



HARVESTMEN (ARACHNIDA: OPILIONES) RECORDS IN ATLANTIC FOREST REMNANTS OF MINAS GERAIS STATE, BRAZIL

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Abstract: Although the Atlantic Forest harbors the world's greatest diversity of harvestmen (Arachnida: Opiliones), many forest areas remain undersampled or lack comprehensive data. Given the significant degradation experienced by the biome, it becomes crucial to perform faunal inventories of this group across different regions. This study aimed to conduct a survey of harvestmen by rapid sampling forest fragments of a Semideciduous Forest, a type of Atlantic Forest vegetation, in Ouro Fino and Itatiaiuçu, Minas Gerais, Brazil. Harvestmen were collected at night using the active search method. A total of 140 individuals from six species and seven morphospecies were collected, revealing the importance of protecting forest fragments of deforestation. Moreover, the findings indicate that more extensive sampling efforts are needed to accurately assess harvestman richness in these forest fragments, which may be under anthropogenic pressure. Additionally, there is a need for further inventories to better understand the conservation status of harvestmen in Brazil, and further contribute for biodiversity management and conservation.

Keywords: arthropods; inventories; rapid surveys.

The Atlantic Forest is the second largest tropical forest in the Americas (Tabarelli *et al.* 2005) and one of the 36 hotspots of biodiversity in the world (Myers *et al.* 2000). It harbors one of the world's greatest species richness, including many species at risk of extinction and several endemic species belonging to the most diverse taxa, such as plants, amphibians, reptiles, birds, mammals, insects, and arachnids (Myers *et al.* 2000, Rocha *et al.* 2004, Giupponi *et al.* 2017, Vale *et al.* 2018, Souza

et al. 2020). Despite its ecological importance, this biome has been reduced to 23% of its original area (Vancine *et al.* 2024) and is highly fragmented. It is therefore critical to conduct inventory studies on overlooked fauna in these forest remnants, such as harvestmen (Arachnida: Opiliones).

Harvestmen comprise harmless arachnids that are little known to the general public due to their cryptic and nocturnal habits (Pinto-Da-Rocha 1999). With over 6600 described species

(Kury 2023), harvestmen comprise the fourth most diverse order of arachnids, after Acariformes, Parasitiformes, and Aranea (Harvey 2007, Van Dam *et al.* 2018, World Spider Catalog 2023). Their distribution is directly linked to factors such as humidity and temperature (Curtis & Machado 2007, Resende *et al.* 2012a), as they are restricted to humid and less anthropized areas (Bragagnolo *et al.* 2007). Ecologically, harvestmen are important for ecosystem maintenance because they promote nutrient cycling (Moore *et al.* 1991, Acosta & Machado 2007) and play an important role in food chains (Rubim *et al.* 2022).

Approximately 1008 harvestmen species have been recorded in Brazil (Kury 2023). The Atlantic Forest is a noteworthy biome in this regard, known for harboring the highest diversity of harvestmen on the planet (Pinto-Da-Rocha *et al.* 2005). A growing number of studies have been conducted on harvestmen in different biomes in Minas Gerais State, such as the Cerrado, Caatinga, and Atlantic Forest (Ázara *et al.* 2016, Ferreira *et al.* 2019, Ferreira *et al.* 2020, Costa *et al.* 2020, Lima *et al.* 2022, Pádua *et al.* 2022, 2023, Rubim *et al.* 2023). Nevertheless, the harvestman fauna of many regions in the state remains undersampled.

In this study, we carried out a rapid sampling of the harvestman fauna in a fragment associated with a mining area and in a fragment exposed to both unregulated tourism and advanced agricultural activity. The findings are expected to shed light on the occurrence of harvestmen in fragments of a Semideciduous Forest, a phytophysiognomy of the Atlantic Forest, in Ouro Fino and Itatiaiuçu, Minas Gerais State, Brazil.

