit a certain area, it is virtually impossible to plan conservation policies, especially because many species that are critically endangered or near extinction are not being sampled or remain sub-sampled (Clare et al. 2017). In addition, the lack of standardization across existing mammal surveys poses a challenge to develop *a posteriori* studies to analyse general patterns (*e.g.* meta-analyses, literature reviews, data papers; Clare et al. 2017) that can answer broader ecological questions, test hypothesis and subside effective public policies (Bergallo et al. 2021).

Specifically in Brazil, the decline in mammal population due to human activity and the uncertainty about spatially explicit information are concerning. Furthermore, despite being a megadiverse country and having some of the most biodiverse biomes in the world, only the Amazon biome is significantly occupied by Protected Areas, exposing the high degree of vulnerability of the other biomes that are not as well protected (Pacheco et al. 2018). Moreover, the Atlantic Forest and Cerrado (Brazilian Savannah) biomes have particularly high species diversity, with several endemic mammal species that are at risk of extinction, which classifies those biomes as *hotspots* for biodiversity conservation (Mittermeier et al. 2005, Myers et al. 2000). Nevertheless, the Atlantic Forest has lost most of its natural vegetation since the start of the country's colonial period in the 1500s (Galindo-Leal & Câmara 2003), and the expansion of the agricultural frontier is now reaching the central portion of the country, where the Cerrado biome is located, leading to constant economic pressure on both biomes (Boyd et al. 2008, Dias 2008, Ribeiro et al. 2009, SOSMA e INPE 2016).

The scarcity of synthesised information on mammal distribution patterns in the Atlantic Forest and Cerrado is hindering research efforts to understand the impact of human activities on mammal biodiversity in these biomes. This scarcity of information not only makes it difficult to create guidelines and public policies for the protection of mammals in these biodiversity hotspots but also burdens decision-makers who lack an evidence-based approach to create strategic conservation policies (Sutherland et al. 2004). To our knowledge, there are no studies to date that synthesise the state of the knowledge about medium and large-bodied mammals in the Atlantic Forest and Cerrado. Our study aims to fill this gap by synthesising published papers on the diversity of mammals in those biomes. The overarching objectives of our study are to: 1) understand how surveys of medium and large-bodied mammals are distributed in the Atlantic Forest and Cerrado; 2) provide information on undersampled areas or species and identify priorities for future mammal surveys; 3) provide an overview concerning the species richness patterns for the Atlantic Forest and Cerrado.

Material and Methods

1. Study areas

Our study focused on two distinct biomes: Atlantic Forest and Cerrado, which correspond to a total area of 3.146.630 km², approximately 40% of the territory in Brazil (IBGE 2019; Figure 1). The Atlantic Forest is the third largest biome in Brazil, with an area of approximately 1.110.182 km² (15% of Brazil's territory), encompassing the states of Santa Catarina, Parana, Mato Grosso do Sul, Sao Paulo,

