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Effects of phytoplankton blooms on aquatic macroinvertebrate assemblages in a tropical karst lake

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Article

Keywords: Lentic environments, Flooded cave, Functional feeding groups, Macrophyte-associated invertebrates

Posted Date: September 4th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10654493/v1

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Additional Declarations: No competing interests reported.

Abstract

The karst systems are characterized by a set features developed in water-soluble rocks, rich in limestone. Among these systems, we have the Lagoa Misteriosa, is marked annually by a unique phenomenon called a phytoplankton bloom: with the presence of algal blooms-WAB and absence of algal blooms-AAB. The study investigated whether the presence of a phytoplankton bloom influences the composition and functional groups-FFGs of macroinvertebrates. Six samplings were carried out over the course of a year, divided into two periods. Ecological descriptors were used to characterize the structure of the community. Ordination analysis was performed using NMDS and PERMANOVA. The physical and chemical parameters were correlated with values of aquatic macroinvertebrates using Redundancy Analysis. A total of 9,834 aquatic macroinvertebrates were sampled, representing 42 taxa from the phylum Platyhelminthes, Nematoda, Mollusca, Annelida, and Arthropoda. Among the FFGs, the most common were Predators and Collector-gatherer. Mollusks were dominant in both periods, while Ecological indices did not show significant differences between the periods and FFGs. The OD and pH parameters, the taxa Microcylloepus and Chironominae and the FFG Collector-gatherer are associated with the WAB period. While, the Hydrobiidae, water transparency, conductivity, TDS, and FFG Scraper are associated with the AAB period.

Introduction

Aquatic macroinvertebrates occupy various trophic levels in the food chain (Zepon et al. 2025) and, consequently, belong to different functional feeding groups - FFGs (Tomanova et al. 2008). They consist of various taxa that spend part or all of their life cycle in water, participating in energy flow and nutrient cycling (Gullan and Cranston 2012; Hamada et al. 2018; Ferreira et al. 2020; Santana et al. 2021). These organisms may be associated with various ecosystems, such as karstic lentic waters, where studies stand out in lakes across several countries in the European Alps (Boggero et al. 2006), in Croatia (Turić et al. 2011; Čmrlec et al. 2013), in Slovenia (Zelnik et al. 2018), and in the United States (Jain et al. 2020). In the Neotropical region, especially in Brazil, studies conducted in karst ecosystems are still in their infancy. Among the few available studies, those on macroinvertebrate communities (Taylor and Ferreira 2012), sponges (Machado et al. 2016), and aquatic beetles in cave systems (Zepon et al. 2025) stand out. However, knowledge of the distribution and ecology of macroinvertebrates in karstic lentic environments remains scarce (Vilenica et al. 2018a).

Karst systems are recognized as biodiversity hotspots, harboring numerous endemic, rare, and threatened species (Vilenica et al. 2018b; Simović et al. 2024). It is estimated that they occupy about 21% of continental areas (Bertoli et al., 2022; Simović et al., 2024) and between 3% and 5% of Brazilian ecosystems (Sallun-Filho and Karmann, 2007; Karman 2016). These systems are characterized by a set of morphological, hydrological, and hydrogeological features developed in water-soluble rocks, rich in limestone and highly permeable (Vilenica et al. 2018b; Vilenica et al. 2022; Stanković 2023; Búcan et al. 2025), which connect groundwater to the surface (Field et al. 2002; Ford and Williams 2007; Sallun-Filho and Karmann 2007; Rađa and Šantić 2014; Gary 2017; Cíbik et al. 2021).

In Brazil, the Serra da Bodoquena region stands out located in the Midwest, it is part of the Corumbá Group and boasts the largest known extent and occurrence of karstic underwater caves in the country (Sallun-Filho and Karmann 2007; Karmann 2016). Among the associated environments are karst lagoons, small lentic water bodies that collect and store rainwater and groundwater (Zelnik et al. 2012; Zelnik et al. 2018), as is the case with Lagoa Misteriosa.

Set within this geological and hydrological context, Lagoa Misteriosa is Brazil deepest flooded cave, with a known underwater depth of approximately 220 meters, though its total depth remains unknown (Sallun-Filho and Karman 2007; Coelho 2009; Scheffler et al. 2019). It is a karst sinkhole featuring vertical limestone walls, approximately 400 meters in diameter and 75 meters deep to the water level (Sallun-Filho and Karman 2007; Coelho 2009; Scheffler et al. 2019).

Lagoa Misteriosa is marked annually by a unique phenomenon called a phytoplankton bloom, which occurs during the hottest time of the year and the rainy season, from around October through March (Coelho et al. 2011; Scheffler et al. 2019). During this period, the lagoon's water takes on a greenish hue, and vertical visibility is around two meters (Scheffler et al. 2019). On the other hand, visibility reaches around 45 meters in depth during the dry and cooler season of the year, from April to August, when the waters become crystal clear with a blue hue (Scheffler et al. 2019), and the lagoon opens to tourism. Caldatto et al. (2025) classified these two periods in Lagoa Misteriosa as: with the presence of algal blooms (WAB) and absence of algal blooms (AAB). Its unique geological characteristics, biodiversity, and annual algal bloom cycles give this ecosystem a unique status in Brazil (Coelho et al. 2011; Scheffler et al. 2019).

