Chironomids colonization on *Nymphaea ampla* L. detritus during a degradative ecological succession experiment in a Brazilian coastal lagoon.

GONÇALVES JR., J.F.[1,2]; ESTEVES, F.A.[2] & CALLISTO, M.[1]

[1] Present address: Federal University of Minas Gerais, ICB, Dep. General Biology, Lab. Ecology of Benthos, P.O. Box. 486, 30.161-970, Belo Horizonte, MG, Brazil. e-mail: jfjunior@icb.ufmg.br

[2] Federal University of Rio de Janeiro, CCS, IB, Dep. Ecology, Lab. of Limnology, P.O. Box 68020, 21941-590, Rio de Janeiro, RJ, Brazil.

ABSTRACT: Chironomids colonization in *Nymphaea ampla* L. detritus during a degradative ecological succession experiment in a Brazilian coastal lagoon. The objective of this study was to evaluate the colonization of Chironomidae larvae assemblage throughout the process of degradative ecological succession of detritus of *Nymphaea ampla* L. The experiment was performed at the littoral zone of the Jurubatiba coastal lagoon, Parque Nacional da Restinga de Jurubatiba, Macaé, State of Rio de Janeiro, Brazil. The colonization was followed through 16 days of an "in situ" experiment. During this 16 days period the detritus decomposed c. 90%. Nine genera from the Tanypodinae and the Chironominae were identified and *Rheotanytarsus* had the highest density (590 ind/100g DW). The predominant functional trophic group found among the Chironomidae genera was the collector-gatherers. The role of the Chironomidae larvae on the processes of aquatic macrophyte decomposition and degradative ecological succession of *N. ampla* was discussed. It was observed that the unstable substrate colonization leads to a decrease in density and diversity of the Chironomidae larvae.

Key-words: aquatic macrophytes, Chironomidae, detritus, decomposition, *Nymphaea ampla*.

RESUMO: Colonização de larvas de Chironomidae em detrito de *Nymphaea ampla* L. durante a sucessão ecológica degradativa em uma lagoa costeira brasileira. O objetivo desta pesquisa foi avaliar a colonização da assembléia de larvas de Chironomidae ao longo do processo de sucessão ecológica degradativa de detritos de *Nymphaea ampla* L., na região litorânea da lagoa de Jurubatiba, Parque Nacional da Restinga de Jurubatiba, Macaé, Estado do Rio de Janeiro, Brasil. A colonização foi acompanhada durante 16 dias de experimento "in situ", período no qual o detrito decompôs-se cerca de 90%. Foram identificados 9 gêneros das sub-famílias Tanypodinae e Chironominae. Dentre os gêneros encontrados *Rheotanytarsus* obteve a maior densidade (590 ind/100g PS). Coletor-catador foi o grupo trófico funcional dominante nos gêneros de Chironomidae. Foi observado que a colonização de substratos instáveis leva a uma diminuição na densidade e diversidade de larvas de Chironomidae.

Palavras-chaves: macrófitas aquáticas, Chironomidae, detritos, decomposição, *Nymphaea ampla*.

Introduction

The aquatic macrophytes have an important role on the productivity of lacustrine ecosystems, especially in tropical regions where they present wide distribution and great species diversity on the littoral zone (Menezes et al., 1993; Wetzel, 1993; Palma-Silva, 1998). They are used as habitat for miner insects, substrate for periphyton colonization and gastropod foraging (Gonçalves et al., 1998), and also as shelter for planktonic invertebrates and juvenile fish against predators (Hanlon, 1982; Trivinho-Strixino & Strixino, 1993; Furtado, 1994; Callisto et al., 1996; Humphries, 1996; Esteves, 1998).

During the aquatic macrophytes decomposition, the detritus are processed and the nutrients are mineralized. Many invertebrates take an important role as a link between the energy stocked in the detritus to the upper trophic levels in the aquatic food webs (Allan, 1995; Wallace et al., 1997; Gessner et al., 1999).