Sampling was performed in remnants of a Semideciduous Seasonal Forest, a phytophysiognomy belonging to the Atlantic Forest domain (Oliveira Filho 2006). We performed field observations in a forest fragment at the Taboão Waterfall (22°11'03"S 46°25'23"W), Ouro Fino, Southern Minas Gerais State, covering an area of 11.40 ha (Figure 1A). This fragment contains lotic aquatic environments, including streams and waterfalls, along with rocky outcrops and caves within the forest. However, the area is subject to several human activities, such as livestock farming, coffee farming, and unregulated tourism, leading to vegetation trampling and waste accumulation. In Itatiaiuçu (20°12'33"S, 44°23'27"W), we sampled a 40.08 ha fragment (Figure 1B) located more than 4 km away from a mining area. The fragment

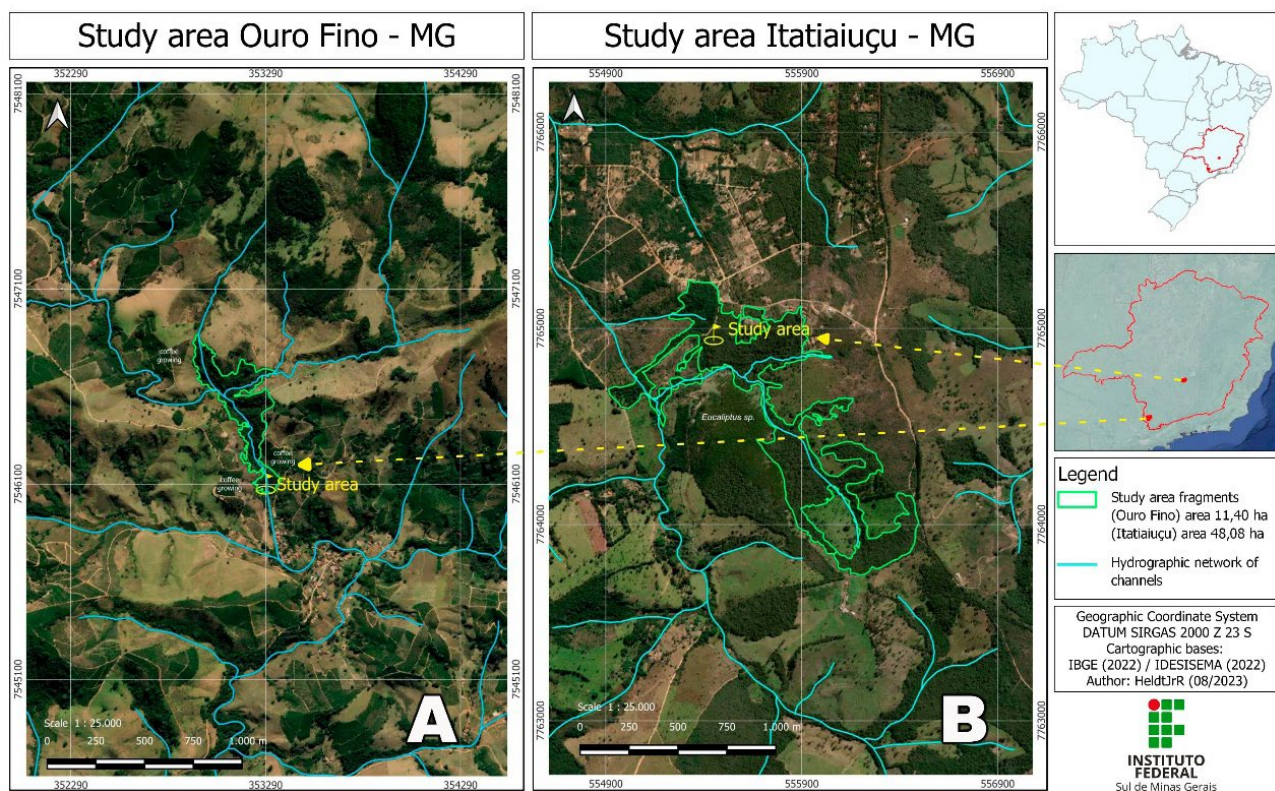


Figure 1. Forest fragments where harvestmen were sampled in Minas Gerais State, Brazil. (A) Forest fragment at the Taboão Waterfall in Ouro Fino (left). (B) Forest fragment in Itatiaiuçu (right).

comprises an ecotone between Atlantic Forest and Cerrado biomes and lies within the buffer zone of the Espinhaço Range Biosphere Reserve, making it a *a priori* area for conservation (IDE-Sisema 2023). ICMBio/SISBio authorization number 91709-1.

At the Taboão Waterfall in Ouro Fino, sampling was conducted over 6 days between April and May 2023, totaling 18 h of sampling effort. In Itatiaiuçu, sampling was performed from December 14th to 16th, 2022, resulting in only 9 h of collection time, due to local issues. In both areas, harvestmen sampling took place from 19:00 to 21:00 h, corresponding to the period of peak activity (Resende *et al.* 2012a). We used the active search method, which involves walking along existing trails within the interior and edges of forest fragments. The search included inspecting leaf litter, rocky crevices, embankments, and the surfaces of logs and leaves.

