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Immature Odonata-Anisoptera in the Iguatemi river basin, upper Paraná River, Mato Grosso do Sul State, Brazil

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ABSTRACT. This study present an inventory of the genera of Odonata-Anisoptera in lotic environments of the Iguatemi River basin, upper Paraná River, Mato Grosso do Sul State, Brazil. Samplings were performed from December 2006 to February 2009 in the Iguatemi River and eight streams of the basin. We collected 739 immature Odonata, distributed in 25 genera and three families; of which one genus represent a new record for the Mato Grosso do Sul State. *Progomphus*, *Tramea*, *Elasmotemis*, *Macrothemis*, *Aphyla* and *Phylocycla* were the most representative genera in the Iguatemi River basin. The genus accumulation curve predicts an increase of new genera for the Iguatemi River basin.

Keywords: lotic environment, aquatic macroinvertebrate, odonatofauna, richness, composition.

Imaturos de Odonata-Anisoptera da bacia do rio Iguatemi, alto rio Paraná, Mato Grosso do Sul, Brasil

RESUMO. Este trabalho apresenta um inventário de gêneros de Odonata-Anisoptera em ambientes lóticos da bacia do rio Iguatemi, alto rio Paraná, Mato Grosso do Sul, Brasil. As amostragens ocorreram no período de dezembro de 2006 a fevereiro de 2009 no rio Iguatemi e em oito riachos distribuídos na bacia. Foram coletados 739 imaturos de Odonatas, distribuídos em 25 gêneros e três famílias, do qual um gênero representa um novo registro para o Estado de Mato Grosso dos Sul. *Progomphus*, *Tramea*, *Elasmotemis*, *Macrothemis*, *Aphyla* e *Phylocycla* foram os gêneros mais representativos na bacia do rio Iguatemi. A curva de acumulação de gênero sugere a expectativa de incremento de novos gêneros para a bacia do rio Iguatemi.

Palavras-chave: ambiente lótico, macroinvertebrado, odonatofauna, riqueza, composição.

Introduction

Insects are an important component of invertebrate assemblages in almost all water bodies, and often numerically dominant (Rincon & Cressa, 2000, Graça et al., 2004). The distribution of this group in aquatic environments is mainly influenced by physical-chemical and biogeographical factors and by the habitat structure (Baptista et al., 2014).

Among the insects, the order Odonata, popularly known as dragonflies, is a group with low number of species, compared with other groups of insects (Buzzi, 2013), characterized by present aquatic nymphs and terrestrial flying adults (Corbet, 1980). Adults of this order are among the best known insects with respect to taxonomy and distribution (Kalkman et al., 2008). They have beautiful colors and acrobatic skills that fascinate the man for centuries. They are diurnal insects, found near water bodies, but some species circulate widely even in areas far from their breeding niche (Clausnitzer et al., 2009). In turn, immatures are widely distributed in the aquatic environment; have gray-brown coloring and primarily benthic mode of life (Corbet, 1980, Remsburg & Turner, 2009). These organisms are important biological components structuring freshwater ecosystems, with a key role in the food chain because they are predators at all stages of their life cycle (Corbet, 1999, Carchini, Della-Bella, Solimini, & Bazzanti, 2007) and are food sources for fish, amphibians and reptiles (Souza & Costa, 2006). Besides, they are used as indicators of human disturbance affecting the aquatic environment (Simaika & Samways, 2011, Monteiro-Júnior, Couceiro, Hamada, & Juen, 2013, Dutra & De Marco, 2015).

The majority of Odonata species is cosmopolitan and divided into three sub orders, Zygoptera, Anisoptera and Anisozygoptera, the latter

represented by only one genus and four species (Schorr & Paulson, 2017). Currently, the order is composed about of 6,230 species (3140 zygopterans and 3086 anisopterans), 671 genera distributed into 40 families (Schorr & Paulson, 2017). The distribution of Odonata fauna in Brazil is poorly known and only 29% of the Brazilian territory presents data on richness, concentrated mainly in the southern and southeastern regions (De Marco & Viana, 2005), with 828 recognized species (Costa, Santos, & Oldrini, 2012). For the Mato Grosso do Sul, the knowledge about the richness of Odonata is concentrated mainly in the Pantanal region (Longfield, 1929, Santos, 1944, Souza, Costa, & Santos, 1999, Souza, Costa, & Espindola, 2002, Souza & Costa 2006, Heckman, 2006, Pessacq & Costa 2007, Heckman, 2008, Dalzochio, Costa, & Uchôa, 2011a, Dalzochio, Souza, Uchôa, & Costa, 2011b). Specifically, for the Iguatemi River basin, a study with this approach was performed only at streams of the lower stretch of this basin (see Soares et al., 2015).

Considering that knowledge of the basic characteristics of biological assemblages is the first step for the development of effective conservation policies (Súarez et al., 2011), this study present an inventory of the genera of immature Odonate-Anisoptera found in lotic environment of the Iguatemi River basin, upper Paraná River, Mato Grosso do Sul State, Brazil. Thus, this survey should serve as a reference for the region, partially supplying a biogeographic gap in the knowledge of the Odonata fauna of this basin.

Material and methods

Study area

The Iguatemi River basin, upper Paraná River, is located at the Southern end of the Mato Grosso do Sul State (MS), Brazil, occupies 9.595,82 km^2 area and contains a large network of small streams. The Iguatemi River is a floodplain river with meandering course witch flows from an average altitude of 520 m on its headwater (municipality of Coronel Sapucaia/MS), runs, approximately, 235 km until get to 226 m altitude on its mouth atthe right bank of the Paraná River (between the municipalities of Mundo Novo/MS and Guaíra/PR).

The vegetation remaining in the study area corresponds to the Atlantic Forest biome (semideciduous forest). The climate of the region is tropical of altitude with two distinct periods related to rainfall dynamics: a rainy period (October to March) and a dry period (April to September) with annual mean temperature between 21 and 28ºC and rainfall between 1,000 and 1,500 mm (Godoy, 1986, Campo, 2001).

The area covered in this study (23°13' 27.35" S - 55° 25' 14.43" W and 23° 55' 24.66" - 54° 9' 24.10" W) included the Iguatemi River and eight streams (Comprida, Nhu-Verá, Cerro-Verde, Guaçú, Douradão, Água Boa, Perobão and Santa Maria) of the Iguatemi River basin. Among the environmental impacts in this basin, siltation is the most prominent, resulting from susceptibility of the sandy soil to erosion and lack of soil conservation practices in the drainage basin. Another important factor in this scenery is the current conservation of the riparian vegetation, ranging from the presence of forest fragment remnants in stretches of the Iguatemi River margin and in some of its tributaries to the complete replacement with pastures and crop cultivars.

Sampling

Thirty-one sampling sites were established in the Iguatemi River basin, as follows: i) thirteen sites were located in the Iguatemi River channel; ii) three in each of the streams Guaçú, Douradão, Água Boa, Perobão and Santa Maria, comprising the upper, intermediate and lower stretches thereof, totaling 15 sites and; iii) one site in each of the streams Comprida, Nhu-Verá and Cerro-Verde (Figure 1).

Sampling were conducted fortnightly from December 2006 to October 2007 in the Douradão and Guaçú Streams and the Iguatemi River (lower stretch); quarterly from January to November 2008 in the Perobão, Água Boa and Santa Maria Streams and the Iguatemi River (lower section); and only the months the January and February 2009 in the Cerro Verde, Nhu-Verá and Comprida Streams and the Iguatemi River (upper and middle stretch).

For a better representativeness of the Odonata fauna, samples were taken from the water surface, aquatic vegetation and sediment. Samples of the water surface were obtained with a conical-cylindrical net (0.5 mm mesh size). The individuals associated with the aquatic vegetation were collected using a sieve (3.0 mm mesh size). The individuals in the sediment were caught with the use of two samplers, a D-net (3.0 mm mesh size) for the capture of epifauna, and Petersen type grab sampler for the capture of infauna. For sampling optimization, we also included Odonata (from different substrates in the streams) caught along with fish samplings (not used in this study) by electrofishing (two dip nets and a portable generator - Toyama 1600, 220V, DC). The length of each stretch sampled by this methodology was established according to Fitzpatrick et al. (1998).

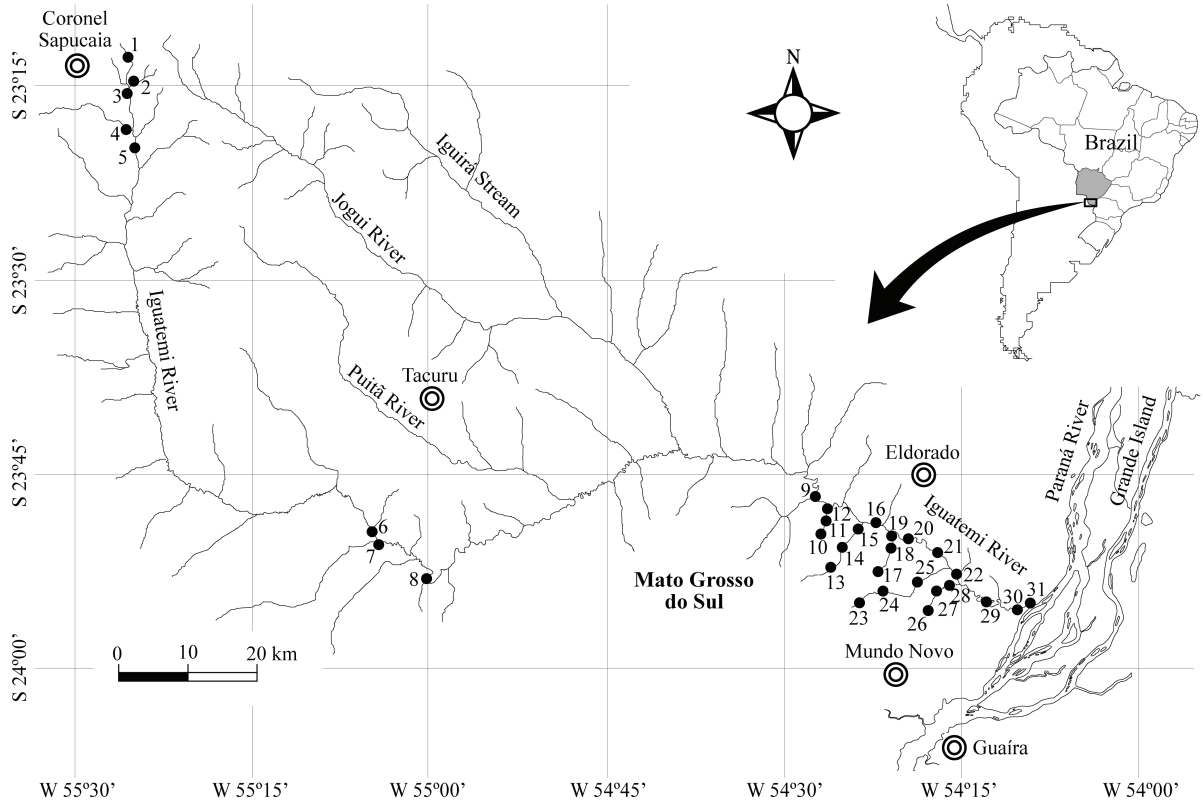

Figure 1. Location of the 31 sampling sites in the Iguatemi River basin, upper Paraná River, Mato Grosso do Sul, Brazil. Iguatemi River = 1, 3, 5, 7, 8, 9, 16, 20, 21, 22, 29, 30 and 31; Comprida Stream = 2; Nhu-Verá Stream = 4; Cerro Verde Stream = 6; Perobão Stream = 10, 11 and 12; Doradão Stream = 13, 14, 15; Água Boa Stream = 17, 18 and 19; Guaçú Stream = 23, 24 and 25; Santa Maria Stream = 26, 27 andf 28.

A single pass of dip nets was used to take immature Odonata in each site. At the end of each stretch it was installed blocking nets (10.0 x 2.0 m; 5.0 mm mesh size) to capture the material carried by the flow. The use of these sampling methods is justified on the basis of differences in equipment efficiency on different substrates (Alves & Strixino, 2003, Juen, Cabette, & De Marco, 2007).

In the laboratory, samples were washed through a set of sieves with different mesh sizes (2.0, 1.0 and 0.5 mm). Samples from the water surface, marginal vegetation, sediment and electrofishing were sorted using a transilluminated tray, stored in labeled vials and preserved in 70% alcohol. Immature individuals of Odonata were identified to the lowest possible taxonomic level, based on Carvalho and Calil (2000), Costa, Souza, and Odrini (2004), Lencione (2005) and Souza, Costa, and Oldrini (2007). Voucher genus are deposited in the *Laboratório de Ecologia Aquática* of the *Universidade Estadual de Mato Grosso do Sul*, *Unidade Universitária de Mundo Novo*, MS, Brazil.

The assemblages attributes assessed in this study were composition and richness. The efficiency of the sampling effort was evaluated by the collector's curve and the estimated number of genera was calculated using the first order Jackknife estimator. Both analyses were performed for the Iguatemi River basin using the software PCord 5.0 (McCune & Mefford, 2006).

Results and discussion

The 739 immature Odonata collected were distributed in 25 genera and three families, being that genus *Desmogomphus* is a new record for the Mato Grosso do Sul State. The family with the greatest number of genera was Libellulidae with 13 genera, followed by Gomphidae (09 genera) and Aeshnidae (03 genera) (Table 1). *Progomphus* (148 individuals), *Tramea* (80 individuals), *Elasmotemis* (65 individuals), *Macrothemis* (58 individuals), *Aphyla*and *Phylocycla* (56 individuals each), were the most abundant genera, contributing with 62.7% of the collected individuals.

Regarding genera richness for biotope, we identified 24 genera (11 exclusive) at streams and 14 (only one exclusive) at channel Iguatemi River. Thirteen genera were common in both biotopes.

The genus accumulation curves did not reach the asymptote (Figure 2). The estimated richness (Jackknife 1) for the basin was 29.8 Odonata genera,

indicating that 83.9% of the genera were sampled. Specifically, for the streams and river the estimated richness was 27.7 and 17.7 genera, respectively (Table 1).

Table 1. Composition, number total of individuals (N), relative abundance (%), presence (+) and absence (-) of Odonata for Iguatemi river basin and sampled biotopes. *New record for the Mato Grosso do Sul State.

Genera	Basin		Biotopes	
	N	%	Stream	River
Aeshnidae				
Coryphaeschna Williamson, 1903	07	1.0	+	-
Gynacantha Rambur, 1842	06	0.8	+	-
Triacanthagyna Selys, 1883	01	0.1	+	-
Gomphidae				
Aphylla Selys, 1854	56	7.6	+	+
Cyanogomphus Selys, 1873	03	0.4	+	-
Desmogomphus Williamson, 1920*	01	0.1	-	+
Erpetogomphus Selys, 1858	07	1.0	+	-
Gomphoides Selys, 1854	01	0.1	+	-
Phyllocycla Calvert, 1948	56	7.6	+	+
Phyllogomphoides Belle, 1970	05	0.7	+	-
Progomphus Selys, 1854	148	20.0	+	+
Zonophora Selys, 1854	11	1.5	+	-
Libellulidae				
Brechmorhoga Kirby, 1894	35	4.7	+	+
Elasmothemis Westfall, 1988	65	8.8	+	+
Erythrodiplax Brauer, 1868	40	5.4	+	+
Gynothemis Calvert *in* Ris, 1909	12	1.6	+	+
Libellula Linnaeus, 1758	33	4.5	+	+
Macrothemis Hagen, 1868	58	7.9	+	+
Miathyria Kirby, 1889	12	1.6	+	-
Micrathyria Kirby, 1889	02	0.3	+	-
Orthemis Hagen, 1861	22	3.0	+	+
Perythemis Hagen, 1861	01	0.1	+	-
Planiplax Muttkowski, 1910	26	3.5	+	+
Tramea Hagen, 1861	80	10.8	+	+
Zenithoptera Selys, 1869	51	6.9	+	+
Total	739	100.0		
Total richness	25		24	14
Estimated richness	29.8		27.7	17.7
Number of sites sampled	29		17	12

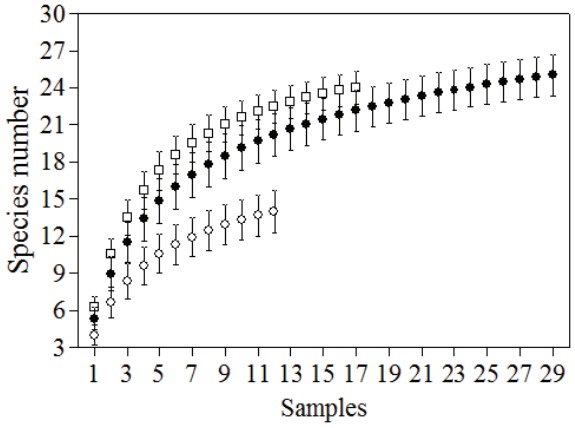

Figure 2. Accumulation curve of Odonata genera for the Iguatemi River basin (filled circles), streams (squares) and river (empty circles). Vertical lines = standard deviation.

The Odonata fauna of the suborder Anisoptera registered in the Iguatemi River basin (25 genera) represented 68.0% of all genera recorded for the Mato Grosso do Sul State, revealing that this basin contains a relatively rich fauna of this group. It is important to emphasize that the values of richness here mencioned for this sub order are above those recorded in other environment of the upper Paraná River basin (see Franco & Takeda, 2002 - 6 genera, Fulan & Henry 2006 - 5 genera, Souza, Fogaça, Cunico, & Higuti, 2015 – 14 genera). Among of the Odonata-Anisoptera genera recorded for the state (37 genera), six of these were found only in the Iguatemi River Basin (*Tetracanthagyna*, *Erpetogomphus*, *Phyllogomphoides*, *Zonophora* and *Libellula* - Soares et al., 2015, *Desmogomphus* in this study). As the surveys in the Mato Grosso do Sul State were conducted only in the Serra da Bodoquena (Dalzochio et al., 2011a, 2011b, 23 genera), in the Aporé-Sucurui Complex (Souza & Costa, 2006, 28 genera) and Iguatemi River basin (Soares et al., 2015, 24 genera and present study; 25 genera), surveys in other regions will certainly increase the list of genera of the suborder for the Mato Grosso do Sul State.

Among the three families of Anisoptera recorded in the Iguatemi River basin, Libellulidae showed the highest richness of genera (13). A comparison with other studies on the richness of Odonata demonstrates that this pattern is common in the Neotropics (Souza & Costa, 2006, Muzón et al., 2008, Muzón, 2009, Von Ellenrieder, Molineri, & Emmerich, 2009, Altamiranda, Pérez, & Gutiérrez, 2010, Dalzochio et al., 2011a, Carvalho, Pinto, Oliveira-Júnior, & Juen, 2013, Pires, Kotzian, Spies, & Neri, 2013, Rodríguez, Gomez, & Molineri, 2014), which has 38 genera cataloged making Libellulidae the richest family in this region (Kalkman et al., 2008). A plausible explanation is that most immature individuals of this group shows wide geographical distribution and can colonize different types of habitat, from preserved aquatic environments to areas with reduced or absent riparian vegetation, often reported in open areas (Ferreira-Peruquetti & De Marco, 2002, Kalkman et al., 2008, Juen, Oliveira-Júnior, Shimano, Mendes, & Cabette, 2014, Koch, Wagner, & Sahlén, 2014). Our results confirm this pattern, since most of the sampling sites show the surroundings covered mainly by grass pastures and fragments of riparian vegetation.

In relation to the factors that influence the richness of Odonata, the quantity and heterogeneity of microhabitat are the most crucial for the establishment of this group in aquatic environments (see Dalzochio et al., 2011a, Bagatini, Delariva, &

Higuti, 2012, Souza et al., 2015). Although not quantified, we observed a higher environmental heterogeneity (stones, branches, aquatic vegetation and varied substrate) in streams relative to the main river, which may explain our results.

With respect to the representativeness of the Odonata fauna, the six most numerically more expressive genera in the Iguatemi River basin occurred in both biotopes. *Progomphus*, *Tramea* and *Macrothemis* are recorded predominantly in the streams (see Kikuchi & Uieda, 2005, Ferreira-Peruquetti & De Marco, 2002), and exploit different microhabitats (Costa et al., 2004). *Progomphus* are burrowers and colonize sites with water flow and sandy bottom. *Tramea*, with sprawler habit, is present mainly in backwater areas of clay/sandy bottom, while *Macrothemis* has sprawler-burrowers habit, colonizing habitats with low current velocity with sandy and clayey characteristics (Carvalho & Nessimian, 1998). In contrast, *Elasmothemis*, *Aphyla* and *Phyllocycla* occur mainly in rivers (see Assis, Carvalho, & Nessimian, 2004, Figueiredo, Pires, Davanso, & Kotzian, 2013). These genera are known to occupy mainly sandy habitats, living buried in the substrate (*Aphyla* and *Phyllocycla*; burrowers) and colonizing aquatic vegetation (*Elasmothemis*; sprawler-burrower) (Carvalho & Nessimian, 1998).

Although it has been recorded 25 Odonata genera for the Iguatemi River basin, which is considered a good representativeness for the Mato Grosso do Sul State (as discussed earlier), the genus accumulation curve has predicted an increase of new genera. These results, combined with the estimated richness, showed the upward trend in the number of genera with increasing sampling effort. Thereby, conducting long-term studies associated with different types of environments and sampling methods may result in a promising increase of genera, since many genera not yet recorded for the Mato Grosso do Sul State, are known in Brazil.

Conclusion

The results evidenced that the Iguatemi River basin encompasses a highly diverse Odonata fauna. The records of new genres for the state suggests that the Odonata fauna of the study area deserves attention and point to the interest in implementing future protected areas in the southern Mato Grosso do Sul State.

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