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Original Article

Harvestmen Fauna (Arachnida: Opiliones) in a Conservation Unit in Cerrado, Parque Nacional Grande Sertão Veredas, Brazil

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Resumo: (Fauna de opiliões (Arachnida) em uma Unidade de Conservação no Cerrado, Parque Nacional Grande Sertão Veredas, Brasil): O Cerrado compreende cerca de 24% do território brasileiro e abriga uma rica biodiversidade com alta taxa de endemismo, entretanto, estima-se que apenas 8% deste bioma esteja protegido por Unidades de Conservação. Soma-se a isso a crescente redução da área do Cerrado devido ao desmatamento para pecuária e monoculturas, e as poucas informações acerca de muitos táxons, como por exemplo o dos opiliões, aracnídeos que reciclam nutrientes e desempenham importante papel nas cadeias tróficas, pois agem como predadores e presas. Nesse sentido, o objetivo deste estudo foi inventariar pela primeira vez a opiliofauna no Parque Nacional Grande Sertão Veredas (PNGSV), uma das maiores Unidades de Conservação de Cerrado nos estados de Minas Gerais e Bahia, Brasil. O trabalho foi realizado de setembro de 2022 a abril de 2023, no total de 48h de esforço amostral. Foram identificadas 13 espécies para a localidade, sendo a maior riqueza já registrada por estudos de inventários no bioma. As informações apresentadas justificam a necessidade urgente de mais estudos no Cerrado, para conhecer melhor a fauna de opiliões, principalmente em função da perda crescente da área desse bioma; além disso, os dados ratificam a importância do PNGSV para a proteção das comunidades de opiliões no Cerrado mineiro e baiano, e justifica os investimentos públicos para essa UC, que cumpre seu papel proposto de conservação da biota e dos recursos naturais brasileiros.

Palavras-chave: Biodiversidade, inventário, Opiliones, conservação.

Abstract The Cerrado comprises about 24% of the Brazilian territory and harbors rich biodiversity with a high rate of endemism. However, it is estimated that only 8% of this biome is protected by Conservation Units. Adding to this is the ongoing reduction of the Cerrado area due to deforestation for livestock and monocultures, and the limited information on many taxa, such as opiliones, arachnids that recycle nutrients and play an important role in food chains, acting as both predators and prey. In this context, the aim of this study was to inventory for the first time the opiliofauna in the Grande Sertão Veredas National Park (PNGSV), one of the largest Conservation Units in the Cerrado in the states of Minas Gerais and Bahia, Brazil. The work was conducted from September 2022 to April 2023, totaling 48 hours of sampling effort. Thirteen species were identified for the locality, representing the highest richness ever recorded by inventory studies in the biome. The information presented justifies the urgent need for more studies in the Cerrado to better understand the opilionid fauna, especially due to the increasing loss of the biome's area. Additionally, the data confirm the importance of the PNGSV for the protection of opilionid communities in the Cerrado of Minas Gerais and Bahia states, justifying public investments in this Conservation Unit, which fulfills its proposed role in conserving the Brazilian biota and natural resources.

Keywords: Biodiversity, inventory, Opiliones, conservation.

Introduction

The Cerrado, i.e., Brazilian Savanna, is the second-largest biome in the country, covering around 24% of the national territory (Mourão & Lino, 2021; "MMA: Painel unidades de conservação brasileiras", 2023). It encompasses a mosaic of phytophysiognomies, including the Brazilian Savanna, or Cerrado (Cerrado stricto sensu, Campo Cerrado, and Veredas), forest (Gallery Forest, Cerradão and others), and grassland formations (Rocky Grassland, Grassland with shrubs, and Grassland Without shrubs) (Ribeiro & Walter, 1998; Oliveira-Filho, 2006).

The reduction of natural areas by deforestation or the replacement of these areas, mainly driven by increased livestock farming and agriculture, leads to

habitat loss and consequently contributes to the decline of Cerrado biodiversity (Mittermeier et al., 2011; Fines & Curvo, 2019), negatively impacting native fauna and flora. Moreover, many animal species in this biome are endemic and endangered, such as birds, reptiles and insects (Silva, 1997; C. C. Nogueira et al., 2011; ICMBio, 2018; Souza et al., 2020), conditions that have led to the classification of the Cerrado as a global hotspot, making it a priority area for conservation at a global level (Myers et al., 2000; Klink & Machado, 2005).

