

Distribution and composition of Dragonfly and Damselfly species (Odonata) of the upper Rio das Velhas, Ouro Preto, Minas Gerais State, Brazil

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Abstract. This paper describes the composition and distribution of Anisoptera and Zygoptera (Odonata) species of the upper Rio das Velhas in the municipality of Ouro Preto, Minas Gerais State, Brazil. A total of 727 specimens of 40 species were collected near water bodies over a period of 23 months between 2015 and 2017. The families with greatest species richness were Libellulidae (13 species), Coenagrionidae (12 species) and Heteragrionidae and Aeshnidae (4 species each). Notable among the species collected were *Perilestes fragilis* Hagen in Selys, 1862, inhabiting well-preserved forests, *Minagrion waltheri* Santos, 1965, pertaining a endemic genus of Brazil and the recently described *Heteragrion cauei* Ávila-Júnior *et al.*, 2017, and three species recorded for the first time for the state: *Elasmothemis alcebiadesi* (Santos, 1945), *Erythrodiplax melanica* Borror, 1942 and *Erythrodiplax acantha* Borror, 1942, the latter is considered Critically Endangered (CR) by the International Union for Conservation of Nature's (IUCN) Red List.

Key-Words. Anisoptera; Atlantic Forest; Damselfly; Richness; Zygoptera.

INTRODUCTION

Insects perform essential ecosystem services such as pollination, nutrient cycling and biological control (Costanza *et al.*, 2017). Along with butterflies, beetles, locusts and ants, dragonflies (Anisoptera) and damselflies (Zygoptera), order Odonata, are one of the few insects familiar to the general public (Paulson, 2019). They are relatively large in size, have a high variety of coloring, and the larval stage is considered sedentary, living in a restricted area, and because of these biological issues they are sensitive to physical, chemical and biological changes of water, being used constantly as bioindicators of environmental quality (Corbet, 1999). Due to these characteristics (Odonata) arouses interest of both the general public and researchers. There are three extant suborders, Zygoptera (damselflies), Anisoptera (true dragonflies) and Anisozygoptera, however the latter is restricted to the Asia. Suborder

Zygoptera is known for its slender body size, separate eyes and weak flight, and Anisoptera features a more robust body size, most species with eyes close dorsally and a greater capacity for flight, although anisopteran species of Gomphidae and few other in Libellulidae the eyes are separated at the top of the head (Corbet, 1999; Garrison *et al.*, 2006, 2010).

Odonata are conspicuous elements of freshwater systems where they account for a large proportion of biomass and energy transfer between trophic levels (Sanzone *et al.*, 2003, Wittwer *et al.*, 2010). As a species-rich group, with aquatic larvae and terrestrial adults, these organisms provide indications of environmental changes in both environments (Corbet, 1999; Carvalho *et al.*, 2013; Monteiro-Júnior *et al.*, 2013). In this way, Odonata respond rapidly to changes in the environment and are therefore frequently used in conservation studies and the evaluation of different impacts on the environment (Simaika & Samways, 2012;

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Carvalho *et al.*, 2013; Juen *et al.*, 2014; Monteiro-Júnior *et al.*, 2015). They are also voracious predators, both in the adult and larval stages, and thus potentially important in insect pest control (Samways & Steytler, 1996). There are currently about of 900 species of Odonata known for Brazil (Pinto, 2020) being 269 of them registered for the state of Minas Gerais (Vilela *et al.*, 2020a).

Ouro Preto is situated about 100 km from Belo Horizonte, the capital of the state of Minas Gerais, Southeastern Brazil. It is a historical city known worldwide for its architecture and its central role in the gold cycle of the 18th century, having been recognized as a UNESCO World Heritage Site in 1980 (Sorgine, 2008). Herein we present the first checklist of species of Odonata found in the upper Rio das Velhas in the municipality of Ouro Preto.

MATERIAL AND METHODS

Study Area

The work was carried out in the region of the Parque Natural Municipal da Cachoeira das Andorinhas (PNMCA) and its vicinity, from Fazenda da Brígida, owned by Universidade Federal de Ouro Preto, to the district of Catarina Mendes, both located within the Área de Proteção Ambiental (Environmental Protection Area) Cachoeira das Andorinhas (APA Cachoeira das Andorinhas). After the creation of PNMCA in 2005, a new law was approved by municipal administration proposing a new delimitation of the park, which was sanctioned by law Nº 69/05 establishing its current limits encompassing a total of 557 hectares.

