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RESEARCH ARTICLE

Dragonflies (Insecta: Odonata) from Mananciais da Serra, a Tropical-Araucaria Forest ecotonal remnant in the southern Atlantic Forest, state of Paraná, Brazil

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ABSTRACT. This study provides a comprehensive checklist of Odonata species from the protected area of Mananciais da Serra. The survey was conducted in the endangered Atlantic Forest domain at the southern Serra do Mar mountain chain within a well-preserved area in the municipality of Piraquara, state of Paraná, Brazil. Adults and larvae were sampled between June 2017 and March 2020 using different techniques in numerous mesohabitats, including phytotelmata, pools, small streams, and large reservoirs. A total of 1,708 specimens from 9 families, 43 genera and 84 species were sampled resulting in 53 new records for the state of Paraná, almost doubling the known occurrence records for dragonflies and damselflies in that state. Furthermore, two hitherto undescribed females from the genera *Planiplax* and *Heteragrion*, four ultimate stadium larvae from *Planiplax*, *Neocordulia*, *Heteragrion*, and *Acanthagrion*, and five undescribed species were detected, one each from the genera *Heteragrion*, *Progomphus*, *Brechmorhoga*, *Erythrodiplax*, and *Dasythemis*. The estimated richness of odonates in this area is greater than 100 species, while the observed richness corresponding to almost 10% of all Odonata species in Brazil, the species-richest country in the world. These results reiterate the need to investigate undersampled areas to improve knowledge on diversity, taxonomy, and distribution of neotropical species. Finally, taxonomic notes for some species, including the rare corduliid *Neocordulia mambucabensis* Costa & T.C. Santos, 2000, are provided.

KEY WORDS. Anisoptera, conservation, damselfly, inventory, systematics, Zygoptera.

INTRODUCTION

Knowledge of the distribution of extant species is critical for multiple areas of biological sciences and conservation. However, it is strongly biased due to well-known factors such as: sampling efforts are often concentrated in areas near research centers, or sites easier to access, and also taxonomic or social preferences such as large and charismatic organisms (Oliveira et al. 2016, Troudet et al. 2017). These biases produce distortions in the interpretation of community composition and local endemism (Oliveira et al. 2016). Therefore, biological inventories are considered as priority actions to mitigate these biases because they provide primary data to designing conservation strategies and managing biological diversity, especially in the case of under-sampled areas and poorly known taxa (see Novacek and Cleland 2001, Braby and Williams 2016, Oliveira et al. 2016). Most insect taxa are poorly known groups (Novacek and Cleland 2001, Troudet et al. 2017) and are at a higher risk of extinction (Clausnitzer et al. 2009). Deficiencies in the distributional data and sampling bias have been detailed for Odonata in South America (see von Ellenrieder 2009, Vianna and De Marco 2012), and even in the Brazilian Atlantic Forest, widely known as one of the most studied areas in South America, there are poorly sampled sites (cf. Pinto and Kompier 2018, Pinto 2019 and references therein).

The Atlantic Forest is a biodiversity hotspot due to its highly threatened status and endemism levels, holding from 1 to 8% of the world's biodiversity (Laurence 2009). This domain occurs partially in Argentina, Paraguay, and 17 Brazilian states (out of 27), and includes at least eight biogeographical sub-regions (areas of endemism) such as proposed by Silva and Casteleti (2003) (see Ribeiro et al. 2009). The original forest cover remaining for this

domain is approximately 12%, and these remnants are spread in hundreds of thousands of fragments, most of them smaller than 50 ha (Ribeiro et al. 2009). The three largest fragments are in the Serra do Mar, from the states of Santa Catarina at the southern end to Rio de Janeiro in the north, encompassing 13% of the total preserved remnants of Atlantic Forest (Ribeiro et al. 2009).

The Atlantic Forest is the most important component of the natural landscape of Paraná's territory, originally covering 98.1% of its total area (see Campanili and Schaffer 2010). Today, this coverage is 13.1% (SOS Mata Atlântica 2018). The Paraná's Atlantic Forest has four main vegetational formations: grassland, Tropical Atlantic Forest, Semideciduous Seasonal Forest, and the Araucaria Forest (Roderjan et al. 2002) and encompasses the Araucaria, Interior and Serra do Mar biogeographical sub-regions (sensu Silva and Casteleti 2003). The transition between the Araucaria and Serra do Mar biogeographical sub-regions corresponds to the same transition between the Araucaria Forest and Tropical Atlantic Forest formations at the Serra do Mar mountain chain (see Ribeiro et al. 2009).

Dragonflies and damselflies (Odonata) remain as aquatic larvae during most of their post-embryonic life. They are essential components of aquatic communities, responsible for several ecosystem services, keeping the structure and the cycling of nutrients, and are bioindicators of environmental quality (e.g. Oertli 2008, Silva et al. 2010). Brazil has the richest assemblage of these insects (Pinto and Kompier 2018) with more than 900 species (Pinto 2020), and it is estimated that there are many species not yet described (Souza et al. 2017). The Odonata richness of the Atlantic Forest has been estimated to represent 50% of all Brazilian species of the order (Pinto and Kompier 2018). A single site in the Serra dos Orgãos formation is the worldwide hotspot with more than 200 species (Kompier 2015).

Studies focusing on the diversity of odonates in the southern Brazil started at least half of a century ago (e.g. Costa 1971, Teixeira 1971), region that includes the type localities of several species – e.g. the Libellulidae *Libellula herculea* Karsch, 1889 and the Gomphidae *Progomphus virginiae* Belle, 1973 (Karsch 1889, Belle 1973). Notwithstanding, the region lacks compilations of distributional records at the species level, as well as regional inventories with comprehensive checklists. Efforts to understand the diversity of odonates in southern Brazil have dramatically increased in the last decade, at least for Pampean and Atlantic Forest formations in the state of Rio Grande do Sul (e.g. Renner et al. 2016, 2017, Dalzochio et al. 2018, Pires et al. 2019). However, knowledge about Odonata of Paraná is still meager. For example, Vianna and De Marco (2012) found a maximum of approximately 20 species in a single assemblage recorded within a quadrat area 1-degree cell in size, based on a review of the historical records and a few specimens deposited in collections.

The studied area at Piraquara municipality belongs to the Metropolitan Region of Curitiba, region that has been visited by scientists at least since 1896 when B. Bicego collected the holotype of the millipede *Leptodesmus decipiens* Brölemann, 1902 (Schubart 1955), now in the genus *Brasilodesmus* Brölemann, 1929 (Pena-Barbosa 2020). The municipality houses one of the significant remnants of Atlantic Forest near the state capital Curitiba, in the Serra do Mar mountain chain (Reginato and Goldenberg 2007). This municipality includes the region of "Mananciais da Serra" (MASE), a conservation area of high biological importance (Rosa 2007). This is a direct consequence of its particular scientific interest, and the locality has been the subject of several surveys, such as faunistic and floristic inventories (Cáceres 2004, Reginato and Goldenberg 2007, Anjos and Navarro-Silva 2008, Bianchi et al. 2012). It is the type-locality for many species of insects (e.g. Dalmolin et al. 2004, Paladini and Cavichioli 2015), and a sanctuary for threatened or rare mammalian species (Cáceres 2004). In addition, it represents a well-preserved ecotone between Araucaria and Tropical Atlantic Forests due to more than 100 years of conservation policies in that area (Reginato and Goldenberg 2007). The natural and artificial water bodies of MASE favor the existence of a wide variety of mesohabitats, which potentially maintain a high diversity of dragonflies.

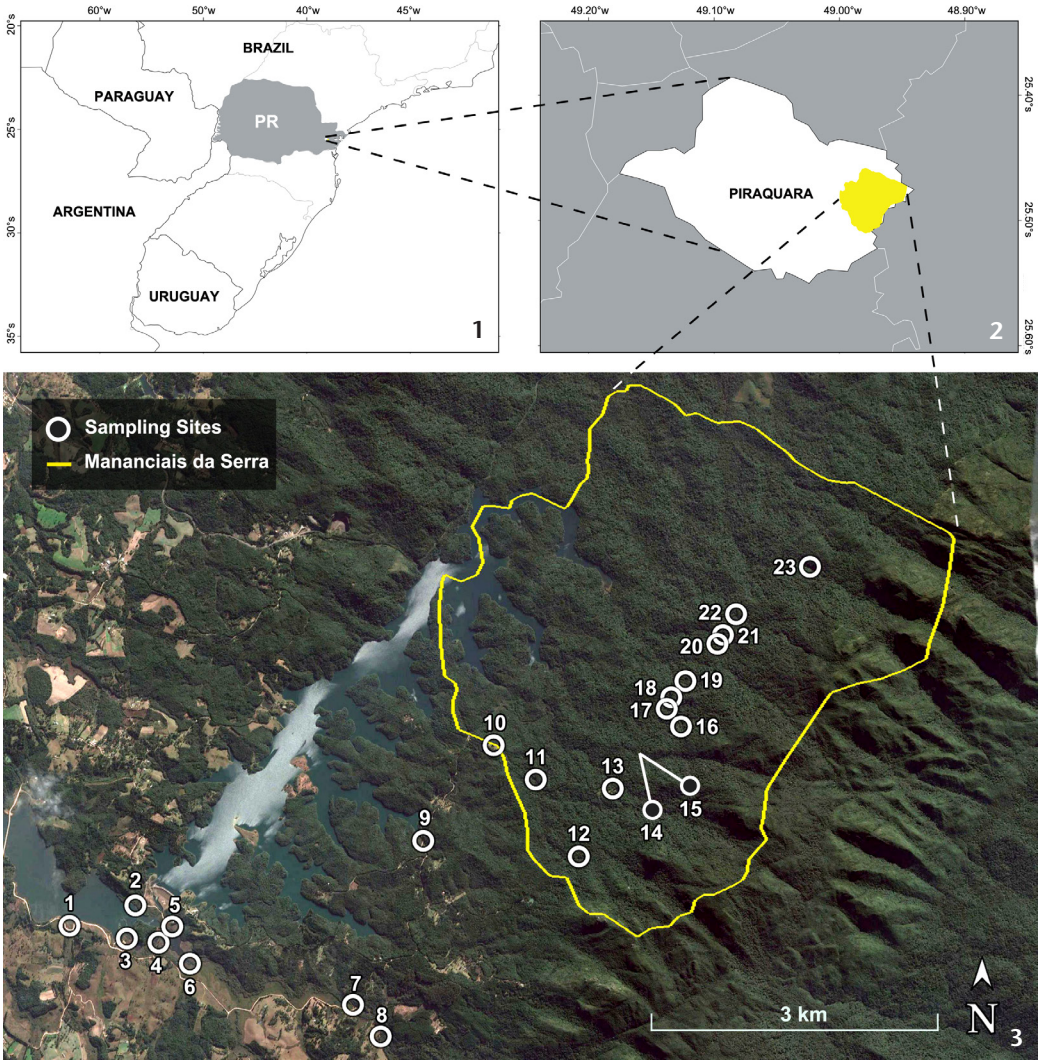
The goal of this study is to provide a comprehensive checklist of damselflies and dragonflies from the region of Mananciais da Serra, southern Atlantic Forest. In addition, the compositional diversity (alpha component) is addressed, and new state records and taxonomic notes including the rare Corduliidae s.l. *Neocordulia mambucabensis* Costa & T.C. Santos, 2000 are given.

MATERIAL AND METHODS

This study was conducted in an ecotone between the Araucaria Forest and Tropical Atlantic Forest (Reginato and Goldenberg 2007) in a fragment of Atlantic Forest in the Serra do Mar mountain chain, maintained by the water and waste management company of the state of Paraná (SANEPAR). This area includes the "Mananciais da Serra" (MASE) and the drainage system of the reservoirs Piraquara I and Piraquara II, in the municipality of Piraquara, Paraná, Brazil (Figs 1–3).

Historically, the protected area "Mananciais da Serra" emerged with the creation of the first public water supply system of Curitiba, capital of the state of Paraná, in 1908 (see Cordeiro 2008). Today, the Mananciais da Serra protected area shelters the historical heritage of the supply system that was replaced by two subsequent reservoirs resulting from the damming of the Piraquara River, the main river of the Piraquara sub-basin (SUDERHSA 2000). The area name, the so-called Mananciais da Serra, refers to the water supply system of the Piraquara sub-basin and the forested area in the watershed, that is partially protected by Pico do Marumbi State Park (Paraná State government Decrees #7300, 1990 and #1531, 2007) and Environmental State Protection Area of Piraquara (Paraná State government Decree # 1754, 1996).

For this survey we considered the vegetal formation separated into two areas: the Tropical Atlantic Forest area (TF), corresponding to the MASE area (Fig. 3, Table 1, sampling sites 10–23), and the Araucaria Forest area (AF), corresponding to the



Figures 1–3. Protected area Mananciais da Serra (MASE), municipality of Piraquara, Paraná, Brazil, and sampling sites of Odonata: (1) Paraná; (2) Piraquara and MASE; (3) MASE limits in yellow. Numbers 1–23 correspond to the sampling sites.

sites outside of the MASE delimitation (Fig. 3, Table 1, sampling sites 1–9). The AF sampling sites were on the banks of reservoirs Piraquara I and II, composed of mostly lentic systems in an open landscape and perturbed sites, and partially riparian forest and some small forested areas around the reservoirs including some lotic or forested sampling sites. In contrast, most TF sampling sites were forested areas and running waters, with a few exceptions of lentic and semi-lentic habitats such as the "Natural pool" (Fig. 7, Table 1, sampling site 16).

Multiple water body types were investigated, including puddles, pools, tanks, dams and streams (Figs 4–9). The adults were collected between June 2017 and March 2020 using three methods: (1) a malaise trap in the field for 144 non-continuous days (from November 2018 to March 2020); (2) 60 active collection events using aerial entomological nets; and (3) occasional sampling of larvae using sieves. A total of 23 sampling sites were investigated (Figs 1–3). Coordinates and mesohabitats are presented in Table 1. Live specimens were photographed in the field or in a portable studio over a white background.

The specimens were identified at species level with the aid of stereomicroscopes and compared to original descriptions and specimens previously identified by specialists. Species of dubious status due to insufficient taxonomic information (e.g. *Limnetron* Förster, 1907), specimens in poor condition (e.g. in *Brechmorhoga* Kirby, 1894), or genera with putative undescribed species (e.g. *Heteragrion* Selys, 1862) are cited as sp., but when possible through examination they were recognized as distinct entities. The specimens were dried in absolute acetone and deposited in the Ento-

Figures 4–9. Mesohabitats of the sampling sites of Odonata in the protected area Mananciais da Serra, Piraquara municipality, state of Paraná, Brazil: (4) Piraquara II reservoir banks; (5) Piraquara II reservoir with macrophytes; (6) Rio Ipiranguinha river; (7) Natural pool; (8) streamlet with semi-lotic water at Aqueduto site; (9) Cayguava catchment reservoir of the old Piraquara supply system. Photos: (4–7, 9) BRA; (8) APP; all in 2019.

Table 1. Sampling sites, coordinates and mesohabitats description for Odonata at the protected area Mananciais da Serra, Piraquara municipality, state of Paraná, Brazil. Catchments refers to small dams of the old water supply system.

Collection site	Coordinates		Mesohabitats
	Latitude	Longitude	
1. RPIV. Piraquara II reservoir bank	-25.509284°	-49.038360°	Composite site, predominantly lentic, banks lacking macrophytes, riparian area with grassland; lotic system composed by small second order stream from the grassland flowing into the reservoir
2. RPV. Piraquara II reservoir bank	-25.507368°	-49.031490°	Lentic with abundant macrophytes and forested riparian area
3. RPIII. Piraquara II reservoir bank	-25.510484°	-49.032375°	Composite site, predominantly lentic, partially inhabited for macrophytes, banks lacking macrophytes; semi-lotic spots formed by small tributaries of Rio Piraquara river throughout the site
4. Piraquara II reservoir adjacent area	-25.510865°	-49.029077°	Lentic, pool linked to Piraquara II reservoir covered with macrophytes and riparian forested area composed by exotic *Pinus* spp.
5. RPI. Piraquara II reservoir bank	-25.509353°	-49.027647°	Lentic, with abundant macrophytes of many species; riparian area composed by open grass field and forest with semi-lotic channels near reservoir
6. RPII. Piraquara II reservoir bank	-25.512844°	-49.025808°	Composite site, lentic spot composed by swamps with grasses and many macrophytes species; lotic spot is as fourth order river tributary of the Piraquara II reservoir
7. River II. River with riparian forest	-25.516721°	-49.008813°	Lotic, fourth order river with modified riparian forest, shaded with sandy bottom
8. Farm marsh. Flood area near to the dirt road	-25.519690°	-49.005925°	Lentic, a shallow swamp with grass vegetation
9. Road. Running water above road	-25.501302°	-49.001491°	Lotic, shallow stream over a dirt road
10. Base lodge	-25.492325°	-48.994150°	Open field, grass camp at front of the base lodge
11. River I. River in forested area	-25.495550°	-48.989764°	Lotic with a well-preserved riparian forest, bottom with rocks, leaf litter and sand
12. Salto catchment. Stream in forested area	-25.502778°	-48.985278°	Composite site, lentic spot formed by damming of a stream rock bottom, a partially shaded artificial pool with dense leaf litter bottom
13. Carvalho catchment. Stream in forested area	-25.496389°	-48.980000°	Composite site with open and forested areas; lentic spot composed by the largest artificial pool with concrete bottom; lotic system composed by first and second order streams with bottom with abundant leaf litter, sand, and rocks;
14. Braço do Carvalho catchment. Stream in forested area	-25.493333°	-48.978333°	Composite site; lentic formed by an artificial pool with concrete bottom with abundant leaf litter and sandy bottom; lotic, a second order forested stream with rocky bottom
15. Stream near to Carambola catchment	-25.487807°	-48.975641°	A partially shaded third order stream with a well-preserved riparian forest, large rocks, sand, and leaf litter bottom
16. Natural pool	-25.490625°	-48.974656°	Lentic, a sunny natural shallow pool in an opened area with clay bottom, riparian area with native herbaceous-shrub vegetation and few exotic *Pinus* spp.
17. Mico catchment	-25.488889°	-48.976111°	Lotic, a first order stream in an out of order dam, a secondary riparian forest
18. Trail between Braço do Carvalho catchment and Ipiranguinha River	-25.493333°	-48.978333°	Composite site; main trail crossing many types of typical lentic to lotic mesohabitats, from artificial pools, small rainy pools, phytotelmata (bamboos and bromeliads) to seepages, streams, and rivers; predominantly shaded (forested) with open spots;
19. Aqueduto. Forested area with small streams	-25.486289°	-48.974170°	Lotic, first order streams/streamlets with a well-preserved riparian forest; Semi lentic shallow pools in flooded areas
20. Cayguava catchment. Stream in forested area	-25.482792°	-48.970836°	Composite site; lotic formed by a second order stream with well-preserved riparian forest, rocky and sandy bottom; lentic correspond to the artificial pool of the Cayguava catchment with sand and leaf bottom
21. Site F. Flooded forested area	-25.481960°	-48.970261°	Lotic and semi-lotic, shallow pools with slow flowing water
22. Iporan catchment. Stream in forested area	-25.480000°	-48.968889°	Composite site; lotic is a second order stream with well-preserved riparian forest, rocky bottom; lentic spot is the artificial pool, of the Iporan reservoir catchment with sandy and leaf bottom
23. Ipiranguinha river. River in forested area	-25.475547°	-48.961192°	Composite site; lotic is a third order river with well-preserved riparian forest, rocky bottom; lentic correspond to the artificial pool of the Ipiranguinha catchment with sandy and leaf bottom

mological Collection Padre Jesus Santiago Moure, Departamento de Zoologia, Universidade Federal do Paraná, Curitiba (DZUP), and in the Entomological Collection of the Museu Nacional, Universidade Federal do Rio de Janeiro, Rio de Janeiro (MNRJ).

In order to investigate new occurrence records, the known distributions of each species were compiled from publications in scientific journals, books, catalogs and specialized literature (e.g. original descriptions and revisions), and gray literature such as unpublished monographs, dissertations and thesis, meeting abstracts, websites, or even records lacking voucher material were disregarded. Digital databases (e.g. Web of Science) were regularly checked for update the data on the species occurrence. The full reference list with previous records in the literature was included in the Catalog of the Brazilian Taxonomic Fauna (Pinto 2020).

Alpha diversity was analyzed based on richness and abundance. The rarefaction and extrapolation curves using

an individual-based (abundance) approach were constructed with the software EstimateS (Version 9.1.0, Colwell 2013) with extrapolation up to 15,000 individuals (S_{est} and SE of Colwell et al. 2012).

RESULTS

Community richness and composition

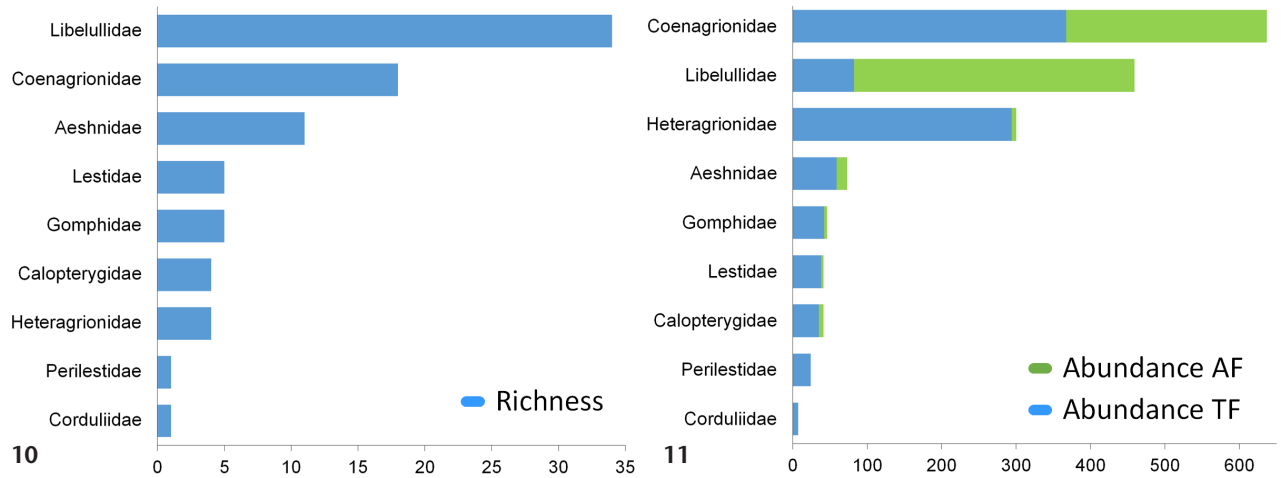
A total of 1,708 specimens from 9 families, 43 genera and 84 species were collected and identified. The species list, sampling sites, new records of occurrences for the state of Paraná, and specimens reared (adults emerged in the laboratory) are presented in Table 2. The AF area was predominantly lentic, and TF sampling sites were mainly lotic, except for lentic or semi-lentic habitats such as the "Natural pool" (see Table 1, sampling site 16, Fig. 7). The "Natural pool" was the richest site with 25 species (8 exclusives). The richest and more abundant families were Libellulidae and Coenagrionidae (Figs 10, 11). No species with crepuscular behavior was collected. The rarefaction and extrapolation curves with their standard deviation based on the number of individuals (Fig. 12) shows the observed richness resulted in an estimated richness of 69 species for TF (observed 52 spp.) and 106 species for the regional pool (observed 84 spp./sampling effort of 79.24%). A significant portion of the community, 36 species, had five or fewer specimens collected, from which 20 were single or

