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# Benthic invertebrate community and trophic structure in two man-made lakes

**Sílvia Topulniak** [1]
**Luci Fátima Pereira** [2]
**Tayane Cristina Buggenhagen** [3]
**Ana Carolina de Deus Bueno Krawczyk** [1*]

[1] Universidade Estadual do Paraná, Campus de União da Vitória
Praça Coronel Amazonas, s/n, CEP 84.600-185, União da Vitória – PR, Brasil
[2] Universidade Federal do Paraná, Curitiba – PR, Brasil
[3] Universidade Estadual do Centro-Oeste, Guarapuava – PR, Brasil
* Autor para correspondência
anackrawczyk@gmail.com

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## Resumo

**Comunidade de invertebrados bentônicos e estrutura trófica em dois lagos antrópicos.** Os invertebrados bentônicos são importantes, tanto em ecossistemas lóticos como lênticos, por conta da contribuição ecológica na ciclagem de nutrientes, na passagem do fluxo de energia pelos níveis tróficos. Este trabalho teve por objetivo verificar a composição da comunidade de invertebrados bentônicos e caracterizar os respectivos grupos tróficos funcionais em dois lagos situados no Parque Ambiental dos Imigrantes (Mallet – PR). As amostragens foram realizadas através de uma peneira com diâmetro (30x30 cm e 0,05 mm de malha) em fevereiro de 2014, totalizando seis amostras em ambos os lagos. Foram coletados 271 invertebrados bentônicos, distribuídos em 24 táxons identificados no nível de gênero, e dentro de três grupos tróficos funcionais (GTF) (predadores, coletores e filtradores-coletores). Os taxa que mais contribuíram para a composição da comunidade foram Belostomatidae, Notonectidae, Chironomidae e Hydropsychidae. Foi observada maior abundância de espécies tróficas pertencentes aos predadores, seguida dos coletores e filtradores-coletores. Os resultados mostram que as características locais dos lagos influenciaram a abundância da comunidade bentônica amostrada, embora não tenha ocorrido diferença na estrutura dos grupos tróficos entre lagos estudados.

**Palavras-chave:** Ambientes lênticos; Grupos tróficos funcionais; Vegetação

## Abstract

Benthic invertebrates are important in both stream and lentic ecosystems, due to their ecological contribution in the nutrient cycling energy flow through the trophic levels. This study aimed to determine the community of benthic invertebrates and to characterize their trophic groups in two lakes located in Parque dos Imigrantes (Mallet, PR, Brazil). Samples were collected using a sieve with a diameter of 30 cm, with a mesh of 0.05 mm in February of 2014, totaling six samples in each lake. We collected 271 benthic invertebrates in the lakes. Over 24 taxa were identified to the genus level, and occurred in three functional trophic groups (FTG). The taxa that contributed most to the community were Belostomatidae, Notonectidae, Chironomidae and Hydropsychidae. A greater abundance of predators was observed, followed by collectors and filterer-gatherers. This work showed that the local characteristics of the lakes influenced the abundance of sampled benthic community, although there was no difference in the structure of trophic groups between the two lakes.

**Key words:** Lentic environments; Trophic groups; Vegetation

## Introduction

Freshwater ecosystems are recognized by two types of environments, lotic and lentic. In a lentic environment, water residence time can be up to 10 years. Generally, shallow tropical environment characteristics do not contribute to physical and chemical stratification (ESTEVES, 1998). Lentic aquatic ecosystems display high complexity, being made up of distinct habitats. Lakes are recognized as accumulation environments of organic and inorganic materials due to frequent terminal deposition at the drainage basin (BENTO et al., 2007). The disordered occupation of urban space, the intensification of agricultural activities, the removal of vegetation, and input of domestic and industrial effluents, affect the aquatic biota in the environment, causing loss of diversity and its natural conditions (BRUNO, 2012).

Man-made lakes represent an environmental alteration since the ground is excavated for sand extraction. However, once this hole is abandoned, water drains into it from the catchment area, forming water mirrors (LELLES et al., 2005). Over flood periods, these holes become full of water, and with the added presence of surrounding vegetation and favorable physical and chemical characteristics, benthic invertebrate colonization can develop (MOLETTA et al., 2005). Anyway, these small shallow lakes with are influenced by any changes in environmental conditions, and this is reflected on water quality and aquatic community structure (BUENO-KRAWCZYK et al., 2013).

Community structure in benthic invertebrates can be understood in relation to trophic groups. Merritt and Cummins (1996) classified these organisms in functional trophic groups (FTG) according to their morphological and behavioral characteristics, which permits the understanding of many ecological processes in a community and in lakes (MERRITT; CUMMINS, 1996; SHIMANO et al., 2012). Besides, benthic invertebrates are relatively sedentary, which can show a local integrity situation; on the other hand, they have a long life cycle, where they are able to provide a record of environmental quality (METCALFE, 1989).

Thus, environmental changes in trophic structure can be related to water pollution and surrounding degradation. Consequently, it is expected that the composition and structure of the benthic invertebrate community are altered in response to changes in these environments.

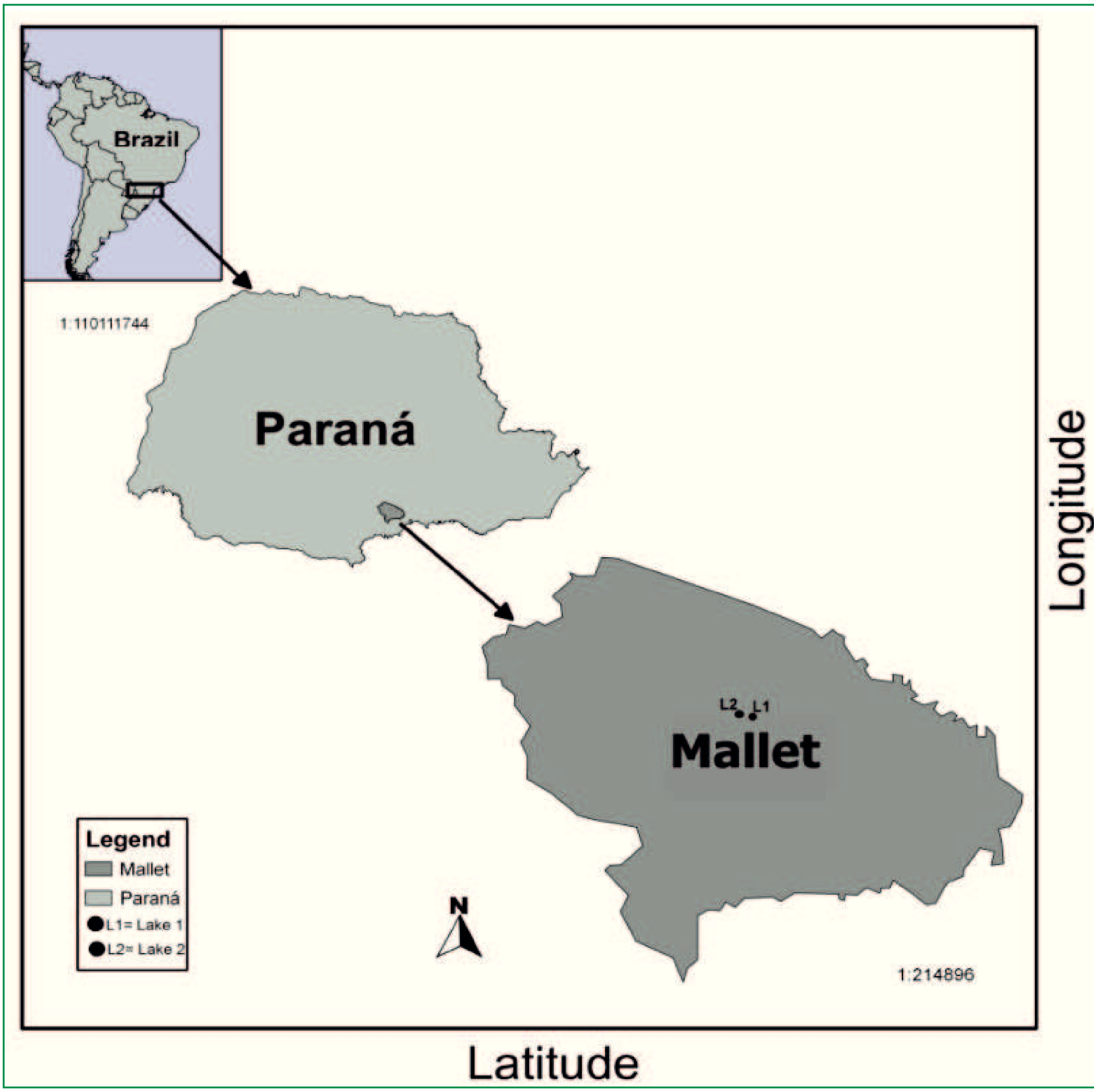
Accordingly, the aims of this study were to investigate the composition of the benthic invertebrate community and characterize their FTG in two lakes with different environmental conditions in Mallet, PR, Brazil. This study represents the first consideration of aquatic ecology in this region.