Specimens were collected, sacrificed, and preserved in 70% ethanol. Then, samples were sent to Dr. Ricardo Pinto da Rocha at the University of São Paulo for identification and subsequent incorporation into the Biological Collection of Social Wasps (CBVS) of the Federal Institute of Education, Science, and Technology of Southern Minas Gerais. For assessment of the sampling effort, a species accumulation curve was constructed using the observed richness at a 95% confidence interval and the Bootstrap 1 estimator. The analysis was conducted using EstimateS software version 9.1.0 (Cowell & Elsensohn 2014).

In total, we recorded 140 specimens belonging to 2 families, 6 species, and 7 morphospecies distributed across the two fragments (Table 1). The most abundant species in the Ouro Fino fragment was *Acutisoma longipes* Roewer, 1913 (Figure 2A), accounting for 33% of the collected specimens. In the Itatiaiuçu fragment, *Mischonyx squalidus* Bertkau, 1880 (Figure 2B) was the most abundant, accounting for 58.3% of the collected specimens.

The high richness and abundance of Gonyleptidae observed in both fragments may be attributed to the prevalence of species from this family in the biome, as reported by Nogueira *et al.* (2019). Therefore, their likelihood of occurrence is high, in agreement with previous studies conducted in the Brazilian Atlantic Forest (Bragagnolo & Pinto-Da-Rocha 2003, Resende *et al.* 2012a, 2012b, Nogueira *et al.* 2019, Ferreira *et al.* 2019, Costa *et al.* 2020).

The presence of *M. squalidus* in both fragments and its higher abundance in the Itatiaiuçu remnant may be attributed to its synanthropic behavior. The species is often recorded in agricultural, urban, and remnant areas that experience anthropogenic pressures, such as the study areas. Its occurrence demonstrates the species' ability to tolerate modified environments (Mestre & Pinto-Da-Rocha 2004, Nogueira *et al.* 2019).

Although four harvestmen species were identified in the forest fragment of Itatiaiuçu, a larger sampling effort is recommended to more accurately assess the occurrence of other species. About 600 species have been recorded in the Atlantic Forest (Pinto-da-Rocha *et al.* 2005), demonstrating not only the abundance of species but also the importance of the Atlantic Forest for this group. Such findings were corroborated by research in analogous environmental settings (Lima *et al.* 2022). Given the substantial mining activity in the region, further investigations are recommended. Mining produces considerable environmental changes, resulting in biodiversity decline, whether through extraction processes or incidents such as tailings dam failures (Pereira *et al.* 2019).

The abundance of *A. longipes* in the Taboão Waterfall fragment can be explained by distinct factors. Firstly, the species has a wide distribution in the Atlantic Forest (DaSilva & Gnaspini 2010). Secondly, it is commonly found in cave-like microhabitats and close to water sources (Machado & Vasconcelos 1998, Machado *et al.* 2000), which occur in the sampled fragment. Moreover, according to Machado *et al.* (2000), the species uses caves or rocky cavities as oviposition sites and typically forms aggregations, which might have facilitated specimen collection.

Despite the anthropogenic pressures that the Taboão Waterfall fragment is currently facing, such as livestock, agriculture, and unregulated tourism, which negatively influence harvestmen richness (Lima *et al.* 2022), the observed richness (Table 1) was expressive in comparison with other studies. Studies using greater sampling efforts in the same phytophysiognomy recorded between 5 and 14 species (Resende *et al.* 2012b, Gomes *et al.* 2021, Lima *et al.* 2022, Rubim *et al.* 2023). In light of the risks and anthropogenic pressures exerted on the Atlantic Forest, further inventory studies are required to monitor biodiversity, even though

Table 1. Number of harvestmen (Opiliones) and overall richness collected in two semideciduous forest fragments at the Taboão Waterfall in Ouro Fino and in Itatiaiuçu, Minas Gerais State.