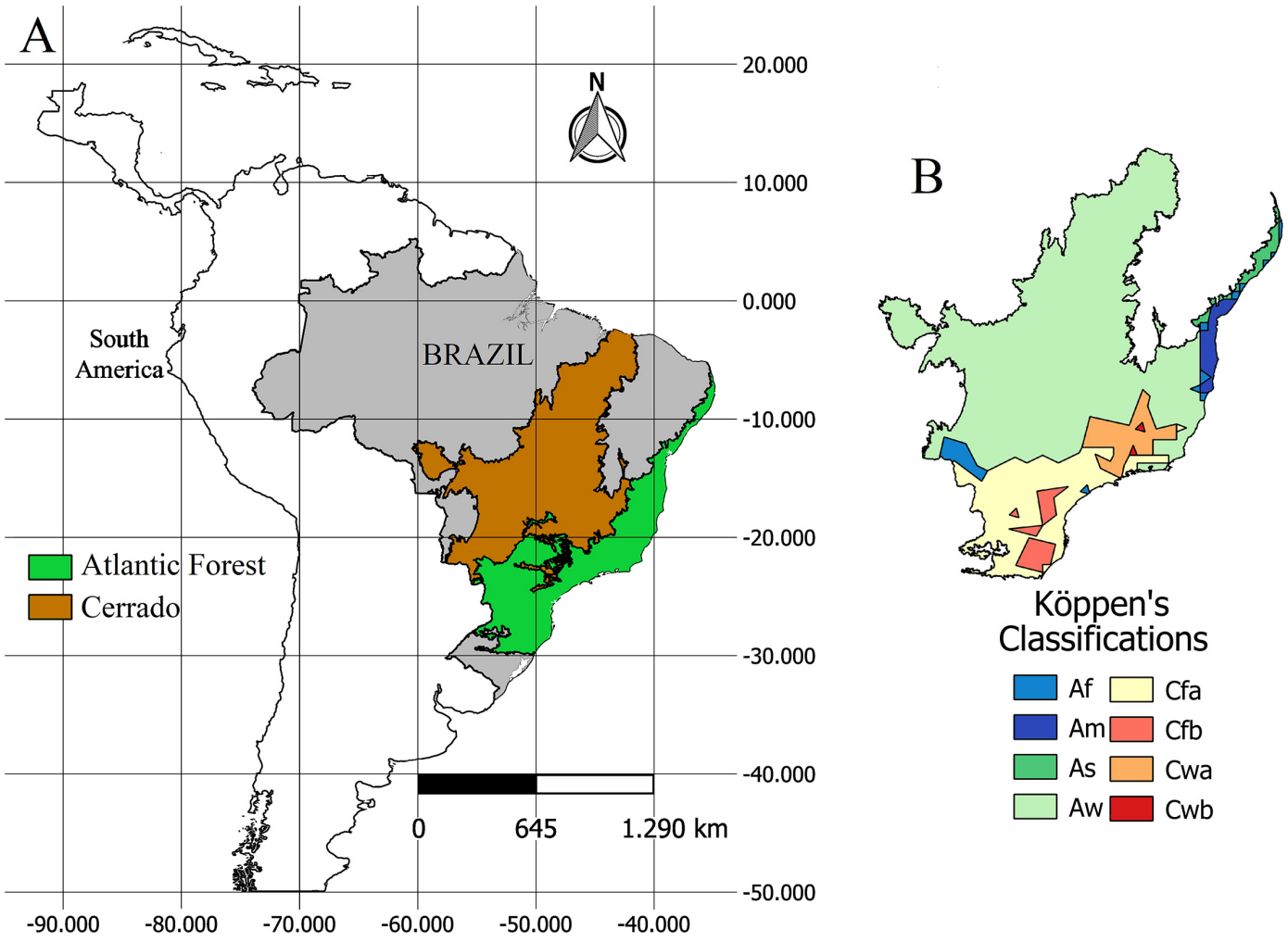

Figure 1. Geographical location of the study areas. A) Map of the limits of the biomes Atlantic Forest and Cerrado. B) Representation of the respective Köppen classification of the climate for the limits of both biomes (KOTTEK, 2006).

Rio de Janeiro and Espirito Santo, and also areas along the coastline such as Sergipe, Alagoas, Pernambuco, Paraíba, and Rio Grande do Norte (IBGE 2019).

As the Atlantic Forest occurs over a wide latitudinal range and is also the second-largest tropical forest in South America (Castuera-Oliveira et al. 2020), the variation in the climate is high across regions. In the southernmost part of the biome, the climate can be classified as *Cfa* (warm temperate, humid with hot summers); in the eastern portion of Minas Gerais and Espirito Santo it can be classified as *Aw* (Equatorial savannah climate with dry winters) and along the northeastern coastline it is classified as *As* (Equatorial savannah climate with dry summers; Kottek et al. 2006; Figure 1).

The Cerrado is the second largest biome in Brazil in terms of area (approximately 2,036,448 km²), and encompasses the States of Distrito Federal, part of Maranhao, Goias, Minas Gerais, Mato Grosso do Sul and Tocantins, and also minor parts of the States Bahia, Sao Paulo, Mato Grosso and Piaui (IBGE 2019). This biome is classified as *Aw* according to Köppen – Equatorial savannah climate with dry winters (Kottek et al. 2006), mean annual precipitation of 1300 to 1600 mm and rainfall lower than 60 mm during the winters. The mean annual temperature is 18ºC, with a maximum temperature of 30ºC and a minimum of 8ºC (Figure 1).

