

Ephemeroptera nymphs from the Iguatemi River basin, upper Paraná River, Mato Grosso do Sul

Ninfas de Ephemeroptera da bacia do rio Iguatemi, alto rio Paraná, Mato Grosso do Sul

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ABSTRACT: This study presents a survey of Ephemeroptera genera from the Iguatemi River basin, upper Paraná River, State of Mato Grosso do Sul, Brazil. Samples were conducted in 23 sites, encompassing streams, lagoons, and main channel of the Iguatemi River. To better represent the nymphs, samples were collected from the water surface, aquatic vegetation, and sediment in different biotopes. The survey of mayfly fauna was based on composition, richness, and sampling efficiency, assessed through a species accumulation curve. A total of 1786 nymphs were collected distributed in 18 genera and five families, with one genus (*Oligoneuria*) recorded for the first time in state of Mato Grosso do Sul. *Aturbina* (Baetidae) and *Farrodes* (Leptophlebiidae) were the most representative genera in the Iguatemi River basin. The species accumulation curve indicated potential for additional genera to be recorded in the Iguatemi River basin.

Keywords: Aquatic environments; Composition; Insects; Richness.

RESUMO: Este trabalho apresenta um inventário dos gêneros de Ephemeroptera da bacia do rio Iguatemi, alto rio Paraná, Mato Grosso do Sul, Brasil. As amostragens foram realizadas em 23 locais, abrangendo riachos, lagoas e a calha principal do rio Iguatemi. Para melhor representatividade das ninfas, foram coletadas amostras do filme d'água, da vegetação aquática e do sedimento em diferentes biótopos. O levantamento da fauna de efemerópteros foi baseado nos atributos de composição e riqueza, e na eficiência do esforço amostral avaliada pela curva do coletor. Foram registradas 1786 ninfas, distribuídas em 18 gêneros e cinco famílias, sendo um gênero (*Oligoneuria*) representa um novo registro para o estado de Mato Grosso do Sul. *Aturbina* (Baetidae) e *Farrodes* (Leptophlebiidae) foram os gêneros mais representativos na bacia do rio Iguatemi. A curva de acumulação revelou potencial para novos registros de gêneros na bacia do rio Iguatemi.

Palavras-chave: Ambientes aquáticos; Composição; Insetos; Riqueza.

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1 INTRODUCTION

Insects of the order Ephemeroptera, popularly known as mayflies, are among the oldest groups of aquatic insects (Sartori; Brittain, 2015). Representatives of this order possess several primitive characteristics, such as the inability to fold their wings over the abdomen, a slight reduction in wing venation, and the presence of ten abdominal segments (Elouard; Gattolliat; Sartori, 2003).

Mayflies are amphibiotic insects that spend most of their life cycle as immature stages in freshwater (Cardoso *et al.*, 2023). The aquatic forms occur in a wide range of microhabitats including rocks, branches, leaves, sand, and sediments, and remain in this stage for periods ranging from a few weeks to more than two years (Bispo; Crisci-Bispo, 2006; Silva; Salles, 2017; Oliveira; Couceiro; Nascimento, 2023). In contrast, adults are strictly terrestrial, with vestigial mouthparts and a very short lifespan limited to the reproductive phase (Jacobus; Macadam; Sartori, 2019).

Ephemeroptera nymphs are among the most important groups of benthic macroinvertebrates. They are remarkably abundant and diverse, occupying a wide variety of microhabitats, from backwater areas to sites with strong currents (Silva; Salles, 2017; Marulanda-Lopez *et al.*, 2021; Oliveira; Couceiro; Nascimento, 2023). These insects inhabit a broad range of ecological niches and exhibit diverse feeding strategies. They also serve as prey for fish, amphibians, and invertebrates (Baptista *et al.*, 2006), thus forming a key link in the trophic networks of freshwater ecosystems (Flowers; De La Rosa, 2010; Jacobus; Macadam; Sartori, 2019; Cardoso *et al.*, 2023).

In addition to their ecological roles, mayfly nymphs provide a wide range of ecosystem services (Jacobus; Macadam; Sartori, 2019), including the fragmentation of wood and vegetation, bioturbation, bioirrigation, and nutrient cycling. These processes contribute to maintaining the natural balance of aquatic ecosystems (Jacobus; Macadam; Sartori, 2019; Cardoso *et al.*, 2023). Furthermore, mayfly nymphs are recognized as excellent bioindicators of ecosystem integrity, since several taxa are highly sensitive to local physical and chemical changes (Shimano; Juen, 2016; Faria *et al.*, 2017; Yalles-Satha *et al.*, 2022). For this reason, they are widely used in water-quality biomonitoring programs (Luiza-Andrade *et al.*, 2017; Espinosa *et al.*, 2020; Albanesi *et al.*, 2020; Schmitt *et al.*, 2020).

Knowledge about the distribution of Ephemeroptera in Brazil has increased in recent years (Lima; Salles; Pinheiro, 2015; Salles; Boldrini; Lima, 2024; Cardoso *et al.*, 2023; Oliveira; Couceiro; Nascimento, 2023; Faria *et al.*, 2023; Mungai; Silva; Salles, 2024). According to the Brazilian Fauna Taxonomic Catalog, 448 species mayflies are currently recorded in the country, distributed across 83 genera and 10 families (Salles; Boldrini; Lima, 2024). However, estimates indicate that more than 10,000 species remain undescribed in Brazil (Cardoso *et al.*, 2015).

For the state of Mato Grosso do Sul, the survey of genera/species of aquatic mayflies is scarce. Existing studies are limited to those by Melo *et al.* (2004, 2018) in the Baía and Ivinhema rivers, and by Silva; Salles (2017), who carried out a checklist based on papers published about the group in the state. However, studies on the distribution of aquatic macroinvertebrates frequently record the occurrence of Ephemeroptera genera, thereby contributing to expansion of knowledge about the richness and distribution of

the group in various aquatic environments in the state (Jorcin; Nogueira; Belmont, 2009; Souza-Franco; Andrian; Franco, 2009; Righi-Cavallaro *et al.*, 2010; Righi-Cavallaro; Spies; Siegloch, 2010; Petsch *et al.*, 2013; Romero *et al.*, 2013; Saulino; Trivinho-Strixinho, 2014; Clemente; Nakagaki; Lima-Júnior, 2019).

In the Iguatemi River basin, located in the southern portion of the state, information on the richness of Ephemeroptera remains scarce. Given the limited data and the recognized ecological relevance of this order, we present an inventory of Ephemeroptera genera from the Iguatemi River basin, within the upper Paraná River basin, thus contributing to a better understanding of local biodiversity.

2 MATERIALS AND METHODS

2.1 STUDY AREA

The Iguatemi River basin (Figure 1), covering an area of 9,595.82 km², is located in the extreme south of the state of Mato Grosso do Sul, Brazil. The Iguatemi River, the main watercourse of this basin, originates between the municipalities of Coronel Sapucaia and Amambaí, both in the state of Mato Grosso do Sul, and runs for approximately 235 km before flowing into the right bank of the upper Paraná River, between the municipalities of Mundo Novo, state of Mato Grosso do Sul, and Guaíra, state of Paraná (Paiva, 1982; Suárez; Petrere, 2006).

The area delimited for this study (23°13'24.1"S - 55°25'15.0"W and 23°55'24.66" - 54°9'24.10"W) comprises the Iguatemi River channel, several streams (Nhun-Verá, Cumprida, Cerro Verde, Douradão, Água Boa, and Guaçu) and oxbow lakes (Bugão and Braço Morto), distributed along the Iguatemi River basin. Among the environmental impacts in this basin, siltation is the most striking is the most prominent, resulting from the sandy soil susceptibility to erosion and the absence of soil conservation practices in its catchment area. Another relevant factor in this scenario is the current state of conservation of riparian vegetation, ranging from the presence of remaining forest fragments in stretches of the bank of the Iguatemi River and some of its tributaries to the complete replacement by pastures and crops (Mendonça *et al.*, 2014).

2.2 SAMPLING

Twenty-three sampling sites were established in the Iguatemi River basin as follows: i) seven sites were located in the Iguatemi River channel; ii) three in each of the streams Guaçu, Douradão, and Água Boa, comprising the upper, intermediate, and lower stretches (totaling nine sites); iii) one site in each of the streams Comprida, Nhu-Verá and Cerro-Verde; iv) three sites in Braço Morto and; v) one site in Lagoa das Cinco (Figure 1).

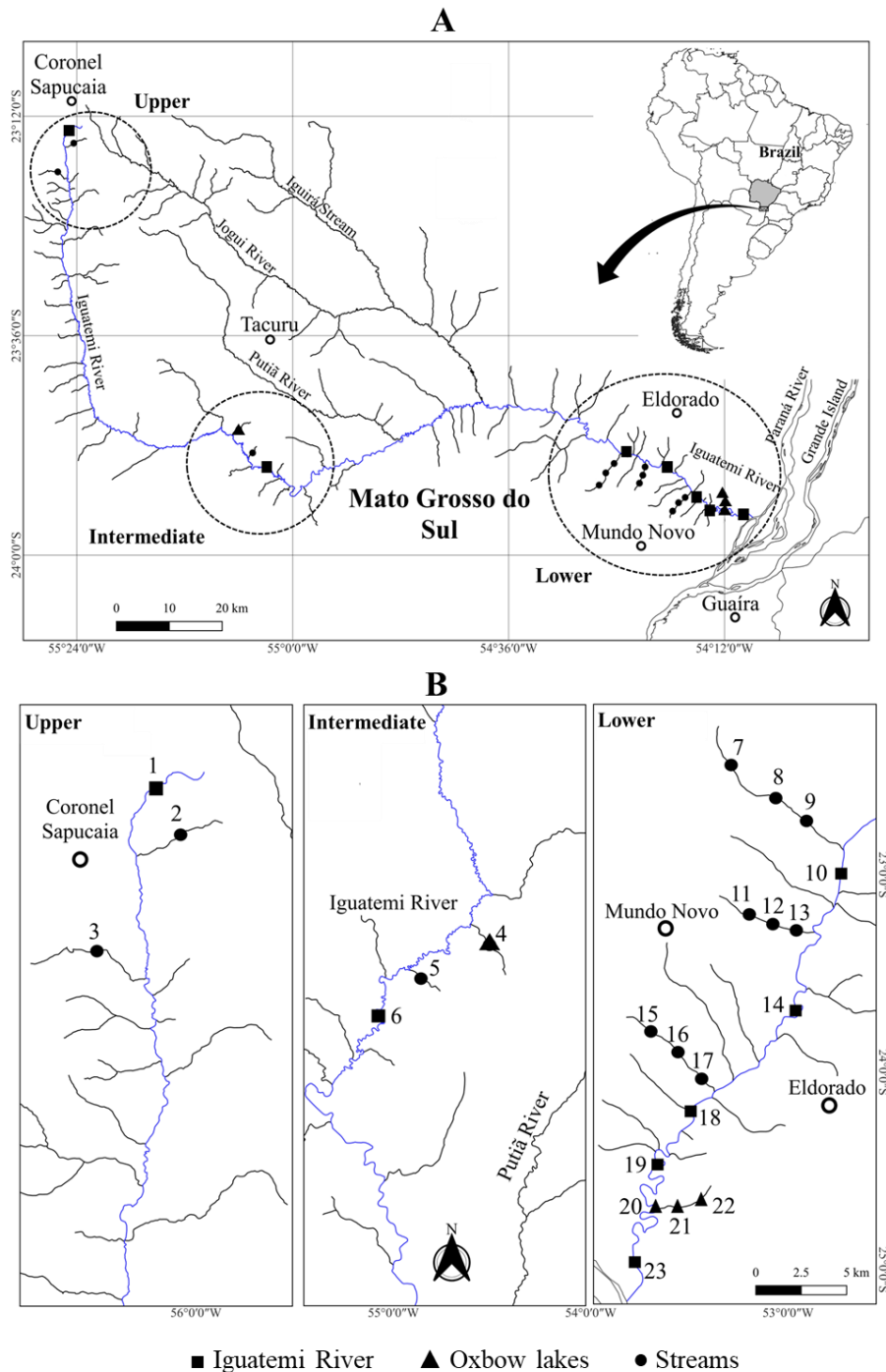


Figure 1. A) Location of the Iguatemi River basin in the context of South America and the state of Mato Grosso do Sul, Brazil, highlighting the 23 sampling sites. B) Upper, intermediate and lower sections of the basin showing the sampled sites. Blue line = Iguatemi River; Squares = samples from the Iguatemi River; circles = streams; triangles = oxbow lakes. Iguatemi River = 1, 6, 10, 14, 18, 19, 23; streams: Nhu-Verá = 2; Comprida = 3; Cerro Verde = 5; Douradão = 7, 8, 9; Água Boa = 11, 12, 13; Guaçu = 15, 16, 17; oxbow lakes: Bugão = 4; Braço Morto = 20, 21, 22

For a better representativeness of the Ephemeroptera fauna, samples were collected from the water surface, aquatic vegetation, and sediment. Water surface samples were obtained using a conical-cylindrical net (0.5 mm mesh). Organisms associated with aquatic vegetation were collected with a sieve (3.0 mm mesh), and those

from sediment with two samplers: a D-net (3.0 mm mesh) for epifauna and a Petersen-type grab sampler for infauna. For sampling optimization, we also included Ephemeroptera (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). A single pass of dip nets was used to collect nymphs in each stretch. At the end of each stretch it were 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, aquatic vegetation, sediment and those obtained by electrofishing were sorted using a transilluminated tray, stored in labeled vials and preserved in 70% alcohol. Immature individuals of Ephemeroptera were identified to the lowest possible taxonomic level, based on Bispo; Crisci-Bispo (2006); Domínguez *et al.* (2006), Mugnai; Nessimian; Baptista (2010). For the validation of genera and taxonomic position indication, the Ephemeroptera database of South America (<http://ephemeroptera.com.br/>) and the Catalogue of Life were utilized. Voucher genera 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 assemblage attributes assessed in this study were species composition and richness. The efficiency of the sampling effort was evaluated using a 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).

3 RESULTS AND DISCUSSION

In total, we collected 1,786 Ephemeroptera nymphs distributed in 18 genera and five families, represented by Caenidae, Baetidae, Leptohyphidae, Leptophlebiidae, and Oligoneuriidae (Table 1). The high representativeness of Ephemeroptera reinforces the importance of the Iguatemi River basin for the diversity of this group in Mato Grosso do Sul, since 43% of the genera known for the state occur in this basin (Melo *et al.*, 2004; Jorcin; Nogueira; Belmont, 2009; Righi-Cavalaro; Spies; Siegloch, 2010; Romero *et al.*, 2013; Saulino; Trivinho-Strixino, 2014; Melo *et al.*, 2018). Among the genera identified, *Oligoneuria* represents the first record for the state, demonstrating the basin's potential for the discovery of new taxa. Thus, additional surveys in other aquatic systems are essential to expand knowledge about the diversity and distribution of Ephemeroptera in the region.

The most representative families were Baetidae, with eight genera, followed by Leptohyphidae and Leptophlebiidae, with four genera each, which together comprised more than 80% of the genera recorded in the basin (Figure 2).

Table 1. List of the Ephemeroptera genera collected at each sampling site in the Iguatemi River basin. See Figure 1 for details of sampling sites

FAMILY GENERA	Sample sites																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
BAETIDAE																							
<i>Americabaetis</i> Kluge, 1992							+				+	+	+				+	+					
<i>Apobaetis</i> Day, 1955					+																		
<i>Aturbina</i> Lugo-Ortiz & McCafferty, 1996			+	+	+	+	+		+	+	+	+	+		+	+	+	+	+	+		+	+
<i>Callibaetis</i> Eaton, 1881				+															+				
<i>Chane</i> Nieto, 2003																						+	
<i>Cryptonympha</i> Lugo-Ortiz & McCafferty, 1998										+	+				+		+						
<i>Waltzoyphius</i> Lugo-Ortiz & McCafferty, 1995							+				+						+						
<i>Zelus</i> Lugo-Ortiz & McCafferty, 1998																	+						
CAENIDAE																							
<i>Caenis</i> Stephens, 1835											+					+	+	+				+	
LEPTOHYPHIDAE																							
<i>Leptohyphes</i> Eaton, 1882							+		+						+		+						
<i>Traverhyphes</i> Molineri, 2001																	+						
<i>Tricorythodes</i> Ulmer, 1920													+	+	+		+				+		
<i>Tricorythopsis</i> Traver, 1958							+	+	+								+						
LEPTOPHLEBIIDAE																							
<i>Farrodes</i> Peters, 1971							+	+	+		+	+	+			+	+		+		+		
<i>Miroculis</i> Edmunds, 1963															+								
<i>Ulmeritoides</i> Traver, 1959										+	+	+	+		+	+	+						
<i>Ulmeritus</i> Traver, 1956											+												
OLIGONEURIIDAE																							
<i>Oligoneuria</i> Pictet, 1843		+																					+

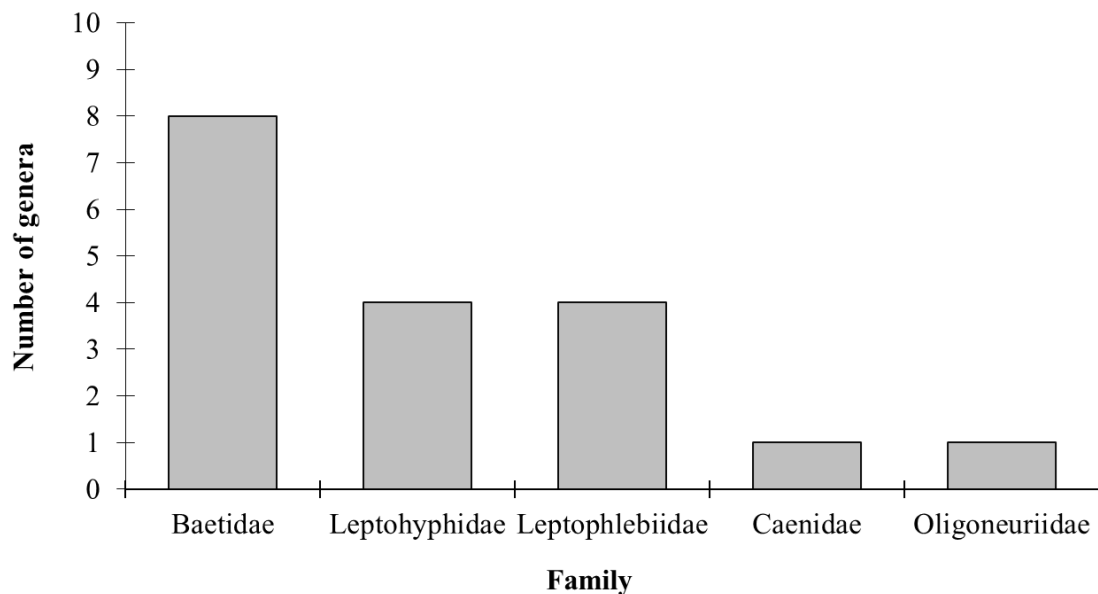


Figure 2. Number of genera recorded for each Ephemeroptera family in the Iguatemi River basin

Similar results have been observed in other regions of Brazil (Falcão; Salles; Hamada, 2011; Lima; Salles; Pinheiro, 2012; Cruz *et al.*, 2021; Lima, Kinpara; Menezes, 2023; Oliveira; Couceiro; Nascimento, 2023), indicating that the predominance of these families is a recurrent pattern in the Ephemeroptera fauna of the country. The nymphs of these families are known for their preference for running waters (Salles *et al.*, 2004; Da-Silva; Nessimian; Coelho, 2010; Belmont; Salles; Hamada, 2012), which is consistent with the predominance of lotic habitats among the sampling sites in the Iguatemi River basin.

Among the 18 genera of Ephemeroptera recorded in the Iguatemi River basin, *Aturbina* (Baetidae) and *Farrodes* (Leptophlebiidae) were the most widely distributed, occurring in 18 and 10 of the 23 sampled sites, respectively (Table 1). *Aturbina* is recognized as a gathering collector (Shimano; Cardoso; Juen, 2018), whereas *Farrodes* is characterized as a scraper and filtering collector (Polegatto; Froehlich, 2001). *Farrodes* is frequently found in a variety of habitats, including marginal vegetation, leaf litter, and rocky substrates, both in backwater and running-water areas (Siegloch; Froehlich; Kotzian, 2008; Shimano *et al.*, 2012; Salles *et al.*, 2016; Melo *et al.*, 2018). Similar patterns of occurrence for these families and genera have been observed in other Brazilian river basins, such as the Campo Belo River in Rio de Janeiro (Francischetti *et al.*, 2004) and the Miranda River basin in Mato Grosso do Sul (Righi-Cavallaro *et al.*, 2010), indicating consistent distributional patterns in lotic environments across Brazil.

On the other hand, the genera *Apobaetis*, *Callibaetis*, *Chane*, *Oligoneuria*, *Traverhyphes*, *Ulmeritus*, and *Zelus* had low occurrences, being recorded at only one or two sampling sites (Table 2). *Apobaetis* and *Callibaetis* are known to prefer environments with low water current and abundant aquatic vegetation, especially in the case of the first (Flowers; Rosa, 2010; Siegloch; Froehlich; Spies, 2012). This preference may explain the limited distribution of these genera in this study, as most of the sampled sites were characterized by lotic environments with little marginal aquatic vegetation. Similar to *Callibaetis* and *Apobaetis*, the other genera also showed low representativeness in other studies (Principe; Corigliano, 2006; Hepp; Restellho, Milesi, 2013; Principe; Marquez;

Cibilis-Martina, 2019; Oliveira; Couceiro; Nascimento, 2023). Therefore, this characteristic may be a particular feature of these genera, indicating a possible specialization or adaptation to specific environmental conditions that may have restricted their distribution in the Iguatemi River basin.

The genera accumulation curve did not reach an asymptote (Figure 3). The estimated richness obtained using the Jackknife 1 estimator was 25.6 mayfly genera for the basin, indicating that 70.3% of the genera were sampled.

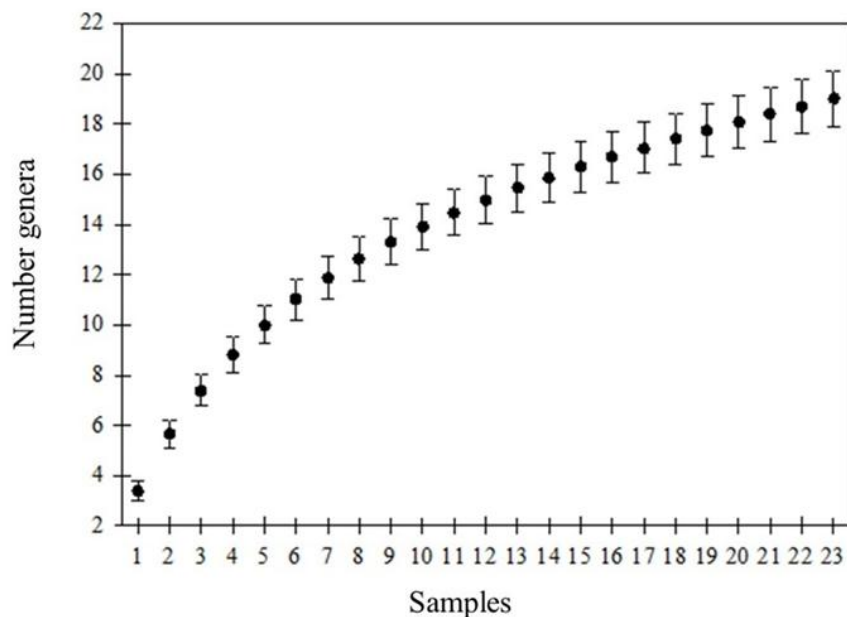


Figure 3. Accumulation curve of Ephemeroptera genera from the Iguatemi River basin, state of Mato Grosso do Sul, Brazil. Vertical lines = 95% confidence interval around the estimated mean

This result suggests that the richness of Ephemeroptera genera in the region is not fully documented. Additional sampling efforts, encompassing different types of environments and sampling methods, could further increase the number of recorded genera. This is supported by the fact some taxa not yet documented in the Iguatemi River basin have already been recorded for the state of Mato Grosso do Sul.

4 CONCLUSION

Our study provides the first detailed inventory of Ephemeroptera nymphs for the Iguatemi River basin, revealing high genus richness and the first record of a new taxon for the state. Based on these findings, continuous monitoring and conservation actions are recommended, such as the implementation and/or expansion of soil conservation practices and the restoration of riparian vegetation. These measures are essential to maintain habitat heterogeneity and natural flow conditions, ensuring aquatic environments capable of sustaining the diversity of Ephemeroptera and the associated aquatic biota.

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REFERENCES

- ALBANESI, S. A.; CRISTOBAL, L.; MANZO, V.; NIETO, C. Dataset of the Baetidae (Ephemeroptera) and Elmidae (Coleoptera) families from the Yungas of Argentina. **Rev. Soc. Entomol. Argen.**, Buenos Aires, v. 79, n. 3, p. 17-23, 2020. DOI: <https://doi.org/10.25085/rsea.790303>.
- ALVES, R. G.; STRIXINO, G. The sampling of benthic macroinvertebrates using two different methods: waiting trays and Ekman collector. **Acta Limnol. Bras.**, São Paulo, v. 15, n. 3, p. 1-6, 2003.
- BAPTISTA, D. F.; BUSS, D. F. L.; DIAS, G.; NESSIMIAN, J. L.; SILVA, E. R.; MORAES, A. H. A.; CARVALHO, N. S. N.; OLIVEIRA, M. A.; ANDRADE, L. R. Functional feeding groups of Brazilian Ephemeroptera nymphs: ultrastructure of mouthparts. **Ann. Limnol. - Int. J. Lim.**, Toulouse, v. 429, n. 2, p. 87-96, 2006. DOI: <https://doi.org/10.1051/limn/2006013>.
- BELMONT, E. L. L.; SALLES, F. F.; HAMADA, N. Leptohyphidae (Insecta, Ephemeroptera) do Estado do Amazonas, Brasil: novos registros, nova combinação, nova espécie e chave de identificação para estágios ninfais. **Rev. Bras. Entomol.**, Curitiba, v. 56, n. 3, p. 289-296, 2012. DOI: <https://doi.org/10.1590/S0085-56262012005000054>.
- BISPO, P. C.; CRISCI-BISPO, V. L. Ephemeroptera. In: COSTA, C.; IDE, S.; SIMONKA, C. E. **Insetos Imaturos: Metamorfose e Identificação**. Ribeirão Preto: Holos, 2006. p. 55-59.
- CARDOSO, M. N.; SHIMANO, Y.; NABOUT, J. C.; JUEN, L. An estimate of the potential number of mayfly species (Ephemeroptera, Insecta) still to be described in Brazil. **Rev. Bras. Entomol.**, Curitiba, v. 59, p. 147-153, 2015. DOI: <https://doi.org/10.1016/j.rbe.2015.03.014>.
- CARDOSO, M. N.; SHIMANO, Y.; CRUZ, P. V.; BOLDRINI, R.; MARIANO, R.; NESSIMIAN, J. L.; JUEN, L. Assessing the distribution of mayflies (Ephemeroptera: Insecta) in the Brazilian Amazon to guide more effective conservation. **Aquat. Conserv.**, v. 33, n. 4, p. 337-348, 2023. DOI: <https://doi.org/10.1002/aqc.3934>.

CLEMENTE, L. Z.; NAKAGAKI, J. M.; LIMA-JÚNIOR, S. E. Benthic macroinvertebrates as bioindicators of environmental quality in three streams of the amambai river basin, Upper Paraná River, Brazil. **Oecol. Austr.**, Rio de Janeiro, v. 23, n. 4, p. 951-960, 2019. DOI: <https://doi.org/10.4257/oeco.2019.2304.18>.

CRUZ, P. V.; NIETO, C.; GATTOLLIAT, J. L.; SALLES, F. F.; HAMADA, N. A. Cladistic insight into the higher level classification of Baetidae (Insecta: Ephemeroptera). **Syst. Entomol.**, London, v. 46, p. 44-55, 2021. DOI: <https://doi.org/10.1111/syen.12446>.

DA-SILVA E. R.; NESSIMIAN, J. L.; COELHO, L. B. N. Leptophlebiidae ocorrentes no Estado do Rio de Janeiro, Brasil: habitats, meso-habitats e hábitos das ninfas (Insecta: Ephemeroptera). **Biota Neotrop.**, Campinas, v. 10, p. 87-94, 2010. DOI: <https://doi.org/10.1590/S1676-06032010000400012>.

DOMÍNGUEZ, E.; MOLINERI, C. M.; PESCADOR, M.; HUBBARD, M. D.; NIETO, C. Ephemeroptera of South America. In: ADIS, J.; ARIAS, J. R.; RUEDA-DELGADO, G.; WANTZEN, K. M. **Aquatic biodiversity in Latin America**. Moscow: Pensoft, 2006, p. 1-46p.

ELOUARD, J. M.; GATTOLLIAT, J. L.; SARTORI, M. Ephemeroptera, mayflies. In: GOODMAN S. M.; BENSTEAD, J. P. **The Natural History of Madagascar**. Chicago: University of Chicago Press, 2003, p.639-645.

ESPINOSA, A. C. E.; SHIMANO, Y.; ROLIM, S.; MAIOLI, L.; JUEN, L.; DUNCK, B. Effects of mining and reduced turnover of Ephemeroptera (Insecta) in streams of the Eastern Brazilian Amazon. **J. Insect Conserv.**, v. 24, p. 1061-1072, 2020. DOI: <https://doi.org/10.1007/s10841-020-00275-7>.

FALCÃO, J. F.; SALLES, F. F.; HAMADA, N. Baetidae (Insecta, Ephemeroptera) ocorrentes em Roraima, Brasil: novos registros e chaves para gêneros e espécies no estágio ninfal. **Rev. Bras. Entomol.**, Curitiba, v. 55, n. 4, p. 516-548, 2011. DOI: <https://doi.org/10.1590/S0085-56262011005000048>.

FARIA, A. P. J.; LIGEIRO, R.; CALLISTO, M.; JUEN, L. Response of aquatic insect assemblages to the activities of traditional populations in eastern Amazonia. **Hydrobiol.**, Brussels, v. 802, p. 39-51, 2017. DOI: <https://doi.org/10.1007/s10750-017-3238-8>

FARIA, A. P. J.; RODRIGUES, J. A. O.; NASCIMENTO, S. R. S.; LIMA, L. R. An updated distribution list of Leptophlebiidae banks, 1900 (Ephemeroptera: Insecta) for Piauí state. **Biota Neotrop.**, Campinas, v. 23, n. 4, e20231544, 2023. DOI: <https://doi.org/10.1590/1676-0611-BN-2023-1544>.

FITZPATRICK, F. A.; WAITE, I. R.; D'ARCONTE, P. J.; MEADOR, M. R.; MAUPIN, M. A.; GURTZ, M. E. **Revised methods for characterizing stream habitat in the national water-quality assessment program**. Raleigh: U.S. Geological Survey Water-Resources Investigations Report, 1998.

FLOWERS, R. W.; DE LA ROSA, C. Ephemeroptera. **Rev. Biol. Trop.**, Costa Rica, v. 58, c. 4, p. 63-93, 2010. DOI: <https://doi.org/10.15517/rbt.v58i4.20083>.

FRANCISCHETTI, C. N.; DA-SILVA, E. R., SALLES, F. F.; NESSIMIAN, J. L. A Efemeropterofauna (Insecta: Ephemeroptera) do trecho inferior do Rio Campo Belo, Itatiaia, RJ: composição e mesodistribuição. **Lundiana**, Belo Horizonte, v. 5, n. 1, p. 33-39, 2004. DOI: [10.35699/2675-5327.2004.21898](https://doi.org/10.35699/2675-5327.2004.21898).

HEPP, L. U.; RESTELLO, R. M.; MILESI, S. V. Distribution of aquatic insects in urban headwater streams. **Acta Limnol. Bras.**, São Paulo, v. 25, n. 1, p. 1-9, 2013. DOI: <https://doi.org/10.1590/S2179-975X2013005000014>.

JACOBUS, L. M.; MACADAM, C. R.; SARTORI, M. Mayflies (Ephemeroptera) and their contributions to ecosystem services. **Insects**, Basel, v. 10, p. 1-26, 2019. DOI: <https://doi.org/10.3390/insects10060170>.

JORCIN, A.; NOGUEIRA, M. G.; BELMONT, R. Spatial and temporal distribution of the zoobenthos community during the filling up period of Porto Primavera reservoir (Paraná River, Brazil). **Braz. J. Biol.**, São Carlos, v. 69, n. 1, p. 19-29, 2009. DOI: <https://doi.org/10.1590/S1519-69842009000100003>.

JUEN, L.; CABETTE, H. S. R.; DE MARCO, P. Jr. Odonate assemblage structure in relation to basin and aquatic habitat structure in Pantanal wetlands. **Hydrobiol.**, Brussels, v. 579, p. 125-134, 2007. DOI: <https://doi.org/10.1007/s10750-006-0395-6>.

LIMA, L. R. C.; SALLES, F. F.; PINHEIRO, U. Ephemeroptera (Insecta) from Pernambuco State, northeastern Brazil. **Rev. Bras. Entomol.**, Curitiba, v. 56, n. 3, p. 304-314, 2012. DOI: <https://doi.org/10.1590/S0085-56262012005000043>.

LIMA, L. R. C.; SALLES, F. F.; PINHEIRO, U. S. New records of mayflies (Ephemeroptera: Insecta) from Pernambuco state, Northeastern Brazil. **Check List**, Viçosa, v. 11, n. 3, p. 01-07, 2015. DOI: <https://doi.org/10.15560/11.3.1652>.

LIMA, D. V. M.; KINPARA, K. T. A.; MENEZES, D. S. Estrutura de macroinvertebrados bentônicos em uma área de manejo florestal na Amazônia sul-ocidental. **Rev. Conex. Amazon.**, Rio Branco, v. 4, n. 1., p. 76-95, 2023.

LUIZA-ANDRADE, A.; BRASIL, L. S.; BENONE, N. L.; SHIMANO, Y.; FARIAS, A. P. J.; MONTAG, L. F.; DOLÉDEC, S.; JUEN, L. Influence of oil palm monoculture on the taxonomic and functional composition of aquatic insect communities in eastern Brazilian Amazonia. **Ecol. Indic.**, Coimbra, v. 82, p. 478-483, 2017. DOI: <https://doi.org/10.1016/j.ecolind.2017.07.006>.

MARULANDA-LOPEZ, J. F.; SERRÃO, J. E.; KALILE, M. O.; MARQUES, V. M.; CORTES, J. Q.; SALLES, F. F. The oology in taxonomic studies of Terpidinae Kluge (Ephemeroptera: Leptophlebiidae). **Zool. Anz.**, Washington, v. 292, p. 58-63, 2021. DOI: <https://doi.org/10.1016/j.jcz.2021.02.010>.

MCCUNE, B.; MEFFORD, M. J. **PC-ORD**: multivariate analysis of ecological data (Version 5), MjM. 2006.

MELO, S. M.; RAGONHA, F. H.; PINHA, G. D.; TAKEDA, A. M. Effects of food availability and habitat features on the Ephemeroptera species composition at seasonal and spatial scales from neotropical floodplain rivers. **Braz. J. Biol.**, São Carlos, v. 78, n. 1, p. 160-168, 2018. DOI: <http://dx.doi.org/10.1590/1519-6984.168636>.

MELO, S. M.; TAKEDA, A. M.; GRZYBKOWSKA, M.; MONKOLSKI, A. Distribution of ephemeropteran nymphs associated with different stolon sections of *Eichhornia azurea* (Schwartz) in two floodplain lakes of the upper Paraná River (Brazil). **Pol. J. Ecol.**, Warsaw, v. 52, n. 3, p. 369-376, 2004.

MENDONÇA, A.; ABELHA, M. C. F.; BATISTA-SILVA, V. F.; KASHIWAQUI, E. A. L. K.; BAILLY, D.; FERNANDES, C. A. Population parameters of poeciline in streams of Mato Grosso do Sul State, Brazil. **Bol. Inst. Pesca**, São Paulo, v. 40, n. 4, p. 557-567, 2014.

MUGNAI, R.; NESSIMIAN, J. L.; BAPTISTA, D. F. **Manual de identificação de macroinvertebrados aquáticos do estado do Rio de Janeiro**. 1. ed. Rio de Janeiro: Technical Books Editora, 2010.

MUNGAI, R.; SILVA, L. A.; SALLES, F. F. New record of mayflies (Ephemeroptera, Insecta) from Maranhão State, Northeast Brazil. **Int. J. Trop. Insect Sci.**, v. 44, p. 801-806, 2024. DOI: <https://doi.org/10.1007/s42690-024-01188-7>.

OLIVEIRA, L. A.; COUCEIRO, S. R. M.; NASCIMENTO, J. M. C. Ephemeroptera (Insecta) from the metropolitan region of Santarém, Pará, Brazil. **Biota Neotrop.**, Campinas, v. 23, n. 1, e20221437, 2023 DOI: <https://doi.org/10.1590/1676-0611-BN-2022-1437>.

PAIVA, M. P. **Grandes represas do Brasil**. Brasília: Editerra, 1982.

PETSCH, D. K.; PINHA, G. D.; RAGONHA, F. H.; TAKEDA, A. M. Influência dos fatores ambientais sobre a distribuição da comunidade de invertebrados bentônicos em canais de uma planície de inundação neotropical. **Biotemas**, Florianópolis, v. 26, n. 3, p. 127-138, 2013. DOI: <http://dx.doi.org/10.5007/2175-7925.2013v26n3p127>.

POLEGATTO, C. M.; FROEHLIC, C. G. Functional morphology of the feeding apparatus of the nymph of *Farrodes* sp. (Ephemeroptera: Leptophlebiidae). **Acta Zool.**, v. 82, p. 165-175, 2001. DOI: <https://doi.org/10.1046/j.1463-6395.2001.00083.x>.

PRINCIPE, R. E.; CORIGLIANO, M. C. Benthic, drifting and marginal macroinvertebrate assemblages in a lowland river: temporal and spatial variations and size structure. **Hydrobiol.**, Brussels, v. 553, p. 303-317, 2006. DOI: 10.1007/s10750-005-0694-3.

PRINICPE, R. E.; MARQUEZ, F. A.; CIBILIS-MARTINA, L. Distribution and habitat preference of Ephemeroptera and Trichoptera in subtropical mountain streams: implications for monitoring and conservation. **An. Acad. Bras. Cienc.**, Rio de Janeiro, v. 91, n. 3, 2019. DOI: <https://doi.org/10.1590/0001-3765201920180692>.

RIGHI-CAVALLARO, K. O.; ROCHE, K. F.; FROEHLIVH, O.; CAVALLARO, M. R. Structure of macroinvertebrate communities in riffles of a Neotropical karst stream in the wet and dry seasons. **Acta Limnol. Bras.**, São Paulo, v. 22, n. 3, p. 306-316, 2010. DOI: <http://dx.doi.org/10.4322/actalb.02203007>.

RIGHI-CAVALLARO, K. O.; SPIES, M. R.; SIEGLOCH, A. E. Ephemeroptera, Plecoptera e Trichoptera assemblages in Miranda River basin, Mato Grosso do Sul State, Brazil. **Biota Neotrop.**, Campinas, v. 10, n. 2, p. 253-260, 2010. DOI: <https://doi.org/10.1590/S1676-06032010000200028>.

ROMERO, R. M.; CENEVIVA-BASTOS, M.; BAVIERA, G. H.; CASATTI, L. Community structure of aquatic insects (Ephemeroptera, Plecoptera, and Trichoptera) in Cerrado streams of Paraguay, Paraná, and São Francisco River basins. **Biota Neotrop.**, Campinas, v. 13, n. 1, p. 97-107, 2013. DOI: <https://doi.org/10.1590/S1676-06032013000100011>.

SALLES, F. F.; DA SILVA, E. R.; SERRÃO, F. E.; FRANCISCHETTI, C. N. Baetidae (Ephemeroptera) na região sudeste do Brasil: novos registros e chave para os gêneros no estágio ninfal. **Neotrop. Entomol.**, Piracicaba, v. 33, n. 5, p. 725-735, 2004, 2016. DOI: <https://doi.org/10.1590/S1519-566X2004000600010>.

SALLES, F. F., DOMÍNGUEZ, E., MARIANO, R., PARESQUE, R. Then imagos of some enigmatic members of the *Hermanella complex* (Ephemeroptera, Leptophlebiidae). **ZooKeys**, Washington, v. 625, 45-66, 2016. DOI: <http://dx.doi.org/10.3897/zookeys.625.9874>.

SALLES, F.F., BOLDRINI, R.; LIMA, L.R.C. **Ephemeroptera**: Catálogo Taxonômico da Fauna do Brasil. Disponível em: <http://fauna.jbrj.gov.br/fauna/faunadobrasil/122>
Acesso: 30 mar. 2024.

SARTORI, M.; BRITTAIN, J. E. Order Ephemeroptera. In: THORP J.; ROGERS D. C. **Thorpe and Covich's Freshwater Invertebrates**: Ecology and General Biology. 4. ed. New York: Academic Press, 2015, p. 873-891. DOI: 10.1016/B978-0-12-385026-3.00034-6.

SAULINO, H. H. L.; TRIVINHO-STRIXINO, S. Macroinvertebrados aquáticos associados as raízes de *Eichhornia azurea* (Swartz) Kunth (Ponteridaceae) em uma lagoa marginal no

Pantanal, MS. **Biotemas**, Florianópolis, v. 27, n. 3, p. 65-72, 2014. DOI: <https://doi.org/10.5007/2175-7925.2014v27n3p65>.

SCHMITT, R.; SILVA, A. L. L.; SOARES, L. C. M.; PETRUCIO, M. M.; SIEGLOCH, A. E. Influence of microhabitat on diversity and distribution of Ephemeroptera, Plecoptera, and Trichoptera in subtropical forest streams. **Stud. Neotrop. Fauna Environ.**, Ilhéus, v. 55, n. 2, p. 129- 138, 2020. DOI: <https://doi.org/10.1080/01650521.2019.1704984>.

SHIMANO, Y.; SALLES, F. F.; FARIA, L. R. R.; CABETTE, H. S. R.; NOGUEIRA, D. S. Distribuição espacial das guildas tróficas e estruturação da comunidade de Ephemeroptera (Insecta) em córregos do Cerrado de Mato Grosso, Brasil. **Iheringia Ser. Zool.**, Porto Alegre, v. 102, n. 2, p. 187-196, 2012. DOI: <https://doi.org/10.1590/S0073-47212012000200011>.

SHIMANO, Y.; JUEN, L. How oil palm cultivation is affecting mayfly assemblages in Amazon streams. **Ann. Limnol. - Int. J. Lim.**, v. 52, p. 35-45, 2016. DOI: <https://doi.org/10.1051/limn/2016004>.

SHIMANO, Y.; CARDOSO, M.; JUEN, L. Ecological studies of mayflies (Insecta, Ephemeroptera): Can sampling effort be reduced without losing essential taxonomic and ecological information? **Acta Amaz.**, v. 48, n. 2, p. 137 - 145, 2018. DOI: <http://dx.doi.org/10.1590/1809-4392201700583>.

SIEGLOCH, A. E.; FROEHLICH, C. G.; KOTZIAN, C. B. Composition and diversity of Ephemeroptera (Insecta) nymph communities in the middle section of the Jacui river and some tributaries, southern Brazil. **Iheringia Ser. Zool.**, Porto Alegre, v. 98, n. 4, p. 425-432, 2008. DOI: <https://doi.org/10.1590/S0073-47212008000400002>.

SIEGLOCH, A. E.; FROEHLICH, C. G.; SPIES, M. R. Diversity of Ephemeroptera (Insecta) of the Serra da Mantiqueira and Serra do Mar, southeastern Brazil. **Rev. Bras. Entomol.**, Curitiba, v. 56, n. 4, p. 473-480, 2012. DOI: <https://doi.org/10.1590/S0085-56262012000400012>.

SILVA, F. H.; SALLES, F. F. Checklist de Ephemeroptera do Estado de Mato Grosso do Sul, Brasil. **Iheringia Ser. Zool.**, Porto Alegre, v. 107: e2017116, 2017. DOI: <https://doi.org/10.1590/1678-4766e2017116>.

SOUZA-FRANCO, G. M.; ANDRIAN, I. F.; FRANCO, R. M. Comunidade de insetos aquáticos associados a *Eichhornia azurea* (Schwartz) Kunth, em uma lagoa de várzea na planície de inundação do alto rio Paraná, Mato Grosso do Sul, MS, Brasil. **Biológico**, São Paulo, v. 71, n. 1, p. 83-91, 2009.

SÚAREZ, Y. R.; PETRERE-JÚNIOR, M. Gradientes de diversidade nas comunidades de peixes da bacia do rio Iguatemi, Mato Grosso do Sul. **Iheringia Ser. Zool.**, Porto Alegre, v. 96, n. 2, p. 197-304, 2006. DOI: <https://doi.org/10.1590/S0073-47212006000200009>.

YALLES-SATHA, A.; ALAMI, M.; KECHEMIR, L. H.; DESCILETTES, C.; CHENCHOUNI, H. Diversity, phenology and distribution of mayfly larvae (Ephemeroptera) along an altitudinal gradient in two permanent Wadis of Algeria. **Orient. Insects**, Krakow, v. 56, n. 1, p. 14-46, 2022. DOI: <https://doi.org/10.1080/00305316.2021.1904022>.