Little is known about the aquatic macroinvertebrate community, its trophic groups, and its dynamics in Lagoa Misteriosa. The main studies in this environment are by Scheffler et al. (2019), who investigated the physicochemical variations of the water, phytoplankton, zooplankton, and climatological data; and by Caldatto et al. (2025), who analyzed the diet of a nektonic tetra, *Deuterodon luetkenii* Boulenger, 1887. In addition to these studies, other research directly addressing certain groups of macroinvertebrates in Lagoa Misteriosa includes Cordeiro et al. (2014), who identified the presence of *Potiicoara brasiliensis* Pires-Vanin, 1987, and Silva and Roche. (2007), who reported the occurrence of the freshwater cnidarian *Craspedacusta sowerbii* Lankester, 1880. Although karst ecosystems are distributed globally, studies on them remain scarce (Vysoká et al. 2019).

Given the potential impact of algal blooms on a tropical karst pond, the objective was to characterize the composition of the aquatic macroinvertebrate community associated with macrophytes in a tropical karst pond during two distinct periods: with the presence of algal blooms (WAB) and the absence of algal blooms (AAB). To this end, we sought to answer the following questions: (i) are there differences in the composition and richness of macroinvertebrates between the periods? (ii) do the feeding functional groups (FFGs) differ between the periods? (iii) which abiotic variables influence the composition and the FFGs?

The study investigated whether the presence of a phytoplankton bloom influences the composition and functional groups of macroinvertebrates. During the presence of algal blooms (WAB), greater richness and functional diversity of macroinvertebrates associated with macrophytes are expected, due to the greater availability of food resources. Our hypothesis is that the WAB period will show greater taxon richness and a higher prevalence of Scrapers and collector-gatherer. These functional groups are better adapted to being associated with the substrate, such as macrophytes, and their presence increases with food availability during the phytoplankton bloom.

Material and methods

Study area

The Lagoa Misteriosa Natural Cave is located in the central-western region of Brazil (21°27’32.63” S; 56°27’12.31” W), within the Paraguay River basin and situated in the karst landscape of the Serra da Bodoquena (Sallun-Filho et al. 2010), and designated as the Lagoa Misteriosa Protected Area (Brazil 2024). It is situated in a karst sinkhole and stands out for its surrounding vegetation and the crystalline blue of its waters (Coelho 2009; Coelho et al. 2011; Onary-Alves 2015), surrounded by tree vegetation of the seasonal deciduous forest and forested savanna phytophysiognomies (Coelho 2009). During the study period, minimum temperatures were recorded between may and august, with an average of 13,8°C; while the highest temperatures occurred between october and march, with an average of 30,8°C.

The Lagoa Misteriosa (Fig. 1) is formed by groundwater that rises to the surface and is recognized as the deepest flooded cave in Brazil. It forms a lagoon approximately 400 meters in diameter and 75 meters deep to the water level (Sallun-Filho and Karman 2007; Coelho 2009; Scheffler et al. 2019). In addition, it features an underwater cave more than 220 meters deep, although its total depth remains unknown (Sallun-Filho and Karman, 2007; Coelho 2009; Scheffler et al. 2019). Lagoa Misteriosa has a high biomass of macrophytes (Coelho 2009), which increase the number of meso-habitats and favor the diversity of associated macroinvertebrates (Heino 2000; Thomaz et al. 2008; Hassal et al. 2011; Ilg and Oertli 2014; Robin et al. 2014; Pompêo 2017; Aleixo et al. 2022).

Lagoa Misteriosa experiences two distinct periods throughout the year related to phytoplankton blooms and, consequently, water clarity. From september/october through april/may, algal blooms occur during the rainy season and the hottest time of the year, when the water turns greenish and has low transparency (Coelho et al. 2011; Scheffler et al. 2019) and exhibits a high density of aquatic plants. In the remaining months, the lagoon water has high transparency (Coelho 2009). During the months covered by this study, using the Secchi disk, the vertical water transparency in the WAB period averaged 4 meters, while in the AAB period it was 42 meters.

Sampling

Sampling was conducted every two months over the course of a year at three locations along the shores of Lagoa Misteriosa, divided into two periods: october and december 2021 and february 2022 (with the presence of algal blooms - WAB); april, june, and august 2022 (absence of algal blooms - AAB), for a total of six sampling events. In each sampling, nine macrophytes samples were collected, three on each shore, totaling fifty-four samples in the end.

