

Odonates from Bodoquena Plateau: checklist and information about endangered species

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Abstract: Here we provide an updated checklist of the odonates from Bodoquena Plateau, Mato Grosso do Sul state, Brazil. We registered 111 species from the region. The families with the highest number of species were Libellulidae (50 species), Coenagrionidae (43 species) and Gomphidae (12 species). 35 species are registered in the IUCN Red List species, four being Data Deficient, 29 of Least Concern and two species being in the threatened category. *Phyllogomphoides suspectus* Belle, 1994 (Odonata: Gomphidae) was registered for the first time in the state.

Keywords: *Dragonfly, Damselfly, inventory, Cerrado, Brazil*

Libélulas da Serra da Bodoquena: lista de espécies e informações sobre espécies ameaçadas

Resumo: Nós apresentamos um inventário atualizado das espécies de libélulas ocorrentes na Serra da Bodoquena, Estado de Mato Grosso do Sul, Brasil. Nós registramos 111 espécies para a região. As famílias com o maior número de espécies foram Libellulidae (50 espécies), Coenagrionidae (43 espécies) e Gomphidae (12 espécies). 35 espécies são registradas na Lista Vermelha de espécies da IUCN e duas estão em categorias de ameaçadas. *Phyllogomphoides suspectus* Belle, 1994 (Odonata: Gomphidae) foi registrado pela primeira vez no estado.

Palavras-chave: *Libélulas, donzelinhas, Inventário, Cerrado, Brasil*

Introduction

Insects are arthropod group with largely unknown distribution patterns (Diniz-Filho et al. 2010), due to their high species richness, difficulties related to sampling and lack of taxonomic experts. Applying all of these conditions, odonates (Insecta: Odonata) constitutes an important group that play a major role as predators, with several insects making up a large portion of their diets. This group is also a good indicators of water quality, with their nymphs being an important link in food chains for fish and other aquatic vertebrates and serve as an inspired subject for artists, naturalists and collectors (Abbott 2015).

Even with important taxonomists in the recent Brazilian history, odonates are still poorly described and its distribution is deficiently known in the Neotropical region (Kalkman et al. 2008). Local inventories are recorded to several parts of Brazil like São Paulo (Costa et al. 2000), Espírito Santo (Costa & Oldrini 2005), Rio de Janeiro (Anjos-Santos & Costa 2006), Goiás and Distrito Federal (Nóbrega & De Marco 2011), Minas Gerais (Souza et al. 2013), and Rio Grande do Sul (Renner et al. 2016). In Mato Grosso do Sul, state originally covered by Cerrado, Pantanal, Atlantic Forest and Chaco vegetation, 198 odonatan species were registered (Rodrigues & Roque 2017). Despite this number, information gaps are recognized from many areas in this state (Vianna & De Marco 2012, Rodrigues & Roque 2017).

Bodoquena Plateau is a threatened area in the Mato Grosso do Sul state because of the broad conversion of natural areas to pastures and croplands (Roque et al. 2016). In the last five years, several research projects about biodiversity and the ecology of aquatic insects have been developed in Bodoquena Plateau, (e.g. LTER Planalto da Bodoquena, Dragonflies of Serra da Bodoquena Project and Observavua Project). These projects have promoted a great opportunity for extending sampling effort of aquatic insects, especially for odonates (e.g. Koroiva et al. 2016, Rodrigues et al. 2016a, Rodrigues et al. 2016b, Valente-Neto et al. 2016). Until 2011, about 68 Odonata species were registered to Bodoquena Plateau; a number that was considered underestimated because of the broad unsampled area (Dalzochio et al. 2011b). Therefore, even with the publications of checklists (Dalzochio et al. 2011a, Dalzochio et al. 2011b, Rodrigues & Roque 2017), the amount of information generated by these new sampling efforts and visits to museums demand an update.

Here, we provide an updated checklist of the odonates from Bodoquena Plateau, including species records from recent sampling efforts, from the literature, and from specimens deposited in the Reference Collection of the Federal University of Mato Grosso do Sul (CEUFMS). We also provide information about endangered species from the IUCN Red List (IUCN 2016), which is fundamental for updating the status of Brazilian species, as recently emphasized in the 1st Meeting of the Latin American Odonatological Society - SOL.

Material and Methods

1. Sources of data

We used different sources of information to produce the checklist, including samplings (from 2011 to 2016), previous available records on literature and information collected in zoological reference collections of the Mato Grosso do Sul state. For each source, we searched for names and geographic coordinates of the locations. For records that did not have latitude and longitude values, geographic coordinates of the centroid of the place where the site is located.

2. Sampling in study region

All the sampling sites were located within Bodoquena Plateau region (21°08'02" to 20°38'26"S and 56°48'31" to 56°44'28"W). The Bodoquena Plateau is located in the mid-southern portion of Mato Grosso do Sul State, including the cities of Bodoquena, Bonito and Jardim. The region is characterized by a mountain chain, with altitudes varying between 450 and 800 m. The climate is temperate humid with hot summers and two well-defined seasons. The average annual temperature varies between 20 and 22°C and annual rainfall varies between 1300 and 1700 mm. The hydrography of the region is characterized by limestone, rivers with high alkalinity and low turbidity. Its tributaries are part of the Paraguay River watershed (PCBAP 1997).

Bodoquena Plateau has both areas of the Cerrado (Brazilian savanna) and Atlantic Forest biomes. This region is an important ecological corridor for biodiversity and one of the most important areas of Ecotourism in Brazil (Klein et al. 2011). Considered a priority area for conservation by the Brazilian Ministry of Environment (MMA) (Brasil 2016), the region is currently threatened by inadequate exploitation of its resources and the progressive agricultural expansion.

The dataset used in this checklist included 85 lotic environments (Figure 1) sampled during the period between 2011 and 2016. These samples were concentrated on adults from Odonata and were performed during Ph.D studies (Valente-Neto 2015, Rodrigues 2016), Long term ecological research in the Bodoquena Plateau (LTER-Serra da Bodoquena), Dragonflies of Serra da Bodoquena Project and Observagua Project. The sampling method used handheld insect nets, in sunny days, during the peak time of Odonata activities (between 09:00 h to 16:00 h). The collection authorization process was issued by IBAMA, through SISBio system under the number 41313-3 and 54386-1. All specimens collected were deposited in the Reference Collection of the Universidade Federal de Mato Grosso do Sul (CEUFMS), afterwards determined in laboratory according to Garrison et al. (2006, 2010), Heckman (2006, 2008) and Lencioni (2005, 2006). For the systematics classification, we followed Dijkstra et al. (2014) and for scientific names and followed the synonymic list of Garrison & von Ellenrieder (2016). In the laboratory, dragonflies were analyzed under Zeiss Discovery V20 stereoscope and recorded with an AxioCam Icc 5 Microscope Camera. For capturing and editing images, we used the software Zen 2-2011.

3. Data analysis

We estimated the sampling accuracy of sampling sites with incidence-based non-parametric estimators: Chao 2, Jackknife 1 and Jackknife 2. Non-parametric methods have better performance compared to others estimators for aquatic insects (Melo & Froelich 2001). These analyses were performed with EstimateS version 9.1.0 software (Colwell 2013). We set 1000 repetitions to calculated mean values with confidence intervals of 95%.

4. Literature and reference collections information

Aiming to improve our list of species, we used online available databases to find registers of Odonata species from Bodoquena Plateau, specifically Web of Knowledge (which includes the main journals of world), Scielo (which include the main journals of South America) and Google Scholar.

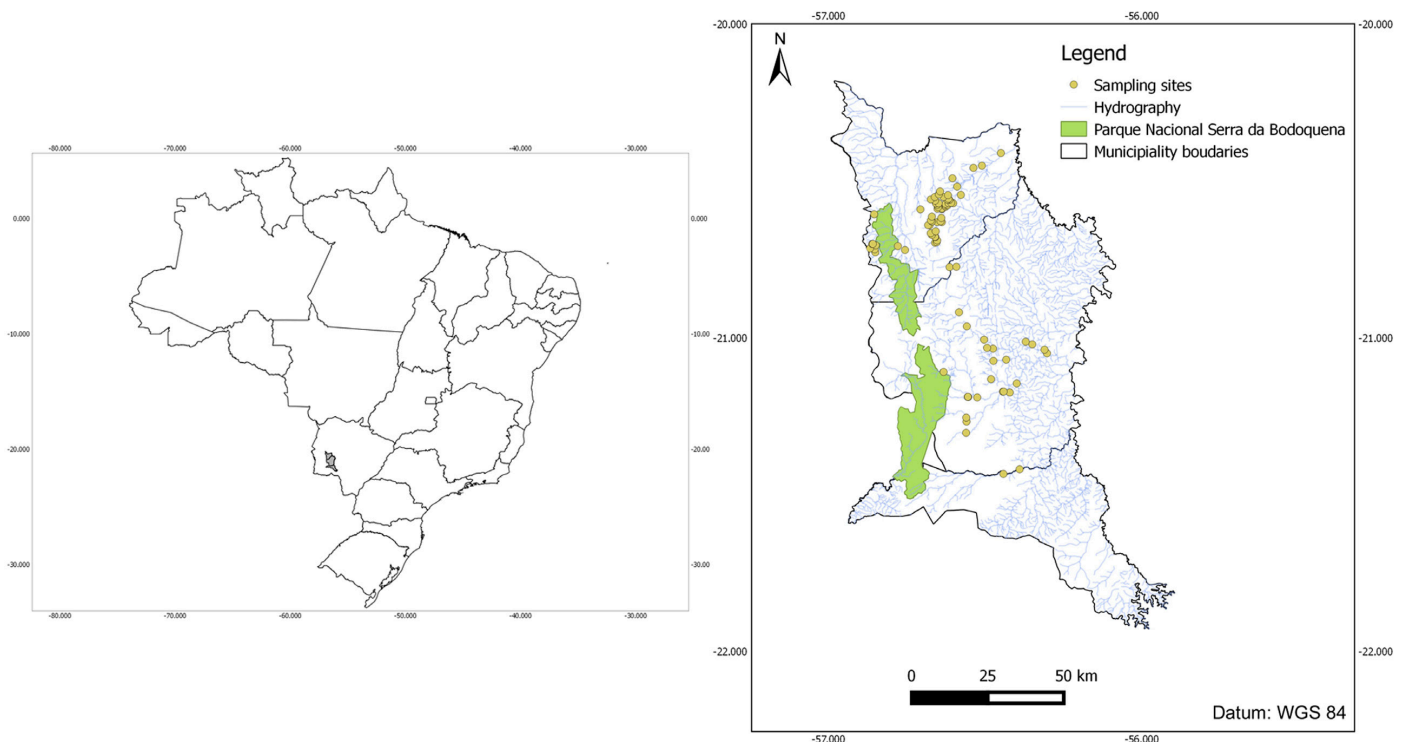


Figure 1. Sampling locations in the Bodoquena Plateau region. On the north is the municipality of Bodoquena; on the middle is the municipality of Bonito and on the south is the municipality of Jardim.

We did the search on general keywords like “Odonata”, “dragonfly” or “libélula” (“Dragonfly” in Portuguese) in combination with “Mato Grosso do Sul”, “Bodoquena Plateau” or “Serra da Bodoquena” (“Bodoquena Plateau” in Portuguese). Souza (2003), Dalzochio et al. (2011a) and Dalzochio et al. (2011b) provided additional information about registers of Odonata species (“Reference” in Table 1).

In addition, we analyzed the deposited specimens from two important Zoological collections of Mato Grosso do Sul state: Reference Collection Universidade Federal de Mato Grosso do Sul (CEUFMS) and Biodiversity Museum of Universidade Federal da Grande Dourados (UFGD). CEUFMS provided additional register besides that found in the project samples or in literature (“CEUFMS” in Table 1).

Table 1. Inventory list of Odonata species from Bodoquena Plateau with information about endangered species (IUCN). CR = Critically Endangered, VU = Vulnerable, LC = Least Concern, DD = Data Deficient; *, first record to Bodoquena Plateau.

Suborder	Family	Species	Source	IUCN Red list status
Anisoptera	Aeshnidae	<i>Castoraeschna</i> sp Calvert, 1952 *	This study (BOMS 0052/UFMS BOMS 0053/UFMS)	-
		<i>Staurophebia reticulata</i> Burmeister, 1839 *	This study (CANI 414/UFMS)	-
	Gomphidae	<i>Agriogomphus ericae</i> Belle, 1966	Reference (Dalzochio et al. 2011b)	-
		<i>Archaeogomphus</i> sp Williamson, 1919	Reference (Dalzochio et al. 2011b)	-
		<i>Cyanogomphus</i> sp Selys, 1873	Reference (Dalzochio et al. 2011b)	-
		<i>Gomphoides infumata</i> Rambur, 1842	Reference (Dalzochio et al. 2011a)	-
		<i>Phyllogomphoides suspectus</i> Belle, 1994 *	This study (6-R15-04/UFMS)	DD
		<i>Phyllocycla</i> sp Calvert, 1948	This study (CANI336/UFMS)	-
		<i>Progomphus amazonicus</i> Belle, 1973	Reference (Dalzochio et al. 2011a)	DD
		<i>Progomphus intricatus</i> Hagen in Selys, 1858	Reference (Dalzochio et al. 2011b)	LC
		<i>Progomphus montanus</i> Belle, 1973	Reference (Dalzochio et al. 2011a)	LC
		<i>Progomphus</i> sp1 Selys, 1854	This study (CANI 411/UFMS)	-
		<i>Progomphus</i> sp2 Selys, 1854	This study (CANI 334/UFMS)	-
		<i>Remartinia</i> sp Navás, 1911 *	This study (CANI 017/UFMS)	-
		Libellulidae	<i>Brechmorhoga</i> sp Kirby, 1894	Reference (Dalzochio et al. 2011b)
	<i>Dythemis sterilis</i> Hagen, 1861		This study (6-R15-21/UFMS)	-
	<i>Elasmothermis cannacrioides</i> Calvert, 1906 *		This study (6-R15-28/UFMS, 6-R15-14/UFMS, 6-R15-8/UFMS)	-
	<i>Elasmothermis williamsoni</i> Ris, 1919		Reference (Dalzochio et al. 2011a)	-
	<i>Elga newtonsantosi</i> Machado, 1992 *		This study (CANI 833/UFMS, CANI 413/UFMS)	CR
	<i>Erythemis vesiculosa</i> Fabricius, 1775		This study (1-R19-3/UFMS)	LC
	<i>Erythemis mithroides</i> Brauer in Therese, 1900 *		CEUFMS (CEUFMS 6048)	LC
	<i>Erythemis peruviana</i> Rambur, 1842 *		CEUFMS (CEUFMS 6044, CEUFMS 6046, CEUFMS 6047)	-
	<i>Erythemis plebeja</i> Burmeister, 1839		CEUFMS (CEUFMS 6043)	LC
	<i>Erythrodiplax basalis</i> Kirby, 1897 *		This study (CANI 011/UFMS, CANI 015/UFMS, CANI 09/UFMS, CANI 222/UFMS)	-
	<i>Erythrodiplax branconensis</i> Sjöstedt, 1929 *		This study (CANI 217/UFMS)	-
	<i>Erythrodiplax famula</i> Erichson in Schomburgk, 1848		Reference (Dalzochio et al. 2011a)	-
	<i>Erythrodiplax fusca</i> Rambur, 1842		This study (3-R14-11/UFMS, 3-R14-10/UFMS, 3-R14-24/UFMS, 6-R15-3/UFMS)	-
	<i>Erythrodiplax kimminsi</i> Borror, 1942 *		This study (CANI 088/UFMS)	-
	<i>Erythrodiplax lativittata</i> Borror, 1942 *		This study (CANI 405/UFMS, CANI 499/UFMS, CANI 505/UFMS, CANI 502/UFMS)	-
	<i>Erythrodiplax ochracea</i> Burmeister, 1839		This study (8-R22-1/UFMS, 8-R22-4/UFMS, 8-R22-5/UFMS)	LC
	<i>Erythrodiplax paraguayensis</i> Förster, 1905		This study (BNBTO-0005/UFMS)	LC
	<i>Erythrodiplax umbrata</i> Linnaeus, 1758		This study (7-R21-1/UFMS, 7-R21-2/UFMS, 7-R21-4)	-
	<i>Macrothemis flavescens</i> Kirby, 1897 *		This study (CANS 480/UFMS)	LC
	<i>Macrothemis hemichlora</i> Burmeister, 1839		This study (BOMS-0328/UFMS)	LC
	<i>Macrothemis heteronycha</i> Calvert, 1909	Reference (Dalzochio et al. 2011b)	LC	
	<i>Macrothemis imitans imitans</i> Karsch, 1890	Reference (Dalzochio et al. 2011a)	-	
	<i>Macrothemis</i> sp Hagen, 1868 *	This study (BOMS0379/UFMS)	-	
	<i>Miathyria marcella</i> Selys in Sagra, 1857	This study (2-R16-3/UFMS, 7-R21-6/UFMS)	LC	
	<i>Micrathyria catenata</i> Calvert, 1909	Reference (Souza 2003)	LC	
	<i>Micrathyria hesperis</i> Ris, 1911	CEUFMS (CEUFMS 6019, CEUFMS 6020, CEUFMS 6021)	-	
	<i>Micrathyria laevigata</i> Calvert, 1909	This study (CANI 019/UFMS)	-	
	<i>Micrathyria longifasciata</i> Calvert, 1909	Reference (Dalzochio et al. 2011b)	LC	

Table 1. Continued...

Suborder	Family	Species	Source	IUCN Red list status
		<i>Micrathyria ocellata</i> Martin, 1897	CEUFMS (CEUFMS 5998, CEUFMS 5999, CEUFM 6008)	-
		<i>Micrathyria pseudeximia</i> Westfall, 1992	Reference (Souza 2003)	-
		<i>Micrathyria pseudhyppodidyma</i> Costa, Lourenço & Viera, 2002 *	This study (CANI 433/UFMS, CANI 432/UFMS)	VU
		<i>Micrathyria stawianskii</i> Santos, 1953 *	This study (BOMS0076/UFMS)	LC
		<i>Micrathyria tibialis</i> Kirby, 1897	Reference (Souza 2003)	LC
		<i>Micrathyria ungulata</i> Förster, 1907 *	This study (CANI 013/UFMS)	-
		<i>Oligoclada</i> sp. Karsch, 1890	Reference (Souza 2003)	-
		<i>Orthemis cultriformis</i> Calvert, 1899 *	This study (BNBTO202-12/UFMS)	-
		<i>Orthemis discolor</i> Burmeister, 1839	This study (1-R19-7/UFMS)	-
		<i>Orthemis ferruginea</i> Fabricius, 1775 *	CEUFMS (CEUFMS 5886, CEUFMS 5888, CEUFMS 5889)	LC
		<i>Orthemis schmidtii</i> Buchholz, 1950	CEUFMS (CEUFMS 59891)	-
		<i>Pantala flavescens</i> Fabricius, 1798	This study (BOMS0088/UFMS)	LC
		<i>Pantala hymenae</i> Say, 1839 *	This study (CANI 041/UFMS)	-
		<i>Perithemis electra</i> Ris, 1930 *	This study (CANI 588/UFMS, CANI 514/UFMS, CANI 517/UFMS, CANI 501/UFMS)	LC
		<i>Perithemis icteroptera</i> Selys in Sagra, 1857 *	This study (13-R31-2/UFMS)	LC
		<i>Perithemis lais</i> Perty, 1834	This study (CANI 301/UFMS, CANI 459/UFMS)	LC
		<i>Perithemis mooma</i> Kirby, 1889	This study (CANI 460/UFMS)	-
		<i>Perithemis thais</i> Kirby, 1889	This study (CANI 481/UFMS, CANI 468/UFMS, CANI 464/UFMS, CANI 463/UFMS)	-
		<i>Tauriphila australis</i> Hagen, 1867	Reference (Souza 2003)	-
		<i>Tramea cophysa</i> Hagen, 1867 *	CEUFMS (CEUFMS 6082, CEUFMS 6093, CEUFMS 6084)	-
		<i>Tramea minuta</i> De Marmels & Rácenis, 1982	Reference (Dalzochio et al. 2011a)	-
		<i>Tramea rustica</i> De Marmels & Rácenis, 1982 *	CEUFMS (CEUFMS 6074, CEUFMS 6075, CEUFMS 6076)	LC
Zygoptera	Calopterygidae	<i>Hetaerina mortua</i> Hagen in Selys, 1853 *	This study (CZYG 693/UFMS)	-
		<i>Hetaerina rosea</i> Selys, 1853	This study (6-R15-23/UFMS, 02-R16-01/UFMS, 4-R17-1/UFMS, 4-R17-2/UFMS)	-
	Coenagrionidae	<i>Acanthagrion aepiolum</i> Tennessen, 2004	This study (12-R25-18/UFMS, 9-R27-5/UFMS, 10-R28-8/UFMS, 13-R30-16/UFMS)	-
		<i>Acanthagrion apicale</i> Selys, 1876	Reference (Dalzochio et al. 2011a)	-
		<i>Acanthagrion ascendens</i> Calvert, 1909	Reference (Dalzochio et al. 2011a)	-
		<i>Acanthagrion chararum</i> Calvert, 1909	Reference (Dalzochio et al. 2011b)	-
		<i>Acanthagrion cuyabae</i> Calvert, 1909	This study (10-R28-2/UFMS, 10-R28-6/UFMS, 10-R28-7/UFMS)	LC
		<i>Acanthagrion gracile</i> Rambur, 1842	This study (8-R22-2/UFMS, 12-R25-20/UFMS, 12-R25-17/UFMS)	-
		<i>Acanthagrion temporale</i> De Marmels, 1985	Reference (Souza 2003)	-
		<i>Acanthagrion truncatum</i> Selys, 1876	Reference (Souza 2003)	LC
		<i>Aeolagrion dorsale</i> Burmeister, 1839 *	This study (CZYG 1011/UFMS, CZYG 1551/UFMS)	-
		<i>Argentagrion ambiguum</i> Ris, 1904 *	CEUFMS (CZYG 5001/UFMS)	-
		<i>Argia chapadae</i> Calvert, 1909 *	This study (5-R13-1/UFMS, 3-R14-16/UFMS, 6-R15-1/UFMS, 1-R19-10/UFMS)	-
		<i>Argia croceipennis</i> Selys, 1865	This study (CZYG 1504/UFMS, CZYG 1837/UFMS, CZYG 1328/UFMS, CZYG 1329/UFMS)	LC
		<i>Argia cupraurea</i> Calvert, 1902	Reference (Souza 2003)	-
		<i>Argia hasemani</i> Calvert, 1909 *	This study (CZYG 1779/UFMS, CZYG 1791/UFMS, CZYG 501/UFMS)	-
		<i>Argia indocilis</i> Navás, 1934	This study (CZYG 873/UFMS)	-
		<i>Argia lilacina</i> Selys, 1865 *	This study (CZYG 412/UFMS)	-
		<i>Argia modesta</i> Selys, 1865 *	This study (BNBTO-0288/UFMS)	-
		<i>Argia mollis</i> Hagen in Selys, 1865 *	This study (3-R14-17/UFMS)	-
		<i>Argia reclusa</i> Selys, 1865 *	This study (6-R15-16/UFMS, 1-R19-11/UFMS, 9-R27-1/UFMS, 13-R30-2/UFMS)	-
		<i>Argia smithiana</i> Calvert, 1909 *	This study (BNBTO-0093)	-

Table 1. Continued...

Suborder	Family	Species	Source	IUCN Red list status
		<i>Argia subapicalis</i> Calvert, 1909 *	This study (CZYG 509/UFMS)	DD
		<i>Argia tamoyo</i> Calvert, 1909	This study (BNBTO-0289/UFMS)	-
		<i>Enallagma novaehispaniae</i> Calvert, 1907	This study (CZYG 742/UFMS, CZYG 1128/UFMS, CZYG 1137/UFMS)	-
		<i>Epileoneura metallica</i> Rácenis, 1955 *	This study (BNBTO244-12/UFMS)	LC
		<i>Epileoneura venezuelensis</i> Rácenis, 1955	This study (CZYG 958/UFMS, CZYG 1112/UFMS, CZYG 1116/UFMS)	-
		<i>Forceptioneura</i> sp. Lencioni, 1999	Reference (Souza 2003)	-
		<i>Homeoura chelifera</i> Selys, 1876	Reference (Dalzochio et al. 2011a)	-
		<i>Homeoura nepos</i> Selys, 1876 *	This study (CZYG 433/UFMS, CZYG 437/UFMS)	-
		<i>Ischnura capreolus</i> Hagen, 1861	Reference (Souza 2003)	-
		<i>Ischnura fluviatilis</i> Selys, 1876	Reference (Souza 2003)	LC
		<i>Metaleptobasis lillianae</i> Daigle, 2004 *	This study (CZYG 1358/UFMS, CZYG 1359/UFMS)	DD
		<i>Neoneura bilinearis</i> Selys, 1860 *	This study (CZYG 2091/UFMS, CZYG 2101/UFMS, CZYG 2099/UFMS)	LC
		<i>Neoneura ethela</i> Williamson, 1917	This study (CZYG 1815/UFMS, CZYG 1828/UFMS, CZYG 1397/UFMS)	-
		<i>Neoneura rubriventris</i> Selys, 1860	This study (CZYG 8908/UFMS, CZYG 8907/UFMS, CZYG 8906/UFMS)	-
		<i>Neoneura sylvatica</i> Hagen in Selys, 1886	This study (05-R13-09/UFMS, 06-R15-31/UFMS, 13-R30-22/UFMS)	-
		<i>Oxyagrion chapadense</i> Costa, 1978	Reference (Dalzochio et al. 2011b)	-
		<i>Oxyagrion sulmatogrossense</i> Costa, Souza & Santos, 2000 *	This study (9-R27-3/UFMS)	-
		<i>Oxyagrion terminale</i> Selys, 1876 *	This study (CZYG 189/UFMS)	-
		<i>Peristicta aeneoviridis</i> Calvert, 1909	This study (CEUFMS 8925, CEUFMS 8926, CEUFMS 8924)	-
		<i>Peristicta muzoni</i> Pessacq & Costa, 2007	Reference (Dalzochio et al. 2011b)	-
		<i>Telebasis sanguinalis</i> Calvert, 1909	Reference (Souza 2003)	-
		<i>Telebasis willinki</i> Fraser, 1948	Reference (Dalzochio et al. 2011a)	LC
		<i>Tigriagrion aurantinigrum</i> Calvert, 1909 *	This study (13-R30-24/UFMS)	-
Lestidae		<i>Lestes forcifcula</i> Rambur, 1842	This study (CEUFMS 8903, CEUFMS 8902, CEUFMS 8901)	-
		<i>Lestes curvatus</i> Belle, 1997	Reference (Souza 2003)	LC

Results

1. Species list

Sampling projects data recorded 67 species, belonging to 42 genera in six families, totaling 1902 collected specimens. The estimators showed that this richness corresponds to 79.99, 76.35 and 69.99% of the medium estimated richness by, respectively, Chao 2 (Sest = 83.76, standard deviation. = ±9.59), Jackknife 1 (Sest = 87.75, standard deviation = ±4.85) and Jackknife 2 (Sest = 95.72). The accumulation curves obtained are non-asymptotic (Figure 2), thus indicating that total species richness would probably increase with additional sampling effort.

The Odonata list records from the Bodoquena Plateau are presented in Table 1. We added another forty-four species that were registered in the literature (34 species) or deposited in the Reference Collection of the Federal University of Mato Grosso do Sul (10 species). Thus, we have considered the presence of 111 Odonata species. We recorded for the first time the presence of 42 species from Bodoquena Plateau (24 anisopterans and 18 zygopterans). In this inventory list, 35 species are registered in IUCN red List (IUCN 2016), with four being in Data Deficient (DD), 29 in Least Concern (LC) and two species are in threatened categories, *Elga newtonsantosi* Machado, 1992 like Critically Endangered (CR)

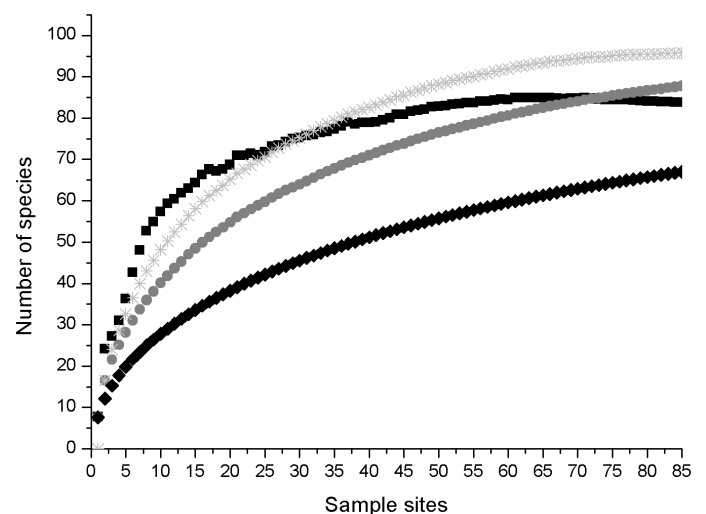


Figure 2. Accumulation curves for observed and estimated number of species collected at 85 sample points. The estimates were calculated with the estimator Chao 2, Jackknife 1 and Jackknife 2. Black diamonds = number of species observed (est); Black squares = Chao 2 richness estimator; Grey circles = Jackknife 1 richness estimator; Grey stars = Jackknife 2 richness estimator. All curves are plotted from the means of 1000 randomizations of sample accumulation order.

and *Micrathyria pseudhypodidyma* Costa, Lourenço & Viera, 2002 like Vulnerable (VU).

The families with the higher number of species were Libellulidae (45.05%), Coenagrionidae (38.74%) and Gomphidae (10.81%) (Table 2). The most speciose genus were *Argia*, *Micrathyria* and *Erythrodiplax*, represented by twelve, ten and nine species, respectively. The endangered species classified in the IUCN Red List, *Elga newtonsantosi* and *Micrathyria pseudhypodidyma*, were registered only in two and one sampled sites, respectively.

2. New record

We found that *Phyllogomphoides suspectus* Belle, 1994 represents a new records of odonate species for Mato Grosso do Sul state, compared with the list published by Rodrigues & Roque (2017). The genus *Phyllogomphoides* Belle, 1970, is composed of 45 species in the Neotropical Region, 29 of these in South America (Belle 1994). *Phyllogomphoides suspectus* Belle, 1994 has a distribution recorded by Belle (1994) and von Ellenrieder (2009a) and is considered exclusive to Brazil. The species distribution ranges from Rondonia to the Mato Grosso with specimens found in Rio Ouro Preto and Sinop, respectively (Belle 1994), around 800 km northwards of our sampling site.

We collected one male adult of *Phyllogomphoides* in the rural area of Bonito, Mato Grosso do Sul state, Brazil. This specimen was identified as *P. suspectus* (Figure 3a), according to the characteristics indicated by Belle (1994) and Heckman (2008), like spines along ventral tergal margins of abdominal segment 7 small and largely black (Figure 3b), the cerci, in

dorsal view, with forcipate shape (Figure 3c) and with a hatchet-shaped inferior protuberance near the base (Figure 3d) and anterior genital hamules without a posterior black hook (Figure 3e).

Discussion

Inventories promote skeletal support in many fields, including biogeography, population and community ecology. Such data establish a baseline of biodiversity and ecological information, which allow their application in conservation strategies. The list of species shown here represents 55.77% of all species recorded for Mato Grosso do Sul (199 species) (Rodrigues & Roque 2017, Rodrigues et al. 2016a), and is a significant advance in comparison with previous accounts (Souza 2013, Dalzochio et al. 2011a, Dalzochio et al. 2011b), increasing by 42 odonate species list of Bodoquena Plateau region.

Considering that insect inventories, especially those of very species-rich taxa in tropical region, are often incomplete (Gotelli & Colwell 2001), our results show that accumulation curves have not tended to stabilize. The reference source emphasize this result, because there are 44 species registered by Souza (2003) and Dalzochio et al. (2011a, 2011b) and not sampled by the projects. Other reasons for the high number of non-sampled species are the large territory of the Bodoquena Plateau and many of these species had been collected in the southern part, region not sampled by the projects. Furthermore, the projects sample sites, like the other previous studies (Souza 2003, Dalzochio et al. 2011a, Dalzochio et al. 2011b), focused on lotic system rather lentic ones, such as lakes and reservoirs. Thus, future inventories in lentic environments and with other sampling methods (e.g. visual record, Malaise trap, light trap) may still increase the species records for Bodoquena Plateau, highlighting the importance of this region, which lies into two highly threatened biomes.

Our new records extend the register of distribution to many species, information considered critical for the definition of their threatened status (IUCN 2016). When considering the IUCN red list, the Odonata species of the Neotropical region have a high number of species listed as Data Deficient (Clausnitzer et al. 2009) or without status definition. In this study, 2/3 of the species do not have classification, which reinforces this information gap related to conservation for the group. Regarding the species classified as threatened, *Elga newtonsantosi* and *Micrathyria pseudhypodidyma* have limited information available about their distribution (number of locations), population size, and ability to survive in reduced habitat (von Ellenrieder

Table 2. Number of Odonata species collected per family in the Bodoquena Plateau.

SUBORDER FAMILY	Number	%
ANISOPTERA		
Aeshnidae	2	1.80
Gomphidae	12	10.81
Libellulidae	50	45.05
ZYGOPTERA		
Calopterygidae	2	1.80
Coenagrionidae	43	38.74
Lestidae	2	1.80
TOTAL	111	100

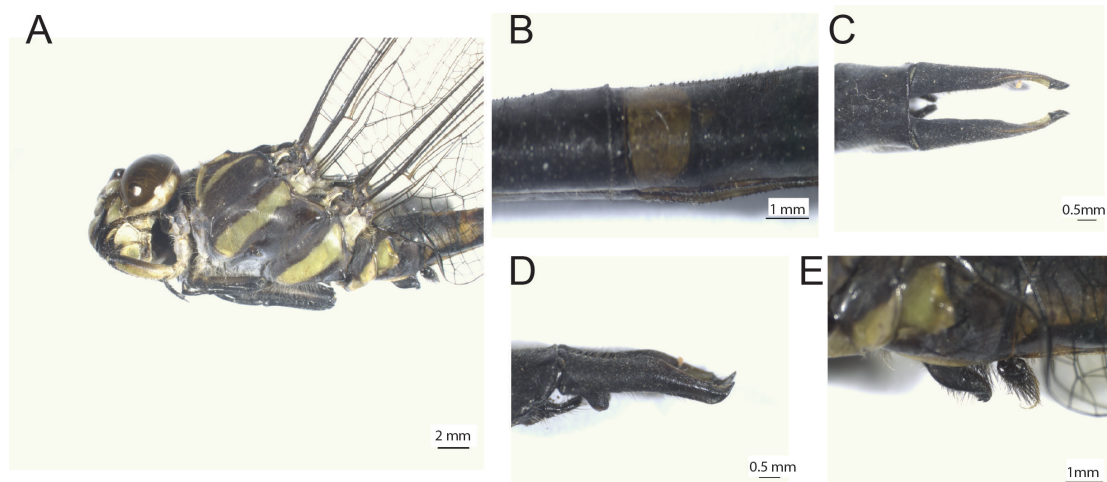


Figure 3. *Phyllogomphoides suspectus* (Belle, 1994): (A) adult male specimen; (B) lateral overview of abdomen (segment 7); (C) male caudal appendices: dorsal view; (D) male caudal appendices: lateral view; (E) male genital hamule: lateral view.

2009b, von Ellenrieder 2009c). From a conservation perspective, the knowledge about threatened species distributions is crucial for biodiversity management, especially for the development and implementation of conservancy plans. Thus, both of them shall be targets of governmental protection plan, as required in the Brazilian legislation on endangered species. In summary, this study highlighted the Bodoquena Plateau as an important habitat for odonates, including species classified as threatened.

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Authors' Contributions

KOROIVA, R., RODRIGUES, M., VALENTE-NETO: contribution to data collection.

KOROIVA, R., RODRIGUES, M., VALENTE-NETO, F. and ROQUE, F.O: contribution to data analysis and interpretation.

KOROIVA, R., RODRIGUES, M., VALENTE-NETO, F. and ROQUE, F.O: contribution to manuscript preparation.

KOROIVA, R., RODRIGUES, M., VALENTE-NETO, F. and ROQUE, F.O: contribution to critical revision, adding intellectual content.

Conflicts of interest

The authors declare that they have no conflict of interest related to the publication of this manuscript.

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