Family	Species or morphospecies	Itatiaiuçu	Taboão Waterfall
Gonyleptidae	<i>Acutisoma longipes</i> Roewer, 1913	0	42
Gonyleptidae	<i>Mischonyx squalidus</i> Bertkau, 1880	7	14
Gonyleptidae	<i>Discocyrtoides nigricans</i> (Mello-Leitão, 1922)	0	21
Gonyleptidae	<i>Acanthogonyleptes marmoratus</i> (Mello-Leitão, 1940)	0	2
Gonyleptidae	<i>Moreiranula saprophila</i> (Mello-Leitão, 1922)	0	6
Gonyleptidae	<i>Eusarcus hastatus</i> Sørensen, 1884	2	0
Gonyleptidae	Pachylinae sp. 1	2	0
Gonyleptidae	Pachylinae sp. 2	1	0
Gonyleptidae	<i>Discocyrtus</i> sp. 1	0	8
Gonyleptidae	<i>Discocyrtus</i> sp. 2	0	1
Gonyleptidae	<i>Discocyrtus</i> sp. 3	0	16
Gonyleptidae	<i>Discocyrtus</i> sp. 4	0	7
Sclerosomatidae	Gagrellinae	0	1
Richness		4	10
Estimated species richness		4,66	11,18
Abundance		12	128

**Figure 2.** (A) *Acutisoma longipes* Roewer, 1913 recorded in the Taboão Waterfall fragment, Ouro Fino, Minas Gerais State; (B) *Mischonyx squalidus* Bertkau, 1880 collected in a forest fragment in Itatiaiuçu, Minas Gerais State.

the biome is the most thoroughly sampled in the country. This necessity becomes evident by the fact that only seven harvestmen species were evaluated with regard to their conservation status by ICMBio (ICMBio 2023), representing only 0.7% of Brazil's harvestmen fauna. This finding highlights the need for protection measures for these arachnids, which provide numerous environmental services, such as nutrient cycling and other roles in trophic chains (Acosta & Machado 2007, Rubim *et al.* 2022).

Therefore, the lack of data precludes a reliable evaluation of the taxon's extinction risk in Brazil.

Species estimation analysis, performed using the Bootstrap method (Figure 3), showed that species richness could reach 11.18 in the Taboão Waterfall and 4.63 in Itatiaiuçu (95% confidence interval). However, the species accumulation curve (Figure 3) did not stabilize, indicating the need for more extensive sampling in both regions. The aim of this study was to provide preliminary

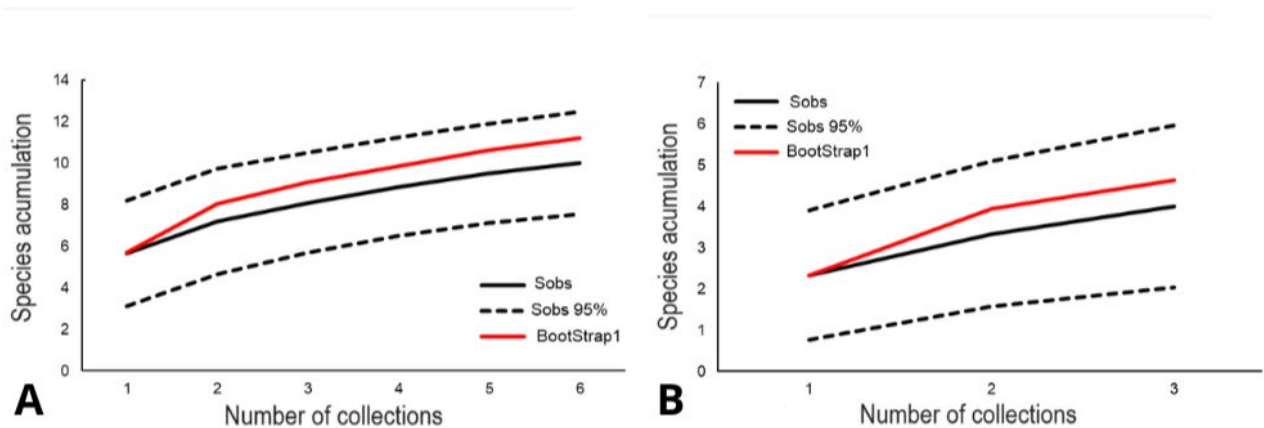


Figure 3. Accumulation curve of harvestman species collected in forest fragments (A) at the Taboão Waterfall in Ouro Fino and (B) in Itatiaiuçu, Minas Gerais State, according to observed species richness (95% confidence interval) and estimated species richness (Bootstrap 1).

findings on the basis of rapid sampling. The results demonstrate that further studies, preferably covering different seasons, are essential for gaining a more accurate view of species richness, particularly in regions where vegetation suppression may affect biodiversity. Nevertheless, our records underscore the significance of protecting the sampled forest fragments, given the variety of anthropogenic pressures they face.

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