PNMCA is situated at the source of Rio das Velhas, in the southeastern region of the mosaic of conservation units of APA Cachoeira das Andorinhas in the municipality of Ouro Preto. Collecting sites numbered 1, 2, 3, 5, 9 and 10 have an average width of 3 m in length and a depth ranging from 20–30 cm, sites 4, 6, 7, and 8 have an average width of 1.5 m with a depth ranging between 10–30 cm, however, both sites feature some kind of semi-lentic systems, forming pools up to 1.5 m deep. The PNMCA Region had a predominance of seasonal semide-

ciduous forest in the Atlantic Forest domain (Scalco & Gontijo, 2011). The sampling sites coordinates and altitude can be found in the Table 1.

Collecting and Specimen Curation

Surveys were conducted bi-weekly over a period of 23 months between April 2015 and March 2017, with some campaigns being cancelled due to bad weather resulting in a total of 27 field campaigns. Ten sample sites were defined along Rio das Velhas and its main tributaries (Fig. 1). Odonates were collected near water bodies at each sampling point during random walks of 1 hour between 10:00h and 15:00h, the hottest period of the day (De Marco-Jr. & Resende, 2002; Juen *et al.*, 2014). The specimens were collected with the aid of an aerial entomological nets, with adults being packed and conditioned following the recommendations of Lencioni (2017). The collected specimens were deposited in the Coleção Entomológica of the Laboratório de Entomologia Ecológica of Universidade Federal de Ouro Preto (UFOP). The collections were performed with the authorization of the Instituto Estadual de Florestas – MG (IEF Nº 039/2016).

Statistical Analysis

Collector and rarefaction curves (interpolation) were generated to verify efficiency of the sampling effort. The ACE (*abundance coverage estimator*) and CHAO estimators were used to estimate the number of species in the region following the routine proposed in the packages “vegan” and “BiodiversityR” (Kindt & Coe, 2005; Oksanen *et al.*, 2018) of the program R (R Core Team, 2019). Rare species were considered those that had only 1 or 2 individuals in the total sample, or “singleton” and “doubleton” species, respectively; and species recorded in only 1 or 2 samples, or “unicate” or “duplicate” species, respectively.

RESULTS

A total of 727 individuals of 40 species were captured, with 21 being of the suborder Zygoptera and 19 of the suborder Anisoptera (Table 2, Figs. 2 and 3). The most species-rich Zygoptera families were Coenagrionidae (12 species) and Heteragrionidae (4 species), while the most species-rich Anisoptera families were Libellulidae (13 species) and Aeshnidae (4 species).

Among the registered species, 11 (27,5%) were “singletons”, and 5 (12,5%) “doubletons”. Sixteen species were considered as “unicates”, and seven species as “duplicates” (Table 2). The most abundant species were *Hetaerina longipes* Hagen *in* Selys, 1853 with 156 individuals (21.5%), and *Argia sordida* Hagen *in* Selys, 1865, with 138 individuals (19.0%).

The collector curves did not stabilize, suggesting that sampling effort was not sufficient to register a represen-

Table 1. Sampling locations of Odonata in the upper Rio das Velhas, Parque Natural Municipal Cachoeira das Andorinhas, Ouro Preto Municipality, Minas Gerais State, Brazil, indicating the name, geographical coordinates and altitude.

Sites	Name	Coordinates		Altitude (m a.s.l.)
		Lat.	Long.	
P 1	Rio das Velhas	20°19'59.24"S	43°30'59.89"W	1080
P 2	Rio das Velhas	20°20'3.67"S	43°30'39.03"W	1083
P 3	Rio das Velhas	20°20'41.97"S	43°29'55.94"W	1082
P 4	Undefined	20°20'54.62"S	43°29'43.70"W	1102
P 5	Rio das Velhas	20°20'52.5"S	43°29'38.7"W	1106
P 6	São Bartolomeu Stream	20°20'28.95"S	43°30'38.43"W	1109
P 7	Undefined	20°22'19.64"S	43°29'29.36"W	1311
P 8	Rio das Velhas	20°21'53.20"S	43°29'30.43"W	1277
P 9	Rio das Velhas	20°21'35.28"S	43°29'18.00"W	1205
P 10	Rio das Velhas	20°21'2.42"S	43°29'24.01"W	1110

Table 2. List of Odonata species collected at the source of Rio das Velhas, in APA Cachoeira das Andorinhas and Parque Natural Municipal Cachoeira das Andorinhas in Ouro Preto, Minas Gerais State, Brazil. (S) Singleton; (D) Doubleton; (1) Presence, (0) Absence. IUCN Status: (DD) Data Deficient, (CR) Critically Endangered, (LC) Least Concern; (*) first record for Minas Gerais State.

