Research Article / Artículo de Investigación

Harvestmen (Arachnida: Opiliones) from the Atlantic Forest of the Fernão Dias Environmental Protection Area, southern Minas Gerais, Brazil

Opiliones (Arachnida: Opiliones) de la Mata Atlántica del Área de Protección Ambiental Fernão Dias, sur de Minas Gerais, Brasil

Thiago Henrique dos Reis Pádua[1], Luis Gustavo Talarico Rubim[2], Mateus Aparecido Clemente[3], Ricardo Pinto da Rocha[4], and Marcos Magalhães de Souza[2]

*[1]Laboratório de Taxonomia de Insetos, ESALQ, Universidade de São Paulo, Piracicaba, São Paulo, Brasil. [2]Laboratório de Zoologia, IF, Instituto Federal de Educação, Ciência e Tecnologia do Sul de Minas, Inconfidentes, Minas Gerais, Brasil. [3]Uninassau, Cacoal, Rondônia, Brasil. [4]Laboratório de Aracnologia, USP, Universidade de São Paulo, São Paulo, Brasil. *thiagopadua133@gmail.com*

ZooBank: urn:lsid:zoobank.org:pub:C67A49FB-1E67-42A2-841D-1ACDE47CCC24
https://doi.org/10.35249/rche.49.4.23.21

Abstract. The Atlantic Forest harbors the world's greatest diversity of harvestmen. However, this biome is highly modified and fragmented, negatively impacting biodiversity. Thus, the present study aimed to inventory the harvestmen fauna in the Fernão Dias Environmental Protection Area (Fernão Dias EPA), in southern Minas Gerais state, Brazil. The study was conducted in the municipality of Gonçalves, within the Fernão Dias EPA. Harvestmen sampling took place from October 2019 to March 2020. A total of 265 individuals from 24 species and morphospecies were collected. Reported six new species for the state: *Acanthogonyleptes singularis* (Mello-Leitão, 1935), *Ampheres luteus* (Giltay, 1928), *Meteusarcoides caudatus* (Piza, 1940), *Ogloblinia intermedia* (Soares, 1944), *Megapachylus anomalus* (Mello-Leitão, 1922), and *Gonyleptes pseudogranulatus* (Soares, 1946). This underscores the importance of the Fernão Dias EPA for the protection of the harvestmen fauna in the state of Minas Gerais.

Key words: Biodiversity; conservation; inventory.

Resumen. La Mata Atlántica alberga la mayor diversidad de opiliones del mundo. Sin embargo, este bioma está muy modificado y fragmentado, lo que afecta negativamente a la biodiversidad. Así, el presente estudio tuvo como objetivo inventariar la fauna de opiliones en el Área de Protección Ambiental Fernão Dias (APA Fernão Dias), en el sur del est ado de Minas Gerais, Brasil. El estudio se realizó en el municipio de Gonçalves, dentro de la APA Fernão Dias. El muestreo de opiliones se realizó desde octubre de 2019 hasta marzo de 2020. Se recolectaron 265 individuos pertenecientes a 24 especies y morfoespecies. Se reportó seis nuevos especies para el estado: *Acanthogonyleptes singularis* (Mello-Leitão, 1935), *Ampheres luteus* (Giltay, 1928), *Meteusarcoides caudatus* (Piza, 1940), *Ogloblinia intermedia* (Soares, 1944), *Megapachylus anomalus* (Mello-Leitão, 1922) y *Gonyleptes pseudogranulatus* (Soares, 1946). Esto resalta la importancia de la APA Fernão Dias para la protección de la fauna recolectora en el estado de Minas Gerais.

Palabras clave: Biodiversidad; conservación: inventario.

Received 22 November 2023 / Accepted 20 December 2023 / Published online 29 December 2023
Responsible Editor: José Mondaca E.

Introduction

The Serra da Mantiqueira constitute a mountain range that spans three states in southeastern Brazil: São Paulo, Minas Gerais, and Rio de Janeiro. This region hosts remnants of the Atlantic Forest, especially in the higher-altitude areas with primary forests (Costa *et al*. 1998). This highlights the importance of conserving this territory, as this biome is considered one of the 25 global hotspots, reflecting its high biodiversity but also the reduction and alteration of its ecosystems (Myers *et al*. 2000; Scarano and Ceotto 2015). The Atlantic Forest is one of the most threatened biomes in the world, primarily due to the loss and fragmentation of natural habitats (Tabarelli *et al*. 2010).

Historically, this biome has been impacted by timber extraction, monoculture of coffee and sugarcane, as well as urban expansion and livestock (Rodrigues *et al*. 2009), which promoted deforestation and forest fires (Ribeiro-Neto *et al*. 2016), which lead to a reduction in the populations of many species and represents a risk to the biodiversity of this tropical forest. As a result of this history of impacts, only 29% of its natural vegetation remains (MMA 2015), primarily in the form of small fragments of secondary forest, with at least 97% of them being smaller than 250 hectares (Ribeiro *et al*. 2009). Additionally, 2.26 million hectares are protected by Conservation Units (Ribeiro *et al*. 2009), which is insufficient to ensure the protection of the entire biodiversity in the region (Lemes *et al*. 2014).

Based on the above, the main cause of biodiversity loss is disturbances of anthropogenic origin (Albuquerque *et al*. 2018), which vary in terms of their nature, frequency and intensity (Gerstner *et al*. 2014), which negatively affects the biodiversity and ecosystem services, which justifies the need for more inventory studies to understand the distribution of species and assess their conservation status.

