

## Research Article / Artículo de Investigación

**Odonatofauna in a Brazilian Cerrado area, featuring the rediscovery of two species**

Odonatofauna en una zona del Cerrado brasileño, con el redescubrimiento de dos especies

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**Abstract.** The Cerrado harbors rich biodiversity and yet faces various anthropogenic pressures, an alarming situation that justifies fauna inventory studies, particularly insects, often overlooked in such endeavors. Additionally, many locations within the Cerrado lack information about the odonatofauna, including Conservation Units (CUs), considered the main tools for biodiversity conservation in Brazil. The objective of our study is to report the Odonata community occurring in the Minas Gerais portion of the Parque Nacional Grande Sertão Veredas (PNGSV), the conservation status of species, taxonomic information for some taxa, and compare the Odonata community along wet and dry seasons. The study was conducted from September 2022 to April 2023, with a total of 576 hours of sampling. We collected 601 specimens from 83 species, highlighting two new species (one recently described and other to be described elsewhere), eight new records for the state, and the rediscovery of the species *Progomphus geijskesi* Needham, 1944, collected for the first time in Brazil since 1918, and *Argia botacudo* Calvert, 1909, previously known only from the type material. The significant richness sampled, new taxa, new records, and the presence of species at some risk of extinction reinforce the Cerrado's relevance as a global hotspot. It also underscores the importance of CUs as a tool to ensure the protection of Odonata communities in Brazil and highlights the need to strengthen public policies to guarantee investments and foster future financial resources for the protection of Brazilian biota, especially for conducting more inventory studies in the Cerrado.

**Key words:** Conservation; dragonflies; Minas Gerais; new records; new species.

**Resumen.** El Cerrado alberga una rica biodiversidad y aún enfrenta diversas presiones antropogénicas, una situación alarmante que justifica estudios de inventario de fauna, especialmente de insectos, a menudo pasados por alto en tales esfuerzos. Además, muchos lugares dentro del Cerrado carecen de información sobre la odonatofauna, incluidas las Unidades de Conservación (UC), consideradas las principales herramientas para la conservación de la biodiversidad en Brasil. El objetivo de nuestro estudio es informar sobre la comunidad de odonatos que se encuentra en la porción de Minas Gerais del Parque Nacional Grande Sertão Veredas (PNGSV), el estado de conservación de las especies, información taxonómica para algunos taxones y comparar la comunidad de odonatos durante las estaciones húmeda y seca. El estudio se realizó de septiembre de 2022 a abril de 2023, con un total de 576 horas de muestreo. Recopilamos 601 ejemplares de 83 especies, destacando dos nuevas especies

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(una recientemente descrita y otra por describirse en otro lugar), ocho nuevos registros para el estado y el redescubrimiento de las especies *Progomphus geijskesi* Needham, 1944, recolectada por primera vez en Brasil desde 1918, y *Argia botacudo* Calvert, 1909, conocida anteriormente solo por el material tipo. La riqueza significativa muestreada, los nuevos taxones, los nuevos registros y la presencia de especies en riesgo de extinción refuerzan la relevancia del Cerrado como un hotspot global. También subraya la importancia de las UC como herramienta para garantizar la protección de las comunidades de odonatos en Brasil y destaca la necesidad de fortalecer las políticas públicas para garantizar inversiones y fomentar futuros recursos financieros para la protección de la biota brasileña, especialmente para llevar a cabo más estudios de inventario en el Cerrado.

**Palabras clave:** Conservación; libélulas; Minas Gerais; nuevas especies; nuevos registros.

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## Introduction

The Cerrado is the second largest Brazilian biome, covering 11 out of the 26 states of the country. Originally, the Cerrado area in Brazil was 204 million hectares, corresponding to about 25% of the whole territory (MMA 2009). The Cerrado harbors rich biodiversity and has a high rate of endemism among the species that inhabit it. It is critically threatened, hence considered a global hotspot (Myers *et al.* 2000; Mittermeier *et al.* 2011; ICMBio 2018). These threats often involve various human activities, especially the expansion of agriculture, such as soy cultivation and livestock farming, which have led to the alteration or elimination of about 46% of the biome in the last 60 years, with only 19.8% of its natural area still intact (MMA 2009; Strassburg *et al.* 2017; Rausch *et al.* 2019).

This situation is alarming and justifies fauna inventory studies. For instance, insects perform various environmental services (Brock *et al.* 2021) and are essential for ecosystem functioning. However, such endeavors often overlook these organisms (Cardoso *et al.* 2011). Dragonflies (Odonata), for example, play important roles in the trophic webs of freshwater environments (lentic and lotic) and terrestrial ecosystems. Dragonflies act as predators in both their aquatic larval and adult stages (Junior *et al.* 2021; Mogali *et al.* 2022) and serve as prey for other organisms (Souza *et al.* 2018; Ferreira *et al.* 2023). Moreover, they function as bioindicators of anthropogenic changes in aquatic environments and climate change (Ferreira-Peruquetti and De Marco Jr. 2002; Ribeiro *et al.* 2021; Vila-Verde *et al.* 2021).

Nevertheless, many locations within the Cerrado, even within Conservation Units (CUs), lack information about the Odonata community. An example of this is the Parque Nacional Grande Sertão Veredas (PNGSV from now on), located in the northern part of the state of Minas Gerais and the southern part of Bahia state. This park is considered a potential and priority area for the conservation of invertebrates in this region (Drummond *et al.* 2005).

The CUs of integral protection or sustainable use are considered the best tools to ensure and protect the Brazilian biota and natural resources (Salvio 2017) and promote deforestation reduction (Clemente *et al.* 2020). However, these areas face various anthropogenic pressures, such as criminal fires, deforestation, illegal mining, and invalidation of Indigenous Lands (Alves *et al.* 2020; Mota Junior *et al.* 2021; Costa *et al.* 2023). This has led to an increase in temperature and a reduction in the humidity of the biome, for example (Hofmann *et al.* 2021).

Such anthropogenic pressures are also reflected in the assessments of the conservation status of species (Francisco *et al.* 2024). In Brazil, 884 species of Odonata are reported, of which 46 are in some category of extinction threat, and 242 of them lack sufficient data (regarding their distribution, ecology, taxonomy, etc.) to allow for a robust analysis of their conservation status (IUCN 2023, see Material and Methods section for a detailed explanation). Taxonomic and distributional impediment, also known, respectively, as Linnean and Wallacean Shortfalls (Hortal *et al.* 2015), is one of the main causes of this deficit

of information about species, and initiatives such as the construction of inventories are essential to alleviate these knowledge gaps.

Therefore, the objective of our study is to report the Odonata community that occurs in the Cerrado of the PNGSV, Minas Gerais state portion, revealing possible taxonomic novelties, new records for the state, compare the Odonata community along wet and dry seasons, and contribute to reducing the knowledge gaps still present for Odonata.

