



Ephemeroptera (Insecta) from the metropolitan region of Santarém, Pará, Brazil

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Abstract: With the objective of improving the knowledge about Ephemeroptera in the North region of Brazil, the group's first survey was carried out for the metropolitan region of Santarém, Pará, Brazil. The specimens analyzed were collected from 2019 to 2020 in 27 aquatic environments distributed in the region. The nymphs were captured in the streams with aquatic entomological nets, in addition to manual collection on the substrates. Adults were collected using light traps and flight intercept traps. To complement the inventory, a bibliographic survey of species previously recorded in the area was carried out. For this, the Taxonomic Catalog of Fauna of Brazil, the website Ephemeroptera in South America and scientific articles were consulted. As a result, eight families, 23 genera and 31 species/morphospecies were recorded for the region, with 13 new records for Pará and 19 for the metropolis of Santarém. This study demonstrates the relevance of surveys for the knowledge of biodiversity and for understanding the geographic distribution of taxa.

Keywords: Diversity; Aquatic Insects; Survey.

Ephemeroptera (Insecta) da região metropolitana de Santarém, Pará, Brasil

Resumo: Com o objetivo de aprimorar o conhecimento sobre Ephemeroptera na região Norte do Brasil, foi realizado o primeiro levantamento do grupo para a região metropolitana de Santarém, Pará, Brasil. Os espécimes analisados foram coletados de 2019 a 2020 em 27 ambientes aquáticos distribuídos na região. As ninfas foram capturadas nos riachos com redes entomológicas aquáticas, além da coleta manual nos substratos. Os adultos foram coletados por meio de armadilhas luminosas e armadilhas de interceptação de voo. Para complementar o inventário, foi realizado o levantamento bibliográfico das espécies previamente registradas na área. Para isso, foram consultados o Catálogo Taxonômico da Fauna do Brasil, o site Ephemeroptera na América do Sul e artigos científicos. Como resultado, oito famílias, 23 gêneros e 31 espécies/morfoespécies foram registradas para a região, sendo 13 novos registros para o Pará e 19 para a metrópole de Santarém. Este estudo demonstra a relevância dos levantamentos para o conhecimento da biodiversidade e para a compreensão da distribuição geográfica dos táxons.

Palavras-chave: Diversidade; Insetos Aquáticos; Levantamento.

Introduction

Ephemeroptera (Insecta) is one of the most important groups of aquatic insects. Representatives of this order are found in lotic and lentic freshwater ecosystems, associated with various substrate types, and participate actively in nutrient cycling and energy flow. In general, they need clean, cold, and well-oxygenated waters for their survival and permanence in the place (Alba-Tercedor 2015), being considered excellent indicators of good water quality because they are sensitive to environmental disturbances (Barbola et al. 2011).

The order is widely distributed on the terrestrial globe, and there are about 3,500 valid species in 450 genera and 42 families

(Sartori & Briittain 2015). According to the Brazilian Fauna Taxonomic Catalog (in Portuguese: Catálogo Taxonômico da Fauna do Brasil), about 432 species distributed in 84 genera and 10 families are registered from Brazil. For Pará state, there were 41 species distributed in 33 genera and nine families (Salles et al. 2022).

The knowledge concerning mayflies (Ephemeroptera: Insecta) in Brazil has increased considerably in the last years. With the increase of taxonomic papers and published geographical distribution, the number of species reported from the country almost doubled in two decades (Da-Silva & Salles 2012, Salles et al. 2022). However, this knowledge is concentrated in some regions (Salles et al. 2022). Most of the studies on the order conducted with material collected in Pará were directed to descriptions

of species of some families (e.g., Dias et al. 2007, Gonçalves 2010, Souto et al. 2016, Boldrini et al. 2017). This situation not only hampers any attempts to uncover the diversity of the aquatic biota in the region, but also prevents directly applicable studies, such as biomonitoring for example.

The metropolitan region of Santarém in Para state, Brazil, has been suffering anthropic impacts for years, including deforestation for the planting of soybeans, rice and corn, pisciculture, the release of untreated sewage in water bodies and channeling rivers (Da Trindade & Cordeiro 2011, Soares et al. 2016, Gomes et al. 2017). Therefore, understanding of Ephemeroptera biodiversity in this region is priority and can contribute to the realization of future actions in the face of these impacts, especially in decision making and public policies for conservation of natural habitats.

Material and Methods

1. Study area

Santarém metropolitan region is in the west of Pará state, comprising the cities of Santarém, Mojuí dos Campos and Belterra, covering a territory of 27,285.426 km² (Figure 1). It has a tropical monsoon climate and an average temperature of 25.6 °C, with an average relative humidity of 80% and annual rainfall of 2,000 mm (Fapespa 2015, De Andrade 2017). The sampled sites are distributed between the Tapajós and Mojuí rivers basins (Lima 2012), including streams, waterfalls, rivers and lakes ecosystems. The region also has a conservation unit – the Floresta Nacional do Tapajós (Tapajós National Forest), an area of approximately

527,319 hectares, covering the following cities: Aveiro, Belterra, Placas and Rurópolis (ICMbio 2019).

2. Collection, Identification and illustrations

The collections were carried out at 27 points distributed in the metropolitan region of Santarém-PA, being 18 in Santarém, seven in Belterra and five in Mojuí dos Campos. The mayflies were collected between June/2019 and October/2020. Nymphs were collected with aquatic entomological nets in addition to manual collection with forceps directly from the substrates. At each collection point, the largest number of possible substrates (sand, gravel, bottom litter, stones, marginal vegetation) was sampled. Imagos and subimagos were collected with light traps (white sheet illuminated with a 15W emergency lamp, Pennsylvania trap and Malaise trap). The subimagos collected alive were kept for about twelve hours in empty microtubules, until they moulted to the imago stage, and then they were fixed in 80% ethanol.

The identifications were based on taxonomic keys (e.g., Domínguez et al. 2006, Salles 2006, Salles et al. 2018) and updated articles for each group (e.g., Boldrini et al. 2018, Araújo & Dias 2020, Oliveira et al. 2020). When needed, structures of the bodies were dissected and mounted between slide and coverslip, using Euparal® as the mounting medium. The specimens are deposited in the Laboratory of Ecology and Taxonomy of Aquatic Invertebrates (UFOPA).

Multilayer photographs were obtained using a Leica M165C stereomicroscope in conjunction with Leica DFC 420 image capturing equipment and LED dome lighting for uniform reflection of light on

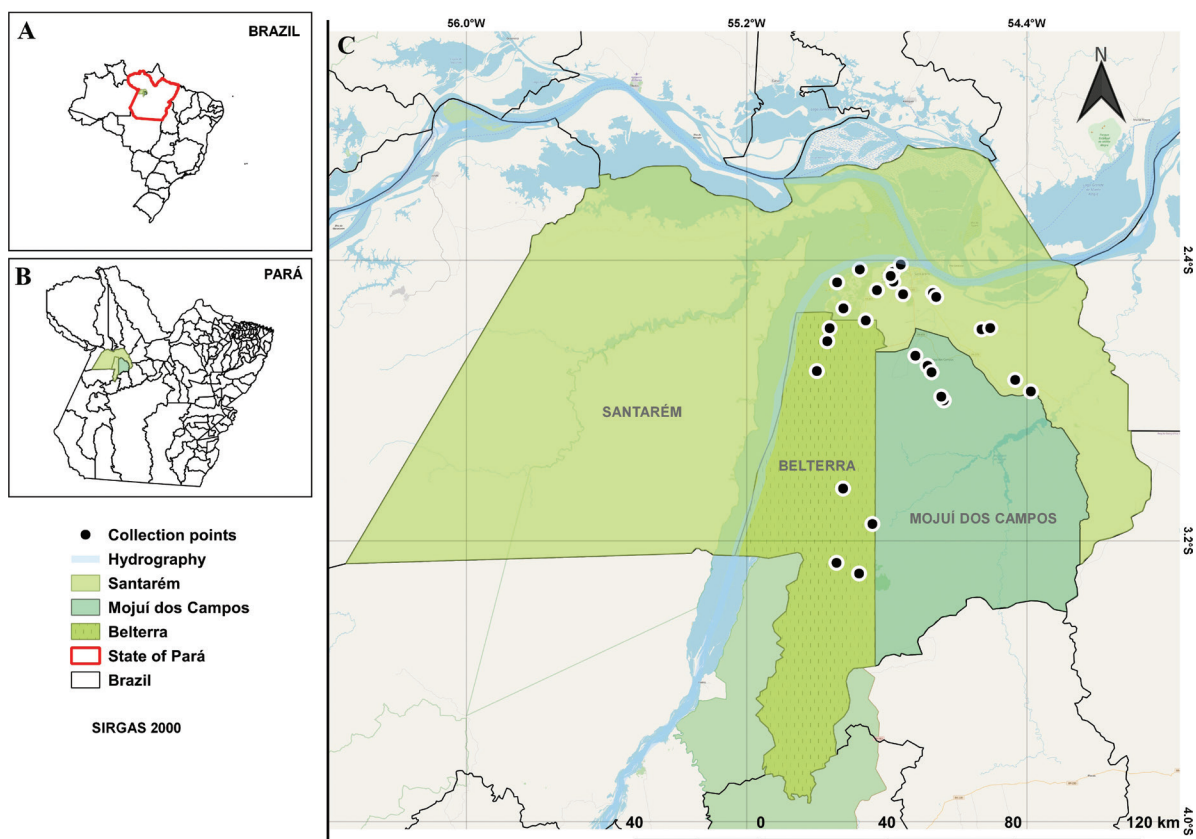


Figure 1. (A-C) Maps. (A) Brazil. (B) Pará state in detail. (C) Metropolitan Region of Santarém with the location of the sampled sites.

the specimens (Kawada and Buffington 2016) and an Olympus BX51 compound microscope in conjunction with an Olympus digital image acquisition system (DP 72 model using the Cell D program). The final images were generated using Digital Leica Application Suite v.3.7 and Helicon Focus (6.7.1 Pro) software.

3. Geographical distribution and material examined

The geographic distribution of the taxa collected in the present study was compiled from the Brazilian Fauna Taxonomic Catalog (Salles et al. 2022), from the Ephemeroptera in South America website and from several articles using data of collections carried out in the region. The new records for Pará state were marked with a positive symbol (+) and the new records only for the metropolis of Santarém were marked with a black asterisk (*).

Results

Based on the literature and new samples, a total of eight families, 23 genera and 31 species/morphospecies have been compiled for the metropolitan region of Santarém, with 13 new records for Pará and 19 new records for the metropolitan region of Santarém (Table 1).

Family Baetidae

Aturbina georgei Lugo-Ortiz & McCafferty, 1996

Geographic distribution. North: Pará, Amazonas, Acre, Roraima. Northeast: Bahia, Pernambuco. Midwest: Mato Grosso. Southeast: Espírito Santo, Minas Gerais, São Paulo, Rio de Janeiro.

Comment. Species described by Lugo-Ortiz & McCafferty (1996a) based on material collected in Paraná do Tapaná, near Santarém, but not collected during the sampling of the present study.

Aturbina maculata Salles, Boldrini & Shimano, 2011

Figure 2A, E

Material Examined. Pará, Santarém: Guaraná stream (02°46'25.9"S; 54°23'20.5"W), 06/iii/2020, Oliveira, LA. col: 2 imagos ♂, 2 imagos ♀. Pará, Mojuí dos Campos: Mojuí dos Caboclos stream (02°42'03.0"S; 54°41'01.0"W), 05/vii/2020, Oliveira, LA. col: 30 imagos ♂, 35 imagos ♀.

Geographic distribution. North: Amazonas, Pará⁺.

Comment. Until now, this species was registered only for its type-locality (Amazonas) (Salles et al. 2011). According to the description presented in Salles et al. (2011), the costal area of the anterior wing of *A. maculata* has four veins. However, based on the material collected in this study, it was observed that this characteristic is variable, with specimens also showing five veins (Figure 2E). This is the first record of this species for Pará state.

Callibaetis gelidus Cruz, Salles & Hamada, 2014

Figure 2B

Material Examined. Pará, Santarém: Amarjuá stream (02°26'56.2"S; 54°47'53.9"W), 13/ix/2019, Oliveira, LA. col: 1 imago ♀.

Geographic distribution. North: Amazonas, Roraima, Rondônia, Pará⁺.

Comment. This is the first record of this species for Pará state.

Callibaetis gonzalezi (Navás, 1934)

Figure 2C

Material Examined. Pará, Santarém: Tapajós river - CDP port (02°25'03.0"S; 54°44'34.0"W), 05/iii/2020, Sousa, CAL. col: 2 imagos ♀.

Table 1. Ephemeroptera (Insecta) recorded for the Metropolitan Region of Santarém. New records: (+) new record for the state; (*) new record for the metropolitan region of Santarém; (?) locality not specified.

Species	Records
Baetidae	
<i>Aturbina georgei</i> Lugo-Ortiz & McCafferty, 1996	
<i>Aturbina maculata</i> Salles, Boldrini & Shimano, 2011	+
<i>Callibaetis gelidus</i> Cruz, Salles & Hamada, 2014	+
<i>Callibaetis gonzalezi</i> (Navás, 1934)	+
<i>Callibaetis nigracyclus</i> Cruz, Salles & Hamada, 2014	*
<i>Cloeodes</i> sp.	+
<i>Camelobaetidius labiosus</i> (Boldrini & Salles, 2017)	
<i>Cryptonympha copiosa</i> Lugo-Ortiz & McCafferty, 1998	
<i>Paracloeodes binodulus</i> Lugo-Ortiz & McCafferty, 1996	
<i>Tupiara ibirapitanga</i> Salles Lugo-Ortiz, Da-Silva & Francischetti, 2003	+
<i>Waltzoyphius roberti</i> Thomas & Perú, 2002	+
Caenidae	
<i>Brasilocaenis mendesi</i> Malzacher, 1998	+
<i>Caenis cuniana</i> Froehlich, 1969	+
<i>Caenis reissi</i> Malzacher, 1986	
Coryphoridae	
<i>Coryphorus aquilus</i> Peters, 1981	
Ephemeridae	
<i>Hexagenia (Pseudeatonica) albivitta</i> (Walker, 1853)	?
Euthyplociidae	
<i>Campylocia demoulini</i> Gonçalves & Salles, 2017	?
Leptohiphidae	
<i>Amanahyphes saguassu</i> Salles & Molineri, 2006	*
<i>Tricorythopsis similis</i> Oliveira, Salles & Couceiro, 2021	+
<i>Macunahyphes australis</i> (Banks, 1913)	*
Leptophlebiidae	
<i>Askola emmerichi</i> Domínguez, Molineri & Mariano, 2009	+
<i>Farrodes xingu</i> Domínguez, Molineri & Peters, 1996	*
<i>Hermanellopsis arsia</i> Savage & Peters, 1983	+
<i>Hydrosmilodon gilliesae</i> Thomas & Perú, 2004	*
<i>Miroculis (Atroari) duckensis</i> Savage & Peters, 1983	+
<i>Simothraulopsis demerara</i> (Traver, 1947)	
<i>Simothraulopsis inaequalis</i> Nascimento, Salles & Hamada, 2017	
<i>Simothraulopsis plesius</i> Kluge, 2007	
Polymitarcyidae	
<i>Campsurus essequibo</i> Traver, 1947	*
<i>Campsurus latipennis</i> (Walker, 1853)	
<i>Campsurus lucidus</i> Needham & Murphy, 1924	+

Geographic distribution. North: Amazonas, Rondônia, Pará⁺. Northeast: Bahia, Pernambuco.

Comment. This is the first record of this species for Pará state.



Figure 2. Baetidae adults. (A) *Aturbina maculata* (male imago). (B) *Callibaetis gelidus* (female imago). (C) *Callibaetis gonzalezi* (female imago). (D) *Callibaetis nigracyclus* (male imago). (E) *Aturbina maculata* (male imago), anterior wing.

***Callibaetis nigracyclus* Cruz, Salles & Hamada, 2014**

Figure 2D

Material Examined. Pará, Mojuí dos Campos: Terra Preta stream (02°43'09.1"S; 54°40'20.7"W), 31/vii/2020; 24/ii/2020, Oliveira,

LA. col: 5 imagos ♂, 1 imago ♀. Água Fria stream (02°47'19.7"S; 54°38'40.9"W), 24/ix/2020, Oliveira, LA. col: 7 imagos ♂, 2 imagos ♀.

Geographic distribution. North: Amazonas, Pará*. Northeast: Piauí.

Comment. Species described by Cruz et al. (2014) based on material from Pará (Parauapebas - Flona do Carajás). This is the first record of this species for the metropolis of Santarém.

***Camelobaetidius labiosus* (Boldrini & Salles, 2017)**

Geographic distribution. North: Pará.

Comment. Boldrini et al. (2017) described *Tapajobaetis labiosus* (a new genus and species) based on material collected in Pará. Recently, in a phylogenetic study (Nieto et al. 2020), this genus was recovered as a synonym for *Camelobaetidius*, and a new combination was proposed for this species. In addition, after analyzing the coordinates provided in Boldrini et al. (2017), it was found that the collection area is in Belterra municipality, instead of Santarém, as described in the original article. This taxon was not collected during the sampling of the present study.

***Cloeodes* sp.**

Figure 3A

Material Examined. Pará, Santarém: Rai stream (02°35'35.3"S; 54°30'18.1"W), 13/xi/19, Oliveira, LA. col: 2 nymphs. Pará, Belterra: stream km-115 (03°17'34.8"S; 54° 52'45.6"W), 20/i/20, Oliveira, LA. col: 1 nymph. Jatuaranã stream (03°15'44.7"S; 54° 56'37.5"W), 11/ii/20, Oliveira, LA. col: 1 nymph.

Geographic distribution. North: Pará*.

Comment. Despite being a genus widely distributed in Brazil, this is the first record for Pará. The specific identification of this morphospecies is in analysis.



Figure 3. Baetidae nymphs. (A) *Cloeodes* sp. (B) *Cryptonympha copiosa*. (C) *Tupiara ibirapitanga*. (D) *Waltzoyphius roberti*.

***Cryptonympha copiosa* Lugo-Ortiz & McCafferty, 1998**

Figure 3B

Material Examined. Pará, Santarém: Guaraná stream (02°46'25.9"S; 54°23'20.5"W), 06/iii/2020, Oliveira, LA. col. (UFOPA): 31 nymphs. Jatobá stream (02°34'17.9"S; 54°51'36.8"W), 10/x/2020, Oliveira, LA. col: 2 nymphs.

Geographic distribution. Brazil: North: Pará, Amazonas, Acre, Roraima, Rondônia. Northeast: Bahia, Maranhão. Midwest: Mato Grosso. South: Rio Grande do Sul and Santa Catarina.

Comment. Species described by Lugo-Ortiz & McCafferty (1998) based on material collected in the surroundings of Santarém.

***Paracloeodes binodulus* Lugo-Ortiz & McCafferty, 1996**

Geographic distribution. North: Pará, Amazonas, Roraima, Amapá.

Northeast: Maranhão. Midwest: Mato Grosso.

Comment. Species described by Lugo-Ortiz & McCafferty (1996b) based on material collected in the vicinity of Santarém and Belterra, but not found during the sampling of the present study.

***Tupiara ibirapitanga* Salles Lugo-Ortiz, Da-Silva & Francischetti, 2003**

Figure 3C

Material Examined. Pará, Santarém: Rocha Negra waterfall (02°29'48.5"S; 54°45'13.3"W), 24/ix/2020, Oliveira, LA. col: 1 nymph.

Geographic distribution. North: Amazonas, Pará⁺. Southeast: Espírito Santo, Minas Gerais, Rio de Janeiro.

Comment. This is the first record of the genus and species for Pará state.

***Waltzoyphius roberti* Thomas & Perú, 2002**

Figure 3D

Material Examined. Pará, Santarém: Guaraná stream (02°46'25.9"S; 54°23'20.5"W), 06/iii/2020, Oliveira, LA. col: 50 nymphs. Cajutuba stream (02°27'39.1"S; 54°46'53.5"W), 11/x/2020, Oliveira, LA. col: 1 nymph.

Geographic distribution. North: Amazonas, Roraima, Rondônia, Pará⁺. Northeast: Bahia. Midwest: Mato Grosso, Goiás.

Comment. This is the first record of this species for Pará state.

Family Caenidae***Brasilocaenis mendesi* Malzacher, 1998**

Figure 4A

Material Examined. Pará, Mojuí dos Campos: Mojuí dos Caboclos stream (02°42'03.0"S; 54°41'01.0"W), 11/xi/2020, Oliveira, LA. col: 133 imagos ♂, 36 imagos ♀.

Geographic distribution. North: Pará⁺. Midwest: Mato Grosso.

Comment. This is the first record of this species for the Pará state.

***Caenis cuniana* Froehlich, 1969**

Figure 4B

Material Examined. Pará, Santarém: Amarjuá stream (02°26'56.2"S; 54°47'53.9"W), 13/ix/2019, Oliveira, LA. col: 4 imagos ♂.

Geographic distribution. North: Roraima, Pará⁺. Northeast: Pernambuco. Midwest: Mato Grosso. Southeast: Espírito Santo, São Paulo, Rio de Janeiro.

Comment. This is the first record of this species for the state.



Figure 4. Caenidae adults. (A) *Brasilocaenis mendesi* (male imago). (B) *Caenis cuniana* (male imago).



Figure 5. *Coryphorus aquilus*, male imago. (A) Dorsal view. (B) Genitalia, ventral view.

***Caenis reissi* Malzacher, 1986**

Geographic distribution. North: Pará.

Comment. Species described by Malzacher (1986) based on material collected in Belterra municipality, but not found during the sampling of the present study.

Family Coryphoridae***Coryphorus aquilus* Peters, 1981**

Figure 5

Material Examined. Pará, Mojuí dos Campos: Mojuí dos Caboclos stream (02°42'03.0"S; 54°41'01.0"W), 11/xi/2020, Oliveira, LA. col. 3 imagos ♂, 1 imago ♀.

Geographic distribution. North: Amapá, Amazonas, Pará, Roraima, Tocantins. Midwest: Mato Grosso.

Comment. Species described by Peters (1981) based on material collected in the vicinity of Santarém.

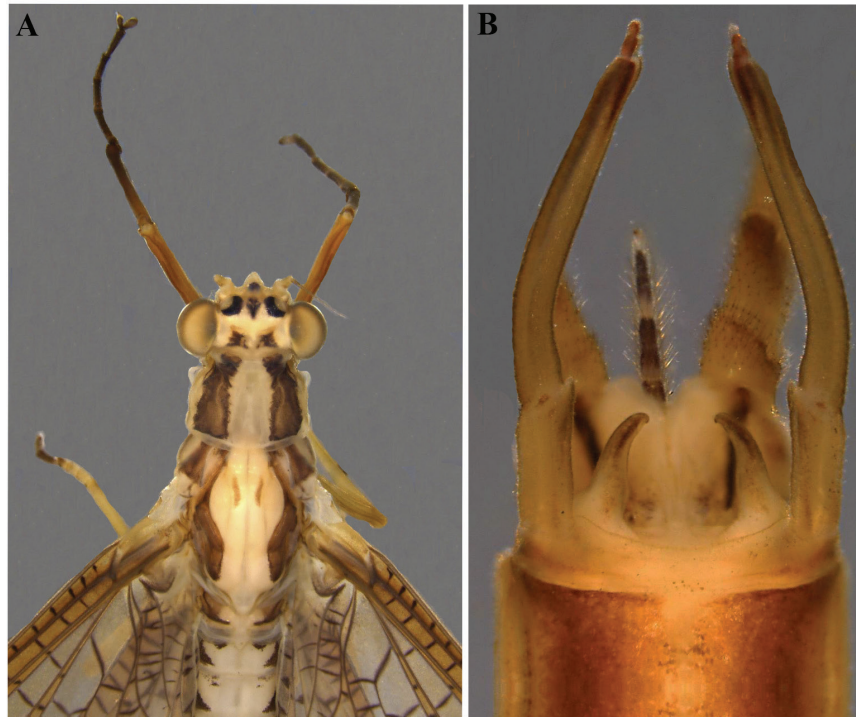


Figure 6. *Hexagenia (Pseudeatonica) albivitta* male imago. (A) Head, thorax and partial region of the abdomen, dorsal view. (B) Genitalia, ventral view.

Family Ephemeridae

Hexagenia (Pseudeatonica) albivitta (Walker, 1853)

Figure 6

Material Examined. Pará, Santarém: Tapajós river – CDP port (02°25'03.0"S; 54°44'34.0"W), 21/viii/ 2020, Sousa, CAL. col: 2 imagos ♂, 7 imagos ♀.

Geographic distribution. North: Amazonas, Pará. Northeast: Bahia. Midwest: Goiás. Southeast: Espírito Santo, São Paulo, Rio de Janeiro. South: Paraná, Rio Grande do Sul.

Comment. Species registered for Pará by Walker (1853), however, more accurate data on the collection sites were not provided in the original article.

Family Euthyplociidae

Campylocia demoulini Gonçalves & Salles, 2017

Figure 7

Material Examined. Pará, Belterra: stream km-115 BR-316 (03°17'34.8"S; 54°52'45.6"W), 23/vii/2020; 11/xii/2020, Oliveira, LA. col: 1 imago ♂.

Geographic distribution. North: Pará, Amazonas, Roraima, Tocantins. Midwest: Mato Grosso, Distrito Federal.

Comment. Species registered for Pará state in Gonçalves et al. (2017), however, more specific data about the collection site were not provided in the original work.

Family Leptohiphidae

Amanahyphes saguassu Salles & Molineri, 2006

Figure 8A

Material Examined. Pará, Mojuí dos Campos: stream km-115 (03°17'34.8"S; 54°52'45.6"W), 23/x/2019, Oliveira, LA. col:

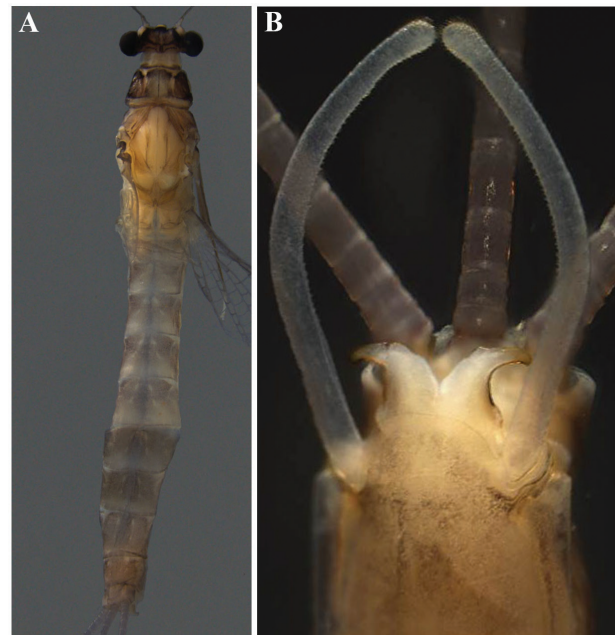


Figure 7. *Campylocia demoulini*, male imago. (A) Dorsal view. (B) Genitalia, ventral view.

10 subimagos ♂, 4 subimagos ♀. Pará, Belterra: stream at the exit of Flona do Tapajós (03°03'02.6"S; 54°55'30.1"W), 20/x/2019, Oliveira, LA. col: 2 subimagos ♂, 5 nymphs.

Geographic distribution. North: Pará*, Amazonas, Amapá. Northeast: Maranhão. Midwest: Mato Grosso.

Comment. This species was previously registered for Pará state by Gonçalves & Da-Silva (2010), for Parauapebas municipality. This is the first record for the metropolitan region of Santarém.

***Tricorythopsis similis* Oliveira, Nascimento & Couceiro, 2021**

Figure 8B

Material Examined. Pará, Santarém: stream Ponte do Juá (02°26'41"S; 54°47'21"W), 06/xii/2019, Santos, SE. col: 1 nymph. Pará, Mojuí dos Campos: stream Mojuí dos Caboclos (02°42'03"S; 54°41'01"W), 05/vii/2020, Oliveira, LA. col: 1 nymph.

Geographic distribution. North: Pará⁺

Comment. This species was first described and recorded for the state of Pará by Oliveira et al. (2021), based on material collected in Santarém and Mojuí dos Campos.

***Macunahyphes australis* (Banks, 1913)**

Figure 8C

Material Examined. Pará, Santarém: Tapajós river – Ufopa port (02°25'03.0"S; 54°44'34.0"W), 19/vi/2020, Oliveira, LA. col: 6 imagos ♂.

Geographic distribution. North: Amazonas, Roraima, Amapá, Pará*. Midwest: Mato Grosso. Southeast: Espírito Santo. South: Paraná.

Comment. This species was registered for Pará for the first time by Molineri (2002) as *Tricorythodes australis*, for Altamira municipality. Later, Dias et al. (2005) proposed a new genus to allocate this species

and recorded its occurrence for Oriximiná (PA). This is the first record for the metropolitan region of Santarém.

Family Leptophlebiidae***Askola emmerichi* Domínguez, Molineri & Mariano, 2009**

Figure 9A

Material Examined. Pará, Belterra: stream km-115 (03°17'34.8"S; 54°52'45.6"W), 23/x/2019, Oliveira, LA. col: 1 subimago ♂, 1 subimago ♀. Stream at the exit of Flona do Tapajós (03°03'02.6"S; 54°55'30.1"W), 20/x/2019, Oliveira, LA. col: 1 subimago ♂, 2 imagos ♀.

Geographic distribution. North: Amazonas, Roraima, Pará*. Northeast: Bahia, Pernambuco, Maranhão.

Comment. This is the first record of this species for Pará state.

***Farrodes xingu* Domínguez, Molineri & Peters, 1996**

Figure 9B

Material Examined. Pará, Santarém: Cavada waterfall (02°35'48.9"S; 54°31'47.3"W), 13/xi/2019, Oliveira, LA. col: 1 subimago ♂, 3 imagos ♀. Débora stream (02°35'48.9"S; 54°31'47.3"W), 21/x/2019, Oliveira, LA. col: 1 subimago ♂. Pará, Belterra: stream km-115 (03°17'34.8"S; 54°52'45.6"W), 23/x/2019, Oliveira, LA. col: 1 subimago ♂.



Figure 8. Leptohyphidae. (A) *Amanahyphes saguassu* (male imago). (B) *Tricorythopsis similis* (nymph). (C) *Macunahyphes australis* (male imago), lateral view.

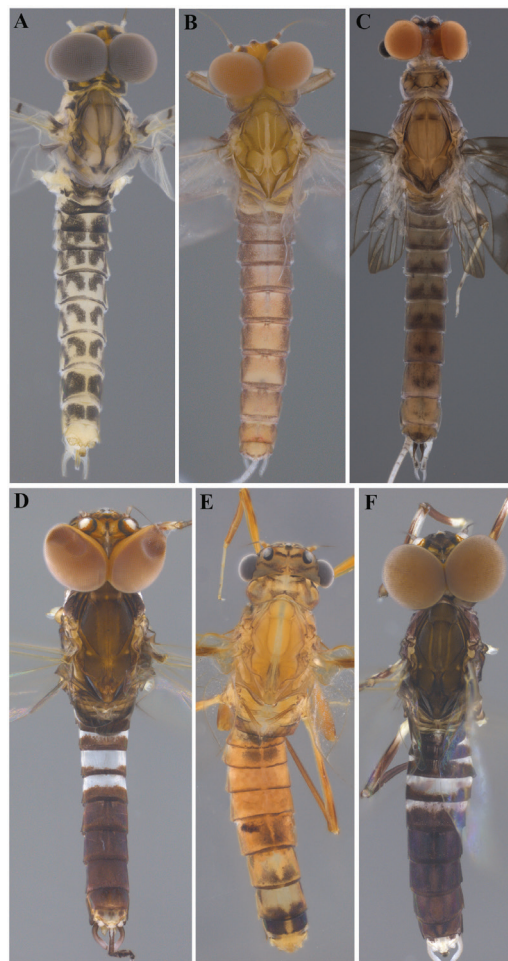


Figure 9. Leptophlebiidae adults. (A) *Askola emmerichi* (male subimago). (B) *Farrodes xingu* (male imago). (C) *Miroculis (Atroari) duckensis* (male imago). (D) *Simothraulopsis demerara* (male imago). (E) *Simothraulopsis inaequalis* (female imago). (F) *Simothraulopsis plesius* (male imago).

Geographic distribution. North: Pará*. Northeast: Maranhão. Midwest: Goiás.

Comment. Species described by Domínguez et al. (1996) based on material collected in Altamira (PA) municipality. This is the first record for the metropolitan region of Santarém.

***Hermanellopsis arsia* Savage & Peters, 1983**

Figure 10A

Material Examined. Pará, Mojuí dos Campos: Mojuí dos Caboclos stream (02°42'03.0"S; 54°41'01.0"W), 21/i/2020, Oliveira, LA. col: 15 imagos ♂, 1 nymph.

Geographic distribution. North: Amazonas, Roraima, Pará+. Northeast: Maranhão.

Comment. This is the first record of the genus and species for Pará state.

***Hydrosmilodon gilliesae* Thomas & Perú, 2004**

Figure 10B

Material Examined. Pará, Santarém: Guaraná stream (02°46'25.9"S; 54°23'20.6"W), 05/iii/2020, Oliveira, LA. col: 4 imagos ♂, 2 imagos ♀, 20 nymphs. Sonrizal stream (02°32'13.6"S; 54°55'26.6"W), 09/viii/2019, Oliveira, LA. col: 1 imago ♂, 4 imagos ♀, 21 nymphs. São Braz stream (02°29'07.0"S; 54°49'41.9"W), 26/vii/2019, Oliveira, LA. col: 1 imago ♂, 8 imagos ♀, 2 nymphs. Diamantino stream (02°30'16.2"S; 54°39'32.9"W), 06/ix/2019, Oliveira, LA. col: 1 imago ♂. Mararu stream (02°29'35.9"S; 54°40'06.6"W), 28/viii/2019, Oliveira, LA. col: 1 imago ♂. Pará, Mojuí dos Campos: Santa Júlia stream (02°40'19.7"S; 54°43'06.9"W), 09/xii/2019, Oliveira, LA. col: 15 imagos ♂, 14 imagos ♀, 27 nymphs. Mojuí dos Caboclos stream (02°42'03.0"S; 54°41'01.0"W), 21/i/2020, Oliveira, LA. col: 15 imagos ♂, 2 imagos ♀, 21 nymphs. Terra de areia stream (02°47'58.7"S; 54°38'15.6"W), 24/i/2020, Oliveira, LA. col: 14 imagos ♂, 5 imagos ♀,

24 nymphs. Pará, Belterra: stream at the exit of the Flona do Tapajós (03°03'02.6"S; 54°55'30.1"W), 20/x/2019, Oliveira, LA. col: 9 imagos ♂, 2 subimagos ♂, 10 imagos ♀, 3 subimagos ♀. Antônio Leite stream (03°09'06.2"S; 54°50'28.7"W), 18/x/2019, Oliveira, LA. col: 1 nymph. Ailton stream (02°35'36.7"S; 54°57'48.4"W), 06/xi/2019, Oliveira, LA. col: 2 imagos ♂. Stream km-115 (03°17'34.8"S; 54°52'45.6"W), 07-14/xii/2019, Oliveira, LA. col: 1 subimago ♂, 3 subimagos ♂.

Geographic distribution. North: Amazonas, Roraima, Pará*. Northeast: Bahia, Pernambuco, Maranhão. Midwest: Mato Grosso. Southeast: Espírito Santo.

Comment. This is the first record of the genus and species for Pará state.

***Miroculis (Atroari) duckensis* Savage & Peters, 1983**

Figure 9C

Material Examined. Pará, Belterra: stream km-115 (03°17'34.8"S; 54°52'45.6"W), 23/x/2019, Oliveira, LA. col: 2 subimagos ♂, 1 subimago ♂, 2 subimagos ♀, 45 subimagos ♂. Stream at the exit of Flona do Tapajós (03°03'02.6"S; 54°55'30.1"W), 20/x/2019, Oliveira, LA. col: 1 imago ♂, 1 subimago ♂, 1 imago ♀.

Geographic distribution. North: Amazona, Pará+. Northeast: Bahia, Maranhão.

Comment. This is the first record of this species for Pará state.

***Simothraulopsis demerara* (Traver, 1947)**

Figure 9D

Material Examined. Pará, Santarém: Tapajós river – CDP port (02°24'50.8"S; 54°44'15.0"W), 05/iii/2020, Sousa, CAL: 1 imago ♂, 3 imagos ♂, 2 subimagos ♀. Tapajós river - Ufopa port (02°25'03.0"S; 54°44'34.0"W), 19/vi/2020, Oliveira, LA. col: 4 imagos ♂, 2 imagos ♂. Tapari lake (02°26'36.1"S; 54°53'53.5"W), 05/vi/2019, Oliveira, LA. col: 2 nymphs.



Figure 10. Leptophlebiidae nymphs. (A) *Hermanellopsis arsia*. (B) *Hydrosmilodon gilliesae*. (C) *Simothraulopsis inaequalis*.

Geographic distribution. North: Pará, Amazonas, Acre, Amapá, Rondônia. Northeast: Ceará, Bahia, Piauí, Pernambuco. Maranhão: Midwest: Mato Grosso, Goiás. Southeast: Espírito Santo. South: Paraná.

Comment. This species was previously registered for Pará state by Nascimento et al. (2017), occurring in Santarém.

***Simothraulopsis inaequalis* Nascimento, Salles & Hamada, 2017**

Figure 9E, 10C

Material Examined. Pará, Santarém: Sonrizal stream (02°32'13.6"S; 54°55'26.6"W), 09/viii/2019, Oliveira, LA. col: 1 nymph. Diamantino stream (02°30'16.2"S; 54°39'32.9"W), 06/ix/2019, Oliveira, LA. col: 1 imago ♀. Pará, Mojuí dos Campos: stream km-115 (03°17'34.8"S; 54°52'45.6"W), 23/x/2019, Oliveira, LA. col: 1 I ♀, 3 nymphs. Pará, Belterra: CEL Batista stream (02°37'50.6"S; 54°58'12.4"W), 08/xi/2019, Oliveira, LA. col: 1 imago ♀.

Geographic distribution. North: Pará, Amazonas.

Comment. Species described by Nascimento et al. (2017) based on material collected in Santarém municipality.

***Simothraulopsis plesius* Kluge, 2007**

Figure 9F

Material Examined. Pará, Santarém: Tapari lake (02°26'36.1"S; 54°53'53.5"W), 05/vi/2019, Oliveira, LA. col: 5 nymphs. Pará, Mojuí dos campos: Mojuí dos Caboclos stream (02°42'03.0"S; 54°41'01.0"W), 05/vi/2019, Oliveira, LA. col: 1 imago ♂, 1 subimago ♂, 2 subimagos ♀.

Geographic distribution. North: Pará, Amazonas.

Comment. This species was previously registered for Pará state by Nascimento et al. (2017), for Alter do Chão, Santarém district.

Family Polymitaecidae

***Campsurus essequibo* Traver, 1947**

Figure 11A

Material Examined. Pará, Santarém: Tapajós river – Ufopa port (02°25'03.0"S; 54°44'34.0"W), 04/v/2020, Oliveira, LA. col: 3 imagos ♂. Tapajós river – CDP port (02°25'03.0"S; 54°44'34.0"W), 19/vi/2020, Sousa, CAL. col: 1 imago ♂.

Geographic distribution. North: Pará*, Amazonas, Roraima.

Comment. This species was registered for Pará state by Molineri & Salles (2017), for Tucuuruí municipality. This is the first record for the metropolitan region of Santarém.

***Campsurus latipennis* (Walker, 1853)**

Geographic distribution. North: Pará, Tocantins. Southeast: Espírito Santo.

Comment. This species was registered for the municipality of Santarém by Lestage (1923); however, it was not found during the sampling of the present study.

***Campsurus lucidus* Needham & Murphy, 1924**

Figure 11B

Material Examined. Pará, Santarém: Tapajós river – CDP port (02°25'03.0"; S 54°44'34.0"W), 05/iii/ 2020, Sousa, CAL. col: 1 subimago ♂.



Figure 11. Polymitaecidae adults. (A) *Campsurus essequibo* (male imago). (B) *Campsurus lucidus* (male subimago).

Geographic distribution. North: Roraima, Pará †. Midwest: Mato Grosso do Sul. South: Santa Catarina.

Comment. This is the first record of this species for Pará state.

Discussion

Ephemeroptera is a group of aquatic insects well studied in some locations due to the permanence of researchers in local institutions and because this is a key group in studies of environmental quality (Alba-Tercedor 2015). Despite the great ecological importance of the group, most of applied studies deal with Ephemeroptera only at the level of genus or family (Chen et al. 2017, Nicacio et al. 2020).

The metropolitan area of Santarém presented a representative diversity of Ephemeroptera for the state, which may be related to the variety of habitats among the sampled sites, mainly in places far from the urban areas of the city. Environmental heterogeneity is considered one of the main factors to explain the high richness of taxa in an area (Chisholm et al. 2011), as they provide more resources and niches for species (Bazzaz 1975). However, it is important to emphasize that the metropolitan region of Santarém is experiencing great anthropic pressures (Sousa et al. 2020) and that a large part of the natural environments is at risk of destruction.

Until the completion of this study, a total of 41 species, distributed in 33 genera and nine families were registered for Pará, of these, only 10 species, 16 genera and six families were registered for the metropolis of Santarém. After this research, Pará state is now represented by 54 species/morphospecies, 36 genera and nine families; the metropolis of Santarém is now represented by 31 species/morphospecies, 23 genera and eight families. Thus, with the present study, there was an increase of 23% in the number of new records of Ephemeroptera registered for Pará state and an increase of 65% in what there was registered for the metropolitan area of Santarém (Table 1). And the metropolitan region of Santarém becomes the area with the largest number of Ephemeroptera

records in the state. Significant numbers, especially because the study area comprises only 2.19% of the state territory (IBGE 2021).

Baetidae and Leptophlebiidae were the most representative families in the metropolitan region of Santarém, with 11 and eight species/morphospecies, respectively, followed by Caenidae (n=3), Polymitaeridae (n=3), Leptohyphidae (n=3), Euthyplocidae (n=1), Ephemeridae (n=1) and Coryphoridae (n=1). This pattern is in line with general studies on the order Ephemeroptera in Brazil, where Baetidae is always identified as the most representative family, followed by Leptophlebiidae and Leptohyphidae (e.g., Francischetti 2007, Salles et al. 2010, Shimano et al. 2011, Lima et al. 2012).

Cloeodes, *Hermanellopsis* and *Tupiara* stand out as the first records for the state of Pará. Even if recorded for some Brazilian states (Salles & Boldrini 2022), on a more precise geographic scale, we still see gaps in their distributions, probably because of sampling being concentrated in certain locations.

Although the three cities are seen as a single region, *Hydrosmilodon gilliesae* and *Simothraulopsis inaequalis* were the only species sampled in the three cities. *Callibaetis gelidus*, *Caenis cuniana* and *Campsurus lucidus* (and others), for example, were sampled in only one of the cities. Likewise, some taxa registered in previous (ecological) studies carried out in the region were not collected in the present study.

Some points were sampled several times to obtain nymphs or adults for the complete identification of the species. Even so, despite the efforts, it was not possible to obtain the necessary stage. These observations underscore the importance of constant surveys with increased sampling efforts to obtain complete knowledge about the diversity of Ephemeroptera in the region.

The results presented in this study increased, in general, the knowledge about the diversity and distribution of Ephemeroptera. This knowledge is fundamental for the understanding of aquatic diversity, both in terms of naming the taxa, given future descriptions of new species collected, and for understanding the distribution of these taxa. In addition, the naming of taxa allows greater accuracy in ecological studies, including studies of aquatic biomonitoring in the region.

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Author Contributions

Laura Almeida de Oliveira: contributed to data collection, species identification and article writing.

Sheyla Regina Marques Couceiro: contributed to the data collection and writing of the article.

Jeane Marcelle Cavalcante do Nascimento: contributed to the identification of species and writing of the article.

Conflicts of Interest

The authors declare that there is no conflict of interest related to the publication of this manuscript.

Data Availability

The data used in our analysis is available at Biota Neotropica Dataverse

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