For the collection of aquatic macroinvertebrates, samples of the fixed submerged macrophyte *Heteranthera zosterifolia* Martius, 1823, were used due to its high abundance at the site. This macrophyte was identified and deposited in the DDMS/UFGD Herbarium (catalog number 7825; code DDMS00007825). The macrophytes were placed in plastic bags, properly labeled, and preserved in a 4% formalin solution. At each sampling point, three measurements of the water's physicochemical parameters were taken: temperature (°C), dissolved oxygen concentration – OD (mg/L), conductivity (μS/cm), total dissolved solids – TDS, and pH, using the HANNA HI9829 multiparameter meter.

In the laboratory, the macrophytes were washed under running water, and the collected aquatic macroinvertebrates were retained in 500µm and 150µm sieves. The material was sorted under a stereomicroscope, and the individuals were preserved in 70% alcohol. Identification was performed to the lowest possible taxonomic level (genera and morphospecies) using specific identification keys (Segura et al. 2011; Hamada et al. 2018; Hamada et al. 2019). Identifications were confirmed by taxonomists specializing in the sampled groups. The macroinvertebrates were grouped into six functional feeding groups (FFGs), namely: collector-gatherer, collector-filterer, scraper, shredder, predator, and piercer (Tomanova et al. 2008). Photographs of the aquatic macroinvertebrates were taken using a camera lucida attached to a Leica DM1000 microscope, with rendering in Adobe Illustrator CS6®.

Density

The *H. zosterifolia* samples were then dried in an oven for 24 hours at 60°C. The plant residues were then weighed to determine their dry weight. Density was calculated by dividing the total number of individuals of the taxon per month by the total dry weight of the macrophyte per month (ind./g).

Data analysis

Ecological descriptors were used to characterize the structure of the aquatic macroinvertebrate community: species composition, taxonomic richness, density (Krebs, 1999), and FFGs (Tomanova et al. 2008). Subsequently, a t-test was applied to verify significant differences between the periods.

The data were normalized using the Hellinger transformation, and the distance matrix was calculated using the Bray-Curtis index. To visualize similarity patterns between the periods and the FFGs, an ordination analysis was performed using Non-Metric Multidimensional Scaling (NMDS) (Anderson 1971). To test for significant differences, Permutational Multivariate Analysis of Variance (PERMANOVA) was applied, with 999 permutations (Anderson 2008).

The physical and chemical parameters of the water (abiotic variables/predictor matrix) were correlated with the inter period density data and the FFGs values of aquatic macroinvertebrates (response variables) using Redundancy Analysis (RDA) (Oliveira et al. 2024). Next, an analysis of variance (ANOVA) was performed to test the significance of the RDA axes. The adjusted R^2 value was also obtained, which corrects for differences in the number of predictor variables and allows for future comparisons with other studies, explaining the percentage of variation in the biological matrix (Oliveira et al., 2024). The level of statistical significance adopted for all tests was $p < 0,001$. The analyses were performed using the vegan and ggplot2 packages, both in R software, version 4.3.2 (R Core Team 2023).

Results

Aquatic macroinvertebrate

A total of 9,834 aquatic macroinvertebrates were sampled, representing 42 taxa from the phylum Platyhelminthes, Nematoda, Mollusca, Annelida, and Arthropoda (Fig. 2; Table 1). Among the FFGs, the most common were Predators with 17 taxa and Collector-gatherer with 13 taxa. The phyla Mollusca and Arthropoda accounted for 98% of the observed density, with Mollusca accounting for 59% of this density, notably Hydrobiidae (44%) and Thiaridae, the latter associated with the presence of the exotic species *Melanoides tuberculata*.

With regard to arthropods, they consisted mainly of insects (29 taxa), accounting for 38% of the density and distributed across seven orders: Ephemeroptera, Odonata, Hemiptera, Coleoptera, Trichoptera, Lepidoptera, and Diptera. The order Coleoptera accounted for about two-thirds of the insect density (24%), consisting mainly of Elmidae (23%), distributed among the genera *Hexacylloepus* and *Microcylloepus*.

Algal bloom effect and abiotic data

The WAB period accounted for 51% of the density, distributed across 39 taxa, while the AAB period accounted for 49% of the density and 27 taxa. Mollusks were dominant in both periods, particularly Hydrobiidae, which stood out during the AAB period. On the other hand, insects showed higher density in the WAB period, mainly *Microcylloepus* and Chironominae.

Ecological indices did not show significant differences between the periods (Fig. 3a–h). Despite this, we observed a greater trend toward richness, collector-gatherer, predators, and piercer for the WAB period, and scrapers for the AAB period.

The pH and OD were higher during the WAB period, while the AAB period showed higher water conductivity, TDS, and transparency (ESM 1). The PERMANOVA performed based on NMDS showed a significant difference between the periods ($F = 7,34$; $p < 0,001$; $R^2 = 0,31$); and FFGs ($F = 20$; $p < 0,001$; $R^2 = 0,55$).

With regard to the RDA of macroinvertebrate density (Fig. 4a), only the first axis shows a significant difference ($F = 12,7$; $p < 0,001$; $R^2 = 41\%$). The OD and pH parameters are linked to the WAB period, positively correlated with the first axis and the *Microcylloepus* and Chironominae taxa. On the other hand, Hydrobiidae and the AAB period were linked to water transparency, conductivity, and TDS, which were negatively correlated with the first axis. The FFGs RDA (Fig. 4b) showed a significant difference only for the first axis ($F = 27,9$; $p < 0,001$; $R^2 = 60\%$), where OD and pH correlated positively, linked to the WAB period and the collector-gatherer. On the other hand, transparency, conductivity, and TDS correlated negatively with the first axis, being linked to the AAB period and the Scrapers.

Discussion

The results of this study demonstrate that seasonal phytoplankton blooms significantly influence the taxonomic and functional structure of the macroinvertebrate community in Lagoa Misteriosa. Although ecological indices did not show significant differences, an influence of the periods on the structure of the macroinvertebrate assemblage was observed, indicating that the physicochemical changes associated with the bloom act as important ecological filters. In aquatic ecosystems, phytoplankton blooms can alter the availability of food resources, water transparency, and habitat structure, directly influencing organisms associated with aquatic macrophytes (Dudley et al. 1986; Townsend 2024). Thus, nutrient input into these environments is higher during algal blooms, where high nutrient concentrations and low light penetration may occur due to low water transparency (Scheffler et al. 2019). In this context, the increased availability of resources during the WAB period may have favored groups functionally associated with the collection of resources deposited on the plant substrate.

The collector-gatherer and predators accounted for the highest FFAs densities in Lagoa Misteriosa, suggesting high resource availability and structural complexity of the habitat. Grazers are associated with the availability of fine particulate organic matter and periphyton (Merritt et al. 2014; Guo et al. 2018; Cummins et al. 2022; Nascimento et al. 2025; Rivera-Perez et al. 2026). On the other hand, predators feed on other invertebrates, regulating populations (Pintar et al. 2018; Rivera-Perez et al. 2026), and predator density is related to prey density (Tomanova et al. 2008; Veselý et al. 2017; Carbonnel et al. 2022; Ramos et al. 2025). Furthermore, aquatic plants provide a greater availability of macroinvertebrates for predation, allowing predators to associate with the complex structure of macrophytes to obtain food (Brito et al. 2021; Ramos et al. 2025).

Mollusks constituted the dominant taxonomic group in Lagoa Misteriosa, particularly the Hydrobiidae, whose high density may be associated with the typical characteristics of lentic environments (Sviben et al. 2024) and with high availability of dissolved carbonates (Lorencová et al., 2020). Species of this family are often strongly associated with periphytic substrates and aquatic macrophytes, using attached algae and organic detritus as their primary food sources (Lodge 1986; D'Agata et al. 2025; Jaszczyńska et al. 2025), and their presence in isolated environments is usually related to active dispersers, such as birds (Kappes and Haase 2012; Lorencová et al. 2020). The occurrence of the exotic species *Melanoides tuberculata*, recognized for its high invasive potential in tropical ecosystems, has also been recorded

(Farani et al. 2015; Okumura and Rocha 2020). The presence of this species warrants attention, as biological invasions can alter the trophic structure and compete with native species for space and food resources (Silva et al. 2019; Sánchez et al. 2020).

The Elmidae family represented the main group of insects in Lagoa Misteriosa, having been found in large numbers in studies conducted in karst aquatic environments (Taylor and Ferreira 2012; Stanković et al. 2015; Zepon et al. 2025) and in relation to rainy seasons (Luna-Luna et al. 2023). Elmidae are known as riffle beetles (Zepon et al. 2025) and true aquatic beetles, as they have both aquatic nymphs and adults (Jäch 1998; Jäch and Balk 2008), with few species common in lentic environments (Jäch and Balk, 2008). The high thermal stability in Lagoa Misteriosa (Coelho 2009; Scheffler et al. 2019) may favor the establishment of the larvae of these aquatic beetles throughout the year (Nair et al. 2023). Adults possess hydrophobic pubescence that functions as a gill plate, allowing for oxygen absorption from the water and survival in these environments (Kodada et al. 2014; Stanković et al. 2015; Luna-Luna et al. 2023). Some recent studies have provided new information on this taxon, which is uncommon in lentic environments, although data on it in Brazil remain scarce (Polizei et al. 2022; Zepon et al. 2025). It is worth noting that the Elmidae recorded in this study correspond to species not yet described, reinforcing the potential of tropical karst ecosystems as important reservoirs of little-known aquatic biodiversity.