The ecological succession concept is an important aspect of the community ecology studies and it has been widely discussed regarding its features, causes, properties, direction of the changes in the composition of the dominant species, diversity, structure complexity, adaptations and productivity (Odum, 1969; Begon et al., 1996; Huszar & Reynolds, 1997).

The degradative ecological succession process occurs through the vegetal or animal detritus decomposition, where microorganisms (especially fungi and bacteria), invertebrates (e.g., immature aquatic insects) and vertebrates (some amphibious and fishes) alternate themselves in a short time scale, ranging between days, weeks and a few months, until the detritus is completely processed and mineralized (Begon et al., 1996; Gonçalves et al., 2000).

Among the invertebrate groups that colonize the organic detritus along the decomposition process, the Chironomidae larvae (Diptera, Insecta) present the highest densities and taxonomic diversity (Smock & Stoneburner, 1980; Callisto et al., 1996; Gonçalves et al., 2000). These organisms are strongly influenced by the physical, chemical and trophic conditions of the habitat (Johnson et al., 1995), thus being commonly used to study the structure and functioning of the lacustrine ecosystems. The Chironomidae are often the first colonizers on a habitat (Batzer & Wissinger, 1996) and the species composition changes due to physical, chemical and biological changes occurred on the habitat through time (Botts, 1997).

To understand the functioning of the freshwater ecosystems it is very important to evaluate the energy flow and the species composition pattern and their role on the organic detritus process. The definition of "engineer species" proposed by Lawton & Jones (1993) points out that these organisms alter the biotic and abiotic composition of the ecosystems, influencing the energy resources to other species, not creating food webs but integrating organism populations to the physical and chemical compartments. The Chironomidae larvae may be a good example of "engineer species" with great influence on the trophic and biotic interactions of many other organisms that participate on the degradative ecological succession process of detritus of aquatic macrophytes (Botts, 1997; Gonçalves et al., 2000; Callisto et al., 2001).

The objective of this study was to evaluate the colonization of the Chironomidae larvae assemblage throughout the ecological succession process during the detritus decomposition of *Nymphaea ampla* L., in an "in situ" experiment performed on the littoral zone of the Jurubatiba coastal lagoon, Parque Nacional da Restinga de Jurubatiba, Macaé, State of Rio de Janeiro, Brazil.

Study Area

Jurubatiba lagoon is located in the "Parque Nacional da Restinga de Jurubatiba" in the northeast of the State of Rio de Janeiro, Brazil (22° 15' S and 41° 40' W). This lagoon shows low anthropogenic influence and its watershed is composed by a coastal sand dune plant community of "restinga".

The climate of the region is the AW type, according to the Köppen system, with warm characteristics (maximum average temperature of 30 °C in February and minimum average of 25,4 °C in July) and humid (maximum pluviometric average of 194,4 mm in January and minimum of 43,8 mm in June). The lagoon is characterized as a brown-water with an average temperature of 23.6 °C and slightly acidic water (pH 6.3) with electrical conductivity average of 0.45 µS/cm, salinity of 0.22 ppt and total alkalinity of 480.8 mEq/L CO_2.

Material and Methods

Adult leaves of *Nymphaea ampla* (about 10g dry weight) were incubated in an "in situ" experiment with litter bags (30 X 30cm with 5 mm mesh) and the decomposition of

the leaf detritus ended up in 16 days. Samples were collected in triplicates at intervals of 1, 2, 3, 9 and 16 days, and the detritus washed over a sieve of 120 mm mesh.

The remaining material was fixed with 10% formaldehyde and organisms were sorted under a stereomicroscope. For taxonomic identification, the Chironomidae larvae were prepared using 10% lactophenol slides and their mouthparts examined under a 400x microscope. The specimens were deposited in the Reference Collection of Benthic Macroinvertebrates of the Institute of Biological Sciences, Federal University of Minas Gerais, Brazil.

The Shannon-Wiener diversity index was calculated according to Magurran (1991).

The classification of the functional trophic groups was performed according to Merritt & Cummins (1984).

Results

The Chironomidae larvae colonization was assessed through a period of 16 days in which the detritus of *N. ampla* decomposed c. 90%. The Chironomidae was the predominant group among the observed invertebrates ranging from 40% