Biota Neotropica 24(2): e20241620, 2024
www.scielo.br/bn

biotaneotropica
ISSN 1676-0611 (online edition)

Inventory

Dragonflies (Insecta, Odonata) from northeast Santa Catarina and notes on the occurrence of species in the region

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CALVÃO, L.B., PIRES, M.M., PÉRICO, E., JUEN, L. **Dragonflies (Insecta, Odonata) from northeast Santa Catarina and notes on the occurrence of species in the region**. Biota Neotropica 24(2): e20241620. https://doi.org/10.1590/1676-0611-BN-2024-1620

Abstract: We present a checklist of Odonata (Insecta) species occurring in streams in the municipality of Araquari, northeastern state of Santa Catarina (SC), southern Brazil. Five stream reaches were surveyed bi-annually from March 2016 to March 2018. Overall, we recorded 18 taxa (16 species) from 12 genera and four families. Coenagrionidae and Libellulidae were the most species-rich families (seven species each; 43% of the total number of species recorded each). *Idioneura ancilla* Selys, 1860, *Telagrion longum* Selys, 1876 (Coenagrionidae) and *Erythrodiplax umbrata* (Linnaeus, 1758) (Libellulidae) are recorded for the first time in the state of Santa Catarina. Species occurrence patterns were remarkably seasonal in the studied streams, with 70% of the species recorded in the summer only, and only 25% of the species occurring in both seasons at the same stream. Our findings revealed odonate communities with marked space-time interactions in species occurrence and contribute to understand odonate biology in subtropical streams in a human-dominated landscape, and also contribute to improve the knowledge on odonate distribution in South America.
Keywords: *Anisoptera; aquatic insects; Atlantic Forest; streams; Zygoptera.*

Libélulas (Insecta, Odonata) no nordeste de Santa Catarina e notas sobre a ocorrência de espécies na região

Resumo: Apresentamos uma lista de espécies de Odonata (Insecta) em riachos do município de Araquari, nordeste do estado de Santa Catarina (SC), sul do Brasil. Cinco riachos foram pesquisados semestralmente entre março de 2016 e março de 2018. Ao todo, registramos 18 taxa (16 espécies) de 12 gêneros e quatro famílias. Coenagrionidae e Libellulidae foram as famílias mais ricas em espécies (sete espécies cada; cada família com 43% do total do número de espécies). *Idioneura ancilla* Selys, 1860, *Telagrion longum* Selys, 1876 (Coenagrionidae) e *Erythrodiplax umbrata* (Linnaeus, 1758) (Libellulidae) são registradas pela primeira vez no estado de Santa Catarina. Os padrões de ocorrência das espécies foram notavelmente sazonais nos riachos estudados, com 65% das espécies registradas apenas no verão e apenas 25% das espécies ocorrendo em ambas as estações no mesmo riacho. Nossas descobertas revelaram comunidades de Odonata com interações espaço-temporais marcantes na ocorrência de espécies e contribuem para a compreensão da biologia de Odonata em riachos subtropicais em uma paisagem dominada pelo homem, e também contribuem para melhorar o conhecimento sobre a distribuição de Odonata na América do Sul.
Palavras-chave: *Anisoptera; insetos aquáticos; Mata Atlântica; riachos; Zygoptera.*

Introduction

Dragonflies and damselflies (order Odonata) are aquatic insects with great importance to the ecological functioning of freshwater ecosystems (May 2019). Although the highest proportion of species of Odonata is found in the Neotropical Region, with over 1700 resident species described (Kalkman et al. 2008; Olaya 2019), reviews on species diversity of the order in Brazil (the largest country of the region, covering ~50% of the South American continent) described a remarkable uneven distribution in studies on Odonata in the country, with only ~1/3 of the territory adequately surveyed (De Marco & Vianna 2005), a trend that still remains in the third decade of the 21st Century (Alves-Martins et al. 2024). Moreover, southern Brazil is one of the least well-studied regions regarding knowledge on the biology and ecology of Odonata (Miguel et al. 2017).

The state of Santa Catarina (SC) has the smallest territorial extension among the three states that comprise the southern region of Brazil (IBGE 2022). The original vegetation of the state entirely belongs to Atlantic Forest biome (IBGE 2004), which has been extensively converted across the state (covering less than 40% of the original

range in the state) (Projeto MapBiomas 2023). Although the number of studies on biology and diversity of odonates in southern Brazil has sharply increased recently, they are mostly concentrated in the states of Rio Grande do Sul and Paraná (Araujo & Pinto 2021; Dalzochio et al. 2018; Pires et al. 2019; Renner et al. 2017). The knowledge of species distribution and life-history in the state of Santa Catarina is by far the most incipient in the region, and, despite recent studies on larval ecology across the state (Pires et al. 2020; Siegloch et al. 2018), the large majority of the current literature on the order Odonata in the state is restricted to taxonomic descriptions and do not provide information about the ecology or life-history patterns of species of the order (Pires & Périco 2024).

Here, we provide a checklist of the species of Odonata occurring in streams from the Atlantic Forest in the state of Santa Catarina. We also investigated seasonal patterns of species occurrence in the study area to improve our knowledge of odonate biology in forest streams from southern Brazil.

Material and Methods

1. Study area

This study was conducted in the municipality of Araquari (central coordinates: 26° 22′ 13″ S; 48° 43′ 24″ W), northeastern region of the state of Santa Catarina (SC), southern Brazil (Figure 1A, B). Streams running through the municipality drain into the Itapocu river basin (belonging to the South Atlantic Basin hydrographic region) (Steinbach et al., 2015). Climate in the area is Cfa according to Köppen classification system (temperate humid and warm summers), with annual precipitation ranging between 1000–1500 mm and annual average temperatures of 20 °C (Marques et al. 2004; Steinbach et al. 2015). The original vegetation in the Itapocu river basin belongs to the Atlantic Forest biome, and in the study area, it is mostly characterized by the Lowland Dense Ombrophylous Forest, of the Submontane Formation type (Holler & Tomaselli 2015). Currently, most part of the watershed is under intense anthropic influence and covers a great variety of human activities, from agricultural (e.g., irrigated rice) to urban uses, but also includes mining and industrial activities (Marques et al. 2004, Antunes & Constante 2016).

2. Study sites

Five collection events of adult odonates were carried out from March 2016 to March 2018 at five stream reaches in the study area (Figure 1C and 2; Table 1).

3. Sampling methods and laboratory procedures

We used the fixed-area scanning method to actively collect adults of Odonata. In this method, a 100-meter section is delimited on the margin of the aquatic system, which is subdivided into 20 five-meter segments; The segments are named from A to K to facilitate the identification of

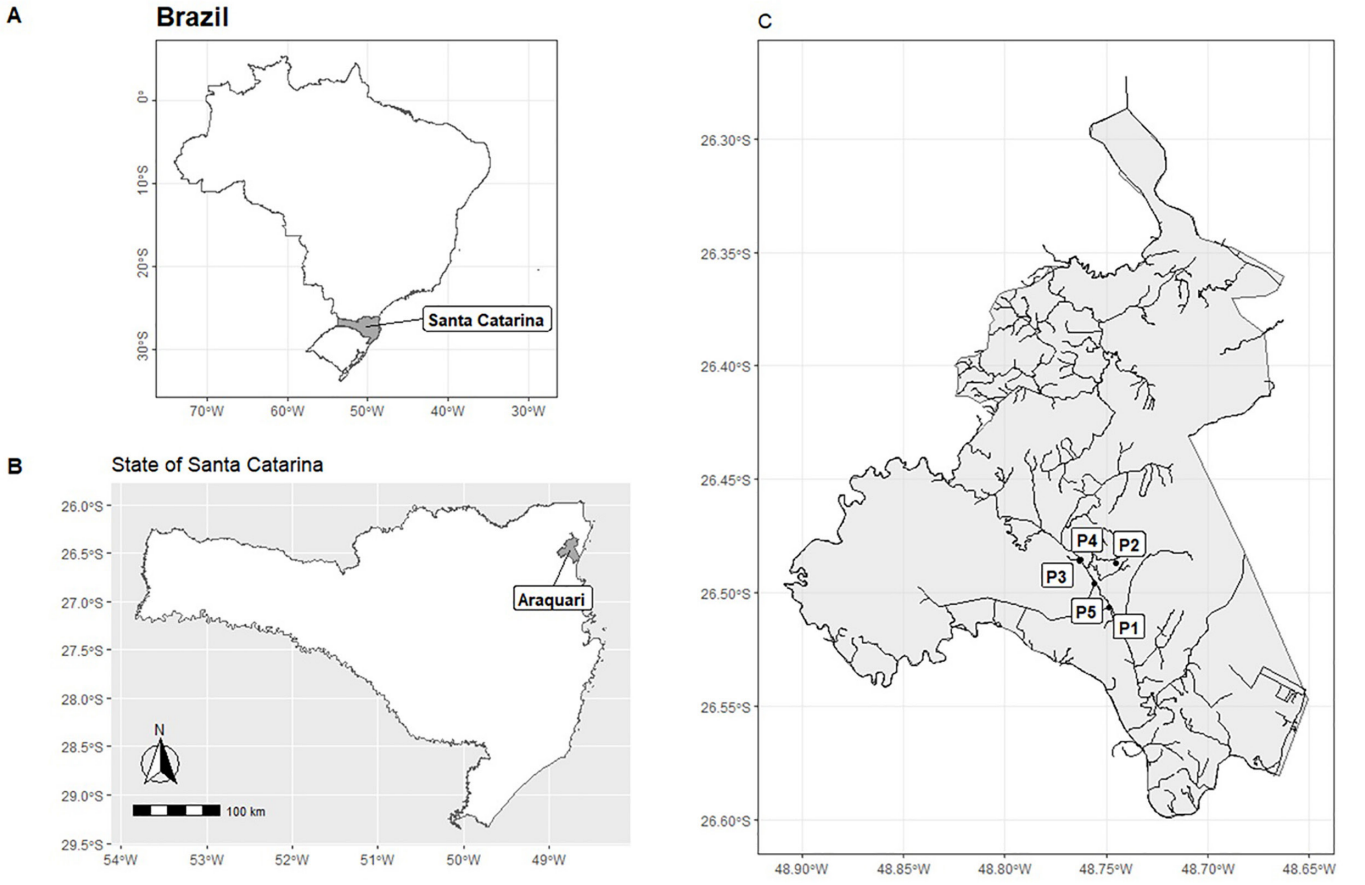

Figure 1. Location of the study area and sampling sites in Araquari municipality, Northeast Santa Catarina.

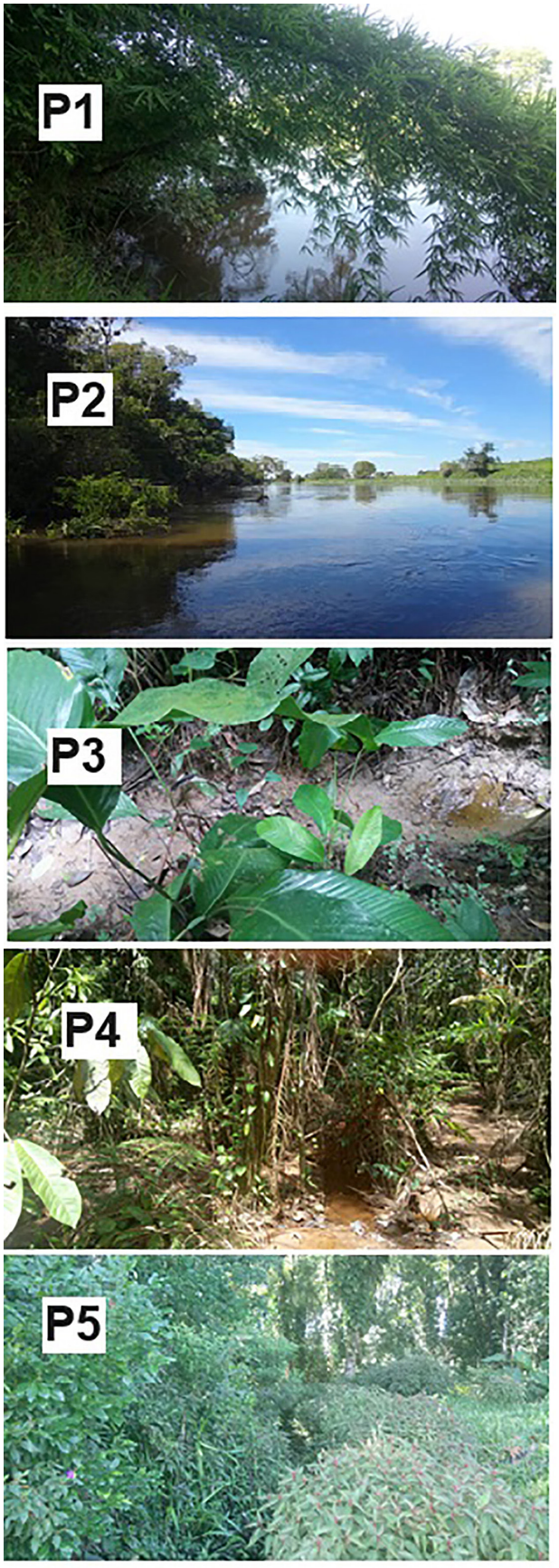

Figure 2. Photographs of the sampling sites in Araquari municipality, Northeast Santa Catarina.

Table 1. Geographical location of the study sites (UTM coordinate system; Datum WGS84).

Site	Latitude	Longitude
P1	–26.495	–48.755
P2	–26.505	–48.748
P3	–26.485	–48.762
P4	–26.488	–48.743
P5	–26.484	–48.752

segments (subsamples) at the time of collection (Figure S1). This method has been used successfully by several authors for both Odonata (Juen & Marco Jr. 2011; Oliveira-Júnior et al. 2015). To identify specimens, we used specialized taxonomic keys publications specialized in Zygoptera (Heckman 2008; Lencioni 2005, 2006) and Anisoptera (Garrison et al. 2006; Heckman 2006). The adults used in the analyzes are only males, as the systematic identification keys are directed to this group. Voucher specimens are deposited in the Scientific Didactic collection of the Zoology Museum of the Federal University of Pará (MZUFPA), Belém, Pará, Brazil (for code numbers, see 'Data availability statement').

4. Data compilation and data analyses

We carried out additional cross-examinations with valid records available in the following data sources: the Taxonomic Catalog of the Brazilian Fauna (Pinto 2024), as well as checklist of specific families and genera of South America (Ellenrieder & Garrison 2008a, 2008b; Pessacq et al. 2012).

We computed sampling completeness estimates and a species accumulation curve for the study area (generated after 500 random permutations), calculated for the total number of samples (25 = five stream reaches x five collection events). We used ordination diagrams based on principal coordinate analysis (PCoA) to analyse seasonal patterns of flight activity of the species in the study area. This analysis was based on a dissimilarity matrix (Euclidean coefficient) of the Hellinger-transformed taxa composition (abundance-based). In this step, we assigned collection events into two major categories taking into account the temperature regime of the region: collections conducted in September or October (winter and early spring) were labelled as 'winter', and collections carried out in March, as 'summer'.

All analyses were carried out in the R statistical environment (R Core Team 2023). Species accumulation curve and sampling completeness were calculated with the functions available in the iNEXT package (Hsieh et al. 2016), and the ordination diagram, with functions from the vegan package (Oksanen et al. 2022).

Results and Discussion

1. Diversity and composition of Odonata species in the study area

We collected 165 specimens from 18 taxa over the study period, including 16 species from 12 genera and four families (and eight specimens assigned to genus level only) (Table 2). The number of species recorded here corresponds to 13% of the total number of species of Odonata mentioned up to the moment for the state of SC (Pires & Périco 2024). Although the observed diversity might seem low at first, the overall richness (~20 species) was similar to streams in the fragmented Atlantic Forest in

Table 2. Composition of species of Odonata recorded in the studied streams.

Suborder/Family/Species	P1	P2	P3	P4	P5	Total	Conservation status
Anisoptera							
Libellulidae							
Erythemis sp.		1				1	
Erythrodiplax atroterminata Ris, 1911	1				1	2	Least Concern
Erythrodiplax fusca (Rambur, 1842)	8	5	16	3	8	40	Least Concern
Erythrodiplax media Borror, 1942	5				2	7	Least Concern
Erythrodiplax umbrata (Linnaeus, 1758)	5	1				6	Least Concern
Micrathyria hypodidyma Calvert, 1906			2			2	Least Concern
Orthemis ambinigra Calvert, 1909			7			7	Least Concern
Pantala flavescens (Fabricius, 1798)		2			1	3	Least Concern
Zygoptera							
Calopterygidae							
Hetaerina rosea Selys, 1853	3			1		4	Least Concern
Coenagrionidae							
Acanthagrion gracile (Rambur, 1842)	1		7	1	23	32	Least Concern
Acanthagrion lancea Selys, 1876	9	2	2	6	22	41	Least Concern
Aceratobasis macilenta (Rambur, 1842)				3		3	Least Concern
Idioneura ancilla Selys, 1860				3	2	5	Least Concern
Ischnura capreolus (Hagen, 1861)					1	1	Least Concern
Ischnura fluviatilis Selys, 1876					1	1	Least Concern
Ischnura sp.1			1		6	7	
Telagrion longum Selys, 1876			1			1	Least Concern
Lestidae							
Lestes pictus Hagen in Selys, 1862				2		2	Least Concern
Total	32	11	36	19	67	165	

southern Brazil using different methodologies and sampling efforts (Pires et al. 2019; Renner et al. 2016). It is thus likely that our results could be associated with the degree of anthropogenic disturbances in the target area. The studied section of the target watershed is characterized by urban land uses (Antunes & Constante 2016), which usually have strong effects on the local diversity of Odonata and favor the occurrence of generalist species (Monteiro-Júnior et al. 2014). In fact, 100% of the species recorded in the sampling sites fall under the 'Least Concern' category of conservation status, according to the IUCN (Table 2), indicating that generalist and widespread species were recorded in the study area.

Coenagrionidae and Libellulidae were the most species-rich families (seven species each; 43% of the total each). The most species-rich genera were *Erythrodiplax* Brauer, 1868 (Libellulidae) (four species), followed by *Acanthagrion* Selys, 1876 and *Ischnura* Charpentier, 1840 (Coenagrionidae) (two species each) (Table 2).

Libellulidae and Coenagrionidae added up to >80% of the species recorded in the study area, following the diversity pattern of odonate families observed in the Neotropics, as both families are the two most speciose families of Odonata (Kalkman et al. 2008). The observed dominance of species of Libellulidae and Coenagrionidae (which added up to more than 80% of the species in the study area) was also detected in streams draining both tropical (Anjos et al. 2023; Ferreira-Peruquetti & Marco Jr. 2002; Guedes et al. 2022; Venâncio et al. 2021) and subtropical regions of the Atlantic Forest biome in Brazil (Araujo & Pinto 2021; Pires et al. 2019; Renner et al. 2015).

In the study area, the diversity pattern observed for genera also agrees with previous studies. *Acanthagrion* and *Erythrodiplax* are among the most speciose genera in the Neotropics (Kalkman et al. 2008), and they have been generally reported as the most species-rich genera in inventories throughout the Brazilian territory (Koroiva et al., 2017; Souza et al. 2013; Vilela et al. 2016) , as well as in other studies conducted in Rio Grande do Sul (Pires et al. 2013; Renner et al. 2016).

2. New records

2.1. Idioneura ancilla *Selys, 1860 (Coenagrionidae)*

Idioneura ancilla (Coenagrionidae) is recorded for the first time in SC. Previous records of the species include the states of Bahia, Espírito Santo, Minas Gerais, Paraná and Rio de Janeiro (Pessacq et al. 2012). Therefore, our study represents the southernmost record of the species in the country.

2.2. Telagrion longum Selys, 1876 *(Coenagrionidae)*

This species is typical of the Atlantic Forest biome; in Brazilian territory, it was previously recorded in the states of Espirito Santo, Rio de Janeiro, São Paulo, and Rio Grande do Sul (Ellenrieder & Garrison 2008a).

2.3. Erythrodiplax umbrata *(Linnaeus, 1758) (Libellulidae)*

This species is widely distributed in the New World, occurring from USA (Craves & O'Brien 2018) to Argentina (Lozano et al. 2020) and widespread in Brazil. Previous records of the species in the country

included states from North, Northeast, and Southeast regions (Costa et al. 2001; Koroiva et al. 2020; Ribeiro et al. 2021) and the neighboring state of Rio Grande do Sul (Dalzochio et al. 2018).

3. Ecological notes

The sampling completeness was 0.973, and the species accumulation curve for all combined samples was close to stabilization, indicating that the asymptote was reached and that our sampling effort was sufficient to cover the species diversity in the study area (Figure 3). In relation to the target ecosystem (i.e., lotic waters), the patterns of environmental preferences of the recorded species were similar to those in the literature. Zygoptera species commonly associated with streams, e.g., *Hetaerina rosea* Selys, 1853 (Calopterygidae), *Aceratobasis macilenta* (Rambur, 1842), *I. ancilla* and *T. longum* (Coenagrionidae) were found in lotic environments, as previously found by authors (Ellenrieder & Garrison 2008a; Garrison et al. 2010). The two species from the remaining genera of Zygoptera (*Acanthagrion* Selys, 1876 and *Ischnura* Charpentier, 1840) and all species of Anisoptera are common to both lentic and lotic waters (Garrison et al. 2006, 2010).

4. Occurrence patterns

Here, thirteen species (~70%) were solely detected in the summer (Figure 4A, B). Previous studies on the temporal distribution of Odonata species in southern Brazilian streams also showed that the great majority of species were detected in warmer seasons (Pires et al. 2019). This result agrees with the general expectations that flying activity patterns of odonates depend on local climate and are strongly correlated with season distribution at low-temperate latitudes (Corbet 2004), such as southern Brazil.

Moreover, only four species (25%; *Orthemis ambinigra* (Calvert, 1909), *Pantala flavescens* (Fabricius, 1798), *A. gracile* (Rambur, 1842) and *A. lancea* (Selys, 1876)) were consecutively detected at the same stream (Figure 5A, B). Assuming that occurrence patterns of adults indicate odonate's life cycles (Corbet 2004), our results strongly suggest that few species were able to complete one or generation per year in the study area. This result agrees with the review on voltinism of odonates (Corbet et al. 2006), which suggests that most species of Odonata inhabiting streams in subtropical latitudes tend to produce one (or less) generation in a single year.

Nevertheless, a clear distinction was observed between suborders regarding seasonal patterns of activities: while most species of Zygoptera were detected in summer, most species of Anisoptera were detected in winter (Figure 4). Although this could be a reflex of the taxonomic affinity for early flight seasons in the temperate-centered species of Anisoptera (Corbet 2004) or the higher dependency on ectothermic species of Zygoptera as most species were detected at a single survey event at each stream (Figure 5A, B). This suggests the existence of space-time interaction, and therefore, that several drivers are affecting the community dynamics in the study area; These might include both immigration or variation in life-history patterns of each species (Corbet 2004) as well as the effect of local habitat conditions in species establishment, which are especially paramount in assembling odonate composition in streams (De Marco Júnior et al. 2015).

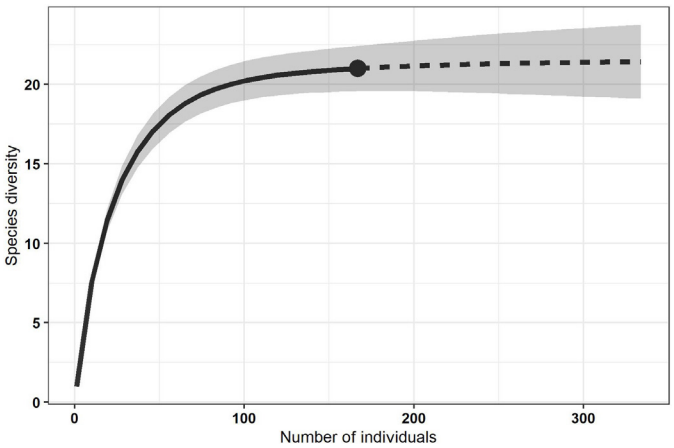

Figure 3. Species accumulation curve for the study region.

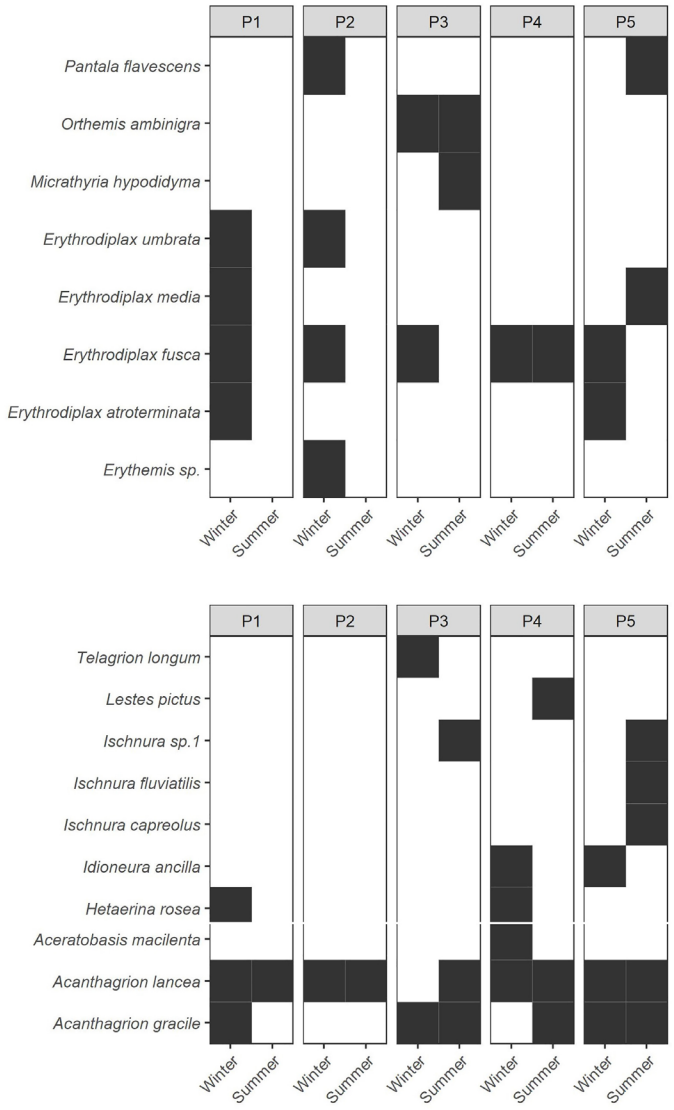

Figure 4. Heatmap indicating the species occurrence (dark squares) across collection events in each stream.

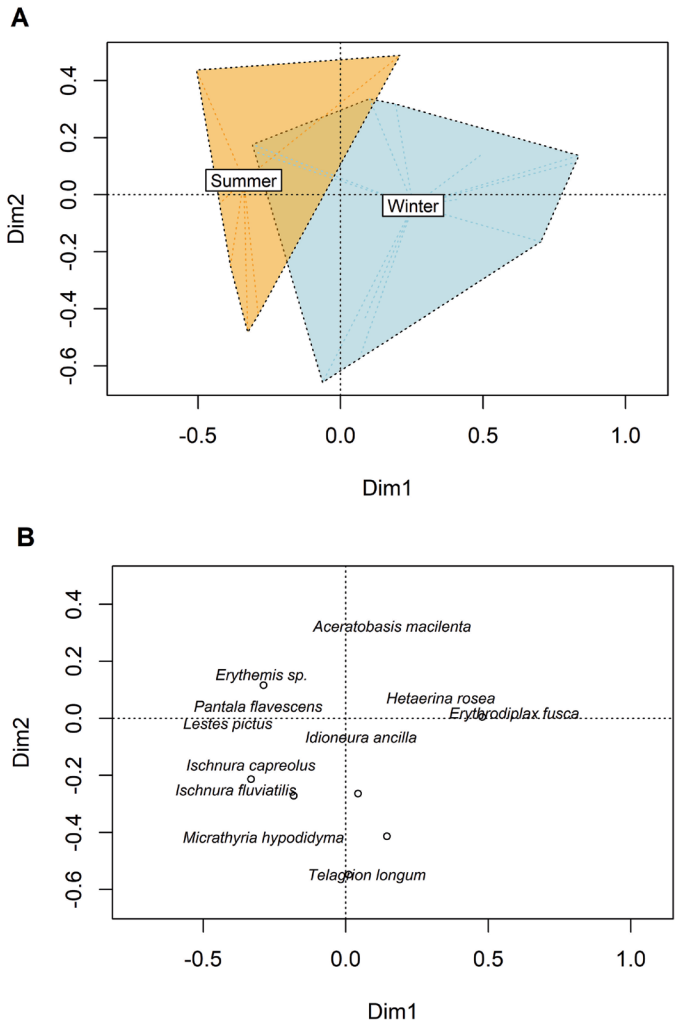

Figure 5. Ordination diagrams for species occurrence patterns in the study area across seasons in the study area.

Supplementary Material

The following online material is available for this article:

Figure S1 – Graphic display of the 100-m stretch demarcated in each stream for collection of adult odonates, subdivided into 20-m segments.

Acknowledgments

We are grateful to the team of Laboratório de Ecologia e Conservação of UFPA for help with specimen identification. LBC was supported by Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq). MMP was supported by CNPq and Fundação de Amparo à Pesquisa do Estado do Rio Grande do Sul (FAPERGS) with a postdoctoral scholarship (#150142/2023-4). We thank CNPq for providing a research productivity grant to EP (#304751/2022-7) and LJ (#304710/2019-9).

Associate Editor

Gustavo Graciolli

Author Contributions

Lenize Batista Calvão: contributed to investigation, methodology, data curation, visualization and manuscript preparation.

Mateus Marques Pires: contributed to conceptualization, formal analysis, software analysis, validation, visualization and manuscript preparation.

Leandro Juen: contributed to project supervision, funding acquisition, visualization and participated in the review and editing of the manuscript.

Eduardo Périco: contributed to project supervision, visualization and participated in the review and editing of the manuscript.

Conflicts of Interest

The author(s) declare(s) that they have 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

Data used in this work were deposited in a permanent repository in accordance with the instructions for authors. Data are available at <https://doi.org/10.48331/scielodata.17NMBG>.

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Received: 19/02/2024

Accepted: 14/06/2024

Published online: 19/07/2024