## Material and Methods

### Study area

Samplings were conducted in two lakes: L1 = lake 1 (25°53'07.66" S; 50°49'45.42") and L2 = lake 2 (25°53'07.04"S; 50°43'38.49"W) in the dry period (summer of 2014); L1 and L2 are the only two lakes in Parque dos Imigrantes in Mallet (state of Paraná). This area is situated in the south-central region of Paraná, with an altitude of 901 m, and is bordered by the cities Rio Azul to the north, São Mateus and Cruz Machado to the east, União da Vitória to the southeast and Paulo Frontin to the south (RUSINEK, 2008) (Figure 1).

FIGURE 1: Location of the 2 lakes sampled for benthic invertebrates in summer of 2014.




## Area characterization

Characterization of the lakes was performed using the development margin index (Ds) (WETZEL, 1990; TUNDISI; MATSUMURA-TUNDISI, 2008). This index indicates the ratio between the perimeter of a water body (W) and the length of the circumference of a circle of equivalent area as the water body. Ds is determined by the equation: $Ds = L/2\sqrt{\pi A}$, where L is the polygon length (from each sample point) and A is the circle circumference with the same lake area. The response values can be close or far from 1. Thus, when Ds is closer to 1, the lake tends to have a circular pattern, and the values far from 1 tend represent a more elongated shape with dendritic pattern (between 3 and 5).

Environmental variables observed in the field were used for comparison with the community structure. Four categories were established as follows: (1) the margin profile; (2) vegetation surrounding the lake; (3) occupation of the water surface by macrophyte stands; and (4) the lake's establishment time. In relation to the margin profile, we used the following scores: (1) flat aspect without bounds, and (2) flat aspect with bounds on the shore. The riverine vegetation was measured according to the following range of values: 1 for shrubs with predominance of grass; 2 for shrubs that allow a little shading (grassy and shrubs); 3 for intact vegetation (grassy, shrubs and trees). The macrophyte proportion was measured by values between 0 and 100%, with the following range of values: (1) for 0 to 25% of macrophytes on the water surface; (2) for 26 to 65% of macrophytes occupation; and (3) for 66 to 100% of macrophytes on the water surface (BUENO-KRAWCZYK et al., 2013).

### Physical and chemical water analysis

The parameters pH, total iron, ammonia and water temperature were recorded in the field with the aid of a titrate test kit. This was performed in both lakes.

### Invertebrates

Invertebrates were sampled from the sediment, along the coast of the lake, using a Ponar type Grab sampler (15 × 15 cm), with three replicates for each sample point in each lake, the substrate sample was collected in random places. These replicates were sampled in the dry period (summer of 2014). All sediment samples were screened on light box and all the organisms were identified to the lowest possible taxonomic level, (PÉREZ, 1988; TRIVINHO-STRIXINO; STRIXINO, 1995; MERRIT; CUMMINS, 1996; WIGGINS, 1996; MUGNAI et al., 2010).

### Data analysis

One-way ANOVA was performed for taxon abundance between sample points. The data satisfied the assumptions of normality and homoscedasticity by the Shapiro-Wilk test for data.

The physical and chemical water analyses were first tested for assumptions of normality and homoscedasticity by the Shapiro–Wilk test. Once these assumptions were satisfied; ANOVA was used, with comparisons between lakes performed using Tukey's test. All tests were performed using a statistical package (HAMMER et al., 2007).

## Results

The lakes were classified as perfectly circular for L1 (Ds = 0.99) and circular for L2 (Ds = 1.54). L1 showed a flat aspect, being bounded on the shore by underbrush, shrubs and trees, and with 25% occupation of the water surface by macrophytes. L2, in turn, showed a flat aspect without bounds but only undergrowth, and with 66-100% occupation of the water surface by macrophytes. The establishment time for both lakes was from 1 to 15 years.

The physical and chemical data did not show a statistically significant difference between lakes ($p>0.05$) (Table 1).