## Material and Methods

### Study area

Our study was conducted in the Minas Gerais portion of the PNGSV (15° 6' S 45° 48' 59" W), in the municipality of Chapada Gaúcha, northern portion of the state. The Park was founded in 1989, with an expansion in 2004, covering an area of 230,671 hectares, with an altitude between 600 and 900 m asl. It is characterized by sandy plateaus covered with Cerrado biome vegetation, protected and preserved, with Cerrado *sensu stricto*, Cerradão, Vereda, Mata de Galeria, Campo Sujo, and Campo Limpo phytophysionomies (Funatura 2003; Ribeiro and Walter 2008). The region has a tropical climate, with an average annual temperature of around 23 °C, with highs ranging from 37 °C to 40 °C and lows between 16 °C and 19 °C. The dry season in winter starts in May and goes on until September/October, and the rainy season in summer lasts from November to March. The average precipitation is 1,400 mm/year. There are different aquatic environments, both lentic and lotic. Many Veredas (*i.e.*, palm swamps), which are important phytophysionomies for protecting springs and providing water, food, and shelter for wildlife (Castro 1980). Additionally, there are permanent rivers within the park, such as Carinhanha, Rio Preto, and Mato Grande (Funatura 2003).

### Collecting events

The study was conducted in four campaigns, from September 2022 to April 2023. Each campaign lasted for six consecutive days, from 9 am to 1 pm and from 4 pm to 6 pm, with four researchers, 144 hours of sampling effort per researcher (576 hours in total). Sampling was carried out in five areas: (i) the region of the Mato Grande waterfall, (ii) the region around the Carinhanha lodging, (iii) Veredas and Mata de Galeria of the Rio Preto, (iv) Veredas and temporary lagoons of the Carinhanha River, and (v) Córrego da Onça.

An active search method was employed to collect the specimens. With the aid of entomological nets, we collected specimens in lentic and lotic environments, in addition to associated terrestrial environments. Collections took place in different physiognomies of the Cerrado, especially in areas of Mata de Galeria and Veredas (Fig 1).

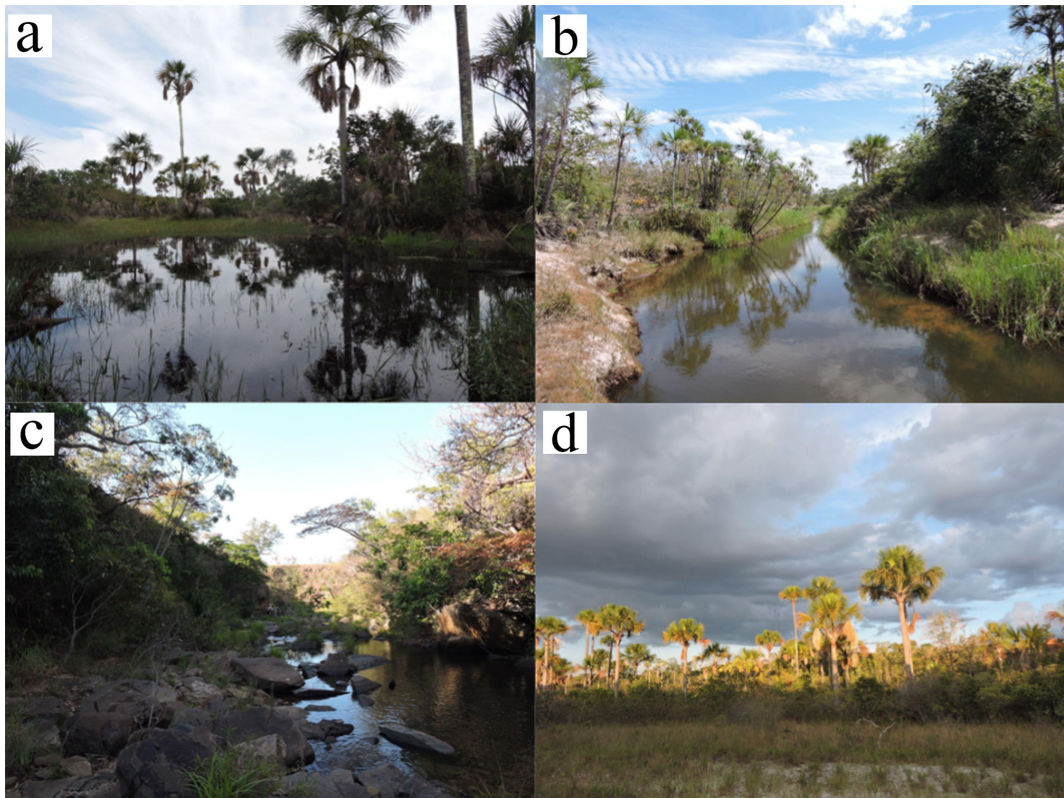
### Identification and taxonomic treatment

After capture, the specimens were placed in entomological envelopes for about six hours (7 x 11 cm) with proper identification (collection location, date, and collector's name) to store the specimens and empty the digestive tract. After this, we proceeded to sacrifice the specimens, which were immersed in PA acetone (pure for analysis), where they remained for about 12 hours, varying according to the size of the species, to dissolve lipids and thus preserve the coloration (Garrison *et al.* 2006; Cezário *et al.* 2021). The species were identified at the generic level using dichotomous keys contained in Garrison *et al.* (2006, 2010) and Lencioni (2017), and at the specific level through competent review articles for each taxon.

The taxonomic treatment of *Progomphus geijskesi* follows the nomenclature proposed by Belle (1966, 1973), for *Argia botacudo* we follow Garrison *et al.* (2010). Measurements are given in millimeters (mm) and include anal appendages. Abbreviations of structures: Abd: abdomen; HW: hind wing; Cpt: coastal side of pterostigma.

IUCN listing of species occurring in Brazil was obtained at IUCN's website by accessing the "Advanced Options" tab, then selecting the filters: taxonomy (Odonata), Land Regions, South America and Brazil.

All specimens were cataloged and deposited in the Coleção Biológica de Vespas Sociais (CBVS) at the Instituto Federal de Educação, Ciência e Tecnologia de Minas Gerais (IFSULDEMINAS) campus Inconfidentes, Minas Gerais state, Brazil, (<https://specieslink.net/col/CBVS/>). The study was authorized by the Sistema de Autorização e Informação em Biodiversidade (SISBio), license no. 83294-1.



**Figure 1.** Lentic (A e D) and lotic (B e C) environments sampled at the PNGSV, Minas Gerais, southeastern Brazil. / **Figura 1.** Ambientes lénticos (A y D) y lóticos (B y C) muestreados en el PNGSV, Minas Gerais, sureste de Brasil.

### Statistical analysis

To assess the sample effort, an accumulation curve was created using the observed richness with a 95% confidence interval, by the Bootstrap 1 estimator in the software EstimateS 9.1.0 (Cowell and Elsensohn 2014). This estimator uses information from all collected species instead of restricting the analysis to rare species (Santos 2003). To evaluate the similarity of the species community between rainy and dry seasons, a Principal Coordinates Analysis (PCoA) using the Jaccard index was performed based on species presence/absence data. Subsequently, a PERMANOVA (Permutational Multivariate Analysis of Variance) was

conducted to test significant differences in the community between seasons, using the Past program (Hammer *et al.* 2005).

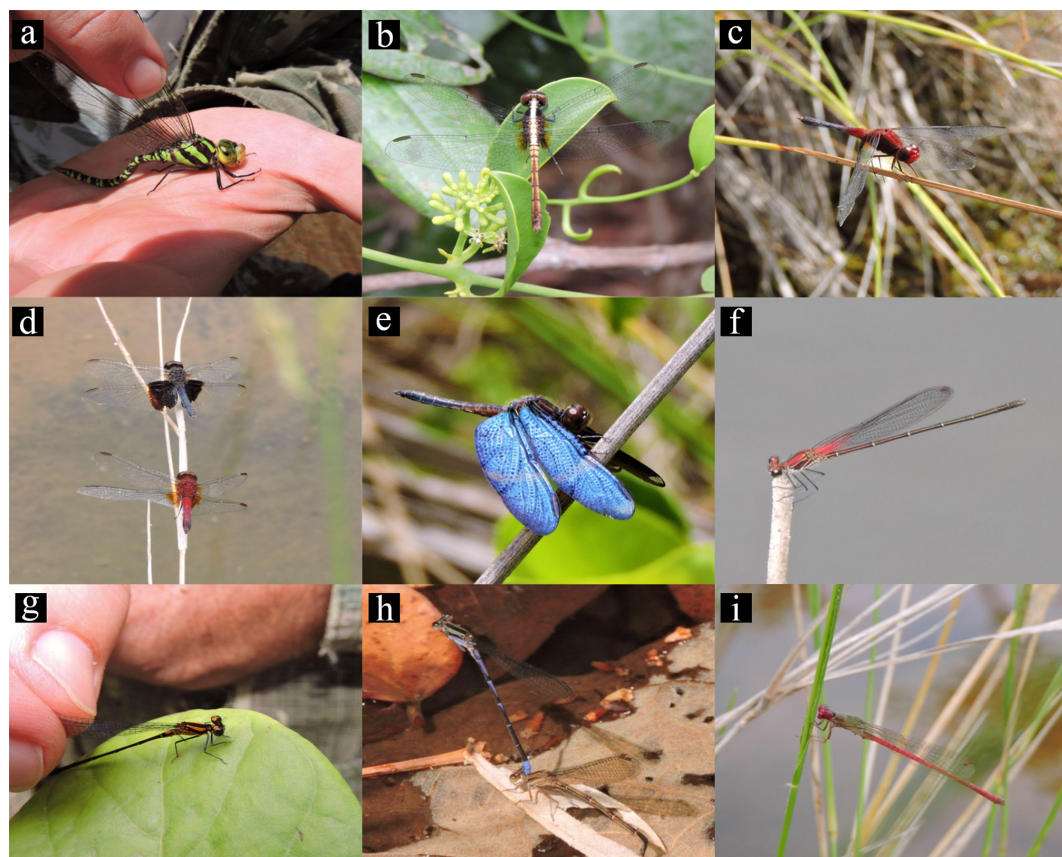
### Conservation status

The data regarding the threat status of the species were obtained by consulting the websites of the International Union for Conservation of Nature (IUCN, iucnredlist.org) and the Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio, salve.icmbio.gov.br).

## Results and Discussion

### Species list

A total of 601 specimens from 83 species were collected, distributed across seven families. Among these, we highlight two species: *Minagrion veredae* Vilela & Souza, 2023 (collected during our samplings, described elsewhere) and *Argia* sp. a possible new taxon. Additionally, we report eight new records for the state of Minas Gerais and two species rediscovered after several decades. Nine species falling into some category of extinction risk (Tab. 1, Figs. 2, 3).



**Figure 2.** Some Odonata species recorded at the PNGSV, Minas Gerais state, southeastern Brazil. / **Figura 2.** Algunas especies de Odonata registradas en el PNGSV, estado de Minas Gerais, sureste de Brasil. **A.** *Castoraeschna januaria*. **B.** *Erythemis peruviana* - female. **C.** *Erythrodiplax fusca*. **D.** *Erythrodiplax latimaculata* (above), *E. fusca* (below). **E.** *Zenithoptera lanei*. **F.** *Hetaerina longipes*. **G.** *Argia* sp. **H.** *Argia botacudo*. **I.** *Oxyagrion impunctatum*.

**Table 1.** Suborder, family, species, conservation status and abundance of dragonflies (Odonata) sampled at the PNGSV, Minas Gerais state, southeastern Brazil. Data Deficient (**DD**), Least Concern (**LC**), Vulnerable (**VU**), Endangered (**EN**), Critically Endangered (**CR**), *International Union for Conservation of Nature (IUCN)* and Instituto Chico Mendes de Conservação da Biodiversidade (**ICMBio**) (\* = new records to Minas Gerais state; ♦ = species under some threatening category). / **Tabla 1.** Suborden, familia, especie, estado de conservación y abundancia de libélulas (Odonata) muestreadas en el PNGSV, estado de Minas Gerais, sureste de Brasil. Datos insuficientes (**DD**), Preocupación menor (**LC**), Vulnerable (**VU**), En peligro (**EN**), En peligro crítico (**CR**), Unión Internacional para la Conservación de la Naturaleza (**IUCN**) e Instituto Chico Mendes de Conservação da Biodiversidade (**ICMBio**) (\* = nuevos registros para el estado de Minas Gerais; ♦ = especies bajo alguna categoría amenazante).

Suborder/Family/Species	IUCN	ICMBio	Abundance
<b>ANISOPTERA</b>			
<b>Aeshnidae</b>			
<i>Castoraeschna januararia</i> (Hagen, 1867) ♦	LC	VU	3
<b>Libellulidae</b>			
<i>Dasythemis venosa</i> (Burmeister, 1839)	LC	LC	2
<i>Diastatops obscura</i> (Fabricius, 1775)	LC	LC	3
<i>Dythemis nigra</i> (Martin, 1897)	LC	LC	1
<i>Erythemis credula</i> (Hagen, 1861)	LC	LC	3
<i>Erythemis haematogastra</i> (Burmeister, 1839)	LC	LC	1
<i>Erythemis plebeja</i> (Burmeister, 1839)	LC	LC	1
<i>Erythemis vesiculosa</i> (Fabricius, 1775)	LC	LC	2
<i>Erythrodiplax amazonica</i> Sjöstedt, 1918	LC	LC	10
<i>Erythrodiplax ana</i> Guillermo-Ferreira & Vilela, 2016 ♦	EN	LC	1
<i>Erythrodiplax anatoidea</i> Borror, 1942*	LC	LC	1
<i>Erythrodiplax avittata</i> Borror, 1942	LC	LC	3
<i>Erythrodiplax castanea</i> (Burmeister, 1839)	LC	LC	4
<i>Erythrodiplax fusca</i> (Rambur, 1842)	LC	LC	52
<i>Erythrodiplax juliana</i> Ris, 1911	LC	LC	12
<i>Erythrodiplax latimaculata</i> Ris, 1911	LC	LC	36
<i>Erythrodiplax lygaea</i> Ris, 1911	LC	LC	26
<i>Erythrodiplax maculosa</i> (Hagen, 1861)	LC	LC	11
<i>Erythrodiplax paraguayensis</i> (Förster, 1905)	LC	LC	29
<i>Erythrodiplax umbrata</i> (Linnaeus, 1758)	LC	LC	5
<i>Gynothemis venipunctata</i> Ris, 1909	LC	LC	4
<i>Idiataphe batesi</i> (Ris, 1913)*	LC	LC	1
<i>Idiataphe longipes</i> (Hagen, 1861)	LC	LC	2
<i>Macrothemis imitans</i> Karsch, 1890	LC	LC	9
<i>Miathyria marcella</i> (Selys, 1857)	LC	LC	4
<i>Miathyria simplex</i> (Rambur, 1842)	LC	LC	1

<i>Micrathyria artemis</i> Ris, 1911	LC	LC	4
<i>Micrathyria catenata</i> Calvert, 1909	LC	LC	1
<i>Micrathyria pseudeximia</i> Westfall, 1992	LC	LC	4
<i>Micrathyria divergens</i> Westfall, 1992 ♦	VU	VU	1
<i>Micrathyria pirassunungae</i> Santos, 1953	LC	LC	3
<i>Nephepeltia berlai</i> Santos, 1950	LC	LC	3
<i>Oligoclada pachystigma</i> Karsch, 1890	LC	LC	1
<i>Oligoclada xanthopleura</i> Borrer, 1931	DD	LC	3
<i>Orthemis aequilibris</i> Calvert, 1909	LC	LC	3
<i>Pantala flavescens</i> (Fabricius, 1798)	LC	LC	2
<i>Perithemis lais</i> (Perty, 1834)	LC	LC	4
<i>Perithemis tenera</i> (Say, 1840)	LC	LC	1
<i>Tholymis citrina</i> Hagen, 1867	LC	LC	2
<i>Tramea abdominalis</i> (Rambur, 1842)	LC	LC	3
<i>Tramea binotata</i> (Rambur, 1842)	LC	LC	1
<i>Uracis siemensi</i> Kirby, 1897	LC	LC	5
<i>Zenithoptera lanei</i> Santos, 1941	LC	LC	7
<b>Gomphidae</b>			
<i>Archaeogomphus densus</i> Belle, 1982	DD	LC	2
<i>Phyllogomphoides</i> sp.	-	-	1
<i>Progomphus complicatus</i> Selys, 1854	LC	LC	3
<i>Progomphus geijskesi</i> Needham, 1944*	DD	DD	2
<b>ZYGOPTERA</b>			
<b>Calopterygidae</b>			
<i>Hetaerina rosea</i> Selys, 1853	LC	LC	29
<i>Hetaerina dutati</i> Machado, 2017* ♦	CR	-	24
<i>Mnesarete guttifera</i> (Selys, 1873)	LC	LC	1
<b>Coenagrionidae</b>			
<i>Acanthagrion aepiolum</i> Tennessen, 2004	LC	LC	4
<i>Acanthagrion cuyabae</i> Calvert, 1909	LC	LC	1
<i>Acanthagrion marinae</i> Lozano & Rodrigues, 2018* ♦	VU	LC	1
<i>Acanthagrion temporale</i> Selys, 1876	LC	LC	16
<i>Acanthagrion truncatum</i> Selys, 1876	LC	LC	30
<i>Argia bicellulata</i> (Calvert, 1909)*	DD	LC	5
<i>Argia botacudo</i> Calvert, 1909	DD	LC	2
<i>Argia hasemani</i> Calvert, 1909	LC	LC	1
<i>Argia lilacina</i> Selys, 1865	LC	LC	11

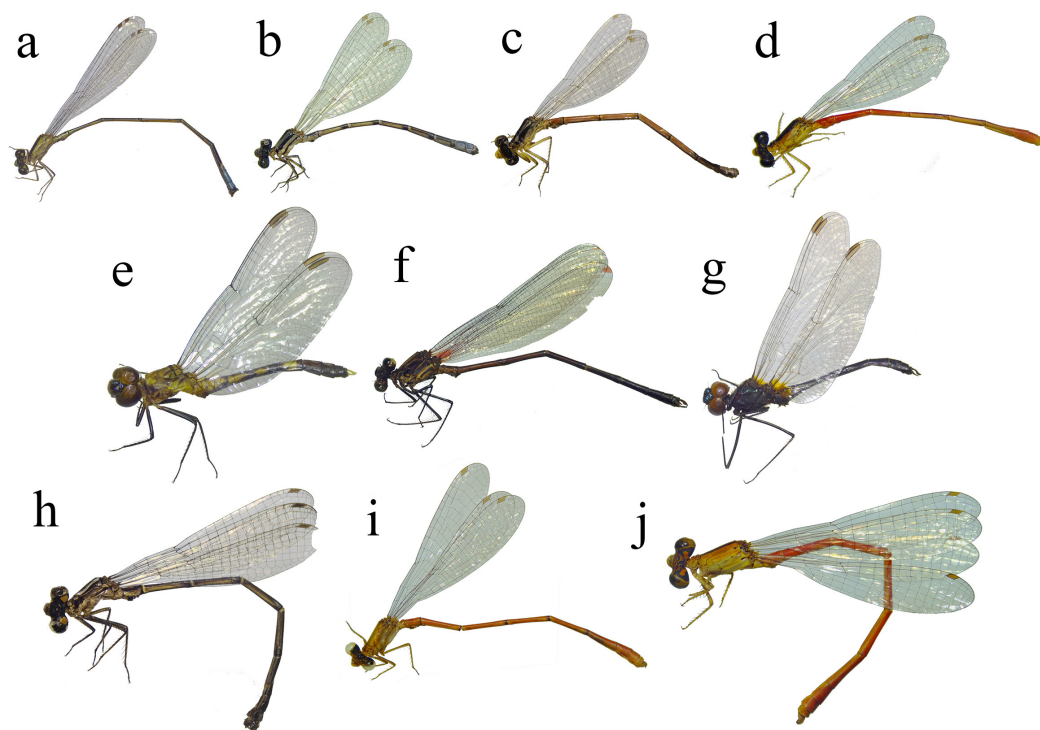
<i>Argia reclusa</i> Selys, 1865	LC	LC	2
<i>Argia smithiana</i> Calvert, 1909	LC	LC	28
<i>Argia</i> sp.	-	-	8
<i>Argia tamoyo</i> Calvert, 1909	LC	LC	14
<i>Argia tinctipennis</i> Selys, 1865	LC	LC	13
<i>Epipleoneura machadoi</i> Rácenis, 1960	LC	LC	9
<i>Epipleoneura williamsoni</i> Santos, 1957	LC	LC	1
<i>Homeoura chelifera</i> (Selys, 1876)	LC	LC	2
<i>Homeoura lindneri</i> (Ris, 1928) ♦	LC	VU	3
<i>Ischnura capreolus</i> (Hagen, 1861)	LC	LC	17
<i>Minagrion veredae</i> Vilela & Souza 2023	-	-	11
<i>Nehalennia minuta</i> (Selys in Sagra, 1857)	LC	LC	3
<i>Neoneura sylvatica</i> Hagen, 1886	LC	LC	8
<i>Oxyagrion fernandoi</i> Costa, 1988	LC	LC	12
<i>Oxyagrion impunctatum</i> Calvert, 1909	LC	LC	5
<i>Telebasis carminita</i> Calvert, 1909*	LC	LC	3
<i>Telebasis coccinea</i> (Selys, 1876)	LC	LC	17
<i>Telebasis racenisi</i> Bick & Bick, 1995*	LC	LC	1
<i>Telebasis simulata</i> Tennessen, 2002*	LC	LC	4
<i>Tigriagrion aurantinigrum</i> Calvert, 1909	LC	LC	14
<b>Dicteriadidae</b>			
<i>Heliocharis amazona</i> Selys, 1853	LC	LC	1
<b>Lestidae</b>			
<i>Lestes dichrostigma</i> Calvert, 1909	LC	LC	1
<i>Lestes forficula</i> Rambur, 1842	LC	LC	3
<i>Lestes minutus</i> Selys, 1862	LC	LC	13
<b>Richness</b>			<b>83</b>
<b>Abundance</b>			<b>601</b>

### New species and a possible new one

A new species was discovered during our sampling events: *Minagrion veredae* Vilela & Souza, 2023, recently described (Vilela *et al.* 2023; Fig 3c). This species is closely associated with the lentic habitats found in the Veredas (*i.e.*, palm swamps; hence its name), like other species of the genus (Vilela *et al.* 2020), perched on the vegetal margin and occurring away from the water. The article describing *M. veredae* was recently published in Zootaxa (Vilela *et al.* 2023).