2. *Data sampling and analysis*

To extensively gather the available information about medium and large mammals in the Atlantic Forest and Cerrado, we searched for papers focusing on animals with a body mass > 1 kg (Figure 2). We searched three databases: *Scopus*, *Web of Science* and *Google scholar* using the keywords: “Mammals” AND “Species Richness” OR “Survey” AND “Atlantic Forest” OR “Cerrado”. To maximise the results of our search we also rearranged the order of the keywords and searched the keywords both in English and Portuguese. After the first search, we found 2000 papers on the topic, which we filtered based on information presented in both their title and abstracts (Figure 2). We excluded papers that were not about medium and large-size mammals (n = 1425), and papers describing studies that were not conducted in the biomes of interest (n = 491). We then compiled the following information from the remaining 84 papers: i) the number of independent sampling points, ii) when the study was carried out, iii) which species

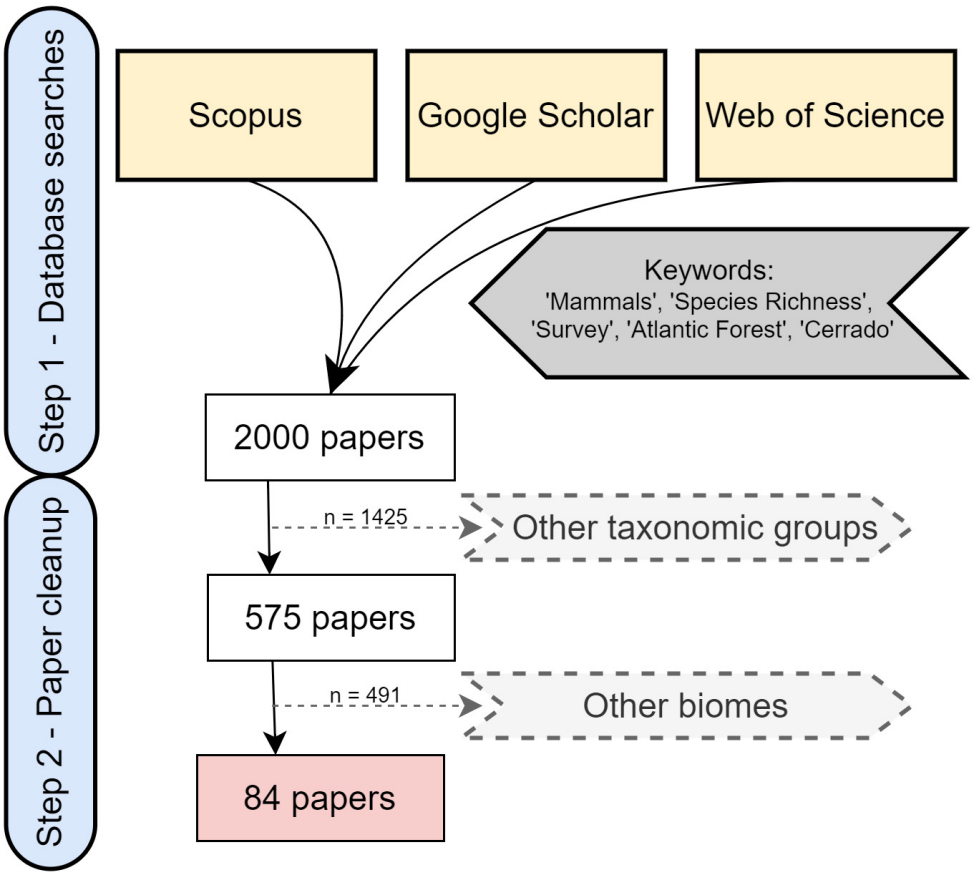

Figure 2. PRISMA Flow diagram depicting the methodology used on the initial search and the reasons that led to the exclusion of papers. Continuous lines represent the direction flow of the research and the dotted lines are the exclusion points showing the reason for the exclusion and the number of papers excluded.

were sampled, and iv) the conservation status of each species, based on the IUCN list. In order to preserve all relevant information from the original surveys, this paper includes data on all species of small mammals (<1 kg), that were accidentally sampled within the medium and large-bodied sampling design. We deemed it important to acknowledge the accidental sampling of smaller mammals, as it was documented in the original papers even though those species were not the focus of our original search.

To compare species richness between biomes and identify undersampled areas, we calculated the species richness and calculated the estimated species richness with the Chao 2 index, to compare the effect of the sampling we built rarefaction curves (Mao Tau) on both biomes based on the increment of the number of sampling points and the number of papers. The Chao 2 index and rarefaction curves were built using the package *vegan* v.2.5–7 (Oksanen et al. 2016) in the program R v.4.0.4 (R Development Team 2022), using the RStudio interface (RStudio Team 2022).

