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ARTICLE

Odonata (Insecta) community in the Environmental Protection Area of the Machado River hydrographic basin, southern Minas Gerais State, Brazil

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Abstract. Only 8% of the approximately 120 conservation units in Minas Gerais State collect information on the order Odonata, which motivated this study. We aimed to survey communities of this insect group in the Environmental Protection Area of the Machado River hydrographic basin, southern Minas Gerais State, Brazil. For this purpose, 12 areas were sampled by active searching from September 2018 to March 2019. Representatives of 71 Odonata species belonging to 8 families were collected. Seven species were found exclusively in this conservation unit, and two species were newly recorded for the state, namely *Erythrodiplax chromoptera* (Borror, 1942) and *Micrathyria venezuelae* De Marmels, 1989. This study surveyed the fifth richest odonatofauna in Minas Gerais State, underscoring the importance of the studied area for conservation of Odonata communities and necessitating actions for decreasing environmental impacts on this biological patrimony.

Keywords. Inventory; Diversity; Dragonflies; Damselflies; Conservation unit.

INTRODUCTION

Odonata comprises insects commonly known in Brazil as *libélulas, jacintas, lava-bunda, lavadeiras,* and *cavalos-de-judeu* (Costa *et al.,* 2012; Brasil & Vilela, 2019). This order encompasses two suborders: Zygoptera, with 11 families recorded in Brazil (Amphipterygidae, Calopterygidae, Coenagrionidae, Dicteriadidae, Heteragrionidae, Lestidae, Megapodagrionidae, Perilestidae, Polythoridae, Protoneuridae, and Pseudostigmatidae), and Anisoptera, with four families occurring in the country (Aeshnidae, Corduliidae, Gomphidae, and Libellulidae) (Bybee *et al.,* 2021).

This order of hemimetabolous insects, whose life cycle consists of egg, larval, and adult stages, serve as bioindicators of associated freshwater and terrestrial environments, given the aquatic habit of their larvae and the flying habit of adults (Corbet, 1999; Júnior *et al.,* 2015; Valente-Neto *et al.,* 2016). Thus, Odonata can be used as a model taxon for understanding the effects of forest fragmentation (Sigutova *et al.,* 2019), in addition to being an important component of aquatic trophic chains, both as predators and preys (Souza *et al.,* 2018).

There are about 900 Odonata species recorded in Brazil (Pinto & De Araujo, 2020), with Minas Gerais State having 324 species (Vilela, 2021). Checklist studies have been conducted in several locations and phytophysiognomies of the state (Table 1), including Poços de Caldas (Santos, 1966); Viçosa and Marliéria, in the Rio Doce State Park (Ferreira-Peruquetti & De Marco-Jr., 2002); Baú Forest, in Barroso (Souza *et al.,* 2013); Serra do Cipó National Park (Almeida *et al.,* 2013); Dragonflies Wildlife Refuge (Bedê *et al.,* 2015); Itorotó Hunting and Fishing Club Ecological Reserve, in Uberlândia (Vilela *et al.,* 2016); Serra do Papagaio State Park (Dos Anjos, 2017); Rio Pandeiros Wildlife Refuge (Souza *et al.,* 2017); Bueno Brandão (Amorim *et al.,* 2018); a stretch of the Uberabinha River in Uberlândia (Barbosa *et al.,* 2018); Fazenda Nova Monte Carmelo, in the municipalities of Araguari, Estrela do Sul, Indianápolis, Nova Ponte, and Romaria (Borges *et al.,* 2019); different localities of the western Cerrado biome (Vilela *et al.,* 2020);

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Table 1. Odonata checklist studies conducted in Minas Gerais State, Brazil, detailing phytophysiognomies, biomes (* Atlantic Forest, ♦ Cerrado, and ¶ Caatinga), whether the survey was carried out in a Conservation Unit (CU), and the number of collected species.