The Atlantic Forest consists of different phytophysiognomies, forming a mosaic of vegetation, for example, there's the Mixed Forest, associated with the presence of *Araucaria angustifolia* (Bertol.), the Semideciduous Forest, which has a deciduous rate of about 50% during the dry season, in addition to the Ombrophilous Forest, highland fields, restinga, and mangroves (Oliveira Filho 2006; IBGE 2012). This makes the Atlantic Forest one of the most important tropical forests in the world, with high rates of endemism among plants, amphibians, reptiles, birds, and mammals (Myers *et al*. 2000; Rocha *et al*. 2004, 2005), as well as invertebrates like insects and arachnids (Giupponi *et al*. 2017; Souza *et al*. 2020).

Harvestmen (Arachnida) have over a thousand species recorded in Brazil, with around 600 occurring in the Atlantic Forest (Kury 2023), making the Atlantic Forest the world's richest area for the occurrence of harvestmen. However, despite the increasing number of inventory studies in this biome (for example, Bragagnolo and Pinto-da-Rocha 2003; Resende *et al*. 2012a, b; Nogueira *et al*. 2019; Ferreira *et al*. 2019, 2020; Costa *et al*. 2020; Rubim *et al*. 2023), there are locations, including Conservation Units (UC), that lack information about the composition of these arachnid communities, such as the Fernão Dias Environmental Protection Area (Fernão Dias EPA, from now on) in the Serra da Mantiqueira, Minas Gerais.

Based on the information presented, the current study aims to inventory the harvestmen fauna in the Atlantic Forest within the Fernão Dias EPA, located in southern Minas Gerais, Brazil.

Material and Methods

The study was conducted in the Environmental Protection Area Fernão Dias, within preserved fragments of mixed and semideciduous forests (Stefani-Santos *et al*. 2021). The area is located in the municipality of Gonçalves (22°39'27"S, 45°46'54"W), Minas Gerais state, Brazil. This area covers over 180,000 hectares (EPA Fernão Dias 2021) and is part

of the mountainous complex of the Serra da Mantiqueira (Reboita *et al*. 2015; Fig. 1). The climate is temperate and humid (Köppen classification: Cwb), with an average annual precipitation of around 1500 mm. Daily average temperatures range from 14 to 19 °C, and elevations vary from 880 to 1670 m.

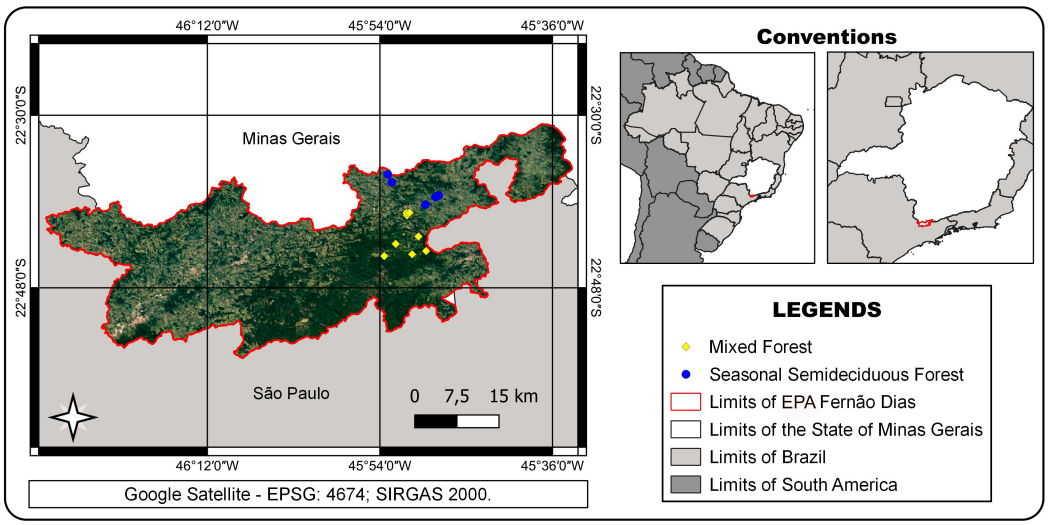

Figure 1. Sampling areas for harvestmen (Arachnida) in the Atlantic Forest of the Fernão Dias EPA in the municipality of Gonçalves, southern Minas Gerais state, in mixed and seasonal semideciduous forests. / Áreas de muestreo para opiliones (Arachnida) en la Mata Atlántica de la APA Fernão Dias en el municipio de Gonçalves, sur del estado de Minas Gerais, en bosques semideciduos mixtos y estacionales.

Eighteen days of collection were conducted by four researchers in the field, between 6:00 PM and 9:00 PM, peak activity times for these arachnids (Resende *et al*. 2012a), totaling 90 hours of sampling effort per researcher. Active searching was performed with the aid of flashlights and forceps, where we inspected slopes, decomposing logs, stem and leaf surfaces, rocky cavities, and leaf litter, a methodology considered the most effective for harvesting harvestmen (Pinto-da-Rocha and Bonaldo 2006). The collected individuals were stored in containers with 70% alcohol, along with information about the collection locations and dates. The material is deposited in the zoological collection of the University of São Paulo (USP) and in the Biological Collection of Social Wasps (CBVS) of the Federal Institute of Southern Minas Gerais, Campus Inconfidentes.

To compare the similarity of the harvestmen community in this study with other inventories conducted in the southeastern region of Brazil, the Jaccard similarity index (SJ) was used, using presence and absence for calculation. This index expresses the similarity between environments based on the number of common species. The resulting harvestmen similarity matrix was used for cluster analysis (UPGMA) and to generate a dendrogram (Sneath and Sokal 1973).

Results

A total of 265 individuals were collected, belonging to 24 species and morphospecies (Tab. 2; Fig. 2). The family with the highest richness was Gonyleptidae, with 19 (79%) species (Tab. 2). The most abundant morphospecies was *Munequita* sp. (Sclerosomatidae), (Fig. 2D), with 59 individuals, representing approximately 22% of the total abundance.