To show the distribution patterns of the sampling points, we conducted a Kernel density estimation analysis on QGis v.3.22.3 (QGIS Association 2021) with the density analysis plugin. The process of density estimation consisted of rasterizing the sampling points' information for each biome into rasters of 2 km cell size, then smoothed the spatial patterns with a Quartic Kernel of a radius of 20 km. We choose a cell size of 2 km based on the assumption of minimal distance between independent surveys that states that surveys will be independent when at least 2 km apart from one another (Srbek-Araujo & Chiarello 2013, 2007). The 20 km radius for the kernel was defined to better capture the fine-scale variation and identify the spatial concentration of sampling points, if the sampling efforts were even or distributed by chance there would be no concentration of the density of sampling points.

Results

1. *Species richness, survey distributions and gaps across Atlantic Forest and Cerrado*

We found 84 papers that sampled 116 species of medium and large mammals in the biomes of interest (Table S1). There were more papers that described survey studies of mammals in the Atlantic Forest than in the Cerrado (48 papers and 38 papers, respectively). There was also a greater number of sampling areas in the Atlantic Forest (279 – with 8 of them in Argentina) compared to Cerrado (250 – all in Brazil). The majority of sampling points in the Atlantic Forest were in Sao Paulo (64), Santa Catarina (27) and Minas Gerais (27), while Paraiba, Sergipe and Rio Grande do Norte had the lowest number of sampling points (4, 2 and 1, respectively). There were no areas in the Atlantic Forest with zero surveys. The majority of sampling points in the Cerrado

were in Minas Gerais (116), Mato Grosso do Sul (62) and Goias (51), while the states with the lowest number of sampling points were Mato Grosso (6), Tocantins (2), Distrito Federal (2), Piaui (1) and Bahia (1). There's a gap in surveys concerning the Cerrado areas in Bahia, Rondonia, Maranhao and Para states. Across all studies, the Atlantic Forest had a higher species richness (Observed richness: 104 species, Chao2 estimated richness: 103 ± 6 species, with an average of 12 species per sampling point) than the Cerrado (Observed richness: 93 species, Chao 2 estimated richness: 92 ± 7 species, with an average of 10 species per sampling point). This pattern is also apparent in the rarefaction curve, which shows a greater increment in the number of species with increasing sampling effort, based on either the number of papers or the total number of sampling points (Figure 3). However, neither rarefaction curve reached an asymptote, indicating that some mammal species are yet to be detected in both biomes and the extrapolation of sampling effort with the rarefaction curve showed that increasing the sampling effort in Cerrado could increase the number of sampled species. This trend of the extrapolated species richness is more evident when looking at the number of papers as the sampling units (Figure 3 – B) than the one shown when comparing the sampling points (Figure 3 – A), but both curves show that an increase in sampling effort could lead to higher species richness in Cerrado, diminishing the differences between the latter and Atlantic Forest.

The spatial distribution of studies differed between the Cerrado and the Atlantic Forest (Figure 4). Most studies were grouped in the south of the Cerrado biome, close to the border with the Atlantic Forest. In addition, there were several clear gaps in the coverage of studies in the Cerrado, representing areas for which we found no published surveys. The areas lacking mammal surveys were mostly located in the northern parts of the Cerrado, encompassing the States of Maranhão, Piaui and Tocantins, the central portion of Goias and next to the frontiers of the States Mato Grosso and Rondonia. By contrast, the States of Mato Grosso do Sul, Minas Gerais and Distrito Federal had the highest concentration of studies about mammals in the Cerrado region, most of which were widely spread across the region.

The studies of mammals in the Atlantic Forest were more uniformly distributed than in the Cerrado, but there were nonetheless some areas with a low concentration of sampling units, such as the northeast region of Minas Gerais State, the countryside of Bahia and North of Parana (Figure 4). In the northeastern distribution of the Atlantic Forest, we found surveys in the states of Paraiba and Pernambuco, being least frequent in Sergipe and Rio Grande do Norte. The coastline region of the state of Alagoas and the northern part of Bahia show a notable scarcity of surveys, which contributes to the data gap in this area (Figure 4).