Despite the significance of the Cerrado, according to ICMBio data (2021), only an estimated 8% of the original area is protected by Conservation Units (UCs), which are considered the primary tool in Brazil for safeguarding natural habitats and maintaining ecosystems (Salvio, 2017). Conservation Units ensure multiple environmental services provided by the biota, such as the ones provided by harvestmen, or opiliones, arachnids that contribute to nutrient cycling (Acosta & Machado, 2007) and are therefore essential parts in many food chains both as predator and prey in different terrestrial ecosystems (Castanho & Pinto-Da-Rocha, 2005; Rubim et al., 2021; Rubim et al., 2021).

In Brazil, there are approximately 1008 described species of harvestmen ("Aracnolab: *A*racnologia MNRJ", 2023), with a significant emphasis on the Mata Atlântica biome, which harbors over half of the Brazilian species (Pinto-Da-Rocha et al., 2005). In this same biome, are concentrated the highest sampling efforts aiming to record these arachnids (Bragagnolo & Pinto-Da-Rocha, 2003; Bragagnolo et al., 2007; L. Resende et al., 2012; L. P. A. Resende et al., 2012; A. d. S. Ferreira et al., 2019; Costa et al., 2020; Gomes et al., 2021; Andrade et al., 2022; Lima et al., 2022; Pádua et al., 2022).

A different scenario unfolds for the Cerrado biome, which lacks inventory studies (Pinto-Da-Rocha et al., 2005; Pinto-Da-Rocha & Carvalho, 2009; Kury et al., 2010; A. Ferreira et al., 2020; Borges, 2021; Lima et al., 2022). This shortfall of studies contributes to the under-sampling of harvestmen in this biome, which justifies research initiatives to better understand their diversity and distribution, especially in areas within Conservation Units. These units require such information to facilitate biodiversity management and conservation efforts (Freitas et al., 2006). Also, organizations that aim evaluating the conservation status of the species such as the International Union for Conservation of Nature (IUCN) and the Brazilian Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio) depends on distributional data to perform accurate assessments for the species.

In this context, the main goal of this study was to conduct an inventory of the harvestmen fauna within the Parque Nacional Grande Sertão Veredas (PNGSV), one of the largest Cerrado reserves spanning the states of Minas Gerais and Bahia, Brazil.

Material and Methods

The study was conducted within the Parque Nacional Grande Sertão Veredas (PNGSV) (15°6'S, 45°48'W), encompassing the municipalities of Chapada Gaúcha, Formoso, and Arinos in the state of Minas Gerais, as well as Côcos in Bahia, Brazil. This park covers an area of 230,671 hectares and is situated at an altitude ranging from 600 to 900 meters. The landscape is characterized by sandy plateaus covered with Cerrado biome vegetation, including various phytophysiognomies such as Cerrado stricto sensu (Brazilian Savannah), Cerradão, Vereda, Gallery Forest, Campo Sujo (grasslands with scattered shrubs), Campo Limpo (grasslands without scattered shrubs) (IBAMA et al., 2003; Ribeiro & Walter, 1998).

The climate of the region is tropical, with subhumid conditions, and an average annual temperature of approximately 23°C, ranging from maximum temperatures of 37°C to 40°C and minimum temperatures between 16°C and 19°C (Funatura 2003). The dry season occurs during winter, from May to September/October, while the rainy season takes place during summer, from November to March. The average annual precipitation is around 1,400 mm (IBAMA et al., 2003).

The sampling campaigns took place during the months of September and November 2022 (dry season) and February and April 2023 (rainy season). We performed four sampling campaigns in our study (Sept. 2022, Nov. 2022, Feb. 2023 and Apr. 2023), each campaign lasted six days consecutively, resulting in a total of 24 collection days. All sampling sites are within the State of Minas Gerais (cachoeira do Mato Grande, near Carinhanha lodge, rio Preto Gallery Forests, rio Carinhanha Gallery Forest and temporary lagoons, and Córrego da Onça).

The fieldwork was carried out by a team of four researchers. The method employed for capturing the harvestmen involved active searching, using tweezers for collection. The researchers conducted walks along pre-existing trails or roads in areas encompassing Gallery Forests, Campo Sujo (grasslands with scattered shrubs), Campo Limpo (grasslands without scattered shrubs), Veredas, and Cerrado stricto sensu (as shown in Figure 1). The sampling efforts were concentrated between 18:00 and 20:00 hours, a period during which these arachnids are most active (L. Resende et al., 2012). In total, each researcher contributed 48 hours of sampling effort, 192 hours of total sampling effort by the team.