Taxon	Sample		IUCN status	Sites									
	S	D		P 1	P 2	P 3	P 4	P 5	P 6	P 7	P 8	P 9	P 10
Zygoptera													
Perilestidae													
<i>Perilestes fragilis</i> Hagen in Selys, 1862	X		DD	0	1	0	0	0	0	0	0	0	0
Calopterygidae													
<i>Hetaerina longipes</i> Hagen in Selys, 1853			DD	1	1	0	1	1	1	0	0	0	0
<i>Hetaerina simplex</i> Selys, 1853	X		DD	0	0	0	1	1	0	0	0	0	0
<i>Mnesarete guttifera</i> (Selys, 1873)			LC	1	1	0	1	1	1	0	0	0	0
Megapodagrionidae													
<i>Allopodagrion contortum</i> (Hagen in Selys, 1862)			LC	0	1	0	1	0	0	0	0	0	0
Heteragrionidae													
<i>Heteragrion cauei</i> Ávila-Júnior et al., 2017			DD	1	1	0	1	1	0	0	0	0	1
<i>Heteragrion rogeritaylori</i> Lencioni, 2013			DD	0	0	0	1	1	0	0	0	0	0
<i>Heteragrion gracile</i> Machado, 2006	X		DD	0	0	0	0	0	1	0	0	0	0
<i>Heteragrion</i> sp.	X			0	0	0	0	1	0	0	0	0	1
Coenagrionidae													
<i>Acanthagrion gracile</i> (Rambur, 1842)			DD	0	0	1	0	0	0	0	0	0	0
<i>Argia clausenii</i> Selys, 1865			DD	1	1	0	1	1	0	0	0	0	0
<i>Argia croceipennis</i> Selys, 1865			LC	1	1	0	1	1	0	0	0	0	0
<i>Argia lilacina</i> Selys, 1865		X	DD	1	1	0	1	1	0	0	0	0	0
<i>Argia reclusa</i> Selys, 1865			DD	1	1	0	1	1	0	0	0	0	0
<i>Argia smithiana</i> Calvert, 1909		X	DD	1	1	0	1	1	0	0	0	0	0
<i>Argia sordida</i> Hagen in Selys, 1865			DD	1	1	0	1	1	0	0	1	1	1
<i>Ischnura capreolus</i> (Hagen, 1861)			DD	0	0	1	0	0	0	0	0	0	0
<i>Minagrion waltheri</i> Santos, 1965		X	DD	0	0	1	0	0	0	0	0	0	0
<i>Oxyagrion basale</i> Selys, 1876			DD	0	0	1	0	0	0	0	1	0	0
<i>Oxyagrion terminale</i> Selys 1876			DD	0	0	1	0	0	0	0	0	0	0
<i>Telebasis carmesina</i> Calvert, 1909	X		LC	0	0	1	0	0	0	0	0	0	0
Anisoptera													
Aeshnidae													
<i>Castoraeschna colorata</i> (Martin, 1908)			DD	0	0	1	0	0	0	0	0	0	0
<i>Castoraeschna margarethae</i> Jurzitza, 1979		X	DD	0	0	1	0	0	0	0	0	0	0
<i>Coryphaeschna perrensi</i> (McLachlan, 1887)			DD	0	0	1	0	0	0	0	0	0	0
<i>Rhionaeschna planaltica</i> (Calvert, 1952)	X		LC	0	0	1	0	0	0	0	0	0	0
Gomphidae													
<i>Progomphus complicatus</i> Selys, 1854			LC	1	1	0	0	1	0	0	0	0	0
<i>Zonophora campanulata machadoi</i> St. Quentin, 1973	X		DD	1	0	0	0	0	0	0	0	0	0
Libellulidae													
<i>Dasythemis mincki mincki</i> (Karsch, 1889)		X	DD	0	0	1	0	0	0	0	0	0	0
<i>Elasmothemis alcebiadesi</i> (Santos, 1954)*			DD	1	1	0	1	1	0	0	0	0	0
<i>Erythrodiplax acantha</i> Borrer, 1942*			CR	0	0	1	0	0	0	0	0	0	0
<i>Erythrodiplax fusca</i> (Rambur, 1842)			LC	0	0	1	0	0	0	0	0	0	0
<i>Erythrodiplax melanica</i> Borrer, 1942*			DD	0	0	1	0	0	0	0	0	0	0
<i>Macrothemis heteronycha</i> (Calvert, 1909)	X		LC	0	0	1	0	0	0	0	0	0	0
<i>Macrothemis tenuis</i> Hagen, 1868			LC	1	1	0	1	1	0	1	0	1	1
<i>Macrothemis declivata</i> Calvert, 1909			DD	1	1	0	1	1	0	1	0	1	1
<i>Macrothemis imitans imitans</i> Karsch, 1890			DD	1	1	0	1	1	0	0	0	0	0
<i>Micrathyria athenais</i> Calvert, 1909	X		DD	0	0	1	0	0	0	0	0	0	0
<i>Orthemis discolor</i> (Busmeister, 1839)	X		LC	0	0	1	0	0	0	0	0	0	0
<i>Pantala flavescens</i> (Fabricius, 1798)			LC	1	1	1	0	0	0	0	0	0	0
<i>Tamea binotata</i> (Rambur, 1842)	X		DD	0	0	1	0	0	0	0	0	0	0

