DIVERSITY AND BIOMASS OF CHIRONOMIDAE (DIPTERA) LARVAE IN AN IMPACTED COASTAL LAGOON IN RIO DE JANEIRO, BRAZIL

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ABSTRACT

Diversity and biomass of Chironomidae larvae were studied between January-November 1993 and March-November 1994 in an impacted lagoon in Rio de Janeiro, Southeastern Brazil, in an attempt to establish the ecological consequences of anthropogenic eutrophication processes. Nine hundred and seventy-five organisms belonging to the Tanypodinae, Orthocladiinae, and Chironominae were collected. *Polypedilum* (62%) and *Chironomus* (58%) were the most common genera found in the limnetic and littoral zones.

Key words: biodiversity, eutrophication, chironomids, bioindicators, coastal lagoon.

RESUMO

Diversidade e biomassa de larvas de Chironomidae (Diptera) em uma lagoa costeira impactada no Estado do Rio de Janeiro, Brasil

Foram estudadas a diversidade e a biomassa de larvas de Chironomidae entre janeiro e novembro de 1993 e março-novembro de 1994 em uma lagoa costeira no Estado do Rio de Janeiro, Sudeste do Brasil, com o objetivo de identificar as conseqüências ecológicas do processo de eutrofização artificial. Ao todo, 975 larvas de Tanypodinae, Orthocladiinae e Chironominae foram coletadas e *Polypedilum* (62%) e *Chironomus* (58%) foram os *taxa* mais comuns nas regiões litorânea e limnética.

Palavras-chave: biodiversidade, eutrofização, Chironomidae, bioindicadores, lagoa costeira.

INTRODUCTION

Taxonomic diversity (including taxonomic richness and evenness) and biomass are fundamental in describing the structure and distribution of communities (Begon *et al*., 1996). This information is an important ecological tool for biological studies of pollution level indicators in freshwater ecosystems, in well-balanced monitoring programs involving physical, chemical, and biological measurements.

The Imboassica Lagoon has suffered multiple anthropogenic impacts. Among these are urbanization of its margins; landfills; and frequent and aperiodic openings of the sandbar separating it from the ocean (Faria *et al.*, 1998; Fernandes, 1998; Gonçalves *et al*., 1998a; Albertoni *et al.*, 1999). The most frequent consequences are predominance of fine particles (silts and clay), increase in organic matter accumulation on the sediment due to enhanced detritus production, and increased production of toxic gases such as H_2S and CH_4 with consequent decrease in dissolved oxygen concentration at the bottom, near the sediment-water interface (Esteves, 1998; Gonçalves *et al.*, 1998b).

The benthic macroinvertebrate community in Imboassica Lagoon is dominated by Gastropoda

(*Heleobia australis)*, Polychaeta-Nereidae, and Chironomidae larvae. Together they represent ca. 95% of the fauna (Callisto *et al*., 1998b; Gonçalves *et al*., 1998a). Chironomidae are broadly distributed worldwide and frequently are the most abundant insects in many freshwater ecosystems. Certain species show ecological adaptations, in ecosystems at different trophic levels, to extreme environmental situations related to high temperature, pH, organic matter content in the sediment, and low dissolved oxygen in the water-sediment interface (Cranston, 1995). High diversity of chironomids (estimated at more than 15,000) is better known taxonomically in temperate Northern Hemisphere countries. In the Neotropics, especially Brazil, which is known as a megabiodiversity country (Barbosa *et al*., 1998; Myers *et al*., 2000), it is estimated that more than 98% of the chironomid species are still undescribed. A shortage of specialists and a lack of basic information at the species level, limit taxonomic identification of the genera, especially in ecological studies of immature forms of Brazilian chironomids (Nolte, 1989; Nessimian & Sanseverino, 1995; Callisto, 1997).

Chironomidae larvae play an important ecological role in the bioturbation process at the sediment-water interface. In eutrophic environments, they do so in nitrogen remobilization for the primary producers (Fukuhara & Sakamoto, 1988; Svensson & Leonardson, 1996; Svensson, 1997). In lacustrine ecosystems, these organisms participate in two webs: (a) by the detritus chain, ingesting organic fragments and associated microorganisms, (b) by the food-web, by eating smaller organisms and being consumed by other insects, alevins, aquatic birds, and benthophagous fishes (Callisto *et al*., 1996; Branco *et al*., 1997; Galdean *et al*., 1997; Aguiaro & Caramaschi, 1998). Therefore, in lake environments, they are important components needing further study.