Reference	Phytophysiognomy and biome	Carried out in CU	Number of species
Santos (1966)	Montane Semideciduous Seasonal Forest*	No	59
Ferreira-Peruquetti & De Marco-Jr. (2002)	Ombrophilous and Semideciduous Seasonal Forest*	Yes	28
Souza *et al.* (2013)	Montane Semideciduous Seasonal Forest*♦	No	57
Almeida *et al.* (2013)	Cerrado♦	Yes	23
Bedê *et al.* (2015)	Montane Semideciduous Seasonal Forest, Cerrado and Rupestrian F1ields*♦	Yes	128
Vilela *et al.* (2016)	Cerrado ♦	Yes	31
Dos Anjos (2017)	Mixed Forest and Altitude Fields*	Yes	68
Souza *et al.* (2017)	Deciduous Seasonal Forest (dry forest) *¶	Yes	48
Amorim *et al.* (2018)	Montane Semideciduous Seasonal Forest *	No	73
Barbosa *et al.* (2018)	Cerrado ♦	No	42
Borges *et al.* (2019)	Cerrado ♦	No	36
Vilela *et al.* (2020)	Cerrado ♦	No	90
Dos Anjos *et al.* (2020)	Rupestrian Fields♦*	Yes	20
Silva & Souza (2020)	Montane Semideciduous Seasonal Sorest *	No	71
De Ávila-Júnior *et al.* (2020)	Semideciduous Seasonal Forest*	Yes	40
Stefani-Santos *et al.* (2021)	Mixed Forest and Semideciduous Seasonal Forest*	Yes	39
Venâncio *et al.* (2021)	Cerrado ♦	Yes	101

Ibitipoca State Park (Dos Anjos *et al.,* 2020); Inconfidentes, Ouro Fino, and Tocos do Moji (Silva & Souza, 2020); Cachoeira das Andorinhas Protected Area, in Ouro Preto (De Ávila Junior *et al.,* 2020); Fernão Dias Environmental Protected Area (Stefani-Santos *et al.,* 2021); and several localities on the outskirts of Uberlândia (Venâncio *et al.,* 2021).

Most of these studies were carried out within conservation units (Table 1), which are legally delimited areas demarcated by public authorities for biodiversity protection and conservation purposes, as well as natural attractions (IEF, 2019). Such areas may be classified as Integral Protection Units, where exploring or disturbing natural resources is prohibited, except for their manage-