Five species are considered rare in the study area, as they are represented by only one individual (singletons): *Acanthogonyleptes variolosus*, *Goniosoma macracanthum*, Gonyleptinae sp., and *Progyndes* sp.; or two individuals (doubletons): *Camarana* sp.

Table 1. Number of species, morphospecies and abundance of harvestmen (Arachnida) recorded and collected at the Fernão Dias EPA, southern Minas Gerais state, Brazil. / Número de especies, morfoespecies y abundancia de opiliones (Arachnida) registradas y recolectadas en la APA Fernão Dias, sur del estado de Minas Gerais, Brasil.

Family	Species and morphospecies	Abundance
Cryptogeobiidae	*Camarana* sp.	2
Gonyleptidae	*Acanthogonyleptes variolosus* (Mello-Leitão, 1940)	1
	Acanthogonyleptes singularis (Mello-Leitão, 1935)	4
	Acutisoma longipes (Roewer, 1913)	43
	Ampheres luteus (Giltay, 1928)	16
	Discocyrtus flavigranulatus (Soares, 1944)	3
	Krateromaspis lata (Mello-Leitão, 1935)	1
	Discocyrtus sp.	6
	Encheiridium montanum (Mello-Leitão,1941)	6
	Goniosoma macracanthum (Mello-Leitão,1922)	1
	Goniosomatinae sp.	5
	Gonyleptes pseudogranulatus (Soares, 1946)	28
	Gonyleptinae sp.	1
	Longiperna trembao Pinto-da-Rocha & Bragagnolo, 2010	3
	Meteusarcoides caudatus (Piza, 1940)	5
	Mischonyx squalidus Bertkau, 1880	7
	Ogloblinia loretoensis Canais, 1933	4
	Pachylinae sp.	3
	Progyndes sp.	1
	Megapachylus anomalus (Mello-Leitão, 1922)	14
Sclerosomatidae	Gagrellinae sp.	8
	Abaetetuba sp.	16
	Munequita sp.	59
	Holcobunus sp.	28
Richness		**24**
Abundance		**265**

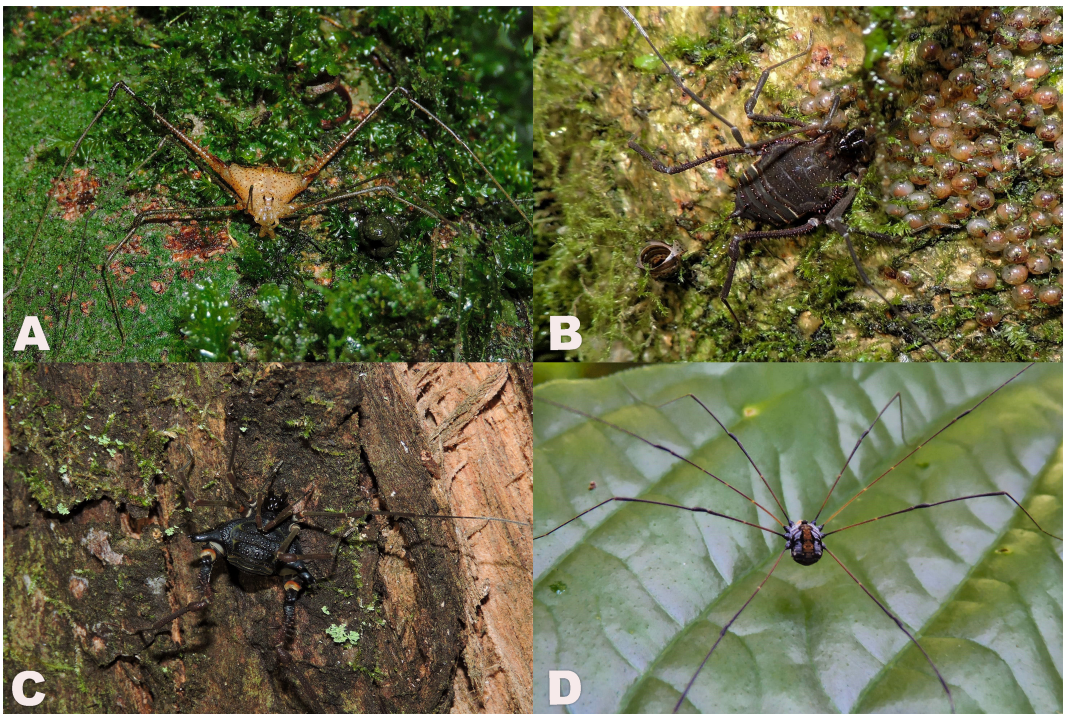

Figure 2. Harvestmen records at the Fernão Dias EPA, Gonçalves municipality, southern Minas Gerais state: **A)** *Ampheres luteus* (Giltay, 1928). **B)** *Megapachylus anomalus* (Mello-Leitão, 1922). **C)** *Gonyleptes pseudogranulatus* (Soares, 1946). **D)** *Munequita* sp. / Registros de opiliones de la APA Fernão Dias, municipio de Gonçalves, sur del estado de Minas Gerais: **A)** *Ampheres luteus* (Giltay, 1928). **B)** *Megapachylus anomalus* (Mello-Leitão, 1922). **C)** *Gonyleptes pseudogranulatus* (Soares, 1946). **D)** *Munequita* sp.

Our study brings new records to Minas Gerais state: *A. singularis* (Mello-Leitão, 1935), *A. luteus* (Giltay, 1928), *M. caudatus* (Piza, 1940), *O. loretoensis* Canais, 1933, *M. anomalus* (Mello-Leitão, 1922) and *G. pseudogranulatus* (Soares, 1946).