Table 2. Species list, abundance, and new state records for Odonata at the protected area Mananciais da Serra, Piraquara municipality, state of Paraná, Brazil. Sampling sites 1–21 as in Table 1.

Taxa	Sampling site	Abundance	Reared larvae	Araucaria Forest	Tropical Atlantic Forest	New state Record
Zygoptera						
'Perilestidae'						
Perilestes fragilis Hagen in Selys, 1862	12, 13, 22	24	x		x	x
Lestidae						
Archilestes exoletus (Hagen in Selys, 1862)	12, 16	5			x	
Lestes auritus Hagen in Selys, 1862	4, 16	29			x	x
L. pictus Hagen in Selys, 1862	12, 16	6			x	x
L. tricolor Erichson in Schomburgk, 1848	5	2		x		
Heteragrionidae						
Heteragrion aurantiacum Selys, 1862	7, 11	7		x	x	x
H. freddiemercuryi Lencioni, 2013	11, 12, 13, 18, 20–23	212			x	x
Heteragrion sp. A	12, 13, 18–20, 22	54			x	
Heteragrion sp. B	11–13, 18, 20	52			x	
Calopterygidae						
Hetaerina brightwelli (Kirby, 1823)	11–13, 20, 21, 23	23	x		x	x
H. hebe Selys, 1853	7, 12, 13	5		x	x	x
H. longipes Hagen in Selys, 1853	11, 12, 19, 20, 23	11			x	x
H. rosea Selys, 1853	1	3		x		x
Mnesarete borchgravii (Selys, 1869)	18	3			x	x
Coenagrionidae						
*Acanthagrion gracil*e (Rambur, 1842)	1, 2, 4–6, 15	21		x		x
A. lancea Selys, 1876	1–6, 16	55	x	x	x	x
A. truncatum Selys, 1876	3, 4, 6, 15	8		x	x	x
Aceratobasis macilenta (Rambur, 1842)	7	1		x		x
Argia sordida Hagen in Selys, 1865	12, 13, 18–20, 22, 23	218			x	x
Forcepsioneura sancta (Hagen in Selys, 1860)	12, 13, 16–20, 22, 23	79			x	
Homeoura chelifera (Selys, 1876)	16, 8, 13, 16, 20	65	x	x	x	
Ischnura capreolus (Hagen, 1861)	2, 3, 5, 6, 8, 16	30		x	x	x
I. fluviatilis Selys, 1876	3, 4, 13, 16	6		x	x	x
Leptagrion elongatum Selys, 1876	16	1			x	x
L. macrurum (Burmeister, 1839)	12, 13, 16, 18, 20, 21	31			x	x
Minagrion mecistogastrum (Selys, 1876)	5, 7	3		x		
M. waltheri (Selys, 1876)	6	1		x		
Oxyagrion simile Costa, 1978	16	47			x	
O. terminale Selys, 1876	1–6, 8, 9	45		x		
Telebasis carmesina Calvert, 1909	4, 6	2		x		x
T. theodori (Navás, 1934)	5, 6	13		x		x
T. willinki Fraser, 1948	2–6, 16	43		x	x	x

Continues

Taxa	Sampling site	Abundance	Reared larvae	Araucaria Forest	Tropical Atlantic Forest	New state Record
Anisoptera						
Aeshnidae						
Castoraeschna castor (Brauer, 1865)	16	1			x	x
Castoraeschna cf. *margarethae* Jurzitza, 1979	16	1			x	
Coryphaeschna perrensi (McLachlan, 1887)	2–6	9	x	x		
Limnetron sp.	12–14, 20, 22, 23	13			x	
Remartinia l. luteipennis (Burmeister, 1839)	6	1		x		
Rhionaeschna bonariensis (Rambur, 1842)	8	1		x		
R. brasiliensis (von Ellenrieder & Costa, 2002)	5	1		x		
R. confusa (Rambur, 1842)	3	1		x		x
R. decessus (Calvert, 1953)	16, 20, 22	5			x	x
R. punctata (Martin, 1908)	12–14, 20, 22	19			x	x
R. planaltica (Calvert 1952)	4, 10, 12–14, 16, 18, 20	28	x	x	x	
Gomphidae						
Aphylla theodorina (Navás, 1933)	16	2			x	x
Phyllogomphoides annectens (Selys, 1869)	11, 20, 22	7	x		x	
Phyllocycla diphylla (Selys, 1854)	1	1		x		x
Progomphus complicatus Selys, 1854	5, 7, 20	4		x	x	x
Progomphus aff. *gracilis* Hagen in Selys, 1854	11, 13, 20, 22	32			x	
Corduliidae s.l.						
Neocordulia mambucabensis Costa & T.C. Santos, 2000	11, 12, 22	7	x		x	x
Libellulidae						
Brechmorhoga nubecula (Rambur, 1842)	18	1			x	x
Brechmorhoga sp. A	22	1			x	
Brechmorhoga sp. B	13, 20, 23	3			x	
Dasythemis mincki mincki (Karsch, 1889)	2, 4, 6, 13, 19, 20	18		x	x	x
Dasythemis sp.	1, 6	4		x		
Diastatops intensa Montgomery, 1940	2, 3	8		x		x
Dythemis nigra Martin, 1897	2, 4	3		x		x
Erythemis peruviana (Rambur, 1842)	5	1		x		x
Erythrodiplax acantha Borror, 1942	16	17			x	x
E. anomala (Brauer, 1865)	4, 6	5		x		x
E. castanea (Burmeister, 1839)	2, 5, 6, 165	42		x	x	x
E. fusca (Rambur, 1842)	1, 3, 5, 6, 20	20		x	x	
E. hyalina Förster, 1907	4, 13, 16	5		x	x	x
E. media Borror, 1942	1–6, 22	48	x	x	x	x
E. melanorubra Borror, 1942	1–7, 13, 16	100	x	x	x	x
E. paraguayensis (Förster, 1905)	3, 16	4		x	x	x
Erythrodiplax sp.	1, 3, 5, 6	36		x		
Macrothemis imitans imitans (Karsch, 1891)	1–3	9		x		x
M. tenuis Hagen, 1868	7	1		x		x
Miathyria marcella (Selys in Sagra, 1857)	2, 5, 7, 10, 13	7		x	x	x
M. simplex (Rambur, 1842)	2, 3, 5, 6	6		x		x
Micrathyria hypodidyma Calvert, 1906	2, 3, 5–7	24		x		
M. stawiarskii Santos, 1953	5	1		x		
M. ungulata Förster, 1907	15	2			x	
M. venezuelae De Marmels, 1989	12, 15	3			x	x
Nephepeltia flavifrons (Karsch, 1889)	5, 6	10		x		x
Oligoclada laetitia Ris, 1911	1–3	9		x		x
Orthemis discolor (Burmeister, 1839)	1, 13	4		x	x	
Pantala flavescens (Fabricius, 1798)	1, 4, 6, 10, 13, 16	18		x	x	
Perithemis mooma Kirby, 1889	2–6	13		x		
Planiplax erythropyga (Karsch, 1891)	1–5	25	x	x		x
Tauriphila xiphea Ris, 1931	2, 3, 5, 6	10	x	x		x
Tramea binotata (Rambur, 1842)	6, 16	2		x	x	x
T. cophysa Hagen, 1867	5, 16	3		x	x	
T. rustica De Marmels & Rácenis, 1982	3, 6	7		x		x
9 Families, 43 genera, 84 species	–	1,708	12	55	53	53



