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Article

Polymitarcyidae Banks, 1900 (Insecta, Ephemeroptera) from the Western Region of Pará, Brazil

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***Abstract*:** Polymitarcyidae has a worldwide geographic distribution. Their nymphs are adapted to the fossorial habit, while the adults (imagos) have atrophied legs, except for the anterior legs of the males. This study represents the first survey of this family in the western region of Pará. For this purpose, we collected nymphs and adults. Nymphs were captured using aquatic entomological nets and sieves, while adults were obtained using light traps and flight interception. In addition, we used online sources, such as the Brazilian Fauna Taxonomic Catalog, the EPHEMBRAZIL platform and the Ephemeroptera da América do Sul website. The survey revealed the presence of three genera and 13 species of Polymitarcyidae in the region, including six new records for the state of Pará. These results highlight the importance of geographic distribution surveys to expand our knowledge about biodiversity.
***Keywords*:** *Aquatic insects; Freshwater; Survey; Amazon.*

Polymitarcyidae Banks, 1900 (Insecta, Ephemeroptera) da Região Oeste do Pará, Brasil

Resumo: Polymitarcyidae possui uma distribuição geográfica mundial. Suas ninfas são adaptadas ao hábito fossorial, enquanto os adultos (imagos) apresentam pernas atrofiadas, exceto pelas pernas anteriores dos machos. Este estudo representa o primeiro levantamento dessa família na região Oeste do Pará. Para isso, coletamos ninfas e adultos. As ninfas foram capturadas com redes entomológicas aquáticas e peneiras, enquanto os adultos foram obtidos por meio de armadilhas luminosas e de interceptação de voo. Além disso, utilizamos fontes online, como o Catálogo Taxonômico da Fauna do Brasil, a plataforma EPHEMBRAZIL e o website Ephemeroptera da América do Sul. O levantamento revelou a presença de três gêneros e 13 espécies de Polymitarcyidae na região, incluindo seis novos registros para o estado do Pará. Esses resultados destacam a importância dos levantamentos de distribuição geográfica para ampliar nosso conhecimento sobre a biodiversidade.
***Palavras-chave*:** *Insetos aquáticos; Ambiente dulcícola; Inventário; Amazônia.*

Introduction

The Polymitarcyidae Banks, 1900, a family of mayflies (Ephemeroptera: Insecta), exhibits a broad geographic distribution being found in the Holarctic, Palearctic, Eastern and Neotropical regions (McCafferty 2004) and inhabits both lentic and lotic environments (Molineri & Salles 2013). Nymphs of this family are notable for their behavior of excavating tunnels in wood, residing in freshwater porifers, or inhabiting inorganic sediments (Molineri et al. 2015). They are distinguished by sickle-shaped mandibular projections, fused anterior tibia and tarsus, and typically dorsal arrangement of gills (Da-Silva & Salles 2024). Adults of this group are characterized by the presence of atrophied legs, except for the anterior legs in males (Domínguez et al. 2006).

Numerous species actively participate in bioturbation of bottom sediments within watercourses (Fonseca & Assis, 2000; Figueiredo-Barros et al., 2007; Leal et al., 2007), playing crucial roles in both aquatic and terrestrial food chains. Species of Polymitarcyidae

have emerged as significant indicators of water quality, exhibiting a preference for ecosystems with high substrate quality and availability (Hamada & Ferreira-Keppler, 2012; Hamada et al., 2019). This underscores the pivotal role of this group as a vital component within ecosystems (Kuhlmann et al., 2020).

The Polymitarcyidae family is divided into three subfamilies, two of which are found in South America: Asthenopodinae (comprising the genera *Asthenopodes* Ulmer, 1924; *Asthenopus* Eaton, 1871; *Hubbardipes* Molineri, Salles & Peters, 2015; and *Priasthenopus* Molineri, Salles & Peters, 2015) and Campsurinae (comprising the genera *Campsurus* Eaton, 1868; *Tortopus* Needham & Murphy, 1924; and *Tortopsis* Molineri, 2010) (Molineri 2010, Molineri & Salles 2013, Molineri et al. 2015). In Brazil, there are 52 species distributed among seven genera (Salles et al. 2024), with *Campsurus* being the most representative genus, comprising 39 described species to date, and also one of the most specious genera on the American Continent (Molineri & Salles 2017).

In the Amazon biome, the state of Amazonas boasts the highest diversity of Polymitarcyidae, hosting a total of 28 species (Molineri et al. 2015, Salles et al. 2024). In contrast, the state of Pará harbors only two genera and seven species: *Asthenopus curtus* (Hagen, 1861); *Campsurus albifilum* (Walker, 1853); *C. essequibo* Traver, 1947; *C. latipennis* (Walker, 1853); *C. lucidus* Needham & Murphy, 1924; *C. segnis* Needham & Murphy, 1924; and *C. violaceus* Needham & Murphy, 1924 (Hagen 1861, Walker 1853, Molineri & Salles 2017, Oliveira et al. 2023, Needham & Murphy 1924, Demoulin 1955).

Despite the increased focus on taxonomy, geographic distribution, and ecology of the order Ephemeroptera in the state of Pará in recent years (Oliveira et al. 2021, 2023), there remains a lack of knowledge regarding certain taxa, particularly the Polymitarcyidae, leading to limited information about their diversity. According to Cardoso et al. (2023), Pará is one of the North region states with the highest potential for Ephemeroptera species diversity. However, the overall diversity within the Amazon biome remains poorly understood due to various factors, including the scarcity of specialists in the region, insufficient investment in specialist training resources, and the challenges associated with accessing an extensive region (Cardoso et al. 2023).

Another significant challenge to understanding species diversity in Pará arises from human-induced degradation of ecosystems. Even within priority conservation areas like indigenous territories, there is a noticeable trend of progressive ecosystem degradation (Cardoso et al. 2023). This degradation is particularly concerning in areas lacking environmental protection measures, compounded by losses from deforestation. Therefore, there is an urgent need to prioritize undersampled taxa and localities to enhance our understanding of biodiversity. Additionally, it is crucial to emphasize the potential use of sensitive and threatened species in conservation efforts, thereby safeguarding both the species and their habitats (Cardoso et al. 2015, Principe et al. 2019).

Thus, we conducted the inaugural taxonomic survey of the Polymitarcyidae family in Western Pará. Our research delivers valuable insights into new records and geographic distribution within this region.

Material and Methods

1. Study area

The study was conducted from June 2019 to May 2024 across several municipalities in Western Pará, including Santarém, Alenquer, Oriximiná - Distrito de Porto Trombetas, Terra Santa, Monte Alegre, and Óbidos, covering a total of 11 locations (Table 1). The region features a tropical monsoon climate, characterized by an average temperature of 25.6°C, an average relative humidity of 80%, and annual rainfall of 2,000 mm (Fapespa 2015, De Andrade 2017).

The sampled locations encompassed the Tapajós and Lower Amazonas hydrographic regions, focusing on the main rivers such as the Amazon, Tapajós, and Trombetas. In addition to these major rivers, the study also included sampling from lakes and streams.

2. Collection, identification and illustration

The Polymitarcyidae nymphs were collected with the aid of an aquatic entomological net in D (rapiché) and sieves, both with a 1 mm mesh opening (Merrit & Cummins 2008). These tools were

Table 1. Information on collection sites sampled in the study area.

Sites	Municipalities	Sites	Coordinates
S1	Santarém	Praia da Ufopa	02°25'01.7"S 54°44'33.8"W
S2	Santarém	Igarapé do Costa	02°15'14.5"S 54°38'52.2"W
S3	Oriximiná	Rio Trombetas (porto)	01°27'38.8"S 56°22'39.8"W
S4	Oriximiná	Ig. Araticum	01º47'10.1"S 56º27'50.3"W
S5	Alenquer	Rio amazonas (Nova Aurora)	02°00'59.7"S 54°50'11.6"W
S6	Alenquer	Rio amazonas (Valmir)	02°00'29.4"S 54°54'26.4"W
S7	Óbidos	Paraná do Amador	02°04'33.6"S 55°18'14.0"W
S8	Terra Santa	Terminal Hidroviário	02°06'39.3"S 56°29'25.4"W
S9	Terra Santa	Ig. Macarrão – Flona Saracá-Taquera	01º51’29.5”S 56º27'45.9"W
S10	Terra Santa	Ig. Macarrão II – Flona Saracá-Taquera	01º51’41.8”S 56º27'45.3"W
S11	Monte Alegre	Ig. Lagoa Azul	01°51’03.1”S 54°02’43.9”W

systematically dragged across various substrates, including marginal vegetation, sponges, and submerged logs.

The alates were collected at dusk using a white sheet illuminated with a 15W emergency lamp connected to a 12V battery, along with a Pennsylvania-type trap. After collection, the imagos were preserved in vials containing 80% ethyl alcohol (Edmunds et al. 1976), while the subimagos were maintained alive in plastic microtubes until imagos emerged.

Species identifications were conducted using dichotomous keys (e.g., Domínguez et al. 2006) and supplemented with updated bibliographic references on the group (e.g., Molineri & Emmerich 2010, Molineri & Salles 2013, Molineri et al. 2015, Molineri & Salles 2017). For nymph identification, some structures such as mouthparts, legs, and gills were examined under an optical microscope. Adult specimens were examined for features including wings, legs, and male genitalia. Wings were mounted between a slide and coverslip without mounting medium and sealed with adhesive tape. Genitalia were inserted between the slide and coverslip using Hoyer's mounting medium and then dried in an oven at 60°C for two days to produce permanent slides (Edmunds et al. 1976).

For the photographs, a digital camera connected to a stereomicroscope was employed, alongside a computer equipped with the Leica Application Suite programs (Version 2019). Additionally, a Zeiss Axiocam ERc 5s photomicroscope contributed to image capture. The Combine ZP program was used to assemble the layer overlays. Subsequently, the photographs were edited into plates using the Adobe Photoshop CS6® program.

3. *Map construction*

The map illustrating the geographic distribution of Polymitarcyidae species in the study area was constructed using QGIS (v. 3.30.2-'s-Hertogenbosch) with Shapefile files sourced from Brazil and the state of Pará (see Figure 1).

4. *Bibliographic survey and geographic distribution*

The bibliographical survey and compilation of species' geographic distribution were sourced from the Brazilian Fauna Taxonomic Catalog (http://fauna.jbrj.gov.br/), EPHEMBRAZIL (https://ephembrazil.netlify.app/grid_all), Ephemeroptera from South America (http://ephemeroptera.com.br/), as well as specific articles.

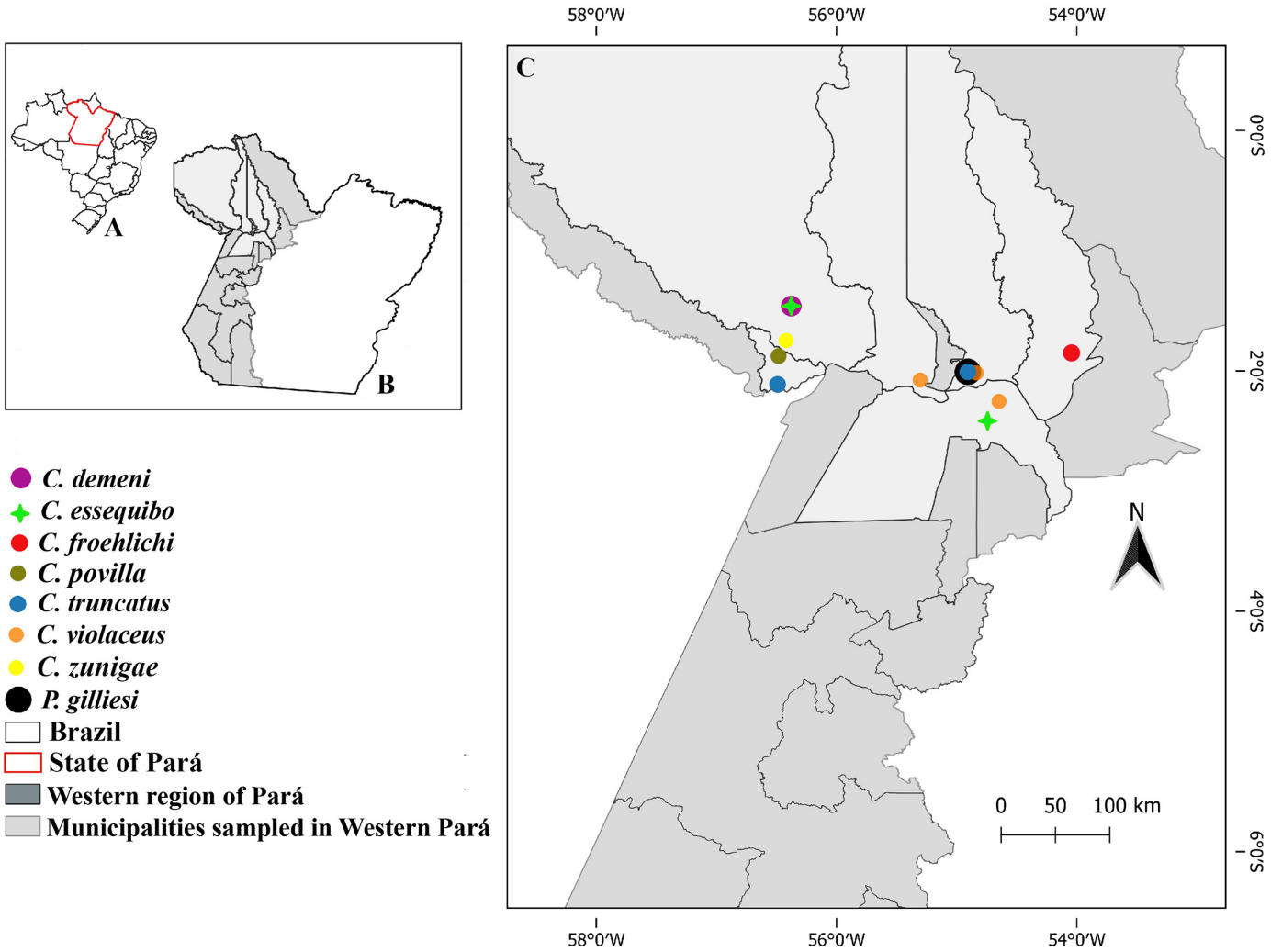

Figure 1. (A–C) Maps with distributional data. (A) Map of Brazil highlighting the Pará State. (B) Map of Pará with the western region of Pará in detail. (C) Distribution of Polymitarcyidae species in Western Pará.

Results

The inventory resulted in the compilation of three genera and 13 species of Polymitarcyidae for the State of Pará, including six new records. Notably, this includes the first record of the genus *Priasthenopus* in the region. Table 1 provides geographic information for the described locations (S) in the examined material.

Checklist and new geographical records

***Asthenopus curtus* (Hagen, 1861)**

Geographic distribution. North: Amazonas (Molineri et al. 2015), Pará (Hagen 1861).

Comment. Species previously recorded for the state of Pará by Hagen (1861), however without details of the type locality.

***Priasthenopus gilliesi* (Domínguez, 1988)**

Figure 2A–B

Material Examined. One ♂ imago, S6, 04/vii/2023, L.A. Oliveira and S.E. Santos cols.

Geographic distribution. North: Amazonas (Domínguez 1988), Roraima (Salles et al. 2023)**. New record of the genus and species for the state of Pará.**

***Campsurus albifilum* (Walker, 1853)**

Geographic distribution. North: Amazonas (Molineri & Salles 2013), Pará (Walker 1853). Midwest: Mato Grosso do Sul (Molineri & Salles 2013). Southeast: Rio de Janeiro (Navás 1916). South: Paraná (Molineri & Salles 2013).

Comment. Species previously recorded for the state of Pará by Walker (1853), however without details of the type locality.

***Campsurus demeni* Molineri & Salles, 2017**

Figure 2C–D

Material Examined. Six ♂ imagos, S3, 09/ii/2024, L.A. Oliveira col.

Geographic distribution. North: Acre (Molineri & Salles 2017), Amazonas (Molineri & Salles 2017), Roraima (Molineri & Salles 2017). **New record of the species for the state of Pará.**

***Campsurus essequibo* Traver, 1947**

Material Examined. 42 ♂ imagos, S1, 13/xii/2022, S.E. Santos and A.S. Corrêa cols.; same data as preceding except 33 ♂ imagos and 12 ♀ imagos, 21/ix/2023, L.A. Oliveira and A.S. Corrêa cols. 43 ♂ imagos, S3, 09/ii/2024, L.A. Oliveira col.

Geographic distribution. North: Amazonas (Molineri & Salles 2017), Pará (Molineri & Salles 2017), Roraima (Molineri & Salles 2017).

***Campsurus froehlichi* Cruz, Molineri & Hamada, 2022**

Figure 2E–F

Material Examined. 13 ♂ imagos and eight ♀ imagos, S11, 28-29/v/2023, L.A. Oliveira and S.E. Santos cols.

Geographic distribution. North: Amazonas (Cruz et al. 2022), Amapá (Cruz et al. 2022). **New record of the species for the state of Pará.**

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

Geographic distribution. North: Pará (Walker 1853), Tocantins (Molineri & Salles 2017). Southeast: Espírito Santo (Salles et al. 2010).

Comment. Species previously recorded for the state of Pará by Walker (1853), however without details of the type locality.

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

Geographic distribution. North: Pará (Oliveira et al. 2023), Roraima (Molineri & Salles 2017). Midwest: Mato Grosso do Sul (Molineri & Salles 2017). South: Santa Catarina (Ulmer 1942).

Comment. Species previously recorded for the state of Pará by Oliveira et al. (2023) for the metropolitan region of Santarém.

***Campsurus segnis* Needham & Murphy, 1924**

Geographic distribution. North: Amapá (Cruz et al. 2022), Pará (Needham & Murphy 1924).

Comment. Species previously recorded for the state of Pará by Needham & Murphy (1924) for the municipality of Igarapé-Açu.

***Campsurus truncatus* Ulmer, 1920**

Figure 2G–H

Material Examined. 15 ♂ imagos, S6, 06-07/vii/2023, L.A. Oliveira col. Five ♂ imagos, S8, 04/v/2023, S.E. Santos col.

Geographic distribution. North: Amazonas (Molineri et al. 2015). North East: Bahia (Lima et al. 2016), Pernambuco (Lima et al. 2015), Piauí (Takiya et al. 2016). Midwest: Goiás (Raimundi 2019). Southeast: Espírito Santo (Ulmer 1920), Minas Gerais (Molineri et al. 2015), Rio de Janeiro (Pereira & Da Silva 1991), São Paulo (Molineri et al. 2015). **New record of the species for the state of Pará.**

***Campsurus violaceus* Needham & Murphy, 1924**

Material Examined. 41 ♂ imagos, S2, 14/vii/2023, S.E. Santos col. 213 ♂ imagos, S5, 04-05/vii/2023, S.E. Santos and L.A. Oliveira cols. 77 ♂ imagos and 15 ♀ imagos, S6, 04-07/vii/2023, S.E. Santos and L.A. Oliveira cols. 19 ♂ imagos and 10 ♀ imagos, S7, 28/v/2023, S.E. Santos col.

Geographic distribution. North: Amazonas (Molineri et al. 2015), Pará (Demoulin 1955). North East: Piauí (Takiya et al. 2016). Midwest: Goiás (Raimundi 2019), Mato Grosso do Sul (Molineri et al. 2015), Mato Grosso (Molineri et al. 2015).

***Campsurus povilla* Molineri & Salles, 2017**

Figure 2I–J

Material Examined. Eight ♂ imagos, S9, 13/v/2024, L.A. Oliveira and S.E. Santos cols. Three ♂ imagos, S10, 14/v/2024, L.A. Oliveira and S.E. Santos cols.

Geographic distribution. North: Amazonas (Molineri & Salles 2017). Midwest: Goiás (Molineri & Salles 2017). **New record of the species for the state of Pará.**

***Campsurus zunigae* Molineri & Salles, 2017**

Figure 2K–L

Material Examined. 19 ♂ subimagos, S4, 14-15/v/2024, L.A. Oliveira and S.E. Santos cols.

Geographic distribution. North: Amazonas (Molineri & Salles 2017), Roraima (Molineri & Salles 2017). North East: Bahia (Molineri & Salles 2017). Midwest: Mato Grosso do Sul (Molineri & Salles 2017). **New record of the species for the state of Pará.**

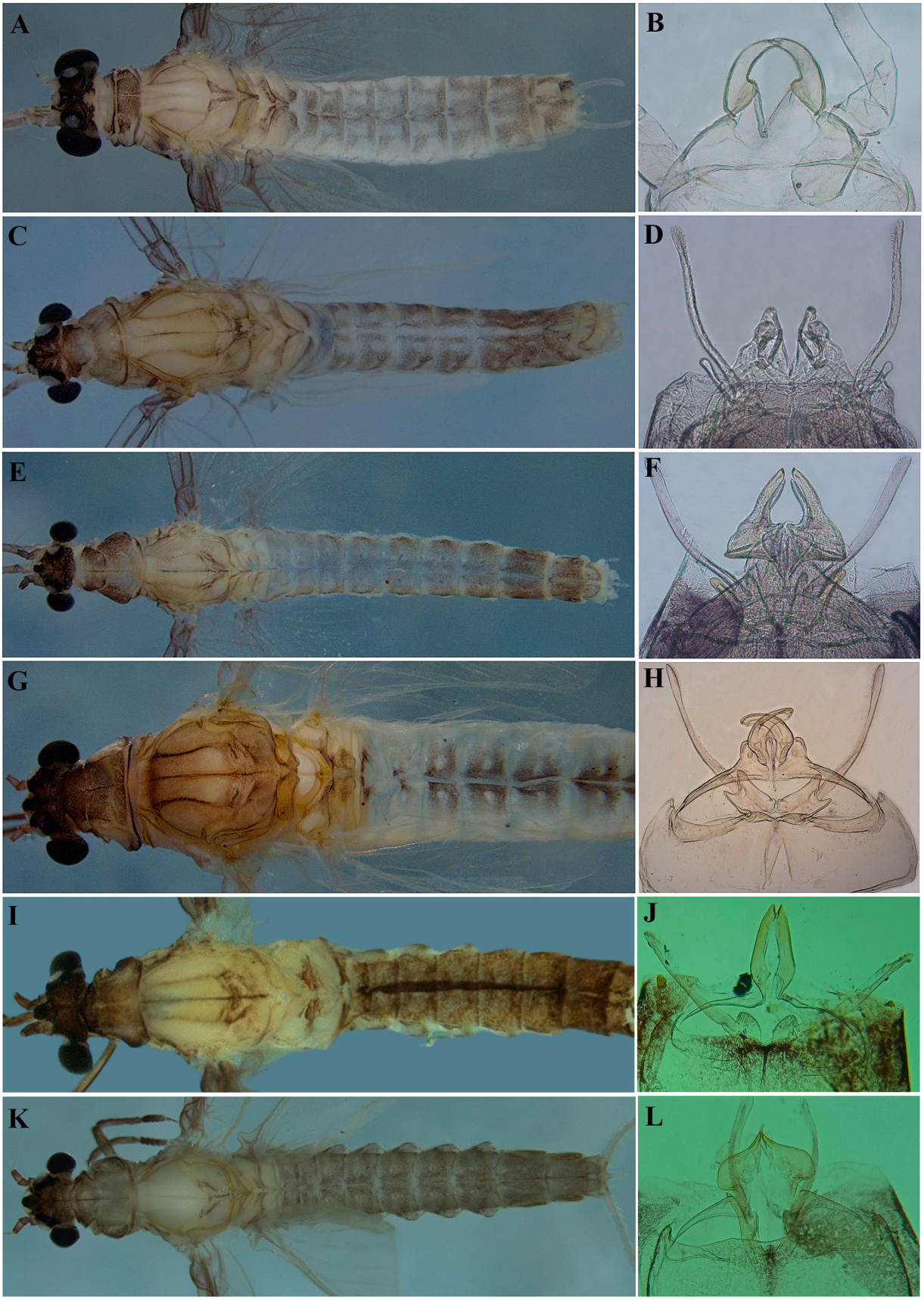

Figure 2. Male imagos of Polymitarcyidae (Ephemeroptera) recorded for the first time in Pará State. (A-B) *Priasthenopus gilliesi*, male imago. (A) Dorsal view. (B) Genitalia. (C–D) *Campsurus demeni*, male imago. (C) Dorsal view. (D) Genitalia. (E–F) *Campsurus froehlichi*, male imago. (E) Dorsal view. (F) Genitalia. (G–H) *Campsurus truncatus*, male imago. (G) Dorsal view. (H) Genitalia. (I-J) *Campsurus povilla*, male imago. (I) Dorsal view. (J) Genitalia. (K–L) *Campsurus zunigae*, male imago. (K) Dorsal view. (L) Genitalia.

Discussion

The bibliographic survey initially identified only seven species, distributed across two genera in Pará. Our study has expanded the state's representation to 13 species spanning three genera. Among the collections, *Campusurus violaceus* emerged as the most abundant species (n = 375), while *Priasthenopus gilliesi* was the least abundant, with only one individual recorded. In terms of geographic distribution, only *C. froehlichi*, *C. demeni*, *C. povilla*, *C. zunigae* and *P. gilliesi* were found to be restricted to a single municipality.

Currently, Pará ranks as the third state with the highest number of Polymitarcyidae records in the North region, trailing behind Amazonas and Roraima (Salles et al., 2024). Following our study, there has been 86% increase in the number of Polymitarcidae species documented for the state. This increase elevates Pará to the second-best sampled state in the region.

Priasthenopus gilliesi, *Campsurus demeni*, *Campsurus froehlichi*, *Campsurus truncatus*, *Campsurus povilla* and *Campsurus zunigae* were the species highlighted as new records for Pará. These species exhibit limited geographical distribution, with some restricted to the northern region, except for *C. truncatus*, which has a broader distribution throughout the country but had not been previously recorded in the state (Salles et al. 2024). This underscores the importance of regular sampling efforts and the expansion of survey areas, as it helps to reduce the Wallacean shortfall (Cardoso et al. 2015).

Pará stands out among states requiring priority surveys for Ephemeroptera, given its areas characterized by low sampling effort and high potential for discovering new species (Cardoso et al. 2023). Furthermore, many areas are unprotected by the arc of deforestation, which accelerates habitat degradation and puts biodiversity at risk (Veríssimo & Pereira 2014, Jacobus et al. 2019). According to Cardoso et al. (2015), despite certain well-studied groups, there remains a pressing need to revise estimates of taxon diversity due to the significant potential for new discoveries, the model predicts that 11,155 species of Ephemeroptera may occur in Brazil, of which 10,864 are not yet known. This is particularly true for Polymitarcyidae, which remain understudied across various Brazilian regions (Ottoni et al. 2009).

Thus, geographic distribution surveys play a crucial role in advancing our understanding of species, particularly those threatened or vulnerable to anthropogenic effects. This is especially pertinent for the species highlighted in this study, as many of them currently have limited distribution across the country.

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José Mermudes

Author Contributions

Amanda da Silva Corrêa: contributed to data collection, species identification and writing of the article.

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

Lucas Ramos Costa Lima: contributed to the identification of the species and writing of the article.

Sheyla Regina Marques Couceiro: contributed to data collection 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.

Ethics

This study did not involve human beings and/or clinical trials that should be approved by one Institutional Committee.

Data Availability

The data used in our analysis is available at Biota Neotropica: https://doi.org/10.48331/scielodata.OBROHU

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