2. *Common species and conservation status*

In the Atlantic Forest, a total of 104 species were surveyed (Table S1), of which the most common were: *Dasypus novemcinctus* (Linnaeus, 1758; found in 203 locations and 42 papers), *Cerdocyon thous* (Linnaeus, 1766; 170 locations and 44 papers) and *Nasua nasua* (Linnaeus, 1766; 163 locations and 35 papers) . The least common species were *Sapajus xanthosternos* (Wied-Neuwied, 1826), *Ozotoceros bezoarticus* (Linnaeus, 1758) and *Metachirus nudicaudatus* (É. Geoffroy, 1803) found in only one sampling location and one paper each.

In the Cerrado, 93 species had been surveyed in total (Table S1), of which the most common were *Cerdocyon thous* (Linnaeus, 1766; present in 162 locations and 34 papers), *Procyon cancrivorus (Cuvier, 1798;* 131 locations and 34 papers) and *Chrysocyon brachyurus* (Illiger, 1815; 127 locations and 29 papers). The least common species were *Tolypeutes matacus* (Desmarest, 1804), *Speothos venaticus* (Lund, 1842) and *Sciurus aestuans* (Linnaeus, 1766), which were found in one sampling location and one paper each.

Across both biomes, 66 species were classified as Least Concern (LC), 12 as Near Threatened (NT), 15 as Vulnerable (VU), five as Endangered (EN) and four as Critically Endangered (CR; Table S1). Three species were classified as Data Deficient (DD) and nine are considered exotic or invasive in the Brazilian territory (Table S2). In the Atlantic Forest, there were 51 species classified as Least Concern, nine as Near Threatened, 15 as Vulnerable, four as Endangered and four as Critically Endangered. In Cerrado, there were 48 species classified as Least Concern, 11 as Near Threatened, eight as Vulnerable, three as Endangered and zero species classified as Critically Endangered.

Discussion

To our knowledge, this is the first study to provide an overview of the available knowledge on survey studies and the occurrences of neotropical medium and large-bodied mammals in the Atlantic Forest and Cerrado biomes. By assessing the spatial distribution of the data regarding mammals surveys, we highlight coverage gaps and priority areas to be sampled in future studies. Our results demonstrate a clear difference in the sampling coverage between biomes, with a higher number of papers and, as a consequence, a higher number of sampling points, in the Atlantic Forest compared to Cerrado. The discrepancy in sampling effort between biomes could partly contribute to the higher total number of species surveyed in the Atlantic Forest. However, the rarefaction curves indicate that both biomes may be undersampled (Chao et al. 2014), showing that there is a greater data deficiency on mammals in the Cerrado and a smaller data deficiency in the Atlantic Forest, which systematic large-scale coordinated surveys should ideally address.

In addition, much of the sampling effort in the Cerrado was concentrated in the southern region of the biome, near the ecotonal region with the Atlantic Forest. We identified extensive areas of the biome for which we have no information about mammal species, such as the states of Maranhão, Piauí and Bahia which have a large percentage of land in Cerrado but present the lowest density of sampling points (Figure 4), the states of Tocantins, Goiás and Mato Grosso all have only had 3 sampling points each. These states represent approximately 69% of the area of Cerrado but have only 25% of the sampling points (65 out of 250 points) that we found. However, the same pattern cannot be observed in the Atlantic Forest biome showing an even distribution of surveys across the entirety of the biome with smaller gaps in Sergipe, Alagoas and Bahia states in northeastern Brazil, and the interior of the state of Paraná, that still have some extension of areas with no published papers.

Our results indicate that medium and large-bodied mammal species richness may follow the same patterns as those found for other taxonomic groups, with higher values for the Atlantic Forest when compared to Cerrado (Costa et al. 2005, Paglia et al. 2012). The Atlantic Forest presents greater diversity and endemism rates, a pattern that is intrinsically different from those found in the other biomes, except for the Amazon Forest (Costa et al. 2005). However, the Cerrado displays lower species richness than expected based on the extension of the biome

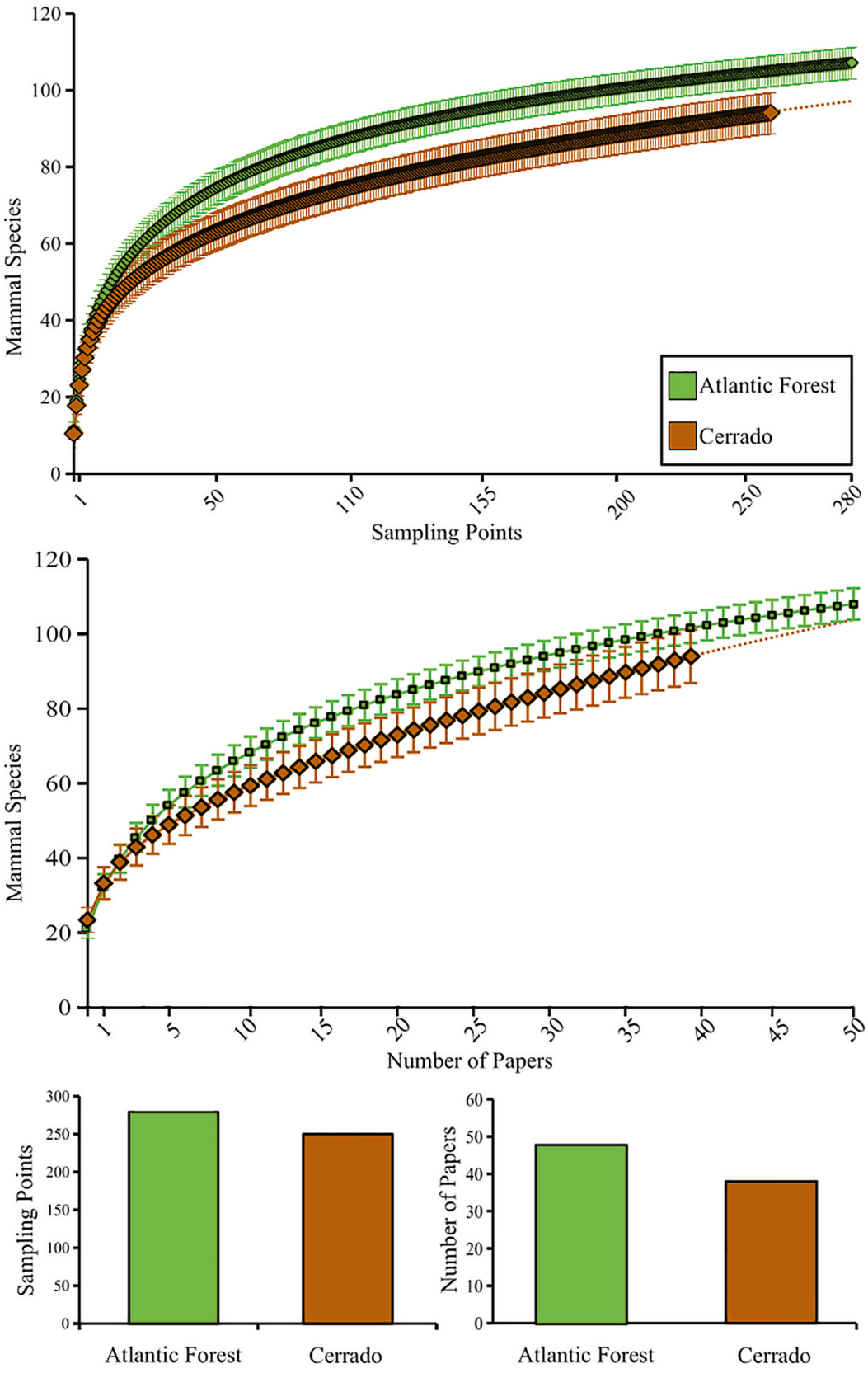

Figure 3. Summary of sampling effort of survey papers, the Atlantic Forest is shown in green and the Cerrado information is shown in brown, the dashed line represents the extrapolation of sampling efforts to account for the differences in sampling efforts between biomes. A) Rarefaction curve estimating the species richness varying by the number of sampling points. B) Rarefaction curve estimating species richness varying by the number of papers by biome. C) Total number of sampling points by biomes. D) Total number of published papers by biomes.