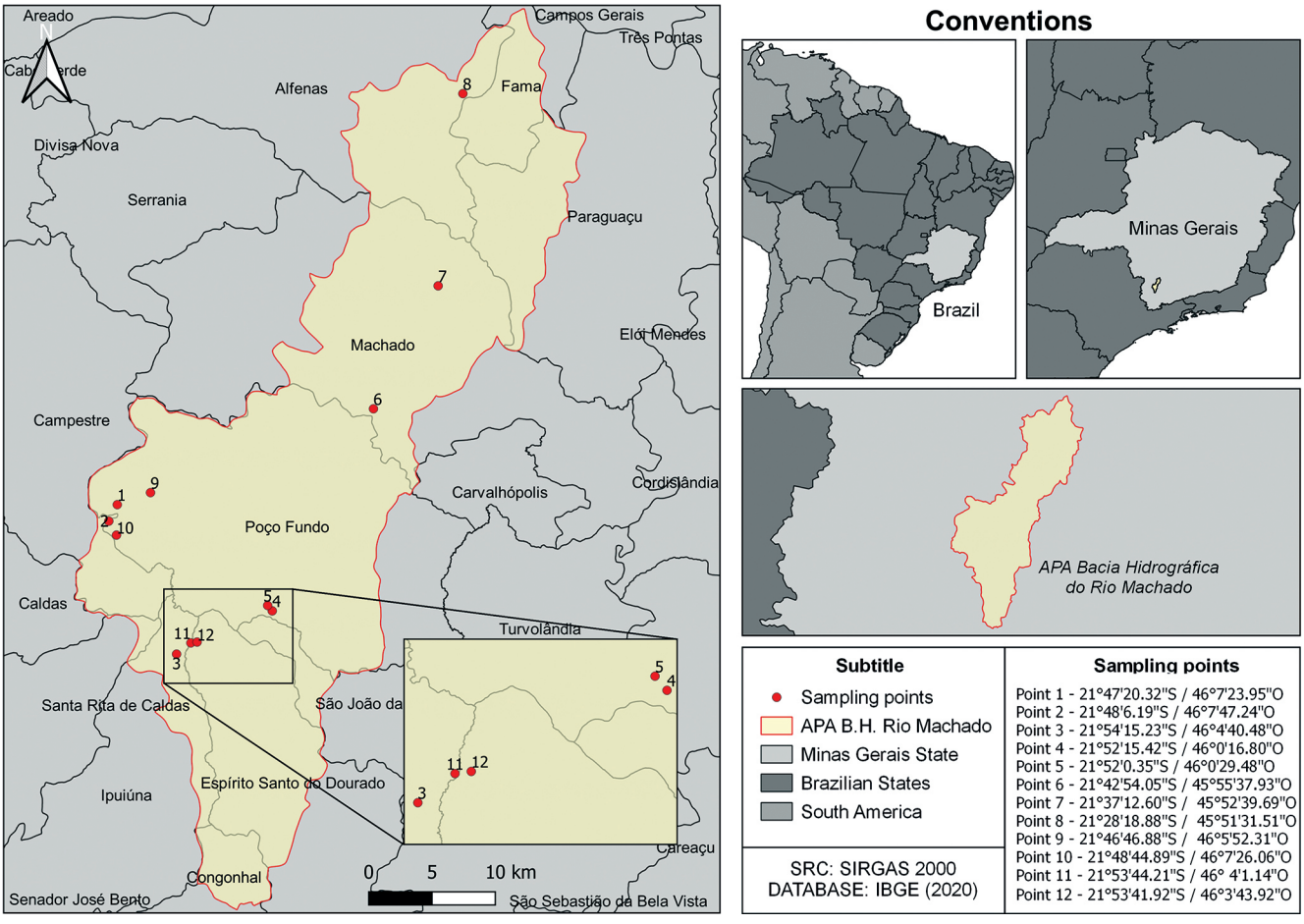

Figure 1. Location maps of the Environmental Protection Area of the Machado River hydrographic basin and sampling points. Source: Jean Victor Nery da Silva.

ment; or as Sustainable Use Units, which can be used for sustainable extraction of renewable resources (IEF, 2019).

In Minas Gerais State, there are approximately 120 conservation units extending over Atlantic Forest, Cerrado, and Caatinga biomes (ISA, 2021). However, only 8% of these units (Table 1) have information on their odonatofauna, which justifies the need for studies in such areas. From this perspective, this study aims to create an inventory of the odonatofauna in the Environmental Protection Area of the Machado River hydrographic basin (EPA-MRHB), southern Minas Gerais State.

MATERIAL AND METHODS

This study was carried out in the EPA-MRHB (Fig. 1). EPA-MRHB was created in May 1999 with the aim of preserving the hydric resources and biodiversity of the region in a context of intense agricultural activity. Extending over more than 200 km^2, it covers the municipalities of Alfenas, Campestre, Carvalhópolis, Congonhal, Espírito Santo do Dourado, Fama, Ipuiuna, Machado, Paraguaçu, Poço Fundo, and São João da Mata (Brasil, 1999). The phytophysiognomy of EPA-MRHB is predominantly montane semideciduous seasonal forest within the Atlantic Forest Domain, in addition to Cerrado enclaves and marshes associated with riparian forest and altitude fields (ISA, 2021).

The sampling period was from September 2018 (spring) to March 2019 (summer), with 7 field campaigns and 2 consecutive collection days per month, between 9 a.m. and 4 p.m., totaling 98 sampling hours distributed over 14 days. The campaigns were carried out over 12 predefined areas in the municipalities of Fama (21°24′21″S; 45°49′43″W), Machado (21°40′29″S; 45°55′11″W), and Poço Fundo (21°24′23″S; 45°49′43″W) (Fig. 1), ranging from terrestrial to aquatic environments, including lentic and lotic ecosystems (Fig. 2), covering the largest area possible while taking into account logistics and accessibility aspects, in order to obtain a representative species checklist.