The physicochemical variables of the water exerted a strong influence on the taxonomic and functional composition of the macroinvertebrate community across the study periods. The RDA analysis showed that OD and pH were more strongly associated with the WAB period, while water transparency, conductivity, and TDS characterized the AAB period. We know that warmer periods have higher OD levels due to the photosynthetic activity of macrophytes (Ramos et al. 2025), we also note that these environments typically exhibit little variation in water temperature throughout the year (Scheffler et al. 2019), and that warmer months exhibit higher levels of OD saturation (Coelho 2009).

In karst environments, the high transparency of the water and its carbonate rich chemical composition are distinctive environmental characteristics (Piló 2000; Medeiros et al. 2020). These characteristics are typical of karst regions with crystal-clear waters, due to the formation of complexes between suspended materials and dissolved carbonates (Scheffler et al. 2009). However, seasonal phytoplankton bloom events can temporarily alter these conditions, affecting light penetration, periphyton availability, and ecological interactions associated with aquatic macrophytes. Thus, the results suggest that the seasonal dynamics of the bloom act as an important structuring factor for the macroinvertebrate community of Lagoa Misteriosa.

The AAB period showed a stronger association with Hydrobiidae and scrapers, indicating that clearer environments may favor organism's dependent on periphyton attached to the substrate. Thus, evidencing its response to high water transparency (Brönmark 1985; Mattson et al. 1995; Hoverman et al. 2011; Lorencová et al. 2020; Vilenica et al. 2024) and a negative response to pH (Wei et al. 2022). This family is highly diverse in freshwater aquatic ecosystems (Delicado et al. 2023), includes many endemic species living in isolated environments (Wilk and Delicado 2019; Delicado et al. 2025), are

predominant in groundwater (Wilk and Delicado 2019; Delicado et al. 2023), and feed primarily by scraping algae attached to the substrate (Martello et al. 2008; Taylor and Ferreira 2012; Miranda and Perissinotto 2014; Raw et al. 2016; Pintar et al. 2018; Rivera-Perez et al. 2026). The high abundance of this group suggests strong adaptation to the environmental conditions typical of the studied karst ecosystem.

In contrast, the WAB period was associated with an increase in *Microcylloepus* and Chironominae, as well as higher average OD and pH values. *Microcylloepus* larvae are generally collector-gatherers, but may exhibit distinct feeding habits depending on food availability (Braun et al. 2017; Hamada et al. 2019; Zepon et al. 2025). These beetles are more abundant during rainy periods, which bring in more sediment, favoring collectors (Meritt et al. 2014; Luna-Luna et al. 2023) and are more strongly influenced by temperature and OD (Luna-Luna et al. 2023). With food sources available in abundance and constant temperatures, their life cycle can be completed in a short period of time (Luna-Luna et al. 2023), and they are associated with aquatic macrophytes (Luna-Luna et al. 2022; Luna-Luna et al. 2023). Furthermore, few studies have been conducted on this taxon in these ecosystems (Zepon et al. 2026), and even fewer discuss niche differentiation among Elmidae (Martins & Ferreira 2020).

As members of the Chironominae, they are typically the most common and abundant insects in aquatic environments (Boggero et al. 2006; Ivković et al. 2015; Aleixo et al. 2022), such as in karst spring systems (Ivković et al. 2015). The larvae are capable of consuming a variety of food resources (Silva and Henry 2018; Hamada et al. 2018), associated with the decomposition of organic matter (Silva and Henry 2018); they are generally collector-gatherer but can also be filter (Hamada et al. 2018). Their abundance can be influenced by water transparency, oxygen, temperature, macrophyte structure, and available food resources (Čerba et al. 2010; Kukuryk 2014), where the accumulation of organic matter tends to increase their presence (Bućan et al. 2025), as do aquatic macrophytes, which provide shelter and food resources (Butakka et al. 2014). These results reinforce the hypothesis that seasonal changes in resource availability directly influence the functional organization of the community.

The aquatic macrophytes likely play a central role in shaping the macroinvertebrate community of Lagoa Misteriosa. We observed that the density of submerged macrophytes was higher during the WAB period, but over time they began to break loose, and by the AAB period, macrophyte density was low. We know that macrophytes are essential for the functioning and balance of the ecological state in karst environments (Zelnik et al. 2018), where their diversity depends on environmental quality and influences the functioning of freshwater environments (Zelnik et al. 2018; Thomaz et al. 2025) and the diversity of aquatic macroinvertebrates (Zelnik et al. 2018). The reduction in macrophyte density during the AAB period leads to a decrease in aquatic macroinvertebrates due to their relationship with these aquatic plants (Song et al. 2025).

Thus, macrophytes support aquatic macroinvertebrate communities by providing shelter, spawning sites, food sources, and functional diversity (Šemnički et al. 2012; Zelnik et al. 2018). On the other hand, the decline in macrophytes during the AAB period may be associated with reduced light penetration due to

lower water transparency (Zhang et al. 2017; Song et al. 2025) caused by algal blooms during the WAB period. Furthermore, seasonal variations in water transparency may indirectly influence macrophyte dynamics and, consequently, the associated community. Thus, the effects of phytoplankton blooms on macroinvertebrates likely occur not only directly but also through structural changes promoted by aquatic macrophytes.

This study expands our ecological understanding of macroinvertebrate assemblages in karstic lentic ecosystems, a type of environment that has been little studied in the Neotropical region. Our results demonstrate that the seasonal dynamics of phytoplankton blooms influence the taxonomic and functional organization of the community, particularly through changes in resource availability, water transparency, and the structure of aquatic macrophytes. Thus, phytoplankton blooms can act as important ecological filters in tropical karst ponds, promoting functional reorganizations in the aquatic biota associated with macrophytes. These findings reinforce the importance of conserving these unique ecosystems, which harbor high biodiversity and species still unknown to science.

Declarations

Acknowledgment. We thank Recanto Ecológico Rio da Prata for the support and provision of the site for conducting this research. We are also grateful to Bruna Mello for her assistance during field collections, and to Bruno Morales for preparing the map of the study area. We acknowledge Thiago Polizei and Lucas Almeida for their support in the identification of aquatic insects and Lucas Lima in the identification of leechs. We further thank Rosa Dias, Lidiany Cavalcanti, Silvia Milesi and Luis Hepp for their contributions to data analysis. É.G.M.N. gratefully acknowledges CAPES for providing a scholarship during the master's program and the Laboratório de Ecologia Aquática – LEAqua/UFGD for supplying materials and technical support.

Author contributions. E.G.M.N and A.F collected the specimens. E.G.M.N identified the specimens, analyzed the data, and preparation of figures and tables. E.G.M.N and A.F conceived the study, compiled and organized the data, drafted the manuscript, and reviewed and approved the final version.

Ethical Approval. This is not applicable.

Data availability. The authors declare the data will be made available upon request to the corresponding author.

Conflicts of interest. The authors declare that they have no conflicts of interest.

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Tables

Table 1 is available in the Supplementary Files section.