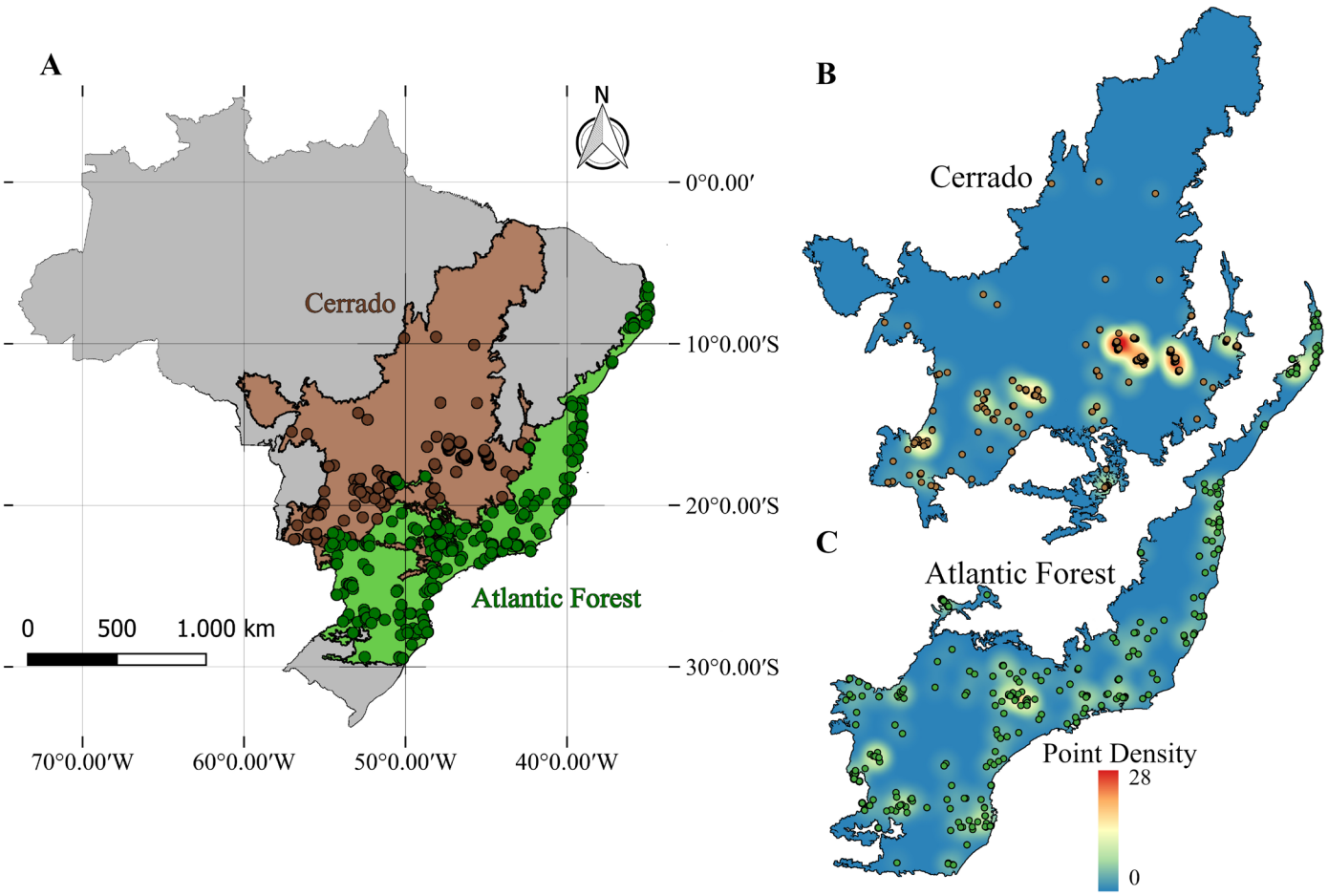

Figure 4. Spatial distribution of the sampling points for medium and large-bodied mammals (body mass >1 kg) in the Atlantic Forest (green) and Cerrado (brown) biomes, based on a literature search in the "Scopus", "Web of Science" and " Google Scholar" databases). A) Each circle represents an independent sampling point. B) Sampling density estimation in Cerrado Biome. C) Sampling density estimation in the Atlantic Forest biome. Both estimations were calculated using a raster image of the biome limits with a 2 km cell size and kernel density estimation with a 20 km radius.

(Costa et al. 2005, Fonseca et al. 1999). Although the same patterns of distribution and species richness between biomes can be found for other taxonomic groups, such as birds (Jenkins et al. 2015), plants (Castuera-Oliveira et al. 2020) and other mammal groups (Costa et al. 2005), our study indicates that lower species diversity in the Cerrado might be partly attributed to the lower sampling effort and large gaps in survey coverage. For example, it is striking that the southern region of the Cerrado, with the highest number of species, is also the area with the highest density of sampling points (Figure 4). Expanding survey coverage to other areas of the Cerrado is likely to result in revised species distribution maps and new species records for medium and large-bodied mammals. The differences in sampling effort and concentration between biomes, can also affect the rarity of found species since differences in sampling methodology and sampling efforts can be correlated with sampling success of species, especially rare species (Chao et al. 2014; Lima et al. 2017).