Only full-grown individuals were sampled. Specimens were collected by an active method using entomological nets (Cezário *et al.,* 2020). Collected specimens were stored in individual envelopes for approximately 4 h to ensure that the digestive tract of insects was empty. Then, individuals were sacrificed by submersion in pure acetone for 12 to 16 h. This incubation procedure allows acetone to dissolve body fat, helping preserve specimen colors (Carneiro *et al.,* 2016). Subsequently, envelopes were identified with the place and date of collection and the collector's name. The material was photographed for record and sent to Prof. Dr. Ângelo Parisse Pinto at the Federal University of Paraná (UFPR, Brazilian Portuguese acronym) for identification. Specimens were deposited in the university collection under licenses IBAMA/SISBIO (63914-1) and State Institute of Forests (IEF) (062/2018).

Figure 2. (A) Semideciduous and (B) riparian forests associated with (C) lotic and (D) lentic environments in the Environmental Protection Area of the Machado River hydrographic basin, southern Minas Gerais State.

RESULTS

We collected 354 individuals, classified into 71 species (39 Zygoptera and 32 Anisoptera), 8 families, and 30 genera (Table 2, Fig. 3). The family with the highest richness was Libellulidae (28 species), followed by Coenagrionidae (27 species). The latter family had the most abundant species, namely *Ischnura capreolus* (Hagen, 1861), with 20 individuals, followed by *Acanthagrion gracile* (Rambur, 1842) and *Oxyagrion terminale* Selys 1876, both with 17 individuals each.

According to the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (2021), of the 71 sampled species, 59 (83%) are classified as least concern, 4 (6%) as data deficient or not included in the list, and 1 (1%) as vulnerable (Table 2). Seven individuals were classified only at the genus level.

In terms of number of species, this study presents the fifth richest odonatofauna in Minas Gerais State (Table 1) and includes two new records in the state, namely *Erythrodiplax chromoptera* (Borror, 1942) and *Micrathyria venezuelae* De Marmels, 1989.

Comparison with studies carried out in Conservation Units in Minas Gerais revealed seven species occurring exclusively in EPA-MRHB: *Rhionaeschna bonariensis* (Rambur, 1842), *Navicordulia kiautai* Machado & Costa, 1995, *Forcepsioneura machadorum* Vilela, Venâncio & Santos, 2020, *Micrathyria laevigata* Calvert, 1909, *Tholymis citrina* Hagen, 1867, *Oxyagrion hempeli* Calvert, 1909, and *Oxyagrion machadoi* Costa, 1978.

DISCUSSION

Because of their large body size and thermoregulation ability, Libellulidae individuals have high dispersion potential compared with other Anisoptera (Dalzochio *et al.,* 2011), contributing to their wide geographic distribution. In addition to having one of the highest richness within the order (Costa *et al.,* 2012), this family includes many species that are tolerant to anthropized areas, which may explain the results of the current study. Within the suborder Zygoptera, Coenagrionidae has the highest number of species in the country (Lencioni, 2006). The family comprises species tolerant to anthropized areas (Boti *et al.,* 2007) and that inhabit different lentic and lotic environments, including phytotelmata, explaining its richness. The majority of inventories carried out in Minas Gerais State are similar to that of the present study, with the exception of inventories reported by Almeida *et al.* (2013), whose results were likely influenced by the use of Malaise traps for sampling, and Dos Anjos *et al.* (2020), who sampled individuals exclusively in lotic environments of rupestrian fields, differing from other studies (Table 1).

The species *I. capreolus, A. gracile,* and *O. terminale* have wide distribution in Minas Gerais, occurring in different phytophysiognomies of the Atlantic Forest and Cerrado biomes (Dos Anjos, 2017) and being commonly found in lentic environments (Nobre & Carvalho, 2014; Vilela *et al.,* 2016). Such environments are frequent in EPA-MRHB, explaining the abundance of these species in the present study.

Regarding the distribution of the two species that were recorded for the first time in Minas Gerais, *E. chromoptera* is known to occur in Paraná State (Borak, 2016) and Rio Grande do Sul State (Kittel & Engels, 2016) and *M. venezuelae* in Amazonas State (Koroiva *et al.,* 2020) and Paraná State (Araujo & Pinto, 2021).

The fact that 6% of the species were either registered as data deficient or not found in the IUCN database underscores the importance of carrying out inventories,

Figure 3. Odonata species sampled in the Environmental Protection Area of the Machado River hydrographic basin: (A) *Erythrodiplax media* Borror, 1942; (B) *Erythrodiplax paraguayensis* (Förster, 1905); (C) *Tholymis citrina* Hagen, 1867; (D) *Miathyria marcella* (Selys in Sagra, 1857); (E) *Hetaerina longipes* Hagen in Selys, 1853; (F) *Homeoura lindneri* (Ris, 1928); (G) *Telebasis willinki* Fraser, 1948; and (H) *Argia mollis* Hagen in Selys, 1865.

Table 2. Families, abundance, number of individuals per sex, and classification according to the IUCN Red List of Threatened Species (2021) of Odonata individuals sampled in the Environmental Protection Area of the Machado River hydrographic basin, southern Minas Gerais State, Brazil (LC, least concern; DD, data deficient; 0, not registered in the platform; –, species identified at the genus level).

Suborder/Family/Species	Number of Individuals	♀	♂	IUCN
Anisoptera				
Aeshnidae				
Castoraeschna colorata (Martin, 1908)	2	0	2	LC
Remartinia luteipennis (Burmeister, 1839)	2	0	2	LC
Rhionaeschna bonariensis (Rambur, 1842)	3	1	2	LC
Corduliidae				
Navicordulia kiautai Machado & Costa, 1995	1	0	1	DD
Libellulidae				
Dasythemis mincki mincki (Karsch, 1889)	11	3	8	LC
Elasmothemis constricta (Calvert, 1898)	6	0	6	LC
Erythrodiplax castanea (Burmeister, 1839)	2	0	2	LC
Erythrodiplax fusca (Rambur, 1842)	15	9	6	LC
Erythrodiplax chromoptera Borror, 1942	1	0	1	LC
Erythrodiplax juliana Ris, 1911	5	0	5	LC
Erythrodiplax latimaculata Ris, 1911	1	0	1	LC
Erythrodiplax media Borror, 1942	9	5	4	LC
Erythrodiplax melanorubra Borror, 1942	8	1	7	LC
Erythrodiplax ochracea (Burmeister, 1839)	4	4	0	LC
Erythrodiplax pallida (Needham, 1904)	1	0	1	LC
Erythrodiplax paraguayensis (Förster, 1905)	4	4	0	LC
Erythrodiplax umbrata (Linnaeus, 1758)	3	3	0	LC
Erythrodiplax sp.	10	7	3	—
Macrothemis imitans imitans Karsch, 1890	2	0	2	LC
Macrothemis tenuis Hagen, 1868	1	1	0	LC
Miathyria marcella (Selys *in* Sagra, 1857)	13	7	6	LC
Micrathyria hypodidyma Calvert, 1906	2	0	2	LC
Micrathyria hesperis Ris, 1911	2	1	1	LC
Micrathyria laevigata Calvert, 1909	3	0	3	LC
Micrathyria sp.	1	1	0	—
Micrathyria stawiarskii Santos, 1953	9	0	9	LC
Micrathyria venezuelae De Marmels, 1989	8	2	6	LC
Nephepeltia berlai Santos, 1950	1	0	1	LC
Orthemis discolor (Burmeister, 1839)	2	1	2	LC
Perithemis tenera (Say, 1839)	3	0	3	LC
Tholymis citrina Hagen, 1867	2	1	1	LC
Tramea cophysa Hagen, 1867	2	2	0	LC
Zygoptera				
Calopterygidae				
Hetaerina longipes Hagen *in* Selys, 1853	7	2	3	LC
Hetaerina rosea Selys, 1853	14	4	10	LC
Hetaerina sp.	1	1	0	—
Coenagrionidae				
Argia lilacina Selys, 1865	4	0	4	LC
Argia modesta Selys, 1865	6	1	5	LC
Argia mollis Selys, 1865	2	0	2	LC
Argia reclusa Selys, 1865	1	0	1	LC
Argia sordida Selys, 1865	3	0	1	LC
Argia sp.	7	6	1	—
Acanthagrion aepiolum Tennessen, 2004	4	1	3	LC
Acanthagrion gracile (Rambur, 1842)	17	0	17	LC
Acanthagrion lancea Selys, 1876	5	1	4	LC
Acanthagrion truncatum Selys, 1876	14	2	12	LC
Forcepsioneura machadorum Vilela, Venâncio & Santos, 2020	7	0	7	0
Homeoura chelifera (Selys, 1876)	11	4	7	LC
Homeoura lindneri (Ris, 1928)	6	2	4	LC
Homeoura sp.	1	1	0	—
Ischnura capreolus (Hagen, 1861)	20	12	8	LC
Ischnura fluviatilis (Hagen, 1861)	4	1	3	LC
Neoneura sylvatica Hagen *in* Selys, 1886	3	0	3	LC
Oxyagrion hempeli Calvert, 1909	3	2	1	LC
Oxyagrion machadoi Costa, 1978	1	0	1	DD
Oxyagrion microstigma Selys, 1876	1	0	1	LC
Oxyagrion santosi Martins, 1967	1	1	0	LC
Oxyagrion simile Costa, 1978	9	2	7	LC
Oxyagrion terminale Selys, 1876	17	1	15	LC
Telebasis carmesina Selys, 1876	3	2	1	LC
Telebasis erythrina (Selys, 1876)	1	0	1	LC
Telebasis willinki Fraser, 1948	5	1	4	LC
Tigriagrion aurantinigrum Calvert, 1909	3	1	2	LC
Heteragrionidae				
Heteragrion cauei De Ávila-Júnior, Lencioni & Carneiro, 2017	2	0	1	VU
Heteragrion rogertaylori Lencioni, 2013	3	1	2	DD
Heteragrion sp. A	3	1	2	—
Heteragrion sp. B	6	4	3	—
Lestidae				
Archilestes exoletus (Hagen *in* Selys, 1862)	10	1	9	LC
Lestes minutus Selys, 1862	1	0	1	LC
Lestes paulistus Calvert, 1909	2	1	1	LC
Lestes pictus Hagen *in* Selys, 1862	1	0	1	LC
Megapodagrionidae				
Allopodagrion contortum (Hagen *in* Selys, 1862)	6	3	3	LC