The collected harvestmen were fixed and stored in 70% ethanol; and identified by Dr. Ricardo Pinto da Rocha at the University of São Paulo for identification. Subsequently, they were incorporated into the Biologi-

cal Collection of Social Wasps (CBVS) at the Instituto Federal de Educação, Ciência e Tecnologia do Sul de Minas.

To assess the sampling effort, an accumulation curve was constructed using the observed richness with a 95% confidence interval, utilizing the Bootstrap 1 species estimator in the software EstimateS 9.1.0 (Colwell & Elsensohn, 2014). This estimator considers information from all collected species rather than restricting the analysis only to rare species (A. Santos, 2003). The study was authorized by SISBIO license No. 83294-1.

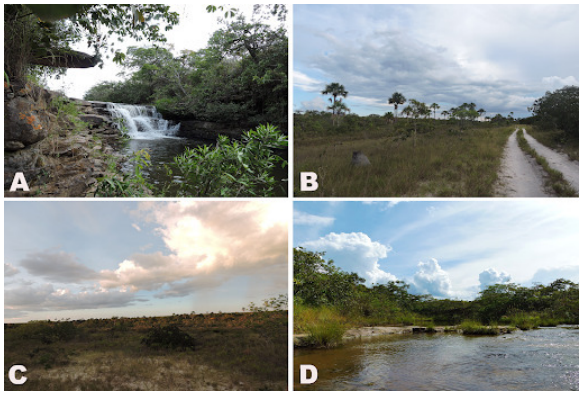


Figure 1: Sampling areas of the harvestmen community in Parque Nacional Grande Sertão Veredas, Minas Gerais and Bahia, Brazil. **A, D.**Gallery Forest. **B.** Veredas and Campo Limpo (grasslands without scattered shrubs). **C.** Campo Sujo (grasslands with scattered shrubs).

Results

A total of 108 specimens from 13 species and morphospecies were collected (Figure 2, belonging to three families: Cosmetidae, Gonyleptidae and Stygnidae. The most abundant species was a probably new genus and species (Figure 2a) with 58 individuals collected and the least abundant was *Discocyrtoides nigricans* (Mello-Leitão, 1922) and *Discocyrtanus pertenuis* (Mello-Leitão, 1935) with one specimen (Table 1).

The estimated species number by the BootStrap1 estimator shows that the harvestmen richness at the PNGSV could reach 15, within the 95% confidence interval of the observed richness (Figure 3).

Discussion

The PNGSV with 13 harvestmen species/morphospecies harbors the highest richness for a locality in the Cerrado biome, which is higher than expected for the whole biome, as suggested by Pinto-Da-Rocha et al. (2005). In their study, they recorded four to seven species per locality in the Cerrado (Pinto-Da-Rocha et al., 2005; A. A. Nogueira et al., 2019), however, their sampling localities were restricted to the State of São Paulo. This result is similar to the observed in other inventory studies, which ranged from two to eight species per sampled locality (Pinto-Da-Rocha et al., 2005; Pinto-Da-Rocha & Carvalho, 2009; Kury et al., 2010; A. Ferreira et al., 2020; Borges, 2021; Lima et al., 2022).

Table 1: Abundance and geographical distribution of harvestmen recorded in the Parque nacional Grande Sertão Veredas. Brazilian States (BA = Bahia; CE= Ceará; DF = Distrito Federal; ES= Espírito Santos; GO= Goiás;MG= Minas Gerais; MS= Mato Grosso do Sul; MT= Mato Grosso; PA= Pará; PB= Paraíba; PE= Pernambuco; SP= São Paulo).

Families	Species and Morphospecies	Abundance	Distribution	References
Gonyleptidae	*Inhuma singularis* B.Soares, 1944	03	BA, GO, MG	Kury et al., 2022
Gonyleptidae	New genus and species	58		
Gonyleptidae	*Discocyrtanus pertenuis* (Mello-Leitão, 1935)	01	Argentina-Missiones; GO, MG, PR, SP	Kury & Carvalho, 2016
Gonyleptidae	*Discocyrtus flavolimbatus* B.Soares, 1944	02	MG, SP	Kury et al., 2018
Gonyleptidae	*Discocyrtoides nigricans* (Mello-Leitão, 1922)	01	MG, SP	Kury, 2019
Gonyleptidae	*Eusarcus aduncus* Mello-Leitão 1942	02	BA, DF, ES, GO, MG	Hara & Pinto-Da-Rocha, 2010
Cosmetidae	*Gryne dimorpha* Mello-Leitão, 1928	02	MG, MS, MT	Kury, 2003
Cosmetidae	*Gryne leprosa* Sørense, 1932	10	BA, CE, ES, MG, PA, PB, PE	Kury, 2003
Cosmetidae	*Metavononoides* sp.	11		
Cosmetidae	gen. sp.	11		
Stygnidae	*Sickesia* sp.	05		
Stygnidae	*Stygnus polyacanthus* (Mello-Leitão 1923)	01	BA, PE	Pinto-Da-Rocha, 1997
Richness		**13 spp.**		
Abundance		**107**		