The species *Argia* sp. (Figs. 2g, 3h) was not formally described yet and will be treated further in another study. However, Rosser Garrison (an authority in the genus *Argia*) have confirmed that this is possibly a new species. This species was found associated with lotic and open habitats, similarly to the one found in Fig 1c, often perched on the marginal rocks.

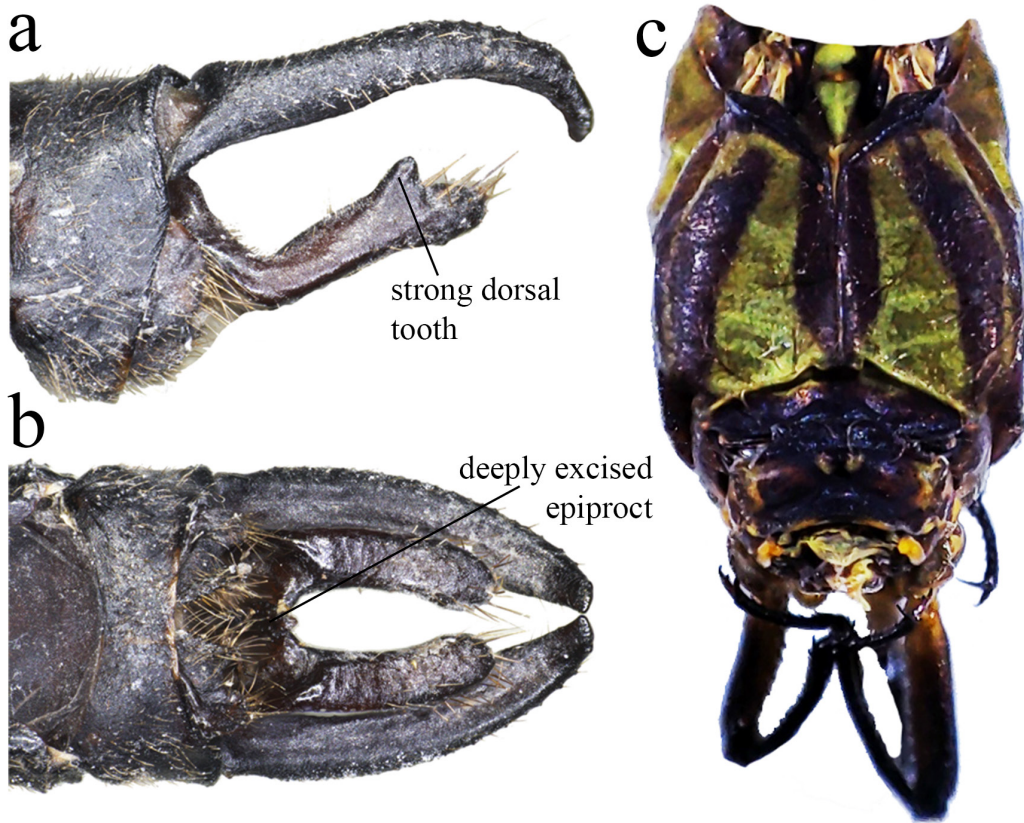




**Figure 3.** New species and new records to Minas Gerais state / **Figura 3.** Nuevas especies y nuevos registros para el estado de Minas Gerais. (a) *Acanthagrion marinae* Lozano & Rodrigues, 2018. (b) *Argia bicellulata* (Calvert, 1909). (c) *Minagrion veredae* Vilela & Souza, 2023 (paratype). (d) *Telebasis carminita* Calvert, 1909. (e) *Erythrodiplax anatoidea* Borror, 1942. (f) *Hetaerina dutati* Machado, 2017. (g) *Idiataphe batesi* (Ris, 1913). (h) *Argia* sp. (i) *Telebasis racenisi* Bick & Bick, 1995. (j) *Telebasis simulata* Tennessen, 2002.

### The rediscovery of *Progomphus geijskesi* Needham, 1944 and *Argia botacudo* Calvert, 1909

*Progomphus geijskesi* was lastly collected in 1959 by Jean Belle (Belle 1966), who described the hitherto unknown male allotype. He stated that this species is a “borderline member of the genus”, mainly because of its anal appendage morphology, where the cerci are cylindrical instead of the usual plated shape of *Progomphus* (Belle 1966). In his revision of the genus Belle brought other records to this species, including an old record for the northern portion of Pará state, and another one from “Chapada”, both from 1918 (Belle 1973). The “Pará” record is mentioned as “Upper Rocana River”, which represents an area near the border with the French Guyana, in the Brazilian state of Amapá (dismembered from Pará state in 1943), in a river known as Urucaua, located at the northernmost portion of Brazil. The second record, at “Chapada”, probably represents the Chapada dos Guimarães in Mato Grosso state. However, we consider this record as dubious, as the collected female had large portions of the abdomen missing (including the ovipositor). Here we present the first specimens collected in Brazil after 105 years, its first record to the southeastern region of Brazil representing the southernmost record of this species so far, along with the first photographs of the appendages and thoracic color pattern (Fig 4).



**Figure 4.** *Progomphus geijskesi* Needham, 1944. (a) Lateral view of anal appendages. (b) Ventral view of anal appendages. (c) Anterior view of pterothorax. / **Figura 4.** *Progomphus geijskesi* Needham, 1944. (a) Vista lateral de los apéndices anales. (b) Vista ventral de los apéndices anales. (c) Vista anterior del pterotórax.