A total of 271 benthic invertebrates were identified in the two lakes, in which the community was distributed in 24 taxa identified to the genus level, and belonged to three FTG. Most individuals were found in both lakes, but some were exclusive for certain points sampled. *Libellula* sp. (Odonata: Libellulidae), *Neocordulia* sp. (Odonata: Cordulidae), *Archeagomphus* sp. (Odonata: Grompdae), *Caenis* sp. (Ephemeroptera: Caenidae), *Tricoryplopsia* sp. (Ephemeroptera: Leptohyphidae), *Ranatra* sp. (Hemiptera: Nepidae), *Buenoa* sp. (Hemiptera: Notonectidae), *Notonecta* sp. (Hemiptera: Notonectidae), *Brachymetra* sp. (Hemiptera: Gerridae), *Leptonema* sp. (Tricoptera: Hydropsychidae), and *Anopheles* sp. (Diptera: Culicidae) occurred only in

TABLE 1: Results of physical and chemical analysis for the sampled sites. L1 = lake 1; L2 = lake 2.

| Lakes/Parameters | WT (°C) | pH | Ammonia (mg/L) | Iron ( mg/L) | *p* |
|---|---|---|---|---|---|
| **L1** | 19.0 | 6.50 | 0.30 | 0.50 | > 0.05 |
| **L2** | 21.0 | 6.0 | 0.12 | 1.10 | > 0.05 |

L1. However, *Macrothemis* sp. (Odonata: Anisoptera), *Leptohyphes* sp. (Ephemeroptera: Leptohyphidae), *Farrodes* sp. (Ephemeroptera: Leptohyphidae) and *Culex* sp. (Diptera: Culicidae) were recorded only in L2. The genera *Hetaerina* (Odonata: Calopterigidae), *Belostomamecantulum* (Hemiptera: Belostomatidae), *Mesovelia* (Hemiptera: Mesoveliidae), *Smicridea* (Tricoptera: Hydropsychidae), *Uronotaenia* (Diptera: Culicidae) and *Chironomus* (Diptera: Culicidae) were found in L2 (Table 2).

TABLE 2: Total and relative abundance of individuals in L1 and L2. N = total individuals; RA = relative abundance.

| Family/Genus | L1 | | L2 | |
|---|---|---|---|---|
| | N | RA | N | RA |
| **Calopterigidae** | | | | |
| *Hetaerina* sp. | 5 | 0.025 | 12 | 0.167 |
| **Libellulidae** | | | | |
| *Libellula* sp. | 5 | 0.025 | 0 | 0 |
| *Macrothemis* sp. | 0 | 0.00 | 3 | 0.042 |
| *Corduliidae* sp. | | 0.01 | | |
| *Neocordulia* sp. | 2 | 0 | 0 | 0 |
| **Gromphidae** | | | | |
| *Archeagomphus* sp. | 1 | 0.005 | 0 | 0 |
| **Caenidae** | | | | |
| *Caenis* sp. | 2 | 0.010 | 0 | 0 |
| **Leptohyphidae** | | | | |
| *Tricoryplopsia* sp. | 2 | 0.010 | 0 | 0 |
| *Leptohyphes* sp. | 0 | 0 | 6 | 0.083 |
| *Farrodes* sp. | 0 | 0 | 4 | 0.055 |
| **Belostomatidae** | | | | |
| *Belostomamecantulum* sp. | 49 | 0.246 | 7 | 0.097 |
| **Nepidae** | | | | |
| *Ranatra* sp. | 16 | 0.080 | 0 | 0 |
| **Notonectidae** | | | | |
| *Buenoa* sp. | 4 | 0.020 | 0 | 0 |
| *Notonecta* sp. | 33 | 0.165 | 0 | 0 |
| **Gerridae** | | | | |
| *Brachymetraalbinervis* sp. | 5 | 0.025 | 0 | 0 |
| *Eurygerriskahli* sp. | 3 | 0.015 | 7 | 0.097 |
| **Mesoveliidae** | | | | |
| *Mesoveliamulsanti* sp. | 3 | 0.015 | 10 | 0.1388 |
| **Hydropsychidae** | | | | |
| *Leptonema* sp. | 12 | 0.060 | 0 | 0 |
| *Smicridae* sp. | 14 | 0.070 | 1 | 0.0139 |
| **Culicidae** | | | | |
| *Anopheles* sp. | 2 | 0.010 | 0 | 0 |
| *Culexquinquefasciatus* sp. | 0 | 0 | 3 | 0.042 |
| *Uronotaenia* sp. | 4 | 0.020 | 8 | 0.111 |
| **Chironomidae** | | | | |
| *Chironomus* sp. | 26 | 0.130 | 11 | 0.153 |
| **Formicidae (adults)** | 4 | 0.020 | 0 | 0 |
| **Coleoptera (adult)** | | | | |
| *Tropisternus* sp. | 1 | 0.005 | 0 | 0 |

L1 showed a higher total abundance of benthic invertebrates (n = 199). The higher abundance in L1 occurred due to the genus *Belostoma* (0.246), with highest relative abundance recorded, followed by *Notonecta* (0.166). As mentioned, this lake has underbrush, shrubs and trees in its surroundings, and 25% of the water surface is occupied by macrophytes, and there is also the presence of fish. These characteristics demonstrate the importance of vegetation at these sites, which may influence diversity and taxon abundance.