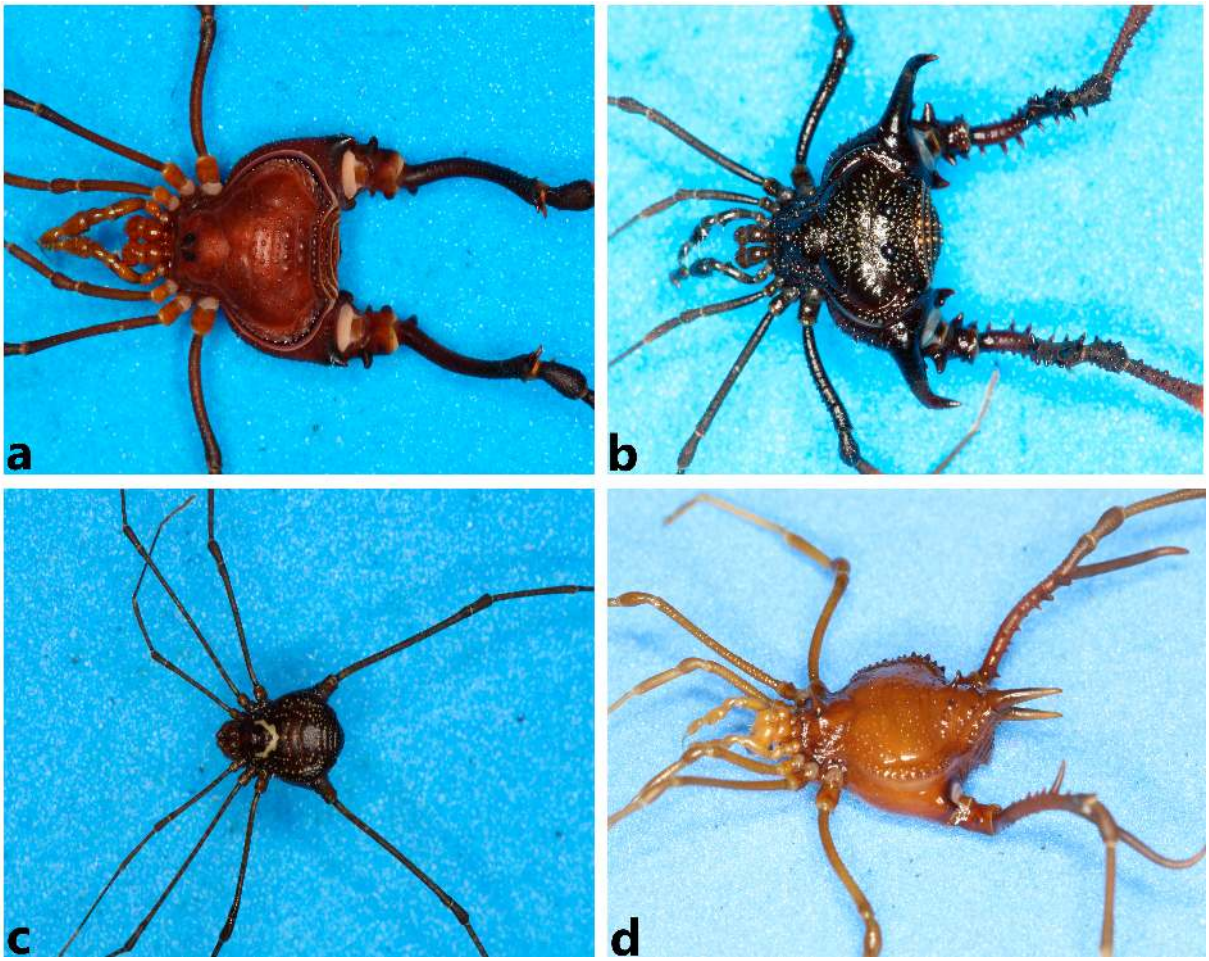


Figure 2: Harvestmen recorded in the PNGSV, Minas Gerais and Bahia, Brazil. **A.** New genus and species, Gonyleptidae. **B.** *Discocyrtus flavolimbatus* B.Soares, 1944. **C.** *Inhuma singularis* B.Soares, 1944. **D.** unidentified Cosmetidae. Photos: R.P. Rocha.