The composition of the fauna in this study showed low similarity compared to other inventory areas conducted in the southeastern region of Brazil and was more similar (still low, around 20%) to areas 2 and 4, EPA Machado (Ferreira *et al*. 2020), and Parque Estadual Serra do Papagaio (Ferreira *et al*. 2019) (Fig. 3).

Discussion

The harvestmen richness found in our study is significant when compared to other studies conducted in areas of Atlantic Forest within the interior of the country, where seasonal semi-deciduous forest predominates (Oliveira Filho 2006). In these regions, the number of species varies from seven to 17 per locality (Ferreira *et al*. 2019, 2020; Gomes *et al.* 2021; Rubim *et al*. 2023). The explanation for the high richness in this study may result from two associated factors: first, the high humidity in the high-altitude forest within the Serra da Mantiqueira, which reaches over 1600 meters (Melo and Salino 2007), decreasing the risk of death due to body dehydration (Curtis and Machado 2007); second, the degree of conservation of the higher fragments in the municipality, as shown in different studies (Stefani-Santos *et al*. 2021; Vieira *et al*. 2022), which increases the richness and abundance of harvestmen, as demonstrated in the studies of Bragagnolo *et al*. (2007) and Andrade *et al*. (2022).

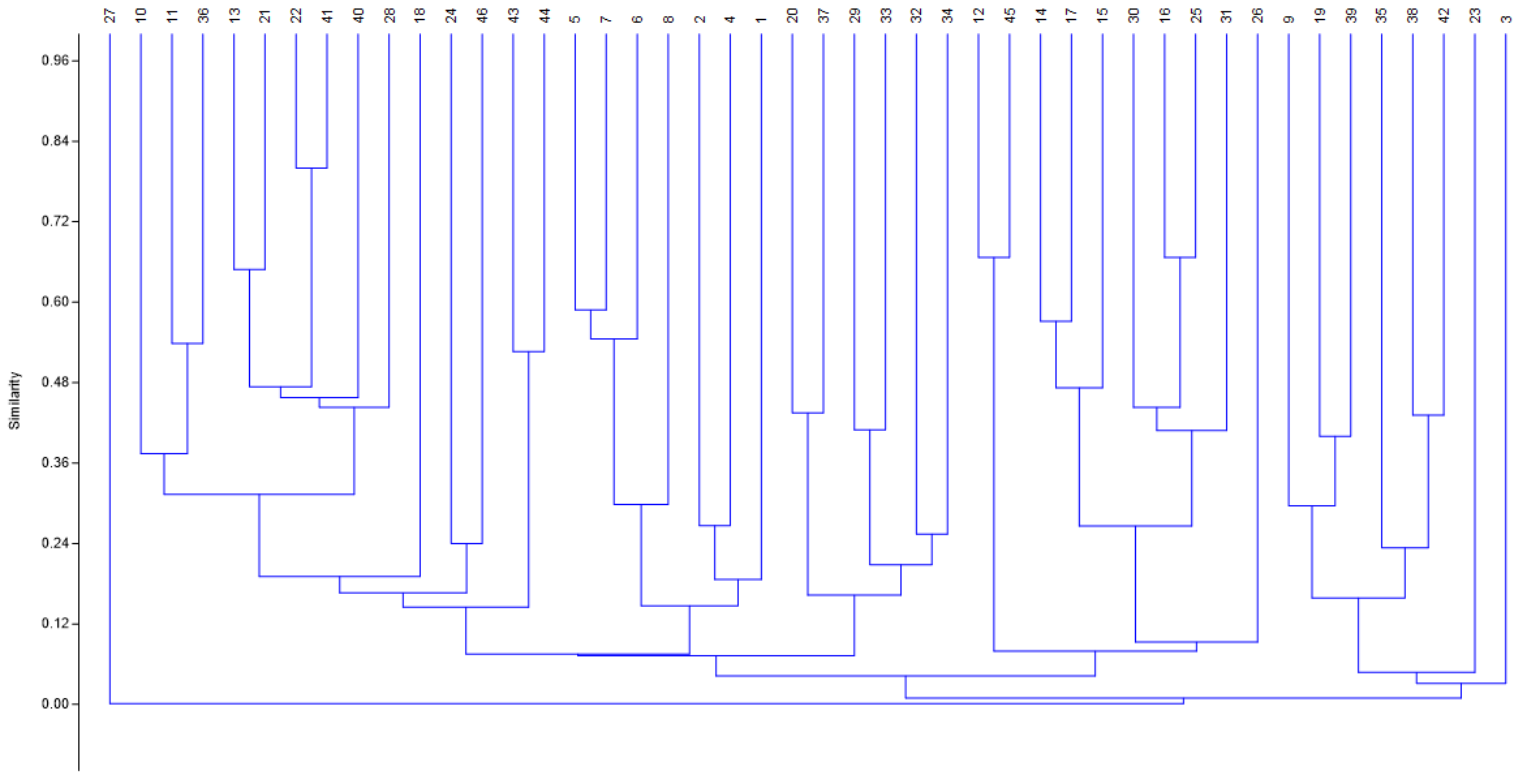

Figure 3. Jaccard similarity index (SJ) of the harvestmen fauna between different inventory studies in areas of the Atlantic Forest in southeastern Brazil (1 present study; 2 EPA Machado, MG; 3 N.P Sempre vivas MG; 4 S.P Serra Papagaio; 5 Atibaia SP; 6 S.P of Serra da Cantareira SP; 7 S.P of Serra do Japi SP; 8 S.P of Campos do Jordão SP; 9 Colatina ES, 10 Cubatão SP; 11 B.S of Boracéia SP; 12 S.E Angatuba SP; 13 S.E of Juréia-Itatins SP; 14 S.E of Assis SP; 15 S.E of Caetetus SP; 16 S.E of Jataí SP; 17 S.E of Santa Bárbara SP; 18 Flona de Ipanema RJ; 19 Flona Goytacazes ES; 20 Mata da Cicuta RJ; 21 Miracatu SP; 22 S.P of Carlos Botelho SP; 23 S.P of Itaúnas ES; 24 S.P of Ilhabela SP; 25 S.P of Morro do Diabo SP; 26 S.P of Turvo SP; 27 S.P Turístico do Alto Ribeira SP; 28 Petrópolis RJ; 29 Piracicaba SP; 30 Pirassununga SP; 31 N.P of Serra da Bocaina SP; 32 N.P of Serra dos Órgãos RJ; 33 N.P of Itatiaia RJ; 34 N.P of Caparaó MG; 35 B.R Serra de Paranapiacaba SP; 36 E.R Guapiassú SP; 37 B.R Augusto Ruschi ES; 38 Reserva Natural da Vale ES; 39 F.R of Morro Grande SP; 40 PNHR Parque da Onça Parda SP; 41 Santa Leopoldina ES; 42 Serra do Cabral MG; 43 Sítio Sossego SP; 44 Taiobeiras MG; 45 Ubatuba SP) EPA = Environmental Protection Area ; S.P= State Park N.P= National Park; B.S = Biological Station , S.E Ecological Station; B.R Biological Reservation ; F.R Forest Reserve; PNHR Private Natural Heritage Reserve; E.R Ecological Reserve.

The opilionid community found at the Fernão Dias EPA is composed of species that inhabit different biomes, such as the Atlantic Forest and the Cerrado. The high richness of Gonyleptidae was expected since this is the dominant family in the Atlantic Forest from the states of Rio de Janeiro to Santa Catarina (Peres *et al*. 2019), as observed in other inventories conducted in the state of Minas Gerais (Ferreira *et al*. 2019; Costa *et al*. 2020), Rio de Janeiro (Bragagnolo and Pinto-da-Rocha 2003), and São Paulo (Resende *et al*. 2012a, b). All these inventories were carried out in the Atlantic Forest and used active searching as the method for collecting harvestmen specimens.