Calopterigidae had the highest species richness and highest relative abundance among the taxonomic groups in L2. The family *Hetaerina* was the most abundant (0.166), followed by Chironomidae, and *Chironomus* (0.152). This site showed only underbrush in its surroundings, with no trees, and the occupation of the environment by macrophytes was around 66-100%, with fish presence.

There was no significant difference in total abundance of taxa (L1 relative abundance = 0.612; L2 relative abundance= 0.860) between the two sampled lakes ($F_{3.96}$= 3.21, p = 0.07).

The benthic invertebrates identified (N = 271) were classified into three FTG, wherein the predator group was most abundant in L1 (n = 131), followed by collectors (n = 32) and filterer-gatherers (n = 26). In L2, predators were also the most abundant group (n = 50), followed by the collector group (n = 21) and filterer-gatherers group (n = 1) (Table 3).

## Discussion

This study represents the first assessment of the benthic invertebrate community in lakes in the region.

Water and chemical analysis did not demonstrate differences between the two lakes. However,

TABLE 3: Functional trophic groups (FTG) in the lakes studied. Lake 1 (L1) and lake 2 (L2). N = number of individuals. TI = Total individuals in lakes.

| Order/Family | L1 (N) | L2 (N) | TI | FTG |
|---|---|---|---|---|
| **Odonata** | | | | |
| Calopterigidae | 5 | 12 | 17 | Predator |
| Libellulidae | 5 | 3 | 8 | Predator |
| Corduliidae | 2 | 0 | 2 | Predator |
| Gromphidae | 1 | 0 | 1 | Predator |
| **Ephemeroptera** | | | | |
| Caenidae | 2 | 0 | 2 | Collector |
| Leptohyphidae | 2 | 10 | 12 | Collector |
| **Hemiptera** | | | | |
| Belostomatidae | 49 | 7 | 56 | Predator |
| Nepidae | 16 | 0 | 16 | Predator |
| Notonectidae | 36 | 0 | 36 | Predator |
| Gerridae | 8 | 7 | 15 | Predator |
| Mesoveliidae | 3 | 10 | 13 | Predator |
| **Trichoptera** | | | | |
| Hydropsychidae | 26 | 1 | 27 | Filterer-gather |
| **Diptera** | | | | |
| Culicidae | 6 | 11 | 17 | Predator |
| Chironomidae | 28 | 11 | 39 | Collector |

environmental characteristics such as proportion of riverine vegetation, presence of macrophytes along the margin, forested areas with greater vegetation cover around occurred in L1, and were associated with supporting greater species richness, offering biotic integrity (BUENO et al., 2003). In contrast, L2 showed poor environmental heterogeneity added to domestic wastewater and community and had lower species richness, which is a response to degradation (BAPTISTA et al., 1998).

Predator groups were dominant in the communities followed by collectors, which is explained by the fact that these animals take advantage of vegetation cover to better perform their hunting strategies (PEIRÓ; ALVES, 2006; ANDRADE et al., 2008). These results corroborate the finding reported by Barbola et al. (2011), in a flooded wealth, where they demonstrated the presence of predators and collectors in greater abundance. These animals explore macrophytes, which are considered the main sources of particulate organic material, in addition to being used for a habitat site, shelter, food and spawning for many organisms (SALCEDO, 2011; SHIMABUKURO, 2013).

In this study, we found that the local characteristics of the lakes influenced the abundance of sampled benthic community, although there was no difference in the structure of trophic groups between the two lakes, which could be related to a relatively short distance between the studied sites.

The marginal vegetation and macrophytes are of great importance to the aquatic environment, mainly for the lentic environment, because these characteristics increase habitat heterogeneity offering food resources, refuge and shelter for the aquatic fauna. It is important to highlight, however, that the availability of food resources is not the only factor driving aquatic communities. The composition, abundance and distribution of benthic organisms in lentic aquatic ecosystems are also determined by a set of physical, chemical and biological factors that act simultaneously.

The results obtained showed that environmental conditions around lakes can influence the benthic community in terms of richness. We demonstrated a prevalence of predators, such as *Belostoma* sp. and Calopterigidae, which was associated with the presence of vegetation at sites sampled. We believe that this information can be useful for future management plans to minimize anthropic actions, emphasizing that for an effective conservation of the benthic community, surrounding environments must be preserved, and that wastes and domestic effluents must be properly disposed.

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