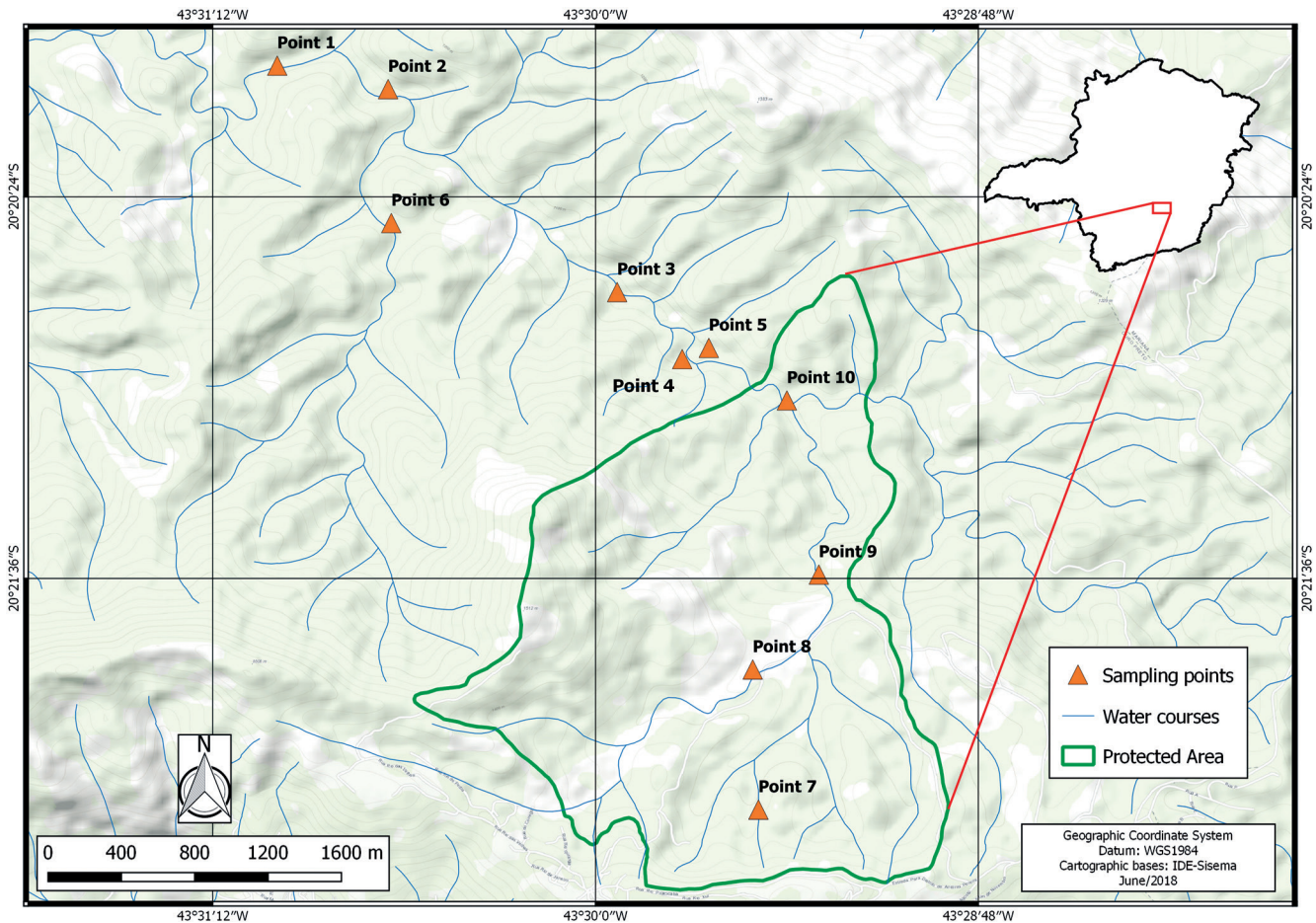


Figure 1. Map showing the sampled sites in the, Parque Natural Municipal Cachoeira das Andorinhas (green line), Ouro Preto Municipality, Minas Gerais State, Brazil.

tative number the species of dragonflies of the region (Fig. 4). The number of species sampled (40) corresponded to 78% of the species estimated by ACE (51 species) and 81% of the species estimated by CHAO (49 species).

DISCUSSION

The higher number of species of Coenagrionidae and Libellulidae sampled here reflects their dominance in Brazil and other regions of the world (e.g., Dijkstra & Clausnitzer, 2006; Bedê et al., 2015; Souza et al., 2017; Vilela et al., 2020a). Dijkstra & Clausnitzer (2006) stated

that these two families are numerically dominant because they are evolutionary and adapted better to unstable habitats than other families of Odonata, however, other factors may influence the sampling of other families, such as: difficulty in capturing due to the high capacity for vagility, habits that are still unknown as noted in Souza et al. (2017).

Some of the recorded species, of special interest, are briefly commented below. *Perilestes fragilis* Hagen in Selys, 1862 are frequently found in forests in a good state of conservation (Lencioni, 2005). *Minagrion waltheri* (Selys, 1876) (Fig. 3g), belongs to a genus endemic to Brazil and the knowledge of its distribution is associat-

Table 3. Comparison of the number of species, abundance of individuals and sampling effort between published works for the Minas Gerais State, Brazil.

Site	Nº of species	Abundance of individuals	Sampling effort	Reference
Serra de São José	128	No data	16 years	Bedê et al., 2015
West of Minas Gerais	90	No data	8 years	Vilela et al., 2020
Bueno Brandão	71	No data	35 fieldwork; 1 year	Amorim et al., 2018
Poços de Caldas	58	720	3 years	Santos, 1966
Mata do Baú-Barroso	57	No data	26 fieldwork; 1 year and 3 months	Souza et al., 2013
Refúgio da Vida Silvestre do Rio Pandeiros	48	97	20 fieldwork; 160 hours	Souza et al., 2017
Reservatório Sucupira-Uberlândia	43	860	4 sections (2 dry season) and (2 rainy season)	Barbosa et al., 2019
Rio das Velhas – Ouro Preto	40	727	27 fieldwork; 2 years	Present study
Triangulo Mineiro	36	860	4 months	Borges et al., 2019
Uberlândia	31	No data	1 year	Vilela et al., 2016
PARNA Serra do Cipó	27	115	2 years	Almeida et al., 2013