Another factor that could be important to explain the differences between species distribution and species richness patterns for both biomes is the local climate (Erwin 2009). Firstly, climate may affect species distribution by determining the primary production of a given area, and therefore influence the amount of energy available in the system (Boucher-Lalonde et al. 2013, Hawkins et al. 2003). In this sense, environments with higher primary productivity can support higher species richness (Brun et al. 2019, Craven et al. 2020, Gorczynski et al. 2021), which could partially indicate why the Atlantic Forest is more diverse when compared to the Cerrado (Delgado et al. 2018). Secondly, the climate can influence species richness patterns by acting as a selective filter, which contributes to the entrance or exclusion of a given species within the system (da Mata et al. 2017, Erwin 2009, Guisan & Rahbek 2011). Biomes with higher climatic variations, such as the Atlantic Forest, are able to harbour higher species richness because it provide a greater range of climatic niches, and thus increase the chances for a given species to find locations with a suitable climate (Graham et al. 2006, Hua & Wiens 2013). Finally, the higher numbers of species richness in the Atlantic Forest could also be explained due to greater historic climatic stability over the past years, compared to the Cerrado (Werneck et al. 2012).

Despite the potential role of climate in explaining the differences in mammal diversity between the Atlantic Forest and the Cerrado, to firmly establish the links between environmental variables and

species richness, our study indicates that we first need to increase the sampling efforts in those areas of the Cerrado that are underrepresented in existing surveys (Figure 3). A greater sampling effort could not only contribute to our knowledge of mammal species richness in the Cerrado but also clarify the role of climate or other variables in determining species distributions, as the influence of environmental variables varies depending on the scale analysed (Brun et al. 2019, Craven et al. 2020). Projects that aim to boost the compilation of unpublished data, such as the Atlantic Datasets, which compiles information on Atlantic Forest biodiversity (Gonçalves et al. 2018, Lima et al. 2017, Souza et al. 2019), are important to ensure that specialists can contribute with information for a wider range of taxa (Nagy-Reis et al. 2020, Souza et al. 2019, Santos et al. 2019). We call for a coordinated effort for the Cerrado biome to accurately assess mammal diversity and the real threat level the biome is facing. This requires addressing the gaps in survey coverage and sampling effort, especially in the northern distribution of Cerrado but also in the northeastern part of Atlantic Forest and interior areas of the Paraná state. Ideally, this effort should be carried out through standardised methodology, which could inform future conservation plans and policy decisions that can be truly effective and contribute to future research that aims to synthesise the knowledge on biodiversity (Clare et al. 2017, Costa & Magnusson 2010, Sutherland et al. 2004).

Supplementary Material

The following online material is available for this article:

Table S1 – Papers that sampled medium and large mammals in Cerrado and Atlantic Forest biomes. The table contains an ID for each research paper, the amount of sampling points and the resumed citation for the paper (Author – Year – Tittle).

Table S2 – Specific information about all species of medium and large mammals that were sampled in the studied papers, the conservation status on Brazil of each species according ICMBIO classification (DD – Data Deficient, VU – Vulnerable, NT – Near Threatened, EN – Endangered and CR – Critically Endangered; Invasive – if the species is not originally from that biome or location.). We also present the sampling points where the species were sampled and the specific paper ID where they were sampled is presented within parenthesis.

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Author Contributions

Luciano Carramaschi de Alagão Querido: Conceptualization; Data curation; Methodology; Writing – original draft; Writing – review & editing.

Aretha Franklin Guimaraes: Data curation; Writing – original draft; Writing – review & editing.

Clarissa Rosa: Data curation; Writing – review & editing.

Emma J. Sayer: Project Administration; Writing – original draft; Writing – review & editing.

Marcelo Passamani: Conceptualization; Data curation; Methodology; Project Administration; Writing – original draft; Writing – review & editing.

Conflicts of Interest

The author(s) declare(s) that they have no conflict of interest related to the publication of this manuscript

Ethics

This study did not involve human beings and/or clinical trials that should be approved by one Institutional Committee.

Data Availability

Supporting data are available at <https://doi.org/10.48331/scielodata.9MQWW3>.

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