We recorded four morphospecies of the family Sclerosomatidae, belonging to the subfamily Gagrellinae, which represent 41.88% of the total abundance. This high richness is similar to other studies in the same biome, in other states than Minas Gerais (Bragagnolo *et al*. 2007; Ferreira *et al*. 2020). However, the high abundance of Gagrellinae differs from other studies conducted in the state of Minas Gerais, whether in the same biome or in the Cerrado (Ferreira *et al*. 2019, 2020; Silva *et al*. 2020). This could also be related to the altitude, humidity, and conservation of the study area. As for the family Cryptogeobiidae, we only recorded a single occurrence, which can be explained by the fact that this family explores cryptic environments, such as natural or artificial caves (Ázara and Ferreira 2018).

Among the 24 species recorded in this study, *M. squalidus* and *E. montanum* are the only ones that occur in the Cerrado (Nogueira *et al*. 2019). The remaining species are in line with the literature, which reports that harvestmen are highly endemic, with 97.5% of the species recorded in the Atlantic Forest biome (Pinto-da-Rocha *et al*. 2005). The species *E. montanum* is commonly found in cave areas in the Cerrado biome and microhabitats in the Mata Atlântica (Ázara and Ferreira 2018; Costa *et al*. 2020). On the other hand, *M. squalidus* is a synanthropic species (Mestre and Pinto-da-Rocha 2004), which is probably why it has a larger distribution range (Kury 2003).

Unlike other arthropods, harvestmen have limited dispersal capabilities, which restrict their ability to colonize new environments (Bragagnolo *et al*. 2007). Harvestmen are susceptible to dehydration, which imposes restrictions on their survival. Therefore, even in forested environments like the Atlantic Forest, these behavioral and physiological characteristics restrict these animals to habitats with high humidity, preferably in more pristine and less disturbed forests, as observed in this study.

The number of rare species (singletons and doubletons), represents 20% of the recorded harvestmen fauna. Certain species, although relatively rare or comprising a small portion of the total biomass of the community, can still have significant effects on ecosystems. Keystone species, for example, are theoretically important in maintaining ecosystem stability, especially in variable (Loreau *et al.* 2001) and highly diverse environments (Mouillot *et al*. 2013), such as the Mata Atlântica biome (Hooper *et al*. 2005).

Regarding the distribution of species recorded for the first time in Minas Gerais state: *M. anomalus* and *M. caudatus* occur in other areas of the Serra da Mantiqueira in the states of São Paulo and Rio de Janeiro (Kury 2003); *A. variolosus*, *A. singularis*, and *A. luteus* are found in the coastal mountains from São Paulo to Espírito Santo states (Kury 2003; Pinto-da-Rocha *et al*. 2012), and *G. pseudogranulatus* has a record in the interior Mata Atlântica of São Paulo (Soares and Soares 1946).

The greatest similarity, around 20%, of the harvestmen community in the Fernão Dias EPA in relation to the Machado EPA, especially in the municipality of Poço Fundo, and Parque Estadual do Papagaio, may be related to the vegetative formation of these conservation units. All of them host the same phytophysiognomy (Semideciduous Forest) located in preserved and humid areas, constituting essential factors for the distribution and diversity of opilionids (Bragagnolo *et al*. 2007; Resende *et al*. 2012a, 2012b). This similarity of around 20% shows how distinct harvestman communities are, even between geographically close areas, the same vegetation matrix and degree of conservation, which

attests to the need to protect these areas in the state of Minas Gerais for the protection of harvestman fauna.