Figures

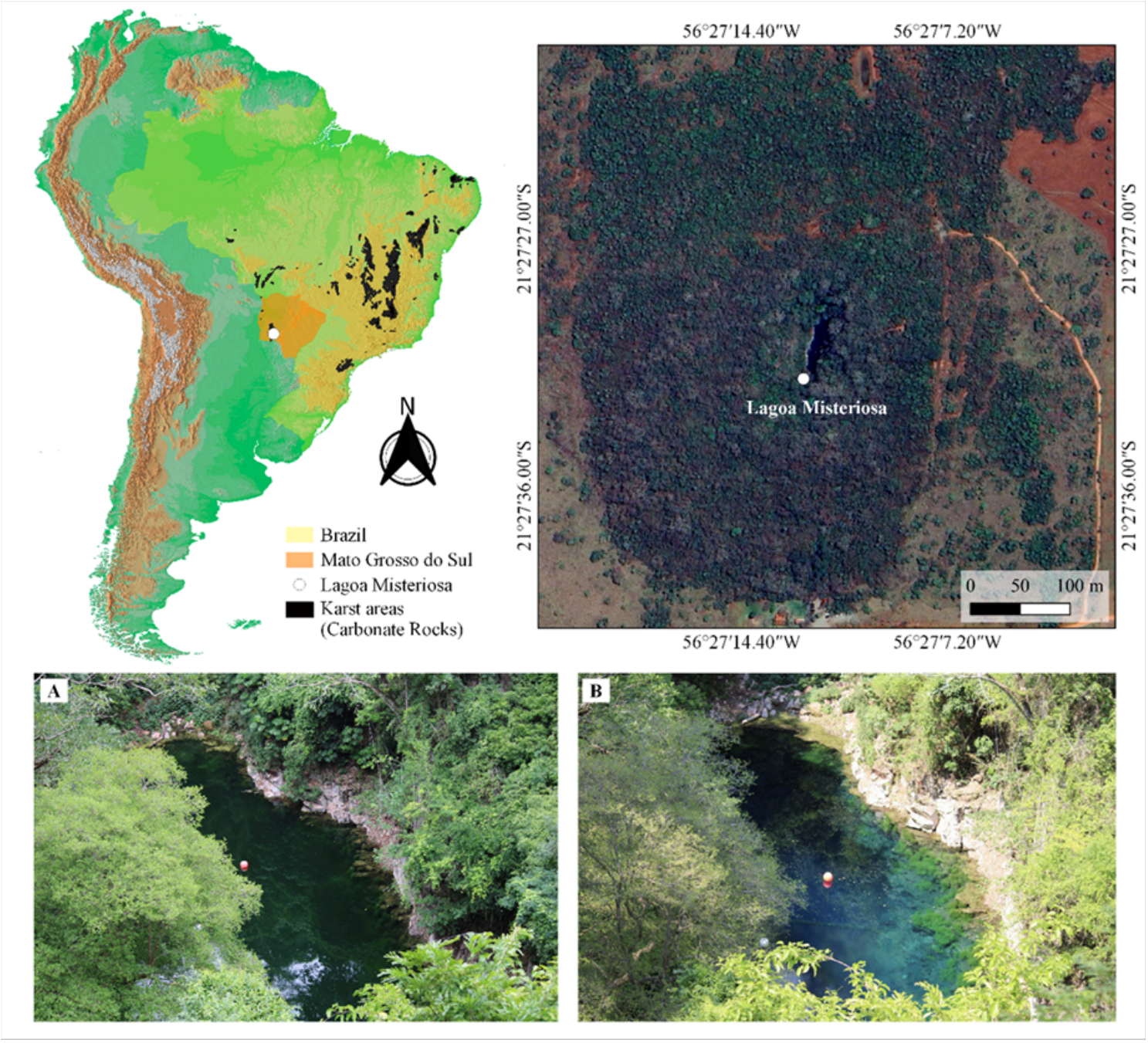


Figure 1

Location map of the Lagoa Misteriosa karst sinkhole, Jardim, Mato Grosso do Sul. (a) With the presence of algal bloom; (b) Absence of algal bloom.



Figure 2

Catalog of aquatic macroinvertebrates in Lagoa Misteriosa, Jardim, MS.

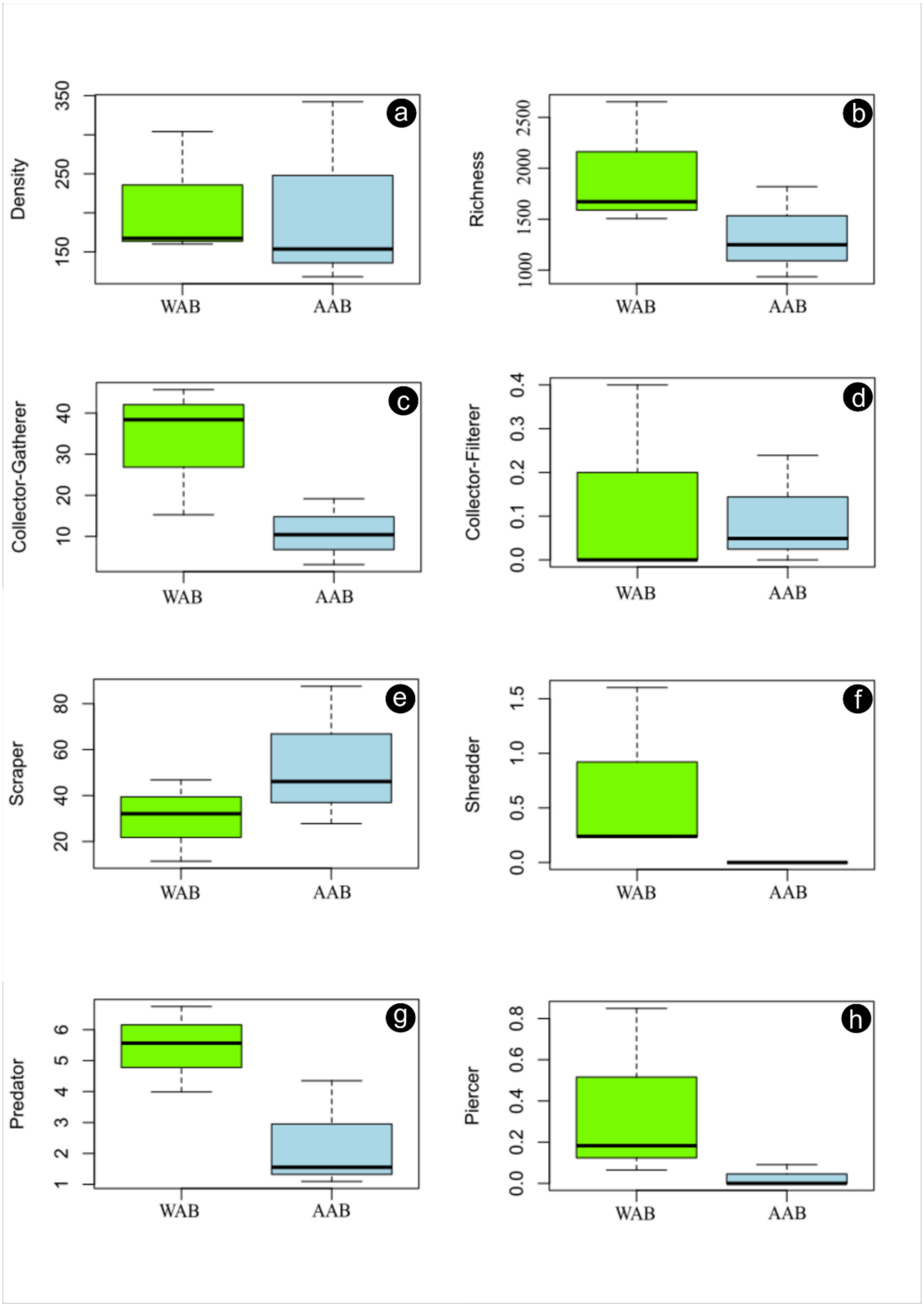


Figure 3

Boxplot of ecological indices during with the presence of algal bloom (WAB) and absence of algal bloom (AAB) in Lagoa Misteriosa, Jardim, MS. **(a)** Density; **(b)**Abundance; **(c–h)** Functional Feeding Groups of aquatic macroinvertebrates.