The aim of this study was to evaluate the diversity of Chironomidae larvae, their distribution and biomass, and to estimate the impacts of the anthropic eutrophication process on this community, by comparing the littoral (close to an untreated sewage channel) and the limnetic zones of Imboassica Lagoon.

Study area

Imboassica Lagoon is located in northern Rio de Janeiro State (22°15'-22°30'S, 41°30'-42° 05'W), and is separated from the sea by a sand bar approximately 50 meters wide. The lagoon is situated on the coastal plain (restinga) where the climate is an AW type (according to Köppen's classification), with hot and humid characteristics.

Temperatures oscillate between 18.7°C and 27.4°C. This ecosystem is situated in the Macaé County urban zone and has an estimated area of 3.26 km^2, with a mean depth of 1.1 m (Panosso *et al.*, 1998). Littoral zone urbanization and domestic waste discharge are important anthropogenic impacts on the lagoon. Artificial openings through the sandbar cause exchange with marine water, resulting in salinity elevation of 0‰ to 35‰ (Gonçalves *et al.*, 1998a; Callisto *et al.*, 1998b). The littoral zone is colonized by *Typha domingensis* (Typhaceae), grasses, *Salvinia auriculata* (Salvineaceae), and *Eichhornia crassipes* (Pontederiaceae). The limnetic zone includes large banks of *Chara* spp. (Characeae).

MATERIALS AND METHODS

Sampling of chironomids

Water and sediment samples were collected during January-November 1993 and March-November 1994, in the limnetic and littoral zones (2 meters from a domestic sewage channel). In some months (February, March, and July 1993, June, August, and September 1994 at the littoral zone; January and February 1993, June and July 1994, at the limnetic zone) no samples were taken due to lagoon emptying after sandbar opening.

Sediment and benthic macroinvertebrates samples were collected using a "corer" sampler (modified from Ambühl & Bührer, 1975), with 8 cm diameter. The studied fraction was 0-10 cm.

Five samples were collected from each sampling station (0.025 m^2 in total area). In the laboratory, sediment samples were washed in two sieves (1.00 and 0.50 mm mesh) and sorted under a stereomicroscope.

Chironomidae larvae were mounted in lactophenol solution 10% and identified under the microscope, using 400x magnification. The sampled individuals are deposited in the Benthic Macroinvertebrate Collection of the Laboratory of Ecology of Benthos, Institute of Biological Sciences, Federal University of Minas Gerais, following methodology described in Callisto *et al*. (1998a).

Data analysis

For larval biomass calculation, the log-linear equation was used: ln W = ln a + b ln l.

We used the equations proposed by Smock (1980), Sephton & Paterson (1986), and Nolte (1990):

- *Polypedilum*:
  ln a = –7.308 and b = 2.603 r = 0.964
- Other Chironominae and Orthocladiinae:
  ln a = –5.279 and b = 2.32 r = 0.94
- Tanypodinae:
  ln a = –5.573 and b = 2.603 r = 0.92

RESULTS

Eleven taxa of chironomids in the littoral zone, and fourteen taxa in the limnetic zone were found in Imboassica Lagoon (Table 1).

Among the taxa found in the littoral zone, larvae of the genus *Chironomus* represented 58% of the fauna, followed by *Polypedilum* (27%), and *Tanypus* (7%).

The maximum densities were found in June, August, and September 1993, and February 1994. In the limnetic zone, *Polypedilum* larvae represented 62% of the fauna, followed by *Ablabesmyia* (3%), and *Goeldichironomus* (2%). Maximum densities were found in May and July 1993.

Biomass value distribution followed the pattern observed for density values. In the littoral zone, *Chironomus* larvae represented 70% to 100% of the organism biomass, except in March 1994, when *Polypedilum* larvae reached maximum values (approximately 70%). As for genera richness, a different variation was observed while comparing the two sampling stations.