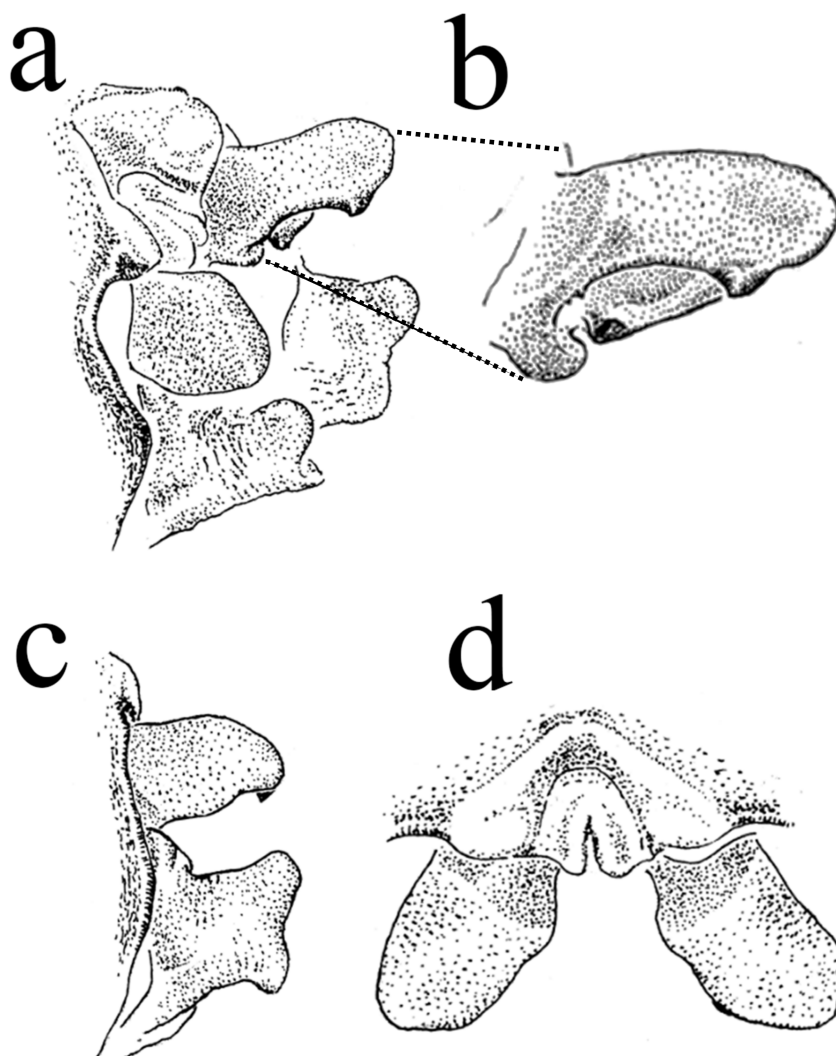
Taxonomic additions to the male description of *P. geijskesi* (details of the original description in parenthesis): face dark brown, anteclypeus dark brown (face brown, anteclypeus green); prothorax dark brown (prothorax dull brown); pterothorax (Fig. 4c) with two thick green mesepisternal stripes, connected above with the thin green stripe near the suture (green stripes thicker, in some specimens interrupted at its middle, as seen in Belle (1966, Fig. 14); the deeply excised epiproct (Figs. 4a-b) bearing large dorsal teeth on each of its branches, not seen in ventral view (bearing smaller dorsal teeth, seen in ventral view); measurements: Abd: 26.3; HW: 19.4; Cpt: 2.6.

*Progomphus geijskesi* is probably one of the rarest species of the genus with five records in over 100 years (Needham 1944; Belle 1966, 1973). In both assessments, from ICMBio and IUCN, this species is classified as DD (data deficient), because the records are old and need confirmation (Cano-Cobos *et al.* 2021; De Marco *et al.* 2023a). Our observations of this species are similar to other species of the genus, in which males are spotted perched on the rocks near the water, chasing smaller dragonflies and often patrolling around.

*Argia botacudo* Calvert, 1909 was currently known only from the type material collected at the Chapada dos Guimarães, Mato Grosso state (Calvert 1909). Since then, some studies have listed this species in their inventories (Rodrigues & Roque 2017; Koroiva *et al.* 2020), however the true identity of *A. botacudo* was very difficult to determine, due mainly to: (i) the simple line drawings provided by Calvert (1909), (ii) the morphological proximity

between the species, (iii) lack of comparison of these specimens with the syntypes of *A. botacudo* and (iv) the large number of species in the genus.

The true identity of *A. botacudo* was determined after we sent some specimens to be determined by Rosser Garrison, a world authority in the taxonomy of *Argia*, author of several review articles on this genus (Garrison 1996; Garrison & von Ellenrieder 2007, 2017, 2018). After the species description in 1909, here we present the first two additional males collected since the early 20th century (Fig. 2h). Our specimens were compared with the syntypes, on loan with Rosser Garrison (Fig. 5), and the structures of the cercus and paraprocts were a perfect match, along with the coloration patterns. A detailed diagnosis and comparison of *A. botacudo* and other *Argia* species occurring in Brazil is currently being prepared and should be published soon (Rosser Garrison pers. comm.).



**Figure 5.** *Argia botacudo* Calvert, 1909. (a) Cercus in mediodorsal view. (b) Closeup of left cercus in mediodorsal view. (c-d) Lateral and dorsal views. Drawings provided by Rosser Garrison. / **Figura 5.** *Argia botacudo* Calvert, 1909. (a) Cerco en vista mediodorsal. (b) Primer plano del cerco izquierdo en vista mediodorsal. (c-d) vistas lateral y dorsal. Dibujos proporcionados por Rosser Garrison.

## New records for Minas Gerais state

We have recorded eight new records to the state of Minas Gerais (Fig. 3):

The newly described *Acanthagrion marinae* (Fig. 3a) was assessed as vulnerable by the IUCN assessors in 2021 (Vilela & Guillermo-Ferreira 2021), due to its occurrence in Veredas outside protected areas. However, in 2023 it was assessed as least concern (LC) by the ICMBio assessment, due to new records added in Mato Grosso do Sul state (De Marco *et al.* 2023b). Here we add new records, also made in Vereda environments, and expand the distribution of this taxon, and corroborating its last conservation assessment by the ICMBio. We expanded its distribution by at least 1000 km with the first record of this species to Minas Gerais state, and to the southeastern region, representing the northernmost record of this species so far.

*Telebasis carminita* (Fig. 3d) is widespread in South America, in Brazil occurring in at least four states other than Minas Gerais: Amapá, Mato Grosso, Mato Grosso do Sul and Roraima. It is assessed as LC by the IUCN and ICMBio, occurring in at least two protected areas (De Marco *et al.* 2023e). It was collected in ponds at the PNGSV. We expanded its distribution by at least 1000 km with the first record of this species to Minas Gerais state, and to the southeastern region, representing the easternmost record of this species so far.

*Telebasis simulata* (Fig. 3j) is a species relatively rare in inventories. It was lastly collected in Brazil in 2008 (Neiss 2012), and before that in 1958 (Tennessen 2002). Nevertheless, it is assessed as LC on both IUCN and ICMBio lists, due to its large distribution, that hitherto ranges from northern Brazil to Trinidad and Tobago (Garrison 2009), in Central America. Here we report the southernmost record for this species. We expanded its distribution by at least 1700 km with the first record of this species to Minas Gerais state, and to the southeastern region, representing the southernmost record of this species so far.

*Telebasis racenisi* (Fig. 3i) is widely distributed in lentic habitats throughout South America, being recorded previously in Brazil to the states of Goiás, Mato Grosso, Rondônia and Tocantins (De Marco *et al.* 2023c). Our new record falls under the expected range of occurrence of the species and represents also the first record of this species to the southeastern region of Brazil. We expanded its distribution by almost 500 km with the first record of this species to Minas Gerais state, and to the southeastern region, representing the easternmost record of this species so far.

*Argia bicellulata* (Fig. 3b) is endemic to Brazil, hitherto known to occur only in two localities, in the states of Mato Grosso and Amazonas (Vilela *et al.* 2018; De Marco *et al.* 2023d). Here, it is also recorded for the first time in the southeastern region of Brazil. This species is known to inhabit Vereda areas (Vilela *et al.* 2018), the same habitat that it was collected at the PNGSV. In the last IUCN assessment, *A. bicellulata* was classified as DD (von Ellenrieder 2009a), whereas a most recent evaluation has assessed this species as LC, due to recent records in protected areas (De Marco *et al.* 2023d). We agree with the most recent evaluation and expand its distribution range to 1300 km.