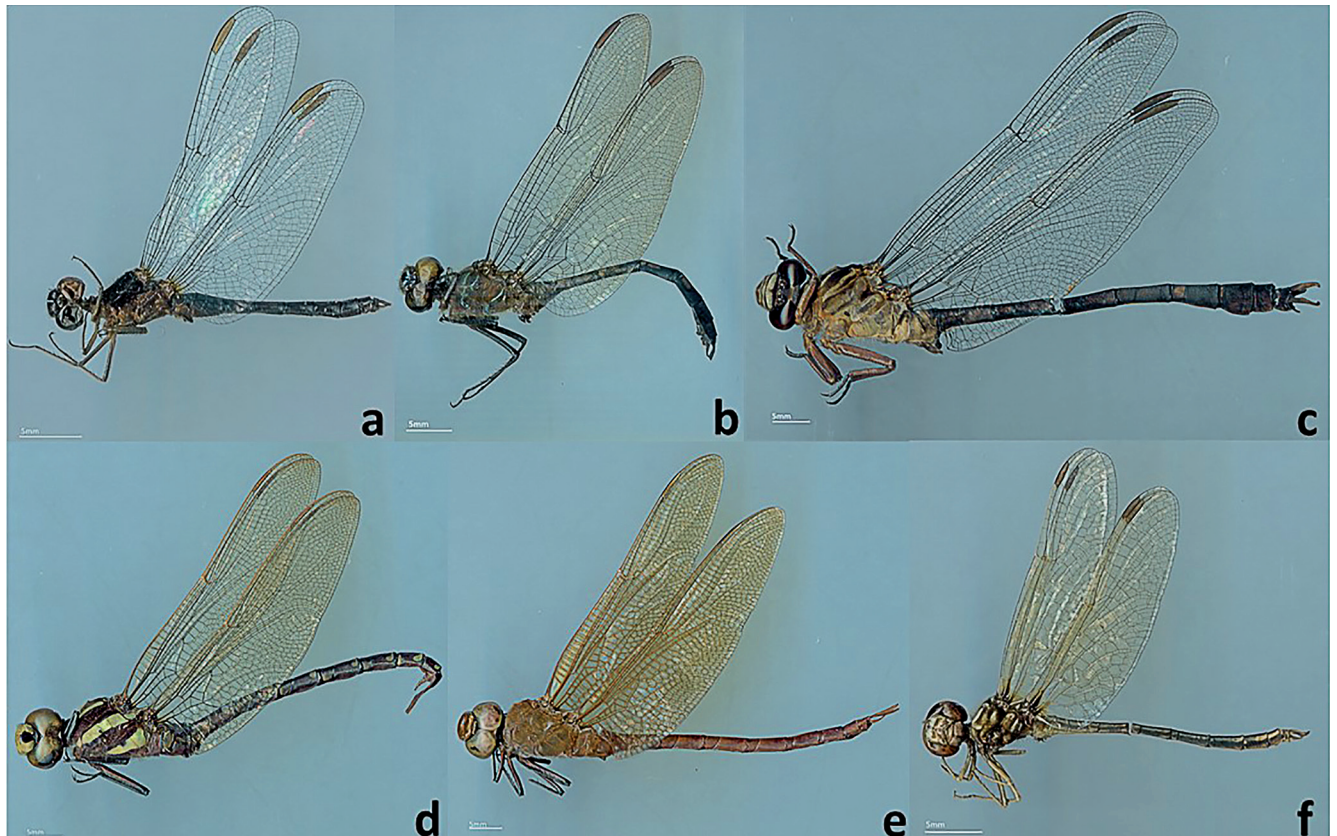


Figure 2. Some species of the suborder Anisoptera collected in the upper Rio das Velhas, Parque Natural Municipal Cachoeira das Andorinhas, Ouro Preto Municipality, Minas Gerais State, Brazil: (a) *Erythrodiplax acantha*, (b) *Elasmothemis alcebiadesi*, (c) *Zonophora campanulata machadoi*, (d) *Castoraeschna colorata*, (e) *Coryphaeschna perrensi* and (f) *Macrothemis heteronycha*.

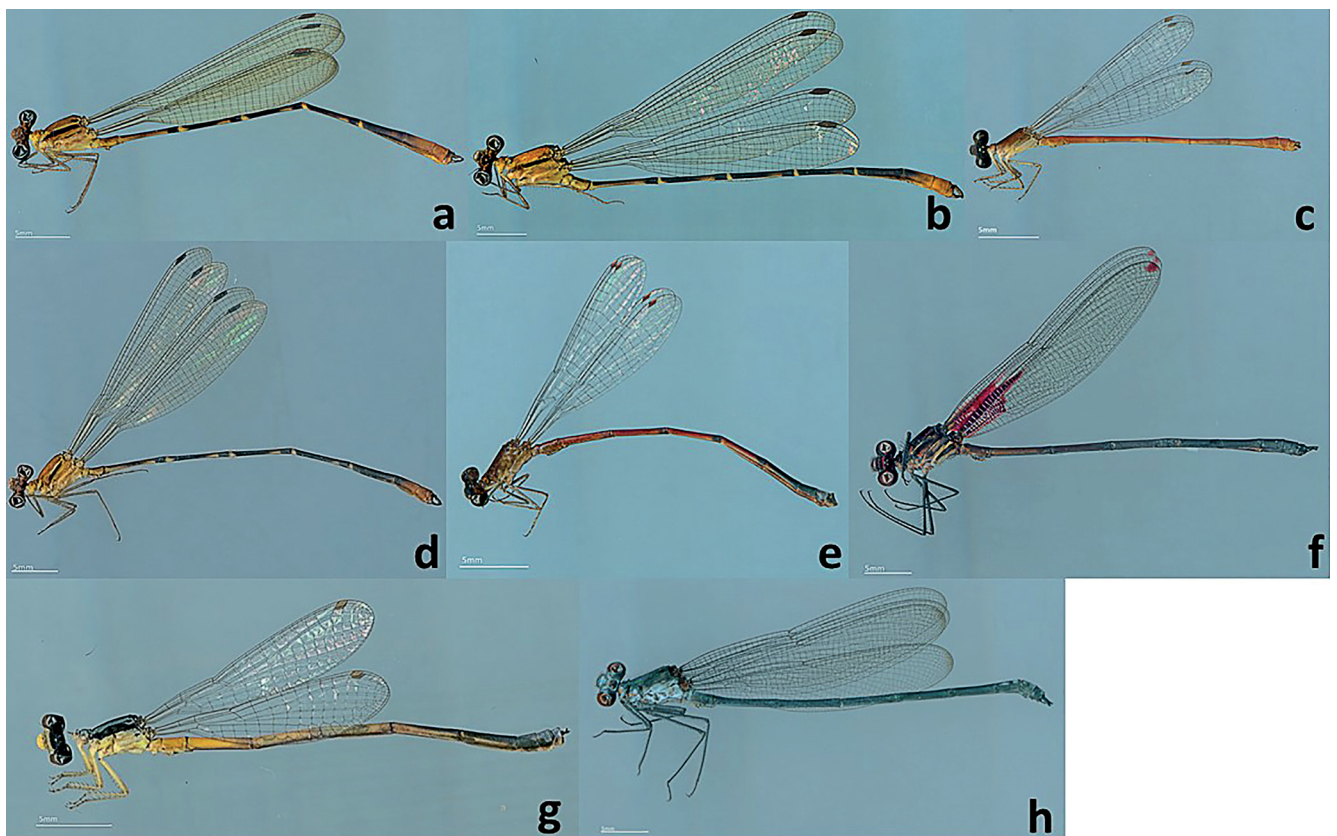


Figure 3. Some species of the suborder Zygoptera collected in the upper Rio das Velhas, Parque Natural Municipal Cachoeira das Andorinhas, Ouro Preto Municipality, Minas Gerais State, Brazil: (a) *Heteragrion cauei*, (b) *Heteragrion rogetaylori*, (c) *Telebasis carmesina*, (d) *Heteragrion gracile*, (e) *Oxyagrion basale*, (f) *Hetaerina longipes*, (g) *Minagrion waltheri* and (h) *Mnesarete guttifer*.

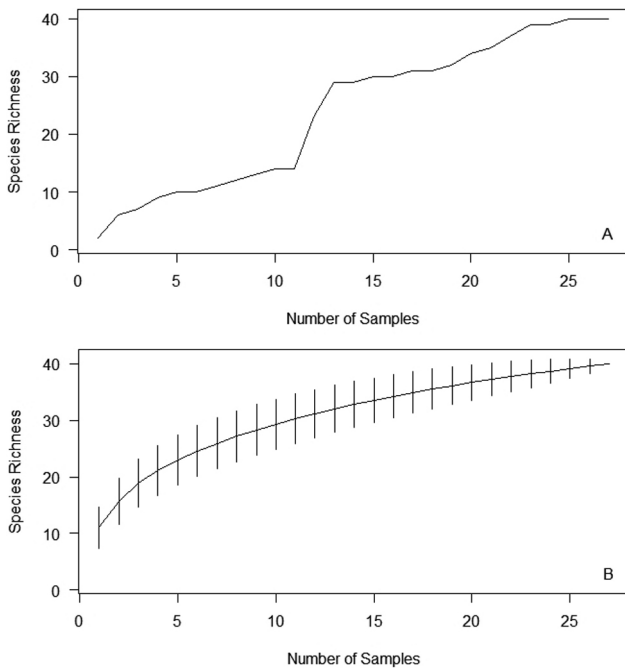


Figure 4. Odonata species accumulation curves: (A) collector method; (B) rarefaction curve. (vertical bars represent ± 2 standard deviations).

ed with preserved areas (Vilela *et al.*, 2020b). Individuals of four species of *Heteragrion* Selys, 1862 were collected, including the recently described *Heteragrion cauei* Ávila-Júnior *et al.*, 2017 (Figs. 3a and 5). Species of this genus are generally considered bioindicators of environmental quality, where the presence of established populations indicates low man-impacted environments (Machado, 1988; Monteiro-Júnior *et al.*, 2015). *Heteragrion cauei* was collected in stretches of the best-preserved ciliary forests of Rio das Velhas, downstream from the Véu da Noiva waterfall to the bridge in the district of Catarina Mendes (sampling points 1-6 and 10; Fig. 1; see also Ávila-Júnior *et al.*, 2017). Three new records for the state of Minas Gerais are highlighted: *Elasmothemis alcebiadesi* Santos, 1945 (Fig. 2b) is recorded only São Paulo State (Costa *et al.*, 2000); *Erythrodiplax melanica* Borror, 1942 with recorded only to Tocantins and Pará States (Cortês *et al.*, 2011; Pinto & Carvalho, 2009) and *Erythrodiplax acantha* Borror, 1942 (Fig. 2a) recorded for São Paulo and Goiás States (Costa *et al.*, 2000; Dutra & De Marco-Jr., 2015), being the latter in Critically Endangered (CR) status with extremely high risk of extinction in the wild (IUCN, 2020).

Compared to other studies conducted in the Minas Gerais, the present survey has a significant number of recorded species (Table 3). The number found in this study (40 species) is within the confidence interval of the mean (Mean = 56.55; CI [36.17, 76.92]) of the longer periods sampled (Bedê *et al.*, 2015; Vilela *et al.*, 2020a). However, the number of species found here was lower than the average of other studies and may be reflect the climatic conditions at Ouro Preto mountain region. According to Köppen & Geiger (1928), the climate of Ouro Preto is characterized as Cwb: (humid temperate climate with dry winter and temperate summer). In the mountain-top regions of the meridional portion of Southeastern Brazil, rainy days are accompanied by a drop in tempera-

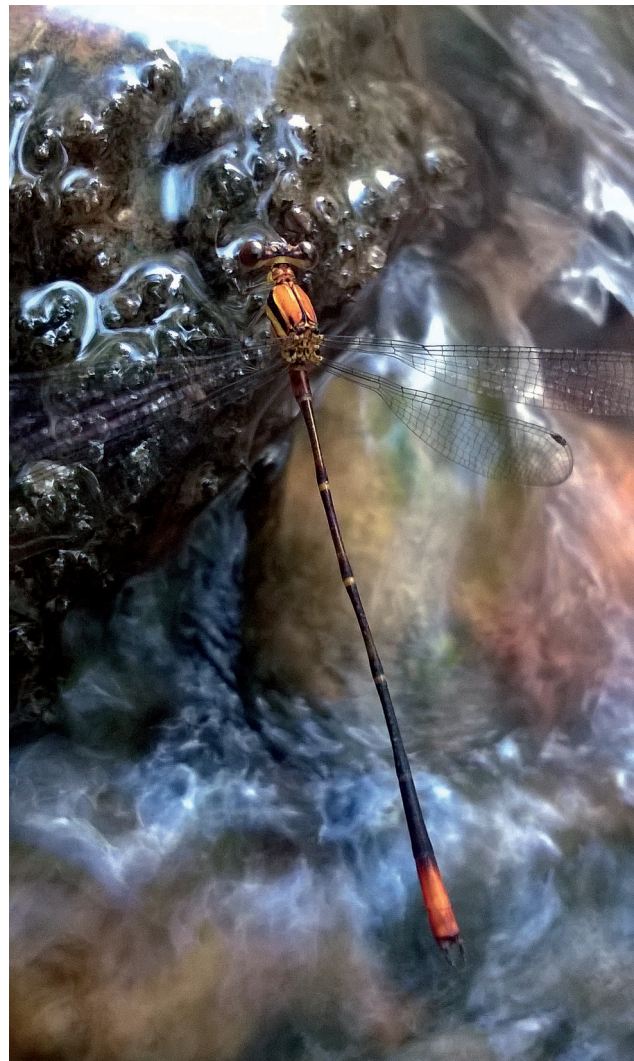


Figure 5. Dorsolateral view of live individual of *Heteragrion cauei* Ávila-Júnior *et al.*, 2017 in life. Photo: W.F. Ávila-Júnior.

ture even in the summer. Many of the field trips had to be canceled due to rain or heavy fog, which is typical of the Ouro Preto. Thus, it is still necessary a larger and longer period sample to better characterize the diversity of Odonata species in the Ouro Preto region.

The species considered rare in the present study may not necessarily be rare in nature, but rather just in the sample. Some of such species may be considered specialists with low populations levels, generalists or tourist species (Schoener, 1987; Novotný & Basset, 2000; Longino *et al.*, 2002). In addition, greater sampling effort or the use of other collection methodologies should be employed as they may present a different scenario in relation to the abundance of these species (Almeida *et al.*, 2013; Souza *et al.*, 2017).

CONCLUSION

The presence of the aforementioned significant species suggests that PNMCA has well-preserved stretches and that study of peri-urban areas would be importance to biodiversity conservation. The continuation Odonata

sampling in the region in the coming years should increase the number, in addition, we encourage further study in areas not yet sampled.

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AUTHORS' CONTRIBUTIONS

Contribution to the study design (WFAJ & MAAC), contribution to the data collection (WFAJ, MAAC & GLVM), contribution to the species identification (WFAJ & FAAL), contribution to the statistical analysis (MAAC & WFAJ), partial funding contribution from the study (MAAC & WFAJ) and contribution to the critical review study (WFAJ, MAAC, FAAL & GLVM).

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