Tanypodinae larvae, predominantly carnivorous, were scarce throughout this study. All larvae were small. In the littoral zone, *Chironomus* larvae presented almost uniform body size distribution among the studied size-classes (Table 2).

TABLE 1

Composition and density (ind/m^2) of the larvae of Chironomidae in the littoral and limnetic zones of the Imboassica Lagoon.

Taxa	Littoral	Limnetic
Tanypodinae		
Ablabesmyia	22	176
Djalmabatista	–	20
Labrundinia	22	40
Tanypus	168	–
Orthocladiinae		
Cricotopus	–	65
Nanocladius	–	34
Chironominae		
Asheum	–	34
Beardius	–	34
Chironomus	1448	1448
Cladopelma	22	56
Goeldichironomus	22	128
Harnischia	22	24
Nimbocera paulensis	22	16
Parachironomus	22	16
Paracladopelma	22	–
Polypedilum	696	3560
Total	**2488**	**5651**

TABLE 2 (a)

Biomass of chironomids (mg/m²) along 1993-1994 sample periods in the littoral zone of the Imboassica Lagoon.

Taxa	1993									1994								
	Jan	Apr	May	Jun	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jul	Oct	Nov	Dec
Tanypodinae																		
Ablabesmyia	–	–	0.24	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Labrundinia	–	–	0.16	0.35	0.14	–	–	–	–	–	–	–	–	–	–	–	–	–
Tanypus	–	–	–	0.07	–	0.36	0.61	–	0.22	0.47	–	–	0.14	–	–	0.24	0.48	0.32
Chironominae																		
Chironomus	–	0.82	1.69	34.07	27.21	22.05	8.73	2.68	4.39	7.06	2.95	0.15	6.26	5.94	0.62	0.49	7.31	–
Cladopelma	–	–	–	0.25	–	–	0.08	0.29	–	0.11	0.05	0.28	–	–	–	–	–	–
Goeldichironomus	–	–	–	–	0.05	–	–	–	–	–	–	–	–	–	0.50	–	–	–
Harnischia	–	0.08	–	0.08	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Nimbocera paulensis	–	–	–	–	0.07	–	–	–	–	–	–	–	–	–	–	–	–	–
Parachironomus	–	–	–	–	0.17	–	–	–	–	–	–	–	–	–	–	–	–	–
Paracladopelma	–	–	–	0.36	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Polypedilum	0.03	–	–	–	0.75	0.01	–	0.06	0.11	0.42	0.98	0.74	0.08	–	–	–	–	–
Total	**0.03**	**0.90**	**2.09**	**35.18**	**28.39**	**22.42**	**9.42**	**3.03**	**4.72**	**8.06**	**3.98**	**1.17**	**6.48**	**5.94**	**1.12**	**0.73**	**7.79**	**0.32**

TABLE 2 (b)

Biomass of chironomids (mg/m²) along 1993-1994 sample periods in the limnetic zone of the Imboassica Lagoon.

Taxa	1993										1994									
	Mar	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Tanypodinae																				
Ablabesmyia	0.30	–	–	0.80	0.03	–	0.03	–	–	0.02	0.27	1.07	0.62	–	–	–	–	–	0.04	–
Djalmabatista	–	–	0.01	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Labrundinia	–	–	–	0.18	–	0.05	–	0.09	0.09	0.11	–	0.08	–	–	–	–	–	–	–	0.03
Orthocladiinae																				
Cricotopus	–	0.11	–	–	–	–	–	–	–	–	–	0.08	0.05	–	–	–	–	–	0.40	0.21
Nanocladius	–	–	–	–	–	–	–	0.16	–	–	–	–	–	–	–	–	–	–	–	–
Chironominae																				
Asheum	–	–	–	0.24	–	–	–	0.10	–	–	–	–	–	–	–	–	–	–	–	–
Beardius	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chironomus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.16	.050	2.17	–	–
Cladopelma	–	–	–	–	–	–	–	–	–	–	–	–	0.16	–	–	–	–	–	–	–
Goeldichironomus	–	–	–	–	–	0.54	0.07	0.27	–	–	0.06	0.18	–	–	–	–	–	–	–	–
Harnischia	–	–	–	–	0.18	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Nimbocera paulensis	–	–	–	–	–	–	–	–	–	–	0.05	0.47	–	–	–	–	–	–	–	–
Parachironomus	–	0.63	–	0.09	–	–	–	0.18	–	–	–	–	–	–	–	–	–	–	–	–
Polypedilum	0.91	0.02	6.27	0.15	2.73	–	1.08	–	–	–	0.18	0.04	–	0.02	0.10	–	–	–	0.01	–
Total	**1.21**	**0.76**	**6.28**	**1.46**	**2.94**	**0.59**	**1.18**	**0.80**	**0.09**	**0.13**	**0.56**	**1.92**	**0.83**	**0.02**	**0.10**	**0.16**	**0.50**	**2.17**	**0.45**	**0.24**