It is important to emphasize that, although the harvestmen fauna of the Atlantic Forest is widely sampled in Brazil, there is an urgent need for more inventory and distribution studies of these arachnids in the country. This need is primarily based on two criteria: first, due to the reduction, fragmentation, and modification of the Atlantic Forest; second, because only seven harvestmen species have their conservation status evaluated by the ICMBio list (ICMBio 2023), representing only 0.7% of the harvestmen fauna in Brazil. This highlights the lack of information to assess the risk of extinction for this taxon in the country.

Final remarks. Our study highlights the relevance of the Fernão Dias Environmental Protection Area (located in the Serra da Mantiqueira) for the protection of harvestmen fauna, as it harbors significant richness for the state of Minas Gerais, including new records of species. This underscores how well this Conservation Unit fulfills its role in protecting Brazilian biota. In addition, there is a need for more harvestmen inventory studies in Brazil, even in Atlantic Forest areas, to better understand the conservation status of the taxon in the country, aiming to provide support for the management and conservation of harvestmen biodiversity.

Acknowledgments

We would like to express our gratitude: to the City Hall of Gonçalves, represented by the Secretary of Tourism Rafaela Rosa; to the Municipal Tourism Council (COMTUR), represented by Isabel Lira; to Councilman Leandro Piola; to the lodges: Bicho do Mato, Espaço Kalevala, Vida Verde, Fazenda das Rosas; to the tourism agencies: Tribo da Montanha, Gonçalves Radical, Conexão Gonçalves; to São Francisco bakery; to Kalapalo editor; to Campesino real estate; to Floresta Barnabé; and to all the people of Gonçalves who contributed directly and indirectly, assisting in the identification of some species. We extend our thanks to the team from the Zoology Laboratory at IFSULDEMINAS, Campus Inconfidentes, for their collaboration in the field, and to IFSULDEMINAS, Campus Inconfidentes, for the logistical support. To researcher Taiguara Pereira de Gouvêa for preparing the map. We appreciate SISBIO (#71076-1) and IEF (#079/2019) for the collection licenses, which were essential for the development of this research.

Literature Cited

Albuquerque, U.P., Gonçalves, P.H.S., Júnior, W.S.F., Chaves, L.S., Oliveira, R.C.S., Silva, T.L.L., Santos, G.C. and Araújo, E.L. (2018) Humans as niche constructors: Revisiting the concept of chronic anthropogenic disturbances in ecology. *Perspectives in Ecology and Conservation*, *16*(1): 1-11. https://doi.org/10.1016/j.pecon.2017.08.006

Andrade, A.R.S., Koch, E.B.A., Nogueira, A.A., Pinto-Da-Rocha, R., Bragagnolo, C., Lorenzo, E., Silva, M.B. and Delabie, J.H.C. (2022) Evaluating higher taxa as surrogates of harvestmen biodiversity (Arachnida: Opiliones) along a latitudinal gradient in the Atlantic Forest. *Austral Ecology*, *48*: 81-101. https://doi.org/10.1111/aec.13252

Ázara, L.N. and Ferreira, R.L. (2018) Annotated checklist of Gonyleptoidea (Opiliones: Laniatores) associated with Brazilian caves. *Zootaxa*, *4439*(1): 1-107. https://doi.org/10.11646/zootaxa.4439.1.1

Bragagnolo, C. and Pinto-da-Rocha, R. (2003) Diversidade de opiliões do Parque Nacional da Serra dos Órgãos, Rio de Janeiro, Brasil (Arachnida: Opiliones). *Biota Neotropica*, *3*(1): 1-24. https://doi.org/10.1590/S1676-06032003000100009

Bragagnolo, C., Nogueira, A., Pinto-da-Rocha, R. and Pardini, R. (2007) Harvestmen in an Atlantic forest fragmented landscape: Evaluating assemblage response to habitat quality and quantity. *Biological Conservation*, *139*(3): 389-400. http://dx.doi.org/10.1016/j.biocon.2007.07.008

Costa, A.G., Ázara, L.N., Clemente, M.A. and Souza, M.M. (2020) Opiliofauna (Arachnida, Opiliones) of the seasonal semidecidual Forest of the State of Minas Gerais, Brazil. *Biotemas, 33*(3): 1-11. https://doi.org/10.5007/2175-7925.2020.E71919

Costa, M.R.C., Hermann, G., Martins, C.M., Lins, L.V. and Lamas, I.R. (1998) *Biodiversidade em Minas Gerais: um Atlas para sua conservação*. Fundação Biodiversitas, Belo Horizonte, 94 pp.

Curtis, D.J. and Machado, G. (2007) Ecology. *In*: Pinto-da-Rocha R, Machado G, Giribet G (eds) Harvestmen: the biology of Opiliones. Harvard University Press, Cambridge. Pp. 280-308.

EPA [Environmental Protection Area] Fernão Dias. Accessed: 25/05/2021. Available at: https://sites.google.com/site/apafernaodias/home

Ferreira, A.S., Pinheiro, I.L.C. and Souza, M.M. (2019) Opiliones (Arachnida) in a mixed forest in Southern Minas Gerais state, Brazil. *Journal of Entomology and Zoology Studies, 7*(5): 666-671.

Ferreira, A.S., Pinheiro, I.L.C., Ázara. L.N., Clemente, M.A. and Souza, M.M. (2020) Biodiversidade de opiliones (Arachnida) em áreas de Cerrado e Mata Atlântica no Brasil. *Nature and Conservation, 13*(2): 38-46. http://doi.org/10.6008/CBPC2318-2881.2020.002.0004

Gerstner, K., Dormann, C.F., Stein, A., Manceur, A.M. and Seppelt, R. (2014) Effects of land use on plant diversity: A global meta-analysis. *Journal of Applied Ecology*, *51*(6): 1690-1700. https://doi.org/10.1111/1365-2664.12329

Giupponi, A.L., Demite, P.R., Flechtmann, C.H.W., Hernandes, F.A., Mendes, A.C., Migliorini, G.H., Miranda, G.S. and Souza, T.G. (2017) Aracnídeos da mata atlântica. Pp. 129-235. *In:* Monteiro Filho, E.L.A. e Conte, C.E. (Eds.). *Revisões em zoologia: Mata Atlântica.* Curitiba, Editora, UFPR. 490 pp

Gomes, P.P.P., Souza, A.S.B., Silva, J.V.N., Ferreira, A.S., Almeida, J.A.M. and Souza, M.M. (2021) Semideciduous seasonal forest opiliofauna (Arachnida, opiliones), state of Parana, Brazil. *Acta Scientiarum. Biological Sciences, 43*: 1-9.