*Hetaerina dutati* (Fig. 3f) is also endemic to Brazil and was recently described from specimens collected in Pará state, northern Brazil (Machado 2017). This is a rare species, threatened by habitat loss and degradation due to agriculture expansion (Bota-Sierra and Sandoval 2021). Due to this, it is assessed as critically endangered (CR) by the IUCN red list evaluation (Bota-Sierra and Sandoval 2021). Here we report the first record of this species to the southeastern region, expanding its distribution by the southernmost record so far. Fortunately, there are other records of this species (outside Pará state) known to us by personal communication: in Maranhão and Bahia states (Daniel Veras and Marciel Rodrigues pers. comm.). We hope that this additional data will contribute to further conservation assessments and reveal a better conservation scenario for *H. dutati*.

*Erythrodiplax anatoidea* (Fig. 3e) has a great distribution range in South America (Mauffray and Tennessen 2020). In Brazil, it was hitherto recorded to the states of Amazonas and Rondônia (De Marco *et al.* 2023f). Here we expand its distribution to at least 2000 km with the first record of this species to Minas Gerais state, and to the southeastern region, representing the southernmost record of this species so far.

*Idiataphe batesi* (Fig. 3g) is also a widely distributed species, occurring in at least five countries in South America (Guzmán Ojeda and González-Soriano 2021). It was recorded previously in Bahia state in a locality near our study area (De Marco *et al.* 2023g). Therefore, although it represents a new record state to Minas Gerais, it lands within the expected distribution range of the species.

### Species at extinction risk and evaluation divergences

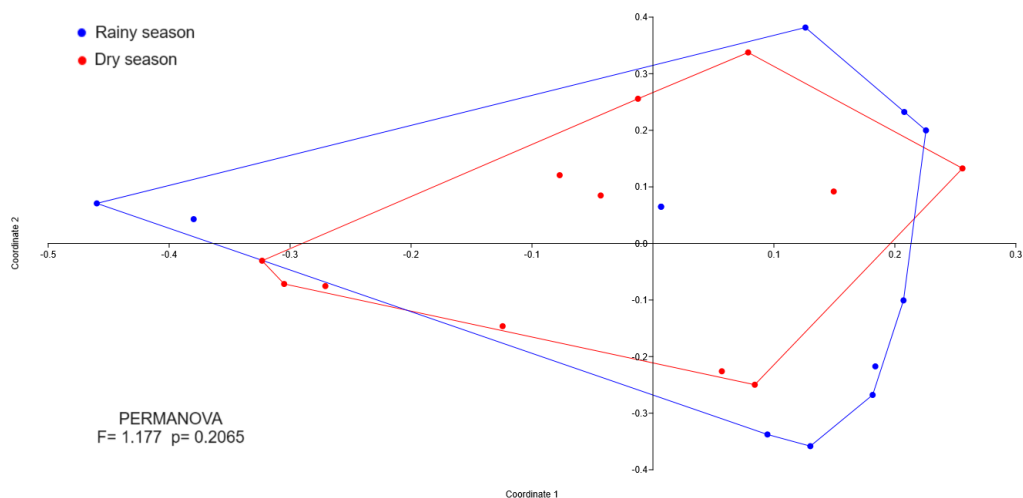
Endemic to Brazil (more specifically, Minas Gerais state) *Micrathyria divergens* Westfall, 1992, is assessed as vulnerable (VU) in both assessments from IUCN and ICMBio (von Ellenrieder 2009b). Apparently, this species has not been recorded for the state since the 60's, and the last literature report of *M. divergens* is the paper describing the species (Westfall 1992). Our record represents the northernmost record of this species so far and adds important data for the future assessments of this species (which are urgent), to determine more precisely its current threatening status. The fact that the species was collected in another protected area is hopefully a sign that *M. divergens* can be less threatened than the current evaluations predict.

For some species, we have also noticed some divergences between the evaluations of the IUCN and the ICMBio: *Acanthagrion marinae*, *Castoraeschna januaria* (Hagen, 1867), *Erythrodiplax ana* Guillermo-Ferreira & Vilela, 2016, *Micrathyria dunklei* Westfall, 1992, *Oligoclada xanthopleura* Borrer, 1931, *Homeoura lindneri* (Ris, 1928). In most of the cases this occurs due to the outdated nature of the assessment (either from IUCN or ICMBio), but it can also be related to the divergent sets of data available to each team at the moment of the assessment, and ultimately due to personal evaluation by the professionals. In any case, we advise for the use of the most recent assessments, as they are often supported by updated data.

### Statistical analysis

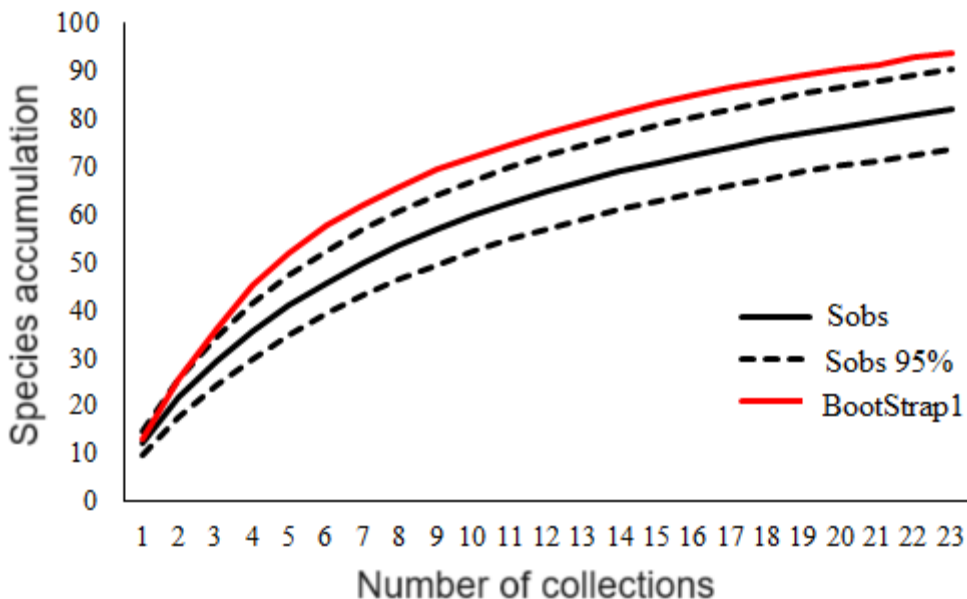
According to our Principal Coordinates Analysis (PCoA) and subsequent PERMANOVA test (Fig. 6), there was no statistical difference between the rainy and dry seasons ( $p=0.2065$ ). This can be explained by the presence of Veredas (*i.e.*, palm swamps), which ensure water in these environments throughout the year, as they are areas where the water table surfaces, and the soil remains saturated with water even during the dry season (Padovesi-Fonseca 2006). This is different, for example, from areas of dry forest in the Caatinga, where the dry period is more prolonged, there are no Veredas, and the ponds reduce their water volume (Gouvea *et al.* 2023).

In addition to the Veredas environments, the presence of permanent rivers such as Carinhanha, Rio Preto, and Mato Grande (Funatura 2003), forming heterogeneous environments, also contributes to sustaining greater Odonata richness in these habitats (Bedê *et al.* 2015), especially when compared to other studies in the same biome and elsewhere (Guedes *et al.* 2022; Gouvea *et al.* 2023). Another relevant factor is the degree of conservation of aquatic environments ensured by the Conservation Unit, as more conserved areas favor greater richness (Santos *et al.* 2021). Additionally, the composition of communities is determined by the presence of riparian vegetation and water quality (Monteiro-Júnior *et al.* 2013; Deacon *et al.* 2018).