On the other hand, in the limnetic zone the majority of *Polypedilum* larvae showed body size reduction (smaller than 0.3 mm).

DISCUSSION

The biomass distribution data can be related to two different situations. The first might be that the larvae were not developing a body size larger than 0.3 mm, probably due to selective predator pressure (Tanypodinae larvae with other chironomids in the gut content, benthophagous fishes, and alevins). The second might be related to intrinsic species aspects with *Polypedilum* present in this lagoon area. Larvae of some *Polypedilum* species might naturally have small body-size. Imboassica Lagoon offers a great diversity of trophic resources, such as aquatic macrophytes, periphyton, plant detritus (notably in the littoral zone), and fine particulate organic matter (Furtado *et al.*, 1997). The high organic matter content in the sediment suggests food limitation neither for *Chironomus* larvae nor for *Polypedilum* in the littoral and limnetic zones, respectively.

Tanypodinae are located at the top of the food web in benthic communities. The abundance of Tanypodinae is regulated directly by available food items (which may be other Chironomidae larvae, Rotifera, Protozoa, Oligochaeta, etc.) (Epler, 1995).

The high abundance of *Chironomus* and *Polypedilum* larvae, predominantly detritivorous, is probably related to the high abundance of organic detritus in the Imboassica Lagoon sediment, as is corroborated by the high content of total and dissolved nutrients in the water and great concentrations in the sediment (Petrucio & Furtado, 1998; Furtado *et al.*, 1997), a typical situation in lacustrine ecosystems subjected to artificial eutrophication.

Some *Chironomus* and *Polypedilum* larvae (about 5% of the studied material) found presented deformities on mouth parts (mentum). Several studies have shown the relationship between the occurrence of structural deformities in Chironomidae larvae and degraded environmental conditions, resulting from contamination by heavy metals, herbicides, fungicides, and insecticides (Dermott, 1991; Warwick, 1985). According to Janssens De Bisthoven *et al*. (1992), these deformities can be interpreted as a sign of sublethal pollutant concentrations which in the Imboassica Lagoon would probably be related to domestic sewage release and even to heavy metal presence. Deformities have been used in environmental impact evaluation studies on freshwater ecosystems (Janssens De Bisthoven *et al.*, 1998; Diggins & Stewart, 1998), and suggested as a biological parameter to be included in long-term water-quality monitoring programs (Callisto *et al.*, 2000).

The results obtained in this research showed that anthropic eutrophication in the Imboassica Lagoon has influenced the structure of the benthic community (prevalence of detritivorous organisms, such as *Chironomus* and *Polypedilum*), resulting in high biomass and low taxonomic diversity, when compared to other studies developed on coastal ecosystems in Rio de Janeiro State (Nessimian, 1995; Nessimian & Sanseverino, 1995). We believe that this information can be useful in making more evident to local communities and politicians the urgent need for measures to minimize the anthropic impacts observed in Imboassica Lagoon.

Ecological information on coastal lagoons subject to anthropic influence is necessary in these areas to define and limit human activities, as well as for establishing the management techniques to be applied in the future. In the Imboassica Lagoon case, new studies should be developed to define species composition and benthic community structures (and their functional role), to better characterize habitats and evaluate impact levels and subsequent aquatic biodiversity loss. Moreover, such results supply fundamental information on the diversity and biomass of one of the benthic macroinvertebrate main groups, besides suggesting their role as environmental quality bioindicators.

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