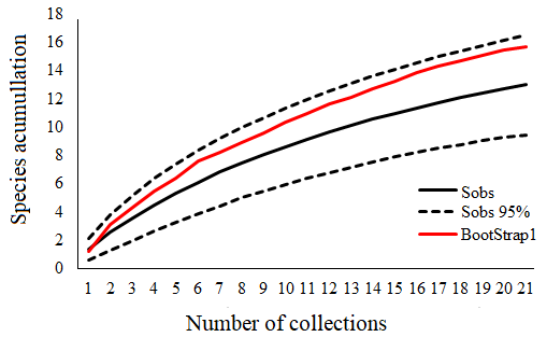


Figure 3: Species accumulation curve for harvestmen collected in the PNGSV using observed species richness (Sobs) within a 95% confidence interval (dotted line), and estimated species richness (Bootstrap 1 - red line).

Although about half of the diversity was properly identified, we can observe the PARNA Grande Sertão Veredas harvestman fauna is made up of widely distributed species. Most species were also recorded in cerrado biome (*Inhuma singularis*, *Discocyrtanus pertenuis*, *Eusarcus aduncus*, *Gryne dimorpha*, *G. leprosa*; and *Styngus polyacanthus*); Atlantic Rain Forest (*Discocyrtanus pertenuis, Discocyrtus flavolimbatus, Discocyrtoides nigricans, Eusarcus aduncus, Stygnus polyacanthus*); also in Amazonian Rain Forest (*Gryne leprosa*); or even in caves (*E. aduncus*). This pattern contrasts with Coastal Atlantic Rainforest opiliofauna, in which most species are endemic to a mountain range (see A. A. Nogueira et al., 2019). Harvestmen seem to be strongly dependent on microclimatic conditions, being adapted to a narrow range of temperature and humidity (Bragagnolo et al., 2007). Santos (2007) studied species from the Atlantic rainforest and concluded that those from coastal areas are more highly vulnerable to water loss than Interior ones.

The species accumulation curve (Figure 3) showed that the richness of the area can reach 15 spp., with 95% reliability, which indicates that sampling of the harvestman community was efficient. The elevated harvestmen richness observed at the PNGSV can be explained by the combination of two conditions: first, the low number of inventories conducted in the Cerrado, which makes estimations of richness uncertain. Thus, harvestmen fauna per locality in this biome is underestimated, and it is observed that the few stud-

ies in the biome were carried out in transition with Caatinga or Atlantic Forest (Figure 4); second, the heterogeneity of phytophysiognomies found in the study area, such as Veredas, Gallery Forest, and Cerradão, which include denser forest formations that likely offer less stressful conditions for opilions, such as shade formation and leaf litter, which could mitigate the water stress to those arachnids (Proud et al., 2012; L. Resende et al., 2012).

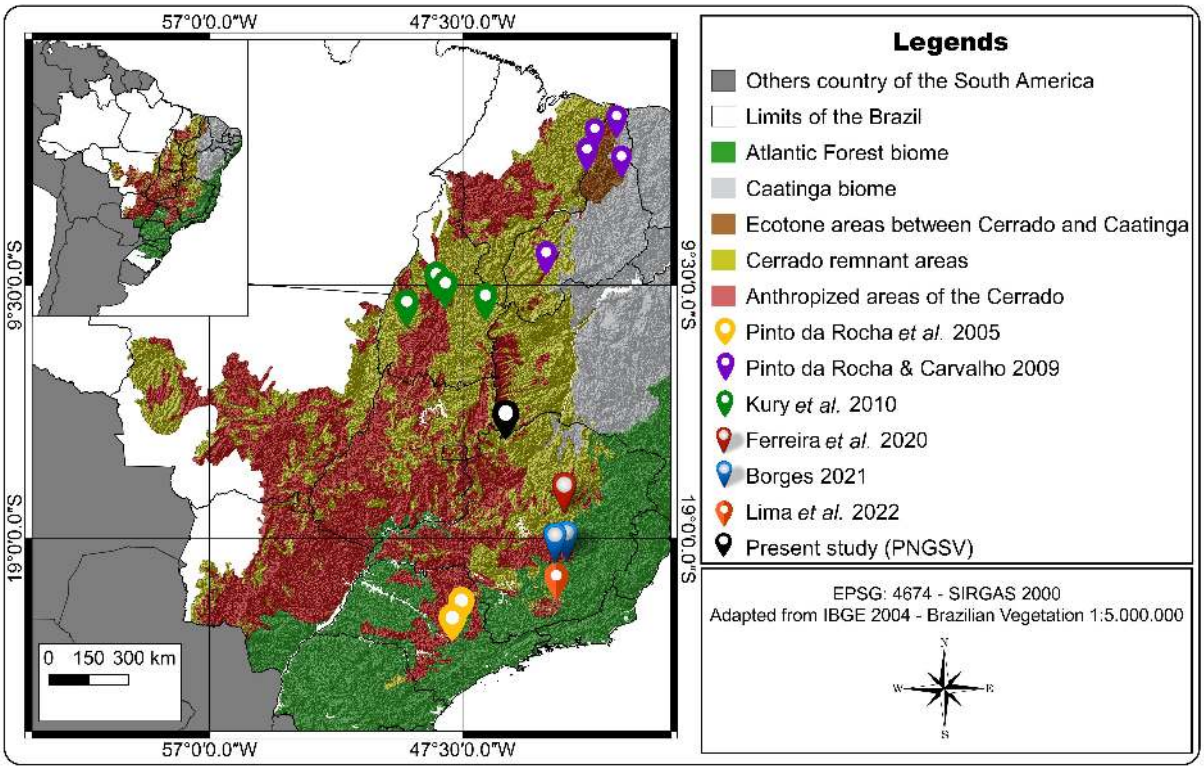


Figure 4: Locations (authors and year of publication of the study) where surveys of harvestmen (Arachnida) inventories were carried out in areas of remnants, anthropic areas and transition from Cerrado to other biomes, no estado de Minas Gerais (A. Ferreira et al., 2020; Borges, 2021; Lima et al., 2022), Piauí (Pinto-Da-Rocha & Carvalho, 2009), São Paulo (Pinto-Da-Rocha et al., 2005) e Tocantins (Kury et al., 2010).

Regarding the harvestmen conservation status in Brazil, the knowledge is still very incipient, as evidenced by the fact that states with large geographical areas and heterogeneous phytophysiognomy, such as Bahia (Moreira & Pigozzo, 2016), Goiás, Maranhão, Mato Grosso, and Mato Grosso do Sul states, do not have inventory studies in their Cerrado areas (Figure 4). Another alarming fact, out of the over 1000 species recorded in Brazil ("Aracnolab: *A*racnologia MNRJ", 2023), only seven have their conservation status evaluated by the ICMBio list, and only two occur in the Cerrado biome ("SALVE: Sistema de Avaliação do Risco de Extinção da Biodiversidade", 2023). International assessment organizations, like the IUCN, have no information about South American opilions, highlighting the lack of data regarding the conservation of opilionids in this region. Additionally, there is no available information on the current conservation status of any of the species recorded in this study. Therefore, our new distributional records add valuable information for future assessments of these species, which are mainly based on the distribution of their populations and their occurrence in conservation areas ("IUCN Red List Categories and Criteria, Version 3.1", 2001).

The ongoing reduction of this biome (Maurano et al., 2019) driven by the advance of agriculture, such as soy cultivation and livestock farming (Rausch et al., 2019), is concerning, especially for species with limited mobility, as is the case with harvestmen (Zampaulo et al., 2007; Siqueira & Radic, 2021). This could put these organisms at risk of extinction. However, due to the scarcity of data on their distribution, a more accurate assessment becomes challenging. Therefore, it is necessary to prioritize inventory studies in the Cerrado, a biome that historically has its biodiversity underestimated (Siqueira & Radic, 2021).

Conclusion

The information hereby presented underscores the urgent need for further studies regarding the harvestmen of the Cerrado biome to better understand its fauna, particularly due to the ongoing area loss of this biome.

Additionally, the data reaffirms the significance of the PNGSV in safeguarding opiliones communities in the Cerrado in states such as Minas Gerais and Bahia. This justification supports public investments in this Conservation Unit, as it fulfills its intended role of conserving Brazil's biodiversity and natural resources.

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