Figures 10–11. Richness and absolute abundance of Odonata families in the protected area Mananciais da Serra, Piraquara municipality, state of Paraná, Brazil. (10) Regional pool richness; (11) Araucaria Forest (AF) and Tropical Atlantic Forest (TF) abundance.

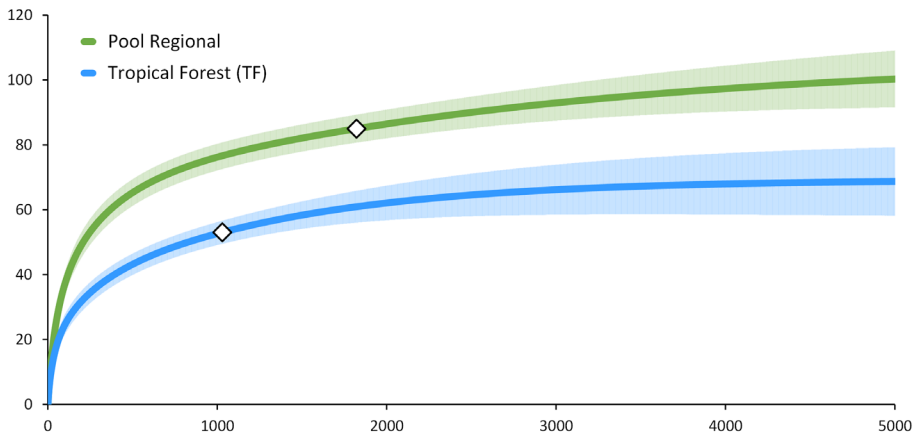


Figure 12. Rarefaction and extrapolation curves up to 15,000 individuals (show only to 5,000) based on abundance data in the protected area Mananciais da Serra, Piraquara municipality, state of Paraná, Brazil. Diamonds shows the observed richness: Pool regional (green), 84 species in 1,708 individuals (estimated richness 106 spp.); Tropical Atlantic Forest (TF, blue), 52 species in 1028 individuals (estimated richness 69 spp.).

doubletons. All families were more abundant in the Tropical Forest area except for Libellulidae.

The hitherto unknown females of *Heteragrion freddiemercuryi* Lencioni, 2013 and *Planiplax erythropyga* (Karsch, 1891) were collected. Four species with unknown larvae emerged in the laboratory: (1) *P. erythropyga*, (2) *N. mambucabensis*, (3) *Heteragrion* sp., and (4) *Acanthagrion lancea* Selys, 1876 (Fig. 16), so these ultimate stadium (F-0) exuviae are available for description. In addition, five undescribed species were detected, one from each genera: *Heteragrion* (Heteragrionidae), *Progomphus* Selys, 1854 (Gomphidae), *Brechmorhoga*, *Erythrodiplax* Brauer, 1868, and *Dasythemis* Karsch, 1889 (Libellulidae), which will be described elsewhere.

Taxonomic notes

Five of the identified species are of special taxonomic interest because they are poorly known, exhibited morphological variation, or their occurrence was unexpected in the region investigated. Such species are commented below.

Heteragrion freddiemercuryi (Fig. 15). The second most abundant species in the survey, it was originally described from Peruíbe, a lowland area at 10 m a.s.l. in the state of São Paulo (Lencioni 2013). In the studied area it was found an abundant population living in a highland area from 1,000 m a.s.l., extending its range considerably and calling into question its lowland habitat preferences.

Forcepsioneura sancta (Hagen in Selys, 1860). *Forcepsioneura* Lencioni, 1999, a small genus of forest-dependent damselflies

Figures 13–18. Habitus of Zygoptera species from the protected area Mananciais da Serra, Piraquara municipality, state of Paraná, Brazil: (13) *Perilestes fragilis*, 'Perilestidae'; (14) *Lestes auritus*, Lestidae; (15): *Heteragrion freddiemercuryi*, Heteragrionidae; (16) *Acanthagrion lancea*, Coenagrionidae; (17) *Leptagrion macrurum*, Coenagrionidae; (18) *Telebasis carmesina*, Coenagrionidae. Photos BRA; 13, 15, 17 and 18 in 2019; 14 and 16 in 2020.

endemic to Brazil, recently was discovered to be more diverse and taxonomically intricate than previously suspected (Pinto and Kompier 2018, Pimenta et al. 2019). Some species are strongly similar, forming complexes, and are diagnosed based on minor morphological differences on the caudal appendages. At first glance, the collected specimens from MASE appeared all to belong to the most widespread species *F. sancta*. However, closer inspection allows us to distinguish two series. Most specimens are consistent with those from the type locality at Lagoa Santa, Minas Gerais, hence, are typical *F. sancta* in coloration, dimensions, and in the shape of caudal appendages (see Machado 2001). Others are larger, with a greenish-orange mesepimeral stripe, cercus with mediobasal process acute and a thinner ventrobasal process that is curved inward, strongly similar to the poorly known *F. haerteli* Machado, 2001 from Santa Catarina. However, the genus is pending a full revision to clarify the status of the available names and specific limits (Pinto and Araujo 2020), including these nominally two cited species. Thus tentatively, it was preferred to consider all specimens as *F. sancta*.

Neocordulia mambucabensis (Fig. 21). We collected a series of adults (six males and one female) in different periods and at three different collection sites in MASE, allowing us to discuss its taxonomic status. The taxonomy of the genus *Neocordulia* Selys, 1882 is plagued by imprecision and misidentifications. Thus, species-level determination has been challenging, with several specific questionable statuses (see Pinto and Carvalho 2011). This is critical, and females, especially, are poorly known; for example, six of the 16 species, the female is still undescribed. The sampled adults and larvae can improve the species delimitation. *Neocordulia mambucabensis* was described based on a male holotype and female paratype from the Rio Mambucaba river, collected in the highlands (approximately 2,000 m a.s.l.) in the Serra da Bocaina National Park (Costa and Santos 2000). Both specimens were collected among a series of ultimate stadium larvae of *Neocordulia* reared in laboratory, and among the five adults emerged in the laboratory are representatives of three distinct species at least. Based on inconsistencies and new data of specimens from MASE, we suspect that the allotype (paratype) female of *N. mambucabensis* was misidentified, as well as the additional females in Kompier (2015). This data, including the description of the unknown larvae, is under preparation and will be published elsewhere.

Erythrodiplax acantha Borror, 1942. This species was described based on a series of four males collected by F.W. Bauer in São Paulo Capital (Borror 1942), and few additional data has been published about this species. It has recently been considered as Critical Endangered on the RedList of that state (Pinto 2018, São Paulo State government Decree # 63.853). It can be considered an exception within the large and taxonomically difficult genus *Erythrodiplax*, easily identified by its unique vesica spermalis (penis) shape, especially by the thorn-shaped (spine) median process (Borror 1942). The eleven examined males agree well with the original description (Borror 1942: 199) except in respect to general coloration. Our specimens were somewhat lighter, and all are brownish-yellow, instead of black and brown like the type series. The postfrons are not clearly flattened and lack bluish metallic reflections, although they show weak purplish metallic reflections. Usually, color variation may be explained due to ontogenetic changes, an aspect well documented in the genus, including in the taxonomic revision of Borror (1942). For instance, in *Erythrodiplax hyalina* Förster, 1907, the general coloration in males varies from brownish-yellow in young specimens to black frons with purple metallic reflections and brownish-black synthorax with bluish pruinosity in older specimens (Borror 1942). However, the coloration in *E. acantha* cannot be explained only by the age of the specimens because all captured males were apparently mature, showing evidence of senility such as pruinosity and a hardened exoskeleton. Most likely the differences in the coloration and unflattened postfrons are populational phenomena. The collected specimens were compared with some more typical males from the state of Minas Gerais and did not see any significant differences except in the coloration. The population of Minas Gerais showed a range of variation in the coloration (polychromatism); some specimens are very dark with bluish pruinosity while others present coloration similar to the specimens from MASE.

Planiplax erythropyga. This species is considered rare in collections, and recorded from Argentina, Uruguay, south of Brazil at state of Rio Grande do Sul (Santos 1949, von Ellenrieder and Muzón 2008) and north to state of Rio de Janeiro (Kompier 2015). Even though periodically, males exhibit a perching behavior, spending most of their time flying along the banks, making them difficult to collect. Individuals of this species were abundant in one sampling site (Fig. 4), allowing for the successful collection of 15 males in a single collecting event in over 3 hours. The males were abundant near the banks without macrophytes, probably the preferred mesohabitat of the species. Comparing the posterior hamule of MASE specimens to those illustrated by Santos (1949) and (Garrison et al. 2006), they are significantly distinct. Further investigations should evaluate if these variations correspond to geographical phenomena, illustration skills, or if more than a single species are involved.

Geographic records

A total of 53 new occurrence records were observed for the state of Paraná (Table 2, Figs 13–24). The species recorded for the first time to Paraná and their previous known distributions compiled from the literature are presented in Appendix 1.

DISCUSSION

Community richness and composition

This first inventory for Mananciais da Serra revealed an impressively rich community with 84 species occurring in a small area. The sampling effort based on estimated richness (106 spp.) is near to 80% (Fig. 12) and shows the potential for

Figures 19–24. Habitus of Anisoptera species from the protected area Mananciais da Serra, Piraquara municipality, state of Paraná, Brazil: (19) *Rhionaeschna punctata*, Aeshnidae; (20) *Aphylla theodorina*, Gomphidae; (21): *Neocordulia mambucabensis*, Corduliidae s.l.; (22) *Erythrodiplax castanea*; (23) *Planiplax erythropyga*, Libellulidae; (24) *Tramea rustica*, Libellulidae. Photos BRA; all in 2019.

future research. The actual richness (current pool of species) is possibly up to 100 species due to the expected occurrence of species not sampled such as common species with wide distribution ranges such as *Erythemis vesiculosa* (Fabricius, 1775) and *Erythrodiplax umbrata* (Linnaeus, 1758), the crepuscular species from genera such as *Triacanthagyna* Selys, 1883 and the sighted but not collected *Erythemis attala* (Selys in Sagra, 1857), *Perithemis icteroptera* (Selys in Sagra, 1857), and an unidentified species of *Mecistogaster* Rambur, 1842, *Gynacantha* Rambur, 1842 and *Libellula* Linnaeus, 1758. Another indicator of the higher richness is that more than half of the registered species (36) had less than five specimens collected, possibly a consequence of the disparities of collection effort across the sampling sites and relative abundance in the field.

The "Natural pool" sampling site is unique among the other sites in TF distinctly characterized as a lentic system. The rocky soil does not support the development of large trees, so this area is not shaded by forest. Such feature influences the physical, chemical, and biological conditions of this aquatic environment and permits most insolation, one of the abiotic features most important in filtering Odonata species occurrence (see Dijkstra and Clausnitzer 2006). So, it turns to a kind of refuge within predominantly lotic systems and forested areas. These aspects allow the occurrence of a unique faunal composition with some well-established abundant species, such as *Lestes auritus* Hagen in Selys, 1862, *Oxyagrion simile* Costa, 1978, *Erythrodiplax acantha*, and *Erythrodiplax castanea* (Burmeister, 1839). Notably, this faunal group is composed of 14 species with lentic habitat preferences (Table 2) that also occur in the AF area, including eight exclusive species and three that occurred in neighboring TF sampling sites.

All families were more abundant in TF except Libellulidae. Despite being the richest family, its representatives occurred at a low frequency in TF, possibly due to the low availability of the characteristically lentic system and its preference; similar results were found by Pires et al. (2019).

Different collection methods can be complementary, assisting in sampling the true diversity of Odonata in inventories (De Almeida et al. 2013). Besides the gaps on larvae taxonomy, in this study, the rearing of larvae obtained by sieve method was important to obtain adults of rare species and females, the latter proportionally less abundant than males in collections (e.g. Paulson and Jenner 1971, see also De Almeida et al. 2013). Five of the seven specimens of *Progomphus* aff. *gracilis* Hagen in Selys, 1854 were collected with a sieve, as was the rare species *Neocordulia mambucabensis*, including the single female. Furthermore, the sieve method allowed for sampling a single female, still undescribed formally, of *P. erythropyga*, four of five females of *Limnetron* sp. and four of five females of *Phyllogomphoides annectens* (Selys, 1869). In addition, the collection of larvae can improve the records of crepuscular species, as shown by Reels (2011) and discussed by Pinto (2019).

Similarly to other exploratory survey research, the crepuscular species (besides sight) were not sampled (Renner et al. 2016, 2017), possibly due to timing of the survey (Reels 2011), collector negligence due to its flier behavior as in some corduliids (see Pinto 2019) or the shortened flying period that makes them less susceptible to capture.

Geographic records

The richness of 84 species in the sampling site was much higher than all the previous records for the entire state of Paraná (60 spp., checklist based on unpublished data), and the 53 new occurrences almost duplicated the state records. This can be explained largely because of undersampling, potentiated by gaps of entomological collections studies or data compilation surveys (Vianna and De Marco 2012). Some of the new records were expected and predictable such as widespread species (e.g. *Acanthagrion gracile* (Rambur, 1842)), species recorded in Paraná's neighboring states in the Rio Grande do Sul and Santa Catarina (e.g. *Leptagrion macrurum* (Burmeister, 1839), *Telebasis carmesina* Calvert, 1909, *Lestes auritus* Hagen in Selys, 1862, Figs 14, 17, 18). Some records are notable because they contribute to expanding the known species occurrence (e.g. *Rhionaeschna punctata* (Martin, 1908), Fig. 19) or because they are rare in collections (e.g. *N. mambucabensis* and *P. erythropyga*, Figs 21, 23). An endangered species for the state of São Paulo (Pinto 2018), *E. acantha*, was recorded.

Concluding remarks

Our study allows us to reach the following conclusions. The richness maintained by Mananciais da Serra represents 9.3% of the Brazilian Odonata (data based on Pinto 2020) and 74.3% of the species known for the state of Paraná. This survey is a clear example of how undersampled areas represent gaps of knowledge that can lead to inconsistencies, such as distribution patterns. The high number of new records and the new species are evidence of a neglected area and alerts us to its potential odonate richness. The female described in the original description of *N. mambucabensis* pertaining to another species of the genus. Considering the high deforestation of Paraná's Atlantic Forest and the majority of remnants concentrated in small fragments, it should be investigated, as proposed by Paulson (2006), to understand how this partitioning of forest cover can influence Odonata diversity and how the fauna recolonizes reforested areas. The data presented here are unprecedented and contribute to the taxonomic and morphological knowledge of the local Odonata community, including adults and larvae.

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APPENDIX

Appendix 1. List of the 53 species recorded for the first time to the state of Paraná with previous known distribution data.

1. *Perilestes fragilis* Hagen in Selys, 1862 (Fig. 13)
   Distribution: Guyana[?], BRAZIL: AM[?], MG, ES, RJ, SP, PR*.
   Remarks: The records from the state of Amazonas and Guyana most likely is due to misidentifications because it is an endemic species of Atlantic Forest; thus, these occurrences should be checked.
2. *Lestes auritus* Hagen in Selys, 1862 (Fig. 14)
   Distribution: Argentina, BRAZIL: MG, RJ, PR*, SC, RS.
3. *Lestes pictus* Hagen in Selys, 1862
   Distribution: Peru, Argentina, BRAZIL: MT, MG, ES, RJ, SP, PR*, RS.
4. *Heteragrion freddiemercuryi* Lencioni, 2013 (Fig. 15)
   Distribution: BRAZIL: SP, PR*.
   Remarks: See taxonomic notes.
5. *Heteragrion aurantiacum* Selys, 1862
   Distribution: Paraguay, Argentina, BRAZIL: BA, MG, ES, RJ, SP, PR*
6. *Hetaerina brightwelli* (Kirby, 1823)
   Distribution: BRAZIL: PA, MG[?], ES, RJ, SP, PR*.
   Remarks: Santos (1970) cited this species from National Park of Itatiaia without locality. Itatiaia massif is in the boundaries of Rio de Janeiro and Minas Gerais, thus the record for MG pending confirmation.
7. *Hetaerina hebe* Selys, 1853
   Distribution: Venezuela, BRAZIL: PB[?], MG, ES, RJ, SP, PR*, SC[?], RS.
   Remarks: Garrison (1990) cited PB doubtful; specimens from SC most likely is this species but pending confirmation.
8. *Hetaerina longipes* Hagen in Selys, 1853
   Distribution: Paraguay, Argentina, BRAZIL: MG, ES, RJ, SP, SC, PR*, RS.
9. *Hetaerina rosea* Selys, 1853
   Distribution: Peru, Bolivia, Paraguay, Argentina, Uruguay, BRAZIL: CE, SE, RO, MT, GO, BA, MG, MS, ES, RJ, SP, PR*, RS.
10. *Mnesarete borchgravii* (Selys, 1869)
    Distribution: BRAZIL: RJ, SP, PR*, SC, RS.
11. *Acanthagrion gracile* (Rambur, 1842)
    Distribution: Peru, Bolivia, Paraguay, Argentina, Uruguay, BRAZIL: CE, SE, MT, GO, BA, MG, MS, ES, RJ, SP, PR*, RS.
    Remarks: Northern South America records most likely refers to other species (cf. Mauffray and Tennessen 2019). Thus, records northern than Bolivia (e.g. Peru, Mexico as cited by Heckman 2008) must be checked.
12. *Acanthagrion lancea* Selys, 1876 (Fig. 16)
    Distribution: Colombia[?], Peru, Paraguay, Argentina, Uruguay, BRAZIL: MG, MS, ES, RJ, SP, PR*, SC, RS.
    Remarks: Northern South America records most likely refers to other species (cf. Mauffray and Tennessen 2019). Thus, records northern than Bolivia (e.g. Peru, Mexico as cited by Heckman 2008) must be checked.
13. *Acanthagrion truncatum* Selys, 1876
    Distribution: Venezuela, Guyana. BRAZIL: PI, TO, MT, GO, BA, MG, MS, SP, PR*.
14. *Aceratobasis macilenta* (Rambur, 1842)
    Distribution: BRAZIL: MG, RJ, SP, PR*, SC.
15. *Argia sordida* Hagen in Selys 1865
    Distribution: BRAZIL: MG, MS, ES, RJ, SP, PR*.
    Remarks: Record to MS is out of Atlantic Forest domain, distant from hitherto known records, thus must be checked.
16. *Ischnura capreolus* (Hagen, 1861)
    Distribution: Mexico south to Panama. Trinidad and Tobago, Colombia, Venezuela, Ecuador, Peru, Bolivia, Guyana, Suriname, French Guiana, Paraguay, Argentina, Uruguay, BRAZIL: RR, AP, PA, AM, AC, PI, CE, PB, PE, SE, MT, RO, GO, BA, MG, MS, ES, RJ, SP, PR*, RS.
17. *Ischnura fluviatilis* Selys, 1876
    Distribution: Venezuela, Ecuador, Peru, Bolivia, Guyana, Suriname, French Guiana, Chile, Paraguay, Argentina, Uruguay, BRAZIL: AP, PA, AM, MA, CE, PB, PE, MT, RO, GO, MG, MS, ES, RJ, SP, PR*, RS.
18. *Leptagrion elongatum* Selys, 1876
    Distribution: BRAZIL: BA[?], ES, RJ, SP, PR*.
    Remarks: Lencioni (2017) mentioned this species from BA, but it was not found records in the literature, thus the occurrence in that state pending confirmation.
19. *Leptagrion macrurum* (Burmeister, 1839) (Fig. 17)
    Distribution: BRAZIL: BA, ES, RJ, SP, PR*, SC.
20. *Telebasis carmesina* Calvert, 1909 (Fig. 18)
    Distribution: Bolivia, Paraguay, Argentina, BRAZIL: MT, MG, MS, RJ, SP, PR*, SC, RS.
21. *Telebasis theodori* (Navás, 1934)
    Distribution: Argentina, BRAZIL: PR*, SC, RS.
22. *Telebasis willinki* Fraser, 1948
    Distribution: Bolivia, Paraguay, Argentina, Uruguay, BRAZIL: BA, MG, MS, SP, PR*, RS.
23. *Castoraeschna castor* (Brauer, 1865)
    Distribution: Suriname, BRAZIL: MG[?], ES, RJ, SP, PR*.
    Remarks: Santos (1970) cited from National Park of Itatiaia without locality. Itatiaia massif is in the boundaries of Rio de Janeiro and Minas Gerais, thus the record for MG pending confirmation.
24. *Rhionaeschna confusa* (Rambur, 1842)
    Distribution: Chile, Paraguay, Argentina, Uruguay, BRAZIL: RJ, PR*, SC, RS.
25. *Rhionaeschna decessus* (Calvert, 1953)
    Distribution: BRAZIL: RJ, PR*.
    Remarks: Part of the records in von Ellenrieder (2003) and Carvalho and Salgado (2004) refers to *R. decessus*-complex and *R. punctata*-complex (Silva et al. in prep.).
26. *Rhionaeschna punctata* (Martin, 1908) (Fig. 19)
    Distribution: BRAZIL: MG, ES, RJ, SP, PR*, SC, RS.

Remarks: Part of the records in von Ellenrieder (2003) and Carvalho and Salgado (2004) refers to *R. decessus*-complex and *R. punctata*-complex (Silva et al. in prep.).

27. *Aphylla theodorina* (Navás, 1933) (Fig. 20)
Distribution: Venezuela, Peru, Guyana, Paraguay, Argentina, Uruguay, BRAZIL: PE, SE, MT, RO, MG, MS, ES, RJ, SP, PR*, RS.

28. *Phyllocycla diphylla* (Selys, 1854)
Distribution: Venezuela, Argentina[?], BRAZIL: AM[?], AL, MG, ES, SP, PR*.
Remarks: Heckman (2006, p. 615) cited occurrence to Argentina and AM (latter record reproduced in Koroiva et al. 2020), but the last updated checklist from Argentina (Lozano et al. 2020) do not cite this record and we did not find other references citing these records.

29. *Progomphus complicatus* Selys, 1854
Distribution: Paraguay, Argentina, BRAZIL: CE, BA, MG, ES, RJ, SP, PR*, SC, RS.

30. *Neocordulia mambucabensis* Costa & T.C. Santos, 2000 (Fig. 21)
Distribution: Brazil: RJ, PR*.
Remarks: See taxonomic notes.

31. *Brechmorhoga nubecula* (Rambur, 1842)
Distribution: Mexico, Belize, Costa Rica, Panama, Trinidad and Tobago, Colombia, Venezuela, Ecuador, Peru, Paraguay, Argentina, BRAZIL: AM, CE, MT, BA, MG, ES, RJ, SP, PR*, SC, RS.

32. *Dasythemis mincki mincki* (Karsch, 1890)
Distribution: Paraguay, Argentina, Uruguay, BRAZIL: GO, MG, ES, RJ, SP, PR*, RS.

33. *Diastatops intensa* Montgomery, 1940
Distribution: Colombia, Peru, Paraguay, Argentina, Uruguay, BRAZIL: PA[?], MT, MG, MS, RJ, SP, PR*, RS.
Remarks: Heckman (2006, p. 147) cited occurrence to PA, but no original record was found.

34. *Dythemis nigra* Martin, 1897
Distribution: Mexico south to Panama, Trinidad and Tobago, Colombia, Venezuela, Ecuador, Peru, Guyana, Suriname, French Guiana, Paraguay, Argentina, BRAZIL: RR, PA, AM, CE, PE, SE, MT, RO, GO, BA, MG, MS, ES, RJ, SP, PR*, SC, RS.

35. *Erythemis peruviana* (Rambur, 1842)
Distribution: USA south to Panama, Trinidad and Tobago, Colombia, Venezuela, Guyana, Suriname, French Guiana, Ecuador, Peru, Bolivia, Paraguay, Argentina, Uruguay. BRAZIL: RR, AP, PA, AM, MA, CE, PE, SE, MT, RO, GO, BA, MG, MS, ES, RJ, SP, PR*, SC, RS.

36. *Erythrodiplax acantha* Borror, 1942
Distribution. BRAZIL: GO, SP, PR*.
Remarks: See taxonomic notes.

37. *Erythrodiplax anomala* (Brauer, 1865)
Distribution: Argentina, BRAZIL: BA, RJ, SP, PR*, RS.

38. *Erythrodiplax castanea* (Burmeister, 1839) (Fig. 22)
Distribution: Belize, Guatemala, Costa Rica, Trinidad and Tobago, Colombia, Venezuela, Guyana, Suriname, French Guiana, Ecuador, Peru, Bolivia, Paraguay, Argentina, BRAZIL: PA, AM, CE, PE, SE, MT, RO, GO, BA, MG, MS, ES, SP, RJ, PR*, SC.

39. *Erythrodiplax hyalina* Förster, 1907
Distribution: Paraguay, Uruguay, BRAZIL: MG, RJ, SP, PR*, SC, RS.

40. *Erythrodiplax media* Borror, 1942
Distribution: Bolivia, Paraguay, Argentina, Uruguay, BRAZIL: MA[?], SE, MG, RJ, SP, PR*, SC, RS.
Remarks: De Marco (2008) recorded this species to MA, in a transitional site between Caatinga and Amazonia. Due to strongly out from the known distribution in the Southern Atlantic Forest, Pampean and Chacoan formations, it may be a misidentification pending confirmation.

41. *Erythrodiplax melanorubra* Borror 1942
Distribution: Venezuela, Ecuador, Peru, Bolivia, French Guiana, Chile, Paraguay, Argentina, BRAZIL: MG, MS, RJ, SP, PR*, SC, RS.

42. *Erythrodiplax paraguayensis* (Förster, 1905)
Distribution: Colombia, Venezuela, Ecuador, Bolivia, Guyana, Suriname, Paraguay, Argentina, Uruguay, BRAZIL: RR, MA, CE, MT, MG, MS, RJ, SP, PR*, RS.

43. *Macrothemis imitans imitans* Karsch, 1890
Distribution: Colombia, Venezuela, Ecuador, Bolivia, Guyana, Suriname, Paraguay, Argentina, BRAZIL: MT, BA[?], MG, MS, ES, RJ, SP, PR*, SC, RS.
Remarks: Barbosa et al. (2019) mentioned this species from BA and PR, but we do not find records in the literature. Hence the occurrence in BA pending confirmation. Our specimens confirm the occurrence of this species in PR.

44. *Macrothemis tenuis* Hagen, 1868
Distribution: Argentina, BRAZIL: MG, ES, RJ, SP, PR*.

45. *Miathyria marcella* (Selys in Sagra, 1857)
Distribution: USA to Panama, Trinidad e Tobago, Colombia, Venezuela, Ecuador, Peru, Bolivia, Guyana, Suriname, French Guiana, Paraguay, Argentina, Uruguay, BRAZIL: RR, AP, PA, AM, MA, CE, PE, SE, MT, BA, MG, MS, ES, RJ, SP, PR*, RS.

46. *Miathyria simplex* (Rambur, 1842)
Distribution: Mexico, Belize, Guatemala, Honduras, Costa Rica, Panama, Cuba, Haiti, Dominican Republic, Puerto Rico, Trinidad e Tobago, Colombia, Venezuela, Ecuador, Peru, Guyana, Suriname, French Guiana, Paraguay, Uruguay, BRAZIL: PA, AM, MT, MS, ES, RJ, SP, PR*, RS.

47. *Micrathyria venezuelae* De Marmels, 1989
Distribution: Venezuela, Ecuador, Paraguay, Argentina, Uruguay, BRAZIL: AM, PR*.

48. *Nephepeltia flavifrons* (Karsch, 1889)
Distribution: Mexico, Belize, Guatemala, Honduras, Costa Rica, Colombia, Venezuela, Ecuador, Peru, Bolivia, Suriname, French Guiana, Paraguay, Argentina, BRAZIL: RR, AP, PE, MT, RO, BA, MG, ES, RJ, SP, PR*, SC, RS.
Remarks: Bastos et al. (2019) mentioned this species from AC, PA, and MS, but any original record was found. In a recent checklist from MS (Rodrigues and Roque 2017) this species is not mentioned.

49. *Oligoclada laetitia* Ris, 1911
Distribution: Argentina, BRAZIL: MG, MS, RJ, SP, PR*, RS.

50. *Planiplax erythropyga* (Karsch, 1891) (Fig. 23)
Distribution: Argentina, Uruguay, BRAZIL: RJ, PR*, RS.

51. *Tauriphila xiphea* Ris, 1931
Distribution: Paraguay, Argentina, Uruguay, BRAZIL: ES, RJ, PR*, RS.
52. *Tramea binotata* (Rambur, 1842)
Distribution: USA to Panama, Trinidad e Tobago, Colombia, Venezuela, Ecuador, Peru, Suriname, French Guiana, Paraguay, Argentina, BRAZIL: AM, PE, SE, MT, BA, MG, MS, ES, RJ, SP, PR*, RS.
53. *Tramea rustica* De Marmels & Rácenis, 1982 (Fig. 24)
Distribution: Colombia, Venezuela, Bolivia, Suriname, French Guiana, Paraguay, Argentina, BRAZIL: AM, MT, RO, MG, MS, RJ, PR*.