**Figure 6.** Analysis of Principal Coordinates (PCoA) and PERMANOVA test for the Odonata community of PNGSV, Minas Gerais state, between the dry and rainy seasons. Different colors indicate different seasons. / **Figura 6.** Análisis de Coordinadas Principales (PCoA) y prueba PERMANOVA para la comunidad Odonata del PNGSV, estado de Minas Gerais, entre la estación seca y la lluviosa. Diferentes colores indican diferentes estaciones.

The dragonfly richness in the PNGSV may be even higher than recorded by this study, as shown by the species accumulation curve (Fig. 7), which did not reach an asymptote. Additionally, the estimated number of species by Bootstrap1 is 94.75, outside the 95% confidence limit.

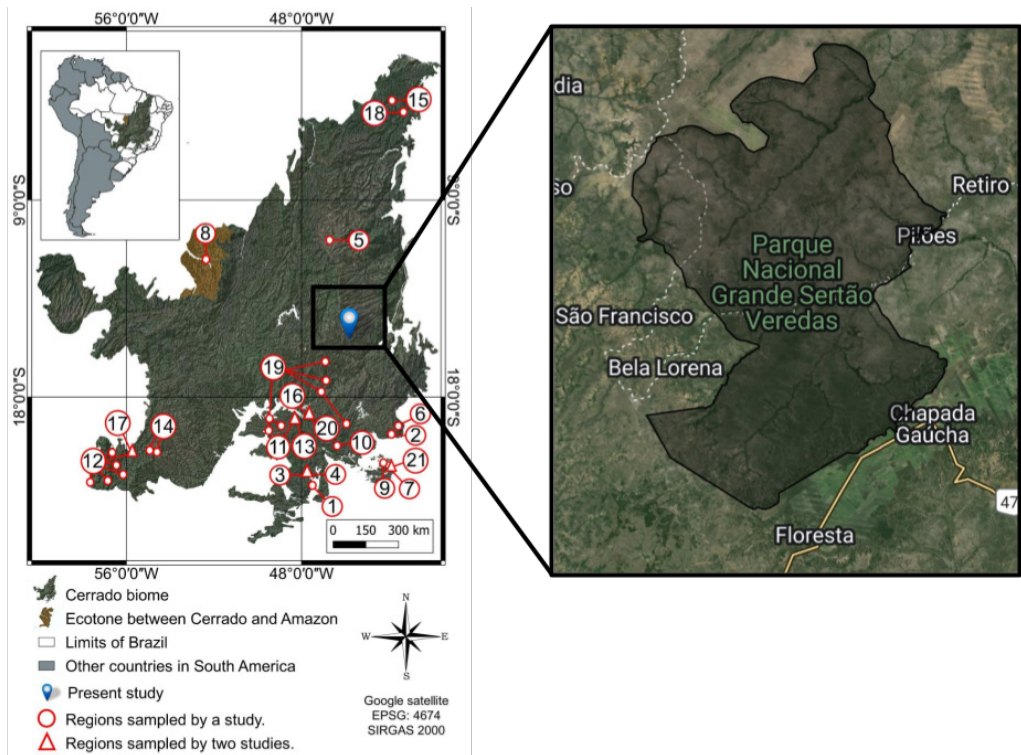


**Figure 7.** Species accumulation curve of dragonflies collected in PNGSV using observed species richness within a 95% confidence interval and estimated species richness (Bootstrap 1). / **Figura 7.** Curva de acumulación de especies de libélulas recolectadas en PNGSV utilizando la riqueza de especies observada dentro de un intervalo de confianza del 95% y la riqueza de especies estimada (Bootstrap 1).

The information presented by our results highlights the need for more Odonata inventory studies in the Cerrado, considering its territorial extension, constant area loss, and the limited number of dragonfly inventory studies. In total, only 21 inventory studies have been conducted in the Brazilian Cerrado, according to a historical survey (Fig. 8).

This inventory sampling in Cerrado areas is poorly representative. This becomes even more evident when considering, for example, the number of Conservation Units in the biome that have information about the odonatofauna: only ten, in more than eight decades of odonatological studies in the country (Santos and Machado 1983; Ferreira-Peruquetti and Fonseca-Gessner 2003; Ferreira-Peruquetti 2004; Cortês *et al.* 2011; Almeida *et al.* 2013; Bedê *et al.* 2015; Machado and Bedê 2015; Vilela *et al.* 2016; Prado *et al.* 2019; Venâncio *et al.* 2021). In total, there are 542 Conservation Units within Cerrado areas, including those of Integral Protection and Sustainable Use, whether Federal, State, or municipal jurisdiction (MMA 2023). Therefore, the odonatofauna is known for only 1.8% of the Conservation Units in the Brazilian Cerrado.

Furthermore, about 60% of these studies are concentrated in the state of Minas Gerais. Therefore, there is a need for investments in studies to understand the composition of communities and distribution of Odonata, especially in states with little or no information (*e.g.*, Goiás, Distrito Federal, Bahia, and Piauí).



**Figure 8.** Odonata inventories conducted in Cerrado areas in Brazil. / **Figura 8.** Inventarios de odonata realizados en áreas del Cerrado en Brasil. 1. Calvert 1948. 2. Santos & Machado 1983. 3. Ferreira Peruquetti & Fonseca Gessner 2003. 4. Ferreira PERRUQUETTI 2004. 5. Cortês *et al.* 2011. 6. Almeida *et al.* 2013. 7. Souza *et al.* 2013. 8. Juen *et al.* 2014. 9. Bedê *et al.* 2015. 10. Machado & Bedê 2015. 11. Vilela *et al.* 2016. 12. Rodrigues & Roque 2017. 13. Barbosa *et al.* 2018. 14. Rodrigues *et al.* 2018. 15. Bastos *et al.* 2019. 16. Borges *et al.* 2019. 17. Prado *et al.* 2019. 18. Moura *et al.* 2020. 19. Vilela *et al.* 2020. 20. Venâncio *et al.* 2021. 21. Gouvêa *et al.* 2023. Note that some areas were sampled in more than one study (represented by triangles), and some studies were conducted in more than one area (*e.g.*, 12, 14, 19). / Tenga en cuenta que algunas áreas fueron muestreadas en más de un estudio (representadas por triángulos) y algunos estudios se realizaron en más de un área (*e.g.*, 12, 14, 19).

**Final remarks.** The significant richness sampled here, the new species, the rediscoveries, new occurrence records for Minas Gerais, and the presence of species at some risk of extinction underscore the importance of the Cerrado as a global hotspot. Furthermore, these results highlight the importance of Conservation Units as a tool to ensure the protection of Odonata communities in Brazil and emphasize the need to strengthen public policies to guarantee investments and foster financial resources for the protection of Brazilian biodiversity, especially for conducting more inventory studies in the Cerrado.

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### Author Contributions

**MMS:** Conceptualization. **GCJ:** Formal analysis. **MMS, GCJ, DSV, TPG, EDFE, TMDO:** Investigation. **MMS, GCJ, DSV, TPG, EDFE, TMDO:** Data curation. **MMS, GCJ, DSV, TPG, EDFE, TMDO:** Writing - original draft. **MMS, GCJ, DSV, TPG, EDFE, TMDO:** Writing - review & editing. **MMS:** Supervision. **MMS:** Project administration.

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