Hooper, D.U., Chapin, F.S., Ewel, J.J., Hector, A., Inchausti, P., LavoreL, S., Lawton, J.H., Lodge, D.M., Loreau, M., Naeem, S., Schmid, B., Setälä, H., Symstad, A.J., Vandermeer, J. and Wardle, D.A. (2005) Effects of biodiversity on ecosystem functioning: a consensus of current knowledge. *Ecological Monographs, 75*(1): 3-35. https://doi.org/10.1890/04-0922

IBGE [Instituto Brasileiro de Geografia e Estatística] (2023) Manual técnico da vegetação brasileira. Série Manuais Técnicos em Geociências. 1, 2ª ed. Rio de Janeiro, Brasil.

ICMBio [Instituto Chico Mendes de Conservação da Biodiversidade] (2023) Ocurrence available from: https://salve.icmbio.gov.br/#/. Sistema de Avaliação do Risco de Extinção da Biodiversidade – SALVE. Accessed on: 18 September 2023.

Kury, A.B. (2003) Annotated catalogue of the Laniatores of the New World (Arachnida, Opiliones). *Revista Ibérica de Aracnologia, 1*: 1-337.

Kury, A.B. (2023) Ocurrence available from: http://www.museunacional.ufrj.br/mndi/Aracnologia/checklaniator.html.Checklist of valid genera of Opiliones of the world. Museu Nacional, UFRJ website. Accessed on: 23 September 2023.

Lemes, P., Melo, A.S. and Loyola, R.D. (2014) Climate change threatens protected areas of the Atlantic Forest. *Biodiversity and Conservation*, *23*(2): 357-368. http://dx.doi.org/10.1007/s10531-013-0605-2

Loreau, M., Naeem, S., Inchausti, P., Bengtsson, J., Grime, J.P., Hector, A., Hooper, D.U., Huston, M.A., Raffaelli, D., Schmid, B. and Tilman, D. (2001) Biodiversity and ecosystem functioning: current knowledge and future challenges. *Science*, *294*(55430): 804-808. https://doi.org/10.1126/science.1064088

Melo, L.C. and Salino, A. (2007) Pteridófitas em fragmentos florestais da APA Fernão Dias, Minas Gerais, Brasil. *Rodriguésia, 58*(1): 207-220. https://doi.org/10.1590/2175-786020075811

Mestre, L.A.M. and Pinto-da-Rocha, R. (2004) Populations dynamics of an isolated population of harvestmen *Ilhaia cuspidata* (Opiliones, Gonyleptidae) in Araucaria Forest (Curitiba, Paraná, Brazil). *The Journal of Arachnology*, *32*(2): 208-220. https://doi.org/10.1636/M02-61

MMA [Ministério do Meio Ambiente] (2023) Ocurrence available from: Microsoft Power BI. Painel Unidades de Conservação Brasileiras - Departamento de áreas protegidas. Accessed on: 30 September 2023.

Mouillot, D., Bellwood, D.R., Baraloto, C., Chave, J., Galzin, R., Harmelin-Vivien, M., Kulbicki, M., Lavergne, S., Lavorel, S., Mouquet, N., Paine, C.E.T., Renaud, J. and Thuiller, W. (2013) Rare species support vulnerable functions in high-diversity ecosystems. *PLoS Biology*, *11*(5): 1-11. https://doi.org/10.1371/journal.pbio.1001569

Myers, N., Mittermeier, R.A., Mittermeier, C.G., Fonseca, G.A.B. and Kent, J. (2000) Biodiversity hotspots for conservation priorities. *Nature, 403*(6772): 853-858. https://doi.org/10.1038/35002501

Nogueira, A.A., Bragagnolo, C., Dasilva, M.B., Martins, T.K., Lorenza, E.P., Perbiche-Neves, G. and Pinto-da-Rocha, R. (2019) Historical signatures in the alpha and beta diversity patterns of Atlantic Forest harvestman communities (Opiliones-Arachnida). *Canadian Journal of Zoology*, *97*(7): 631-643. https://doi.org/10.1139/cjz-2018-0032

Oliveira Filho, A.T. (2006) Definição e delimitação de domínios e subdomínios das paisagens naturais do estado de Minas Gerais. Pp. 21-35. *In:* Scolforo JR, Carvalho LMT. (Eds.). *Mapeamento e inventário de flora e dos reflorestamentos de Minas Gerais*. Lavras MG, Editora UFLA. 288 pp.

Peres, E.A., Benedetti, A.R., Hiruma, S.T., Sobral-Souza, T. and Pinto-da-Rocha, R. (2019) Phylogeography of Sodreaninae harvestmen (Arachnida: Opiliones: Gonyleptidae): insights into the biogeography of the southern Brazilian Atlantic Forest. *Molecular Phylogenetics and Evolution*, *138*: 1-16. https://doi.org/10.1016/j.ympev.2019.05.028

Pinto-da-Rocha, R. and Bonaldo, A.B. (2006) A structured inventory of harvestmen (Arachnida, Opiliones) at Juruti River plateau, State of Pará, Brazil**.** *Revista Ibérica de Aracnologia*, *13*: 155-162.