which may provide more information on geographic distribution for a better understanding of the endangerment status of these Odonata species. *Heteragrion cauei* was collected in a lotic environment of a dense forest, municipality of Poço Fundo, and classified as vulnerable. Until now, the species had been recorded once, in 2017 in the type location, Ouro Preto, Minas Gerais State (De Ávila-Júnior *et al.,* 2017).

EPA-MRHB is home to the fifth richest odonatofauna community in Minas Gerais; this fact, added to the two new records and the occurrence of *H. cauei,* attests to the importance of the area, especially the Poço Fundo municipality, where there are many forest fragments and less impacted riparian vegetation (Dos Santos, 2019). However, the region is also subject to unplanned ecotourism activities and other threats, such as deforestation, fires, silvopasture, use of pesticides, and siltation of the Machado River. Therefore, actions to minimize these environmental impacts are urgently needed.

FINAL CONSIDERATIONS

EPA-MRHB, particularly the Poço Fundo municipality, hosts a rich odonatofauna community in Minas Gerais, including species recorded for the first time in the state.

AUTHORS' CONTRIBUTIONS: MBG: Data curation, Formal analysis, Project administration, Visualization, Writing – original draft; **MMS:** Funding acquisition, Investigation, Supervision; **MBG, MMS:** Conceptualization, **DSV, MMS:** Methodology, Writing – review & editing; **MBG, DSV, MMS:** Validation. All authors actively participated in the discussion of the results and reviewed and approved the final version of the paper.

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