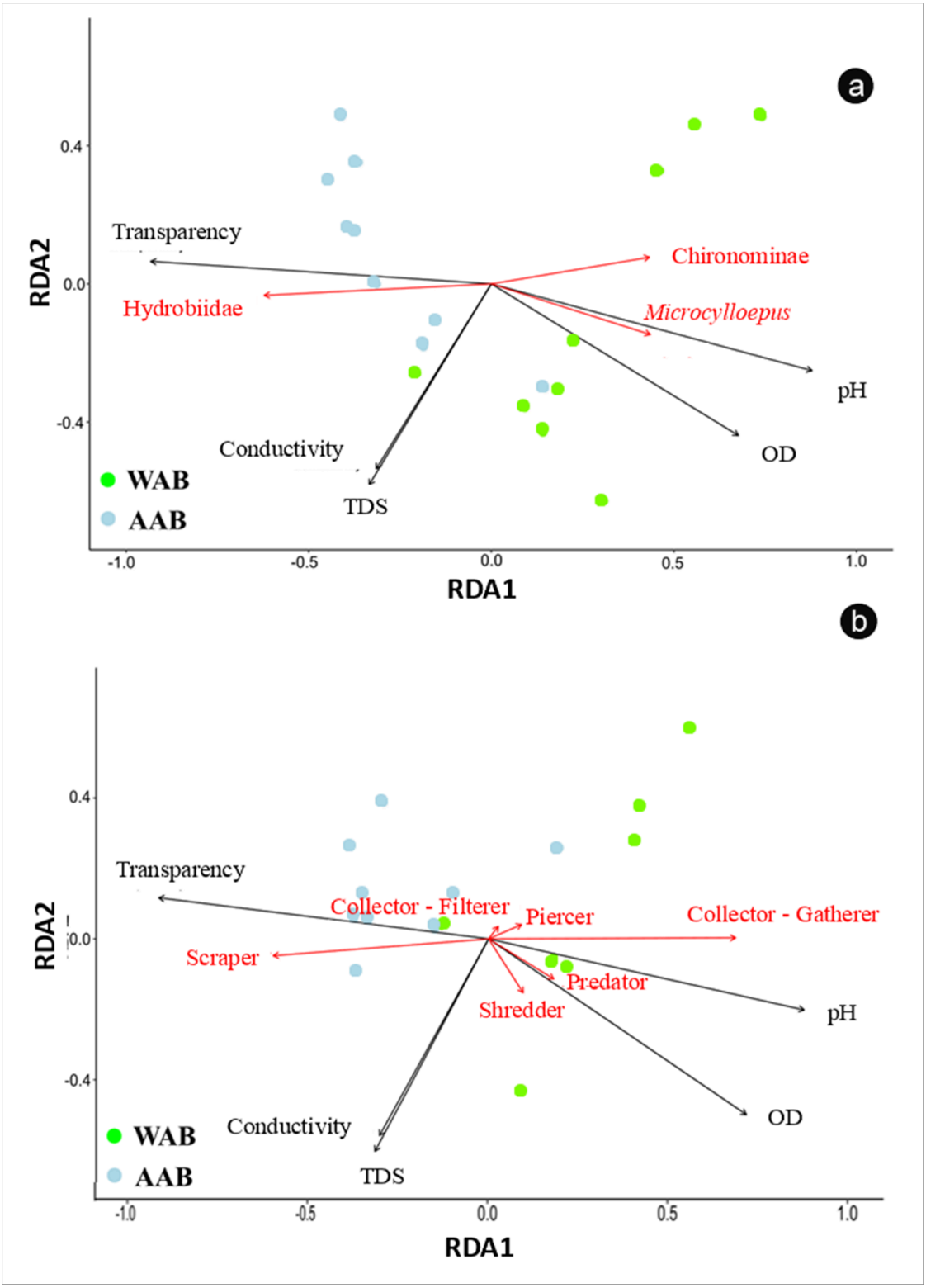


Figure 4

Redundancy Analysis - RDA in Lagoa Misteriosa, Jardim, MS. **(a)**With algal bloom - WAB; **(b)** Without algal bloom - AAB. Abbreviations indicate physical and chemical water parameters. OD = Dissolved oxygen; TDS = Total dissolved solids.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Table.1.pdf
- ESM.1.pdf