Pinto-da-Rocha, R., Benedetti, A.V., Vasconcelos, E.G. and Hara, M.R. (2012) New systematic assignments in Gonyleptoidea (Arachnida, Opiliones, Laniatores). *ZooKeys*, *198*: 25-68. https://doi.org/10.3897/zookeys.198.23377

Pinto-da-Rocha, R., Silva, M.B. and Bragagnolo, C. (2005) Faunistic similarity and historic biogeography of the harvestmen of southern and southeastern Atlantic Rain Forest of Brazil. *The Journal of Arachnology*, *33*(2): 290-300. http://dx.doi.org/10.1636/04-114.1

Reboita, M.S., Rodrigues, M., Silva, L.F. and Alves, M.A. (2015) Aspectos climáticos do estado de Minas Gerais. *Revista Brasileira de Climatologia*, *17*: 206-226. http://dx.doi.org/10.5380/abclima.v17i0.41493

Resende, L.P.A., Pinto-da-Rocha, R. and Bragagnolo, C. (2012a) Diversity of harvestmen (Arachnida, Opiliones) in Parque da Onça Parda, southeastern Brazil. *Iheringia Série Zoologia*, *102*(1): 99-105. https://doi.org/10.1590/S0073-47212012000100014

Resende, L.P.A., Pinto-da-Rocha, R. and Bragagnolo, C. (2012b) The harvestmen fauna (Arachnida: Opiliones) of the Parque Estadual Carlos Botelho, and the Floresta Nacional de Ipanema, São Paulo, Brazil. *Biota Neotropica*, *12*(4): 146-155. https://doi.org/10.1590/S1676-06032012000400016

Ribeiro, M.C., Metzger, J.P., Martensen, A.C., Ponzoni, F.J. and Hirota, M.M. (2009) The Brazilian Atlantic Forest: How much is left, and how is the remaining forest distributed? Implications for conservation. *Biological Conservation, 142*(6): 1141-1153. https://doi.org/10.1016/j.biocon.2009.02.021

Ribeiro-Neto, J.D., Arnan, X., Tabarelli, M. and Lea, I.R. (2016) Chronic anthropogenic disturbance causes homogenization of plant and ant communities in the Brazilian Caatinga. *Biodiversity and Conservation, 25*(5): 943-956.

Rocha, C.F.D., Bergallo, H.G., Pombal, J.R., Geise, L.E., Van Sluys, M., Fernandes, R.O. and Caramaschi, U. (2004) Fauna de anfíbios, répteis e mamíferos do Estado do Rio de Janeiro, sudeste do Brasil. *Publicações Avulsas do Museu Nacional, 104*(1): 3-23.

Rocha, C.F.D., Van Sluys, M., Bergallo, H.G. and Alves, M.A.S. (2005) Endemic and threatened tetrapods in the restingas of the biodiversity corridors of Serra do Mar and of the Central da Mata Atlântica in eastern Brazil. *Brazilian Journal of Biology, 65*: 159-168.

Rodrigues, R.R., Lima, R.A.F., Gandolfi, S. and Nave, A.G. (2009) On the restoration of high diversity forests: 30 years of experience in the Brazilian Atlantic Forest. *Biological Conservation, 142*(6): 1242-125. https://doi.org/10.1016/j.biocon.2008.12.008

Rubim, L.G.T., Pádua, T.H.R., Souza, A.S.B., Almeida, J.A.M., Shimamoto, C.Y., Barbado, N. and Souza, M.M. (2023) Opiliofauna (Arachnida: Opiliones) of the Atlantic Forest in the state of Paraná, Brazil. *Brazilian Journal of Biology, 83*: 1-7**.** https://doi.org/10.1590/1519-6984.274971

Scarano, F.R. and Ceotto, P. (2015) Brazilian Atlantic forest: impact, vulnerability, and adaptation to climate change. *Biodiversity and Conservation, 24*(9): 2319-2331. https://doi.org/10.1007/s10531-015-0972-y

Sneath, P.H. and Sokal, R.R. (1973) *Numerical Taxonomy: The Principles and Practice of Numerical Classification***.** San Francisco. 573 pp.

Soares, B.A.M. and Soares, H.E.M. (1946) Um novo opilião do Estado de São Paulo. *Papéis avulsos do Departamento de Zoologia, 7*(16): 213-216.

Souza, M.M., Guedes, G.T., Milani, L.R., Souza, A.S.B. and Gomes, P.P. (2020) Social wasps (Vespidae: Polistinae) from the Brazilian Atlantic Forest. *Sociobiology, 67*(1): 1-12. https://doi.org/10.13102/sociobiology.v67i1.4597

Stefani-Santos, G., Ávila Júnior, W.F., Clemente, M.A., Henriques, N.R., Souza, A.S.B., Vilela, D.S. and Souza, M.M. (2021) Odonata (Insecta) communities along an elevational gradient in the Atlantic Forest of southeastern Brazil, with the description of the female of *Heteragrion mantiqueirae* Machado, 2006. *International Journal of Odonatology, 24*: 178-196.

Tabarelli, M., Aguiar, A.V., Ribeiro, M.C., Metzger, J.P. and Peres, C.A. (2010) Prospects for biodiversity conservation in the Atlantic Forest: Lessons from aging human-modified landscapes. *Biological Conservation, 143*(10): 2328-2340. https://doi.org/10.1016/j.biocon.2010.02.005

Vieira, L.R., Henriques, N.R. and Souza, M.M. (2022) Communities of Lepidoptera along an elevational gradient in the Brazilian Atlantic Forest (Lepidoptera: Papilionoidea). *Shilap-Revista de Lepidopterologia, 50*: 175-189.