Ephemeroptera, Plecoptera e Trichoptera assemblages in Miranda River basin, Mato Grosso do Sul State, Brazil

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Abstract: The knowledge on the Ephemeroptera, Plecoptera and Trichoptera (EPT) assemblages in running waters of Mato Grosso do Sul State is still deficient. As a contribution to improve this situation, this study presents an inventory of immature EPT assemblages in Miranda River basin. The samples were collected between January and September 2006 from 4th to 7th orders river reaches. A total of 3069 larvae were collected, belonging to 49 genera and 17 families. The caddisflies presented the greatest abundance while the mayflies presented the greatest richness. Of the larvae collected, 22 genera of Ephemeroptera and 20 of Trichoptera are new occurrences for the State. The high genera richness observed in this study, with sites subjected to moderate to high human impacts, as well as the high genera richness indicated by non-parametric estimators and by the genera accumulation curve, indicate that the EPT richness of Miranda River basin is high. This result seems to be related to the environmental heterogeneity of the basin catchment (Cerrado and Pantanal biomes; carbonate, sedimentary and basaltic rocks). Additionally, these results should incentive future ecological and environmental integrity studies in the region, which are urgent in a landscape under fast anthropogenic impacts.
Keywords: *aquatic insects, inventory, taxonomic composition, Pantanal, Cerrado.*

RIGHI-CAVALLARO, K.O., SPIES, M.R. & SIEGLOCH, A.E. **Composição da fauna de Ephemeroptera, Plecoptera e Trichoptera na bacia do Rio Miranda, Estado do Mato Grosso do Sul, Brasil**. Biota Neotrop. 10(2): http://www.biotaneotropica.org.br/v10n2/pt/abstract?inventory+bn02210022010.

Resumo: As comunidades de Ephemeroptera, Plecoptera e Trichoptera (EPT) em ambientes lóticos no Estado do Mato Grosso do Sul são pouco conhecidas. Assim, este estudo teve o objetivo de inventariar a fauna de EPT na bacia do Rio Miranda. As amostras foram coletadas entre janeiro e setembro de 2006, em rios de 4ª a 7ª ordens. Foram coletadas 3069 larvas, pertencentes a 49 gêneros e 17 famílias. Trichoptera apresentou a maior abundância e Ephemeroptera a maior riqueza. Entre as larvas coletadas, 22 gêneros de Ephemeroptera e 20 de Trichoptera são registros novos para o estado. A alta riqueza encontrada nesse estudo, com sítios sujeitos a moderada a alta interferência antrópica, bem como a alta riqueza de gêneros indicada pelos estimadores não-paramétricos e pela curva de acumulação de gêneros, indicam que a riqueza de EPT da bacia do Rio Miranda é alta. Este resultado parece relacionado à heterogeneidade ambiental da área drenada pela bacia hidrográfica estudada (biomas Cerrado e Pantanal; rochas calcárias, sedimentares e basálticas). Além disso, estes resultados servem como incentivo para o desenvolvimento de trabalhos futuros sobre ecologia de insetos aquáticos e integridade ambiental na região estudada, os quais são urgentes em uma paisagem sob rápida degradação ambiental.
Palavras-chave: *insetos aquáticos, inventário, composição taxonômica, Pantanal, Cerrado.*

Introduction

Aquatic insects are important elements in the ecological dynamics and energy flow of lotic environments, presenting high abundances and wide diversity of trophic strategies and habitat occupied (Hynes 1970). Among the aquatic insects, Ephemeroptera, Plecoptera and Trichoptera (EPT) are considered an important taxonomic group at this environment, primarily due their wide distribution, high abundance and species richness and also by represents abundant resources in the food web of streams. These organisms are sensitive to environmental perturbations and usually live mainly in clean and well oxygenated waters (e.g. Lemly 1982, Buss et al. 2004, Bispo et al. 2006). Due to those characteristics, this fauna is commonly considered to be a good indicator of water quality (Rosenberg & Resh 1993). Moreover, this group represents the same ecological patterns of the whole macroinvertebrates community and, for this reason, ecological studies can be restricted to that assemblage (Marchant et al. 1995, Melo 2005).

In Brazil, in recent years, the number of ecological studies on lotic macroinvertebrates communities has increased considerably (e.g. Galdean et al. 2000, 2001, Melo & Froehlich 2001, Buss et al. 2002, Roque et al. 2003, Baptista et al. 2007, Costa & Melo 2008). Studies on distribution of immature aquatic insects (Diniz-Filho et al. 1997, Baptista et al. 1998, 2001) and on Ephemeroptera, Plecoptera and Trichoptera fauna are also becoming more frequent (e.g. Oliveira et al. 1997, Oliveira & Froehlich 1997, Bispo & Oliveira 1998, 2007, Bispo et al. 2001, 2006, Crisci-Bispo et al. 2007). The EPT assemblages are still ill-known in Mato Grosso do Sul State, especially as regards the ecological and biological aspects of those groups. Most published papers in this state have emphasized only taxonomical and geographic distribution aspects (e.g. Flint 1983, Salles et al. 2004, Froehlich 2007, Righi-Cavallaro et al. 2008). The information on aquatic macroinvertebrate communities in Mato Grosso do Sul State are also scarce (Takeda et al. 1991, Favero & Conte 2003, Tanaka et al. 2006), besides of the high ecological importance of this region, which includes the Pantanal and part of the Cerrado biomes.

The Pantanal is one of the largest continuous wetlands of the world, occupying a large portion of the floodplain of the upper Paraguay River basin. The mosaic of habitats resulting from the combination of different soil types and the seasonality of the hydrological regime of the flood-pulse, which regulate the ecological dynamics, are responsible for the extraordinary richness of aquatic and terrestrial biota found in this biome (Pott & Adámoli 1999, Medina-Junior & Rietzler 2005).

The Cerrado is the second largest biome in Brazil, one of the 25 hotspots of the world (i.e. characterized by a high concentration of endemic species) and had suffered great habitat loss (Myers et al. 2000). Furthermore, the Cerrado include the headwaters of main watershed of South America, such as of the headwaters of Parana and Paraguay basins (Pagotto et al. 2006).

The Pantanal and Cerrado biomes are suffering recently a great process of destruction and transformation of its landscape (i.e. natural habitat conversion into deforested agriculture landscape). Their biodiversity, however, is still very high and little known. Therefore, contributions to improve the poor knowledge of EPT assemblages in Mato Grosso do Sul State are extremely necessary. We inventoried immature EPT assemblages, at genus level, in the Miranda River basin. We also include comments on its taxonomic composition, new genera records for Mato Grosso do Sul State and the possible implications this poses for promoting conservation of the region.

Material and Methods

1. Study area

The study was carried out in the Miranda River basin, a subunit of the Upper Paraguay River basin, which includes part of the Pantanal wetlands. The Miranda River basin has an area of roughly 43,000 km^2 and comprises the Miranda River and the Aquidauana River sub-basins. Included in this area are 23 municipalities of Mato Grosso do Sul State (12% of the area of the state). The altitude in the region of Miranda River basin varies from 80 to 700 m. The climate is tropical, with marked wet (October-May) and dry (June-September) seasons. The annual rainfall ranges from 1,200 to 1,700 mm (Tanaka et al. 2006).

This basin includes the transition zone between physiographic regions of the Pantanal lowlands (periodically flooded) and the surrounding uplands (not flooded) (Pereira et al. 2004). In the upper Aquidauana River, the topology presents a series of levels and scarps with volcanic rocks, rarely found in the headwaters of the Miranda River (Pereira et al. 2004). Besides, in the latter sub-basin, the influence of the Pantanal lowlands is larger and there is dominance of Precambrian carbonate rocks (Pereira et al. 2004).

The original vegetation in the area close to the headwaters of the Miranda River basin was composed by savannas (cerrado) and forests (cerradão) included in the Cerrado biome. Currently, most of the vegetation is restricted to isolated fragments. The lower part of the Miranda River catchment is included in Pantanal biome, where flood-pulse dynamics constitute the primary factor regulating the ecology of these plains (Medina-Junior & Rietzler 2005).

The Pantanal lowlands were originally covered by grassland vegetation called "campo limpo", now largely replaced by pasturelands with exotic grass species (Pereira et al. 2004). Moreover, there are "caapões" and "cordilheiras", arboreous vegetation located in areas subjected to occasional or no flood (Pott, A. & Pott, V.J. 2004.), and monospecific forests (e.g., Babaçual, Macaubal, Guerobal, Palmeiral) (Ribeiro & Walter 1998).

The floodplain of the Miranda River basin is about 12,224 km^2 (Hamilton et al. 1996) and are subjected to strong influence of the flood pulse compared to highland areas in the plateau, most influenced by rains. The Pantanal of Miranda and Aquidauana Rivers are considered sub-regions of the Pantanal, comprising about 9% of the total area of this biome. The Miranda River sub-basin has approximately 22,000 km^2, which represents 42.6% of the Miranda River Basin, and includes 11 municipalities. This sub-region includes the susceptible region of limestones, which are being exploited by mining activities near the Bodoquena municipality and by ecotourism activities mainly in Bonito and Jardim municipalities (Pereira et al. 2004). The Aquidauana River sub-basin has approximately 21,000 km^2, which represents 47% of the total area of Miranda River basin, and includes 14 municipalities. Its main environmental problems are impacts of pig ranching and erosion in São Gabriel do Oeste municipality, which is located in the headwaters of the sub-basin. So, the environmental impacts are transported downstream and affect many regions of the sub-basin including the fishing ecotourism (Pereira et al. 2004).

2. Collection and identification

The present study was carried out in 20 sampling sites, which belongs to the region of the Miranda River basin (Figure 1). All sampling sites were near to cities, and presented moderate to high anthropogenic impacts. They showed marked differences in physic and chemical characteristics (Table 1). Width, depth, transparency, electric conductivity, turbidity, dissolved oxygen and alkalinity were

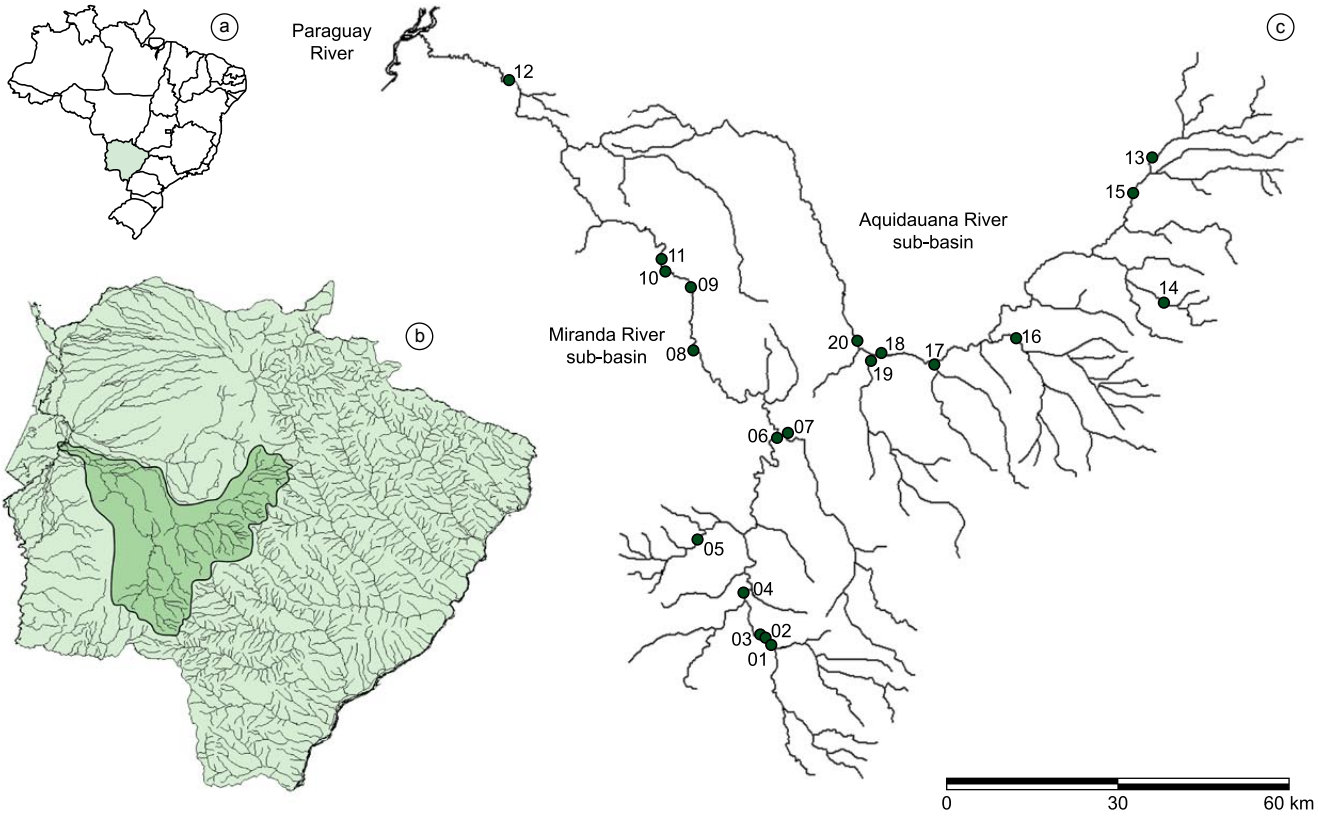

Figure 1. a) Map showing the localization of the sampled area inside Brazil; b) Mato Grosso do Sul State; and c) Localization of the sampling sites inside Miranda River basin.

Figura 1. a) Mapa mostrando a localização da área de estudo no Brasil; b) Estado do Mato Grosso do Sul; and c) Localização dos pontos amostrados na bacia do Rio Miranda.

Table 1. Environmental characterization of the sampling sites in the Miranda River basin, in Mato Grosso de Sul State, sampled between January and September 2006. Temp. = water temperature; O_2 = dissolved oxygen, pH = hydrogenionic potential; Cond. = electric conductivity; Trans. = transparency; Turb. = turbidity; Alka. = alkalinity; CS = coarse substrate; FS = fine substrate.

Tabela 1. Caracterização ambiental dos pontos amostrados na bacia do Rio Miranda, Mato Grosso do Sul, amostrados entre janeiro e setembro de 2006. Temp. = temperature da água; O_2 = oxigênio dissolvido, pH = potencial hidrogeniônico; Cond.= condutividade elétrica; Trans. = transparência; Turb. = turbidez; Alka. = alcalinidade; CS = porcentagem de substrato grosseiro; FS = porcentagem de substrato fino.

Points	Latitude	Longitude	Order	Temp. (°C)	O_2 (mg.L^{-1})	pH	Cond. (uS.cm^{-1})	Trans. (m)	Turb. (NTU)	Depth (m)	Width (m)	Alka. (mEq.L^{-1})	CS (%)	FS (%)
1	21° 28' 56" S	56° 07' 13" W	5	24.7	6.9	7.3	94.4	0.3	48.8	1.1	32.3	940.4	18.9	70.3
2	21° 28' 06" S	56° 07' 30" W	4	25.5	6.7	7.4	104.9	0.4	70.8	1.2	27.0	1085.5	4.1	35.4
3	21° 26' 56" S	56° 08' 48" W	5	25.6	7.0	7.5	102.5	0.4	49.2	1.1	36.3	1014.0	39.9	55.3
4	21° 17' 34" S	56° 13' 52" W	4	24.2	7.0	8.0	262.2	0.6	30.6	1.3	27.2	3177.4	96.2	2.9
5	21° 06' 50" S	56° 23' 02" W	4	23.7	8.0	8.0	338.9	2.7	7.0	4.0	23.5	3902.0	45.6	6.8
6	20° 45' 57" S	56° 04' 53" W	5	24.1	6.6	7.2	100.9	0.3	79.1	2.2	28.1	1031.9	33.5	59.7
7	20° 45' 55" S	56° 05' 24" W	6	24.8	7.3	7.7	171.2	0.4	92.5	2.5	55.8	1799.3	37.7	19.7
8	20° 29' 14" S	56° 23' 20" W	4	25.7	5.7	7.8	333.8	0.5	29.0	2.8	17.4	3887.6	65.4	2.0
9	20° 16' 21" S	56° 23' 26" W	6	26.3	5.8	7.6	175.7	0.2	86.2	3.1	55.0	3710.1	3.6	55.2
10	20° 13' 21" S	56° 29' 35" W	5	25.6	4.8	7.7	449.5	2.6	2.8	3.1	38.4	5427.6	56.3	4.6
11	20° 11' 15" S	56° 30' 19" W	6	26.3	5.4	7.7	220.6	0.3	67.9	5.7	67.6	2398.9	3.7	34.3
12	19° 34' 38" S	57° 01' 05" W	7	26.8	4.6	7.3	143.6	0.5	45.4	3.3	101.0	1335.4	0.3	69.2
13	19° 50' 17" S	54° 49' 43" W	5	23.9	7.8	6.7	44.0	0.3	97.9	1.3	30.9	434.6	0.2	88.5
14	20° 18' 27" S	54° 46' 59" W	4	23.9	7.7	7.5	113.8	0.3	31.6	0.6	10.1	1173.7	86.8	5.3
15	19° 57' 30" S	54° 53' 39" W	5	24.7	8.0	7.0	49.5	0.3	77.5	1.7	33.8	413.5	1.3	95.9
16	20° 26' 30" S	55° 17' 20" W	6	24.6	7.5	7.2	97.4	0.4	58.7	1.8	27.9	1087.1	40.0	55.7
17	20° 31' 54" S	55° 34' 37" W	5	25.6	7.5	7.2	88.9	0.5	100.7	1.8	25.5	811.3	18.3	63.7
18	20° 29' 37" S	55° 46' 42" W	7	25.0	7.4	7.0	65.9	0.3	106.5	2.5	65.4	987.0	7.2	59.3
19	20° 29' 51" S	55° 46' 56" W	5	25.0	6.8	6.9	76.5	0.5	54.9	4.3	33.6	679.6	86.4	6.5
20	20° 27' 35" S	55° 49' 51" W	7	25.3	7.4	7.1	66.2	0.2	106.5	2.4	70.6	589.9	4.4	57.5

the most pronounced. Their width ranged from 10.1 to 101.0 m, depth from 0.6 to 5.7 m, transparency from 0.2 to 2.7 m, electric conductivity from 44.0 to 449.5 μS.cm^{-1}, dissolved oxygen from 4.6 to 8.0 mg.L^{-1}, turbidity 2.8 to 106.5 NTU and alkalinity 413.5 to 5427.6 mEq.L^{-1}. The water temperature and pH values were similar among the sampling sites. The granulometric percentage of coarse substrate ranged from 0.2 to 96.2% while fine substrate ranged from 2.0 to 95.9%. The hydrological order followed Strahler's (1957) classification, and was based in 1:100,000 maps. The sampling sites were of orders 4 to 7 (Table 1).

The EPT assemblages were collected using four distinct sampling methods. A Surber sampler (0.0250 m^2 and 0.250 mm mesh) was used to sample riffles and an Ekman grab sampler (0.026 m^2) was used in pools. At each point, three sampling units were taken in each mesohabitat (riffle and pool) in January and September 2006. Additionally, four sampling units of artificial substrates, prepared with plastic screen bags (25 × 15 × 6 cm), filled with expanded clay balls and some ballast stones, were placed in each sampling site in four dates (February, April, June and August 2006) and remained for colonization during 60 d each. A D-frame net (0.250 mm mesh) was used to sample qualitatively in litter, roots and aquatic macrophytes. The two last sampling methods were used only when the condition of sites allowed the use these methods.

The samples were fixed with 10% formaldehyde. In the laboratory, the material was sorted out under a stereomicroscope and the organisms preserved in 80% ethanol. EPT larvae were identified to genus level using the taxonomic identification keys of Domínguez et al. (2006) for Ephemeroptera, Froehlich (1984) for Plecoptera and Angrisano & Korob (2001), Pes et al. (2005) and Wiggins (1996) for Trichoptera.

3. Data analysis

The efficiency of the sampling effort was evaluated by a genera accumulation curve obtained by averaging 1000 curves generated with random addition of samples without replacement (Colwell & Codington 1994). Besides, the total richness of Miranda River basin was estimated by the qualitative non-parametric estimators Bootstrap, Chao 2 and Jackknife 1 and 2 (Santos 2003). These analyses were performed in EstimateS 8 software (Colwell 2006).

Results

A total of 3069 larvae were collected, belonging to 49 genera and 17 families of EPT (Table 2). The order Trichoptera presented the highest abundance while the order Ephemeroptera presented the highest genera richness (Figure 2). The most abundant genera of EPT were: *Smicridea* (Trichoptera), accounting for 43% of specimens sampled, *Traverhyphes*, *Americabaetis* and *Farrodes* (Ephemeroptera), representing 12, 6 and 4%, respectively. Thus, these four genera comprised 65% of the total abundance recorded in Miranda River basin.

The genera accumulation curve of EPT shows an ascendant shape with large standard deviation, demonstrating that the asymptote was not reached (Figure 3). It indicates that an increase in the number of genera is expected with more sampling effort. The qualitative richness estimators employed support this result (Figure 3), since the estimated richness range from 52.8 (Chao 2) to 58.8 genera (Jackknife 2).

The four sampling methods used in this study were complementary because all methods sampled exclusive genera (Table 2). Five genera were uniquely sampled by artificial substrate, while Surber and D-frame net included four exclusive genera each. One genus was recorded exclusively by Ekman grab sampler (Table 2). The Ekman grab sampler showed lower capture efficiency than other sampling methods, totaling 18 genera. D-frame net, artificial substrate and Surber sampler sampled a total of 29, 28 and 26 EPT genera, respectively (Table 2).

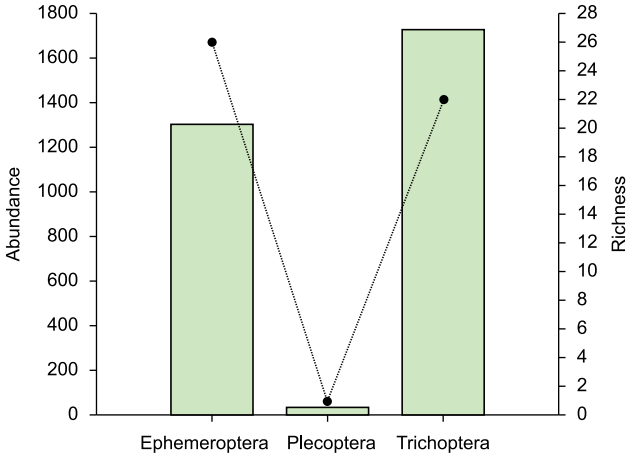

Figure 2. Abundance and richness of the Ephemeroptera, Plecoptera and Trichoptera assemblages in the Miranda River basin in Mato Grosso de Sul State, sampled between January and September 2006.

Figura 2. Abundância e Riqueza das comunidades de Ephemeroptera, Plecoptera e Trichoptera na bacia do Rio Miranda, Mato Grosso de Sul, amostradas entre janeiro e setembro de 2006.

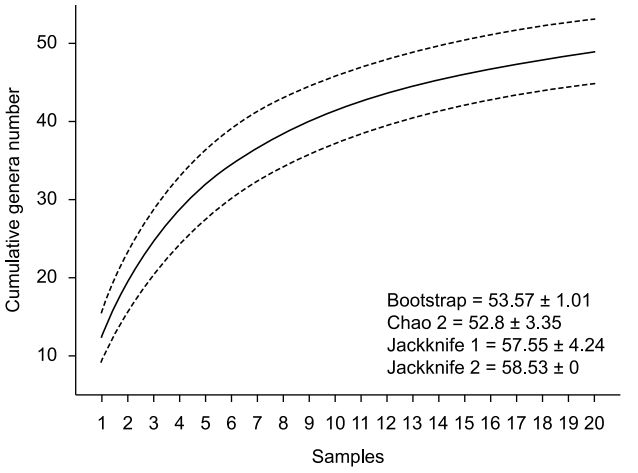

Figure 3. Genera accumulation curve and richness estimators of Ephemeroptera, Plecoptera and Trichoptera assemblages of Miranda River basin, Mato Grosso do Sul State, sampled between January and Setember 2006.

Figura 3. Curva de acumulação de gêneros suavizada e estimadores de riqueza das comunidades de Ephemeroptera, Plecoptera e Trichoptera da bacia do Rio Miranda, Estado do Mato Grosso do Sul, amostradas entre janeiro e setembro de 2006.

Discussion

In Brazil, 66 genera of Trichoptera (Spies & Froehlich 2009) and 68 genera of Ephemeroptera (Salles 2010) are known, whereas Plecoptera has only eight genera (Froehlich 1969, 1984, Olifiers et al. 2004). Until now, the EPT fauna known for Mato Grosso do Sul State was very poor and included five genera of

Table 2. Taxonomic composition, by sampling method, of the Ephemeroptera, Plecoptera and Trichoptera assemblages in the Miranda River basin, in Mato Grosso de Sul State, sampled between January and September 2006.

Tabela 2. Composição taxonômica por método de coleta, das comunidades de Ephemeroptera, Plecoptera e Trichoptera na bacia do Rio Miranda, Mato Grosso de Sul, amostradas entre janeiro e setembro de 2006.

Order/Family	Genera	Sampling methods			
		Surber	Ekman grab	Artificial substrate	D-frame net
Ephemeroptera					
Baetidae	*Americabaetis* Kluge, 1992	X	-	X	X
	Apobaetis Day, 1955	-	X	-	X
	Baetodes Needham & Murphy, 1924	X	-	-	-
	Callibaetis Eaton, 1881	X	-	-	-
	Camelobaetidius Demoulin, 1966	X	-	-	X
	Cloeodes Traver, 1938	X	X	-	X
	Guajirolus Flowers, 1985	X	-	-	X
	Paracloeodes Day, 1955	-	-	-	X
Caenidae	*Caenis* Stephens, 1835	X	X	X	X
	Cercobrachys Soldán, 1986	-	X	-	X
Ephemeridae	*Hexagenia* Walsh, 1863	-	X	-	X
Leptohyphidae	*Leptohyphes* Eaton, 1882	-	-	--	X
	Traverhyphes Molineri, 2001	X	X	X	X
	Tricorythodes Ulmer, 1920	X	X	X	X
	Tricorythopsis Traver, 1958	X	-	X	-
Leptophlebiidae	*Farrodes* Peters, 1971	-	X	X	X
	Hydrosmilodon Flowers & Domínguez, 1991	X-	-	X	X
	Aff. *Miroculis* Edmunds, 1963	X	X	X	-
	Needhamella Domínguez & Flowers, 1989	X	-	-	-
	Segesta Siegloch & Polegatto, 2006	-	-	-	-
	Thraulodes Ulmer, 1920	X	X	X	X
	Traverella Edmunds, 1948	X	-	X	X
	Ulmeritoides Traver, 1959	-	-	X	X
Oligoneuriidae	*Lachlania* Hagen, 1868	X	-	-	X
Polymitarcyidae	*Campsurus* Eaton, 1868	X	X	-	-
	Tortopus Needham & Murphy, 1924	-	X	-	-
Plecoptera					
Perlidae	*Anacroneuria* Klapálek, 1909	X	-	X	X
Trichoptera					
Calamoceratidae	*Phylloicus* Müller, 1880	-	-	X	X
Ecnomidae	*Austrotinodes* Schmid, 1955	-	-	X	-
Glossosomatidae	*Itauara* Müller, 1888	-	-	-	-
	Protoptila Banks, 1904	X	-	-	-
	Mortoniella Ulmer, 1906	-	-	-	X
Helicopsychidae	*Helichopsyche* Siebold, 1856	-	X	X	X
Hydropsychidae	*Blepharopus* Kolenati, 1859	X	-	X	-
	Leptonema Guérin, 1843	X	X	X	X
	Macromema Pictet, 1836	X	-	X	-
	Smicridea McLachlan, 1871	X	-	X	X
Hydroptilidae	*Abtrichia* Mosely, 1939	X	-	-	X
	Hydroptila Dalman, 1819	-	-	X	-
	Neotrichia Morton, 1905	-	-	X	-
	Oxyethira Eaton, 1873	-	X	-	X
Leptoceridae	*Nectopsyche* Müller, 1879	-	X	X	X
	Oecetis McLachlan, 1877	-	-	X	-
	Triplectides Kolenati, 1859	-	-	X	-
	Genus 1	-	-	-	X
Philopotamidae	*Chimarra* Stephens, 1829	X	-	X	X
Polycentropodidae	*Cernotina* Ross, 1938	X	-	X	-
	Cyrnellus Banks, 1913	-	X	X	-
	Polyplectropus Ulmer, 1905	-	X	X	-
Total		26	18	28	29

Ephemeroptera – *Brasilocaenis*, *Callibaetis*, *Campsurus*, *Segesta*, and *Tortopus* (Salles et al. 2004, Domínguez et al. 2006, Righi-Cavallaro et al. 2008), one genus of Plecoptera – *Anacroneuria* (Froehlich 2007), and four genera of Trichoptera – *Leptonema*, *Marilia*, *Oxyethira*, and *Polycentropus* (Paprocki et al. 2004, Souza-Franco et al. 2009). The present study increase considerable the knowledge of EPT fauna at the Mato Grosso do Sul State, through the additional records of 22 genera of Ephemeroptera and 20 genera of Trichoptera. Thus, EPT fauna at the Mato Grosso do Sul State currently account 27 mayfly genera, one stonefly genus, and 22 caddisfly genera.

Anacroneuria was the only genus of Plecoptera registered in the area. This genus is highly diversified, with 65 described species in Brazil (Froehlich 2002). It is the single genus of perlid stoneflies to have invaded the waters of the tropic lowlands and so colonized flowing water throughout the tropics and subtropics of Central and South America (Illies 1964, 1966).

The genera richness found in the present study was considerably high. Bispo et al. (2006) recorded 40 genera of EPT in streams of orders 1 to 4 in Cerrado biome (Pirenópolis, Goiás State). Crisci-Bispo et al. (2007) recorded 38 genera of EPT in a study of streams of orders 2 and 3 in the Atlantic Forest (Parque Estadual Intervales, São Paulo State). Also in Atlantic Forest, Silveira et al. (2006) found 40 genera of EPT in streams of orders 1 to 5 in Macaé River, Rio de Janeiro State. In the central region of Rio Grande do Sul, in regions of Deciduous Seasonal Forest (middle section of the Jacuí River and tributaries), previous studies recorded 44 genera of Ephemeroptera and Trichoptera in streams of orders 3, 4 and 7 in (Spies et al. 2006, Siegloch et al. 2008). However, these studies used only Surber sampler, whereas the present study used other complementary sampling methods. Additionally, those studied covered areas smaller than that of this study.

The high richness of EPT found in the studied area, 49 genera, is at least in part due to the use of distinct sampling methods, which permitted to explore different mesohabitats and so to sample a more diverse fauna of EPT (Domínguez & Fernández 2009). For instance, all four collection methods included exclusive genera and corroborated results from previous inventory studies (e.g. Spies & Froehlich 2009). Additionally, given the well known positive association between species richness and area (Magurran 2004), the large area covered by sampling design in this study also contributes for the high richness recorded.

The Miranda River basin presents 34.5% of the EPT genera known for Brazil. On the other hand, the accumulation curve and the richness estimators indicated that an increase in the number of genera is expected with further sampling, despite the use of a diverse array of sampling methods in this study. The collector curve method is a good way to evaluate how close is observed richness to the total richness of the area (Santos 2003). However, due to high proportions of rare species, species accumulation curves rarely reach an asymptote in tropical regions (Santos 2003).

The most diversified families of mayfly and caddisfly in the Miranda River basin are also the families that present the highest diversity of genera in Brazil. The Ephemeroptera families Leptophlebiidae and Baetidae include 23 and 21 genera, respectively (Salles 2010). The Trichoptera family Hydroptilidae includes 21 genera, while Hydropsychidae and Leptoceridae include nine genera each (Paprocki et al. 2004, Holzenthal & Pes 2004). Thus, diversity of mayfly and caddisfly genera found in the Miranda River basin reflects the genera diversity patterns of these families in Brazil.

The high abundance recorded for the genera *Americabaetis, Farrodes* and *Traverhyphes* (Ephemeroptera) and *Smicridea* (Trichoptera), at least in part, could be related to the high species number included in these genera and by the wide range of habitats occupied. For instance, *Smicridea* is very diverse and generally abundant in Brazil (Flint et al. 1999). It is the caddisfly genus with the highest number of species reported for the country (Paprocki et al. 2004). *Americabaetis* (Baetidae) and *Farrodes* (Leptophlebiidae) occur widely in a variety of habitats and have high species richness in South America (Domínguez et al. 2006). Only the genus *Traverhyphes* shows a restricted distribution, since they are found mainly in riffle zones of rocky bottomed streams (Domínguez et al. 2006).

This paper comprises the first contribution to the knowledge of the taxonomic composition and richness of the EPT assemblages in Mato Grosso do Sul State. The high genera richness recorded in sites of the Miranda River basin sampled in this study (with moderate to high human impact), as well as the high genera richness indicated by non-parametric estimators and the ascendant shape of the genera accumulation curve, indicate that the richness of this basin is high. This result seems to be related to the environmental heterogeneity of the Miranda River basin catchment, which includes portions of Cerrado and Pantanal biomes and areas with carbonate, sedimentary and basaltic rocks. Additionally, these results should motivate future ecological and environmental integrity studies in the region, which are urgent in a landscape under fast anthropogenic impacts.

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References

ANGRISANO, E.B. & KOROB, P.G. 2001. Trichoptera. In Guía para determinación de los artrópodos bentónicos sudamericanos. (H.R. Fernández & E. Domínguez, eds. Universidad Nacional de Tucumán, San Miguel de Tucumán, p.55-92.

BAPTISTA, D.F., BUSS, D.F., EGLER, M., GIOVANELLI, A., SILVEIRA, M. & NESSIMIAN, J.L. 2007. A multimetric index based on benthic macroinvertebrates for evaluation of Atlantic Forest streams at Rio de Janeiro State, Brazil. Hydrobiologia 575:83-94.

BAPTISTA, D.F., DORVILLÉ, L.F.M., BUSS, D.F. & NESSIMIAN, J.L. 2001. Spatial and temporal organization of aquatic insects in the longitudinal gradient of a tropical river. Rev. Bras. Biol. 61(2):295-304.

BAPTISTA, D.F., DORVILLÉ, L.F.M., BUSS, D.F., NESSIMIAN, J.L. & SOARES, L.H.J. 1998. Distribuição de comunidades de insetos aquáticos no gradiente longitudinal de uma bacia fluvial do sudeste brasileiro. Oecologia Bras. Ecologia de insetos aquáticos 5(1):191-207.

BISPO, P.C. & OLIVEIRA, L.G. 1998. Distribuição espacial de insetos aquáticos (Ephemeroptera, Plecoptera e Trichoptera) em córregos de cerrado do Parque Ecológico de Goiânia, Estado de Goiás. Oecologia Bras. Ecologia de insetos aquáticos 5(1):175-189.

BISPO, P.C. & OLIVEIRA, L.G. 2007. Diversity and structure of Ephemeroptera, Plecoptera, Trichoptera (Insecta) assemblages from riffles in mountain streams of Central Brazil. Rev. Bras. Zool. 24(2):283-293.

BISPO, P.C., OLIVEIRA, L.G., BINI, L.M. & SOUSA, K.G. 2006. Ephemeroptera, Plecoptera and Trichoptera assemblages from riffles in mountain streams of Central Brazil: environmental factors influencing the distribution and abundance of immatures. Braz. J. Biol. 66(2b):611-622.

BISPO, P.C., OLIVEIRA, L.G., CRISCI-BISPO, V.L., SILVA, M.M. 2001. A pluviosidade como fator de alteração da entomofauna bentônica

(Ephemeroptera, Plecoptera e Trichoptera) em córregos do Planalto Central do Brasil. Acta Limnol. Brasil. 13(2):1-9.

BUSS, D.F., BAPTISTA, D.F., NESSIMIAN, J.L. & EGLER, M. 2004. Substrate specifity, environmental degradation and disturbance structuring macroinvertebrate assemblages in neotropical streams. Hydrobilogia 518:179-188.

BUSS, D.F., BAPTISTA, D.F., SILVEIRA, M.P., NESSIMIAN, J.L. & DORVILLÉ, L.F.M. 2002. Influence of water chemistry and environmental degradation on macroinvertebrate assemblages in a River Basin in south-east Brazil. Hydrobiologia 481:125-136.

COLWELL, R.W. & CODDINGTON, J.A. 1994. Estimating terrestrial biodiversity through extrapolation. Phil Trans. R. Soc. 345:101-118.

COLWELL, R.W. 2006. Estimates: statistical estimation of species richness and shared species from samples. Version 8. http://purl.oclc.org/estimates (último acesso em: 09/03/2009).

COSTA, S.S. & MELO, A.S. 2008. Beta diversity in stream macroinvertebrate assemblages: among-site and among-microhabitat components. Hydrobiologia 598:131-138.

CRISCI-BISPO, V.L., BISPO, P.C. & FROEHLICH, C.G. 2007. Ephemeroptera, Plecoptera and Trichoptera assemblages in two Atlantic Forest streams, Southeastern Brazil. Rev. Bras. Zool. 24(2):312-318.

DINIZ-FILHO, J.A.F., OLIVEIRA, L.G. & SILVA, M.M. 1997. Explaining the βdiversity of aquatic insects in "cerrado" streams from central Brazil using multiple Mantel test. Rev. Bras. Biol. 58(2):223-231.

DOMÍNGUEZ, E. & FERNÁNDEZ, H.R. 2009. Macroinvertebrados bentônicos sudamericanos: sistemática y biologia. Fundación Miguel Lillo, San Miguel de Tucumán.

DOMÍNGUEZ, E., MOLINERI, C., PESCADOR, M., HUBBARD, M. & NIETO, C. 2006. Aquatic Biodiversity in Latin America: Ephemeroptera of South America. Ed. Pensoft, Sofia.

FAVERO, S. & CONTE, C.O. 2003. Entomofauna aquática associada à macrófitas em uma baia do pantanal do rio Negro, Mato Grosso do Sul. Ens. Cienc. 7:481-487.

FLINT Jr., O.S. 1983. Studies of Neotropical caddisflies, XXXIII: new species from austral South America (Trichoptera). Smithsonian Contr. Zool. 377:1-100.

FLINT Jr., O.S. HOLZENTHAL, R.W. & HARRIS, S.C. 1999. Catalog of the Neotropical Caddisflies (Insecta: Trichoptera). Columbus, Ohio Biological Survey.

FROEHLICH, C.G. 1969. Studies on brazilian plecoptera 1. Some gripopterygidae from the biological station at Paranapiacaba, State of São Paulo. Beitr. Neotrop. Fauna 6(1):17-39.

FROEHLICH, C.G. 1984. Brazilian Plecoptera 4. Nymphs of perlid genera from south-eastern Brazil. Ann. Limnol. 20(1-2):43-48.

FROEHLICH, C.G. 2002. *Anacroneuria* mainly from southern Brazil and northeastern Argentina (Plecoptera: Perlidae). Proc. Biol. Soc. Wash. 115:75-107.

FROEHLICH, C.G. 2007. Three new species of *Anacroneuria* (Plecoptera: Perlidae) from the State of Mato Grosso do Sul, Brazil. Zootaxa 1461:15-24.

GALDEAN, N., CALLISTO, M. & BARBOSA, F.A.R. 2000. Lotic ecosystems of Serra do Cipó, southeast Brazil: Water quality and a tentative classification based on the benthic macroinvertebrate community. Aquatic Ecos. Health Manag. 3(4):545-552.

GALDEAN, N., CALLISTO, M. & BARBOSA, F.A.R. 2001. Biodiversity Assessment of Benthic Macroinvertebrates in Altitudinal Lotic Ecosystems of Serra do Cipó (MG, Brazil). Rev. Bras. Biol. 61(2):239-248.

HAMILTON, S.K., SIPPEL, S.K. & MELACK, J.M. 1996. Inundation patterns in the Pantanal wetland of South America determined from passive macrowave remote sensing. Archiv. fur Hydrobiologie 137:1-23.

HOLZENTHAL, R.W. & PES, A.M.O. 2004. A new genus of long-horned caddisfly from the Amazon basin (Trichoptera: Leptoceridae: Grumichellini). Zootaxa 621:1-16.

HYNES, H.B.N. 1970. The Ecology of Running Waters. Liverpool, University Press.

ILLIES, J. 1964. Südamerikanische Perliden (Plecoptera), besonders aus Chile und Argentinien. Beitr. Neotrop. Fauna 3(3):207-233.

ILLIES, J. 1966. Katalog der rezenten Plecoptera. Das Tierreich. Eine Zusammenstellung und Kennzeichnung der rezenten. Tierformen 82:1-632

LEMLY, A.D. 1982. Modification of benthic insect communities in polluted streams: combined effects of sedimentation and nutrient enrichment. Hydrobiologia 87:229-245.

MAGURRAN, A.E. 2004. Measuring biological diversity. Oxford, Blackwell Science Ltd.

MARCHANT, R., BARMUTA, L.A. & CHESSMAN, B.C. 1995. Inflence of sample quantification and taxonomic resolution on the ordination of macroinvertebrate communities from running waters in Victoria, Australia. Mar Freshwater Res. 46:501-506.

MEDINA-Jr., P.B. & RIETZLER, A.C. 2005. Limnological study of a Pantanal saline lake. Braz. J. Biol. 65(4):651-659.

MELO, A.S. & FROEHLICH, C.G. 2001. Macroinvertebrates in neotropical streams: richness patterns along a catchment and assemblage structure between 2 seasons. J. N. Am. Benth. 20(1):1-16.

MELO, A.S. 2005. Effects of taxonomic and numeric resolution on the ability to detect ecological patterns at local scale using stream macroinvertebrates. Archiv fur Hydrobiologie 164(3):309-323.

MYERS, N., MITTERMEIER, R.A., MITTERMEIER, C.G., FONSECA, G.A.B. & KENT, J. 2000. Biodiversity hotspots for conservation priorities. Nature 403:853-858.

OLIFIERS, M.H., DORVILLÉ, L.F.M., NESSIMIAN, J.L. & HAMADA, N. 2004. A key to Brazilian genera of Plecoptera (Insecta) based on nymphs. Zootaxa 651:1-15.

OLIVEIRA, L.G. & FROEHLICH, C.G. 1997. Diversity and community structure of aquatic insects (Ephemeroptera, Plecoptera and Trichoptera) in a mountain stream in Southeastern Brazil. Acta Limnol. Brasil. 9:139-148.

OLIVEIRA, L.G., BISPO, P.C. & SÁ, N.C. 1997. Ecologia de comunidades de insetos bentônicos (Ephemeroptera, Plecoptera e Trichoptera) em córregos do Parque Ecológico de Goiânia, Goiás, Brasil. Rev. Bras. Zool. 14(4):867-876.

PAGOTTO, T.C.S., CAMILOTTI, D.C., LONGO, J.M. & SOUZA, P.R. 2006. Bioma Cerrado. In Biodiversidade do Complexo Aporé-Sucuriú: subsídios à conservação e ao manejo do Cerrado: área prioritária 316-Jauru. (T.C.S. Pagotto & P.R. Souza). Ed. UFMS, Campo Grande, p.18-30.

PAPROCKI, H., HOLZENTHAL, R.W. & BLAHNIK, R.J. 2004. Checklist of the Trichoptera (Insecta) of Brazil I. Biota Neotrop. 4(1): http://www.biotaneotropica.org.br/v4n1/pt/download?inventory+N01204012004. (último acesso em: 09/03/2009).

PEREIRA, M.C.B., MENDES, C.A.B., DIAS, F.A., LANGE, M.B.R, BECKER, M., BARRETO, S.R. & GREHS, S.A. 2004. Bacia hidrográfica do rio Miranda: estado da arte.1 ed. UCDB, Campo Grande.

PES, A.M.O., HAMADA, N. & NESSIMIAN, J.L. 2005. Chaves de identificação de larvas para famílias e gêneros de Trichoptera (Insecta) da Amazônia Central, Brasil. Rev. Bras. Entomol. 49(2):181-204.

POTT, A. & ADÁMOLI, J. 1999. Unidades de vegetação do Pantanal dos Paiaguás. In Anais do II Simpósio sobre Recursos Naturais e Sócio-econômicos do Pantanal, Manejo e Conservação. EMBRAPA - CPAP, Brasília, DF, p.183-202.

POTT, A. & POTT, V.J. 2004. Features and conservation of the Brazilian Pantanal wetland. Wetlands Ecology and Management 12:547-552.

RIBEIRO, J.F. & WALTER, B.M.T. 1998. Fitofisionomias do Bioma Cerrado. p.89-152. In Cerrado: ambiente e flora (S.M. Sano & S.P. Almeida, eds.). Embrapa – CPAC, Planaltina.

RIGHI-CAVALLARO, K.O.R., SIEGLOCH, A.E., CALHEIROS, D. & BARBOSA, D.S. 2008. *Segesta riograndensis*, Ephemeroptera, Leptophlebiidae, Atalophlebiinae: First record from state of Mato Grosso do Sul, western Brazil. Check List 4(4): http://www.checklist.org.br/getpdf?NGD316-08 (último acesso em: 15/03/2010)

ROQUE, F.O., TRIVINHO-STRIXINO, S., STRIXINO, G., AGOSTINHO, R.C. & FOGO, J.C. 2003. Benthic macroinvertebrates in streams of the Jaragua State Park (Southeast of Brazil) considering multiple spatial scales. J. Insect Cons. 7:63-72.

ROSENBERG, D.M. & RESH, V.H. 1993. Freshwater biomonitoring and benthic macroinvertebrates. 1 ed. Chapman and Hall, London.

SALLES, F.F. 2010. Lista de espécies de Ephemeroptera (Insecta) registradas para o Brasil. http://ephemeroptera.br.googlepages.com/home23 (último acesso em: 09/04/2009).

SALLES, F.F., DA-SILVA, E.R., SERRÃO, J.E., HUBBARD, M.D. & FRANCISCHETTI, C.N. 2004. As espécies de Ephemeroptera (Insecta) registradas para o Brasil. Biota Neotrop. 4(2): biotaneotropica.org.br/v4n2/pt/abstract?inventory+BM04004022004. (último acesso em: 09/04/2009).

SANTOS, A.J.dos. 2003. Estimativas de riqueza em espécies. In Métodos de Estudos em Biologia da Conservação e Manejo da Vida Silvestre (L. Cullen, R. Rudram, & C. Valladares-Padua, eds). Editora da UFPR, Curitiba, p.19-41

SIEGLOCH, A.E., FROEHLICH, C.F. & KOTZIAN, C.B. 2008. Composition and diversity of Ephemeroptera Haeckel, 1896 (Insecta) nymph communities in the middle section of the Jacuí River and some tributaries, State of Rio Grande do Sul, Brazil. Iheringia 98(4):425-432.

SILVEIRA, M.P., BUSS, D.F., NESSIMIAN, J.L. & BAPTISTA, D.F. 2006. Spatial and temporal distribution of benthic macroinvertebrates in a southeastern Brazilian river. Braz. J. Biol. 66(2B):623-632.

SOUZA-FRANCO, G.M., ANDRIAN, L.F. & FRANCO, R.M. 2009. Comunidade de insetos aquáticos associados à *Eichhornia azurea* (Schwartz) Kunth, em uma lagoa de várzea na planície de inundação do Alto Rio Paraná, Mato Grosso do Sul, MS, Brasil. Biológico 71(1):83-91.

SPIES, M.R. & FROEHLICH, C.G. 2009. Inventário de Trichoptera (Insecta) do Parque Estadual Campos do Jordão, São Paulo, Brasil. Biota Neotrop. 9(4): http://www.biotaneotropica.org.br/v9n4/pt/abstract?inventory+bn03509042009. (último acesso em: 09/04/2009).

SPIES, M.R., FROEHLICH, C.G. & KOTZIAN, C.B. 2006. Composition and diversity of Trichoptera Kirby 1813. (Insecta) larvae communities in Jacuí River middle section and some tributaries, Rio Grande do Sul state, Brazil. Iheringia (Zool.) 96:389-398.

STRAHLER, A.N. 1957. Quantitative analysis of watershed geomorphology. Trans. Am. Geophys. Union 38:913-920.

TAKEDA, A.M., BÜTTOW, N.C. & MELO, S.M. 1991. Zoobentos do canal Corutuba-MS (Alto Rio Paraná-Brasil). Rev. UNIMAR 13(2):353-364.

TANAKA, M.O., RIBAS, A.C.A. & SOUZA, A.L.T. 2006. Macroinvertebrate succession during leaf litter breakdown in a perennial karstic river in Western Brazil. Hydrobiologia 568:493-498.

WIGGINS, G.B. 1996. Larvae of the North American Caddisfly Genera (Trichoptera), 2 ed. University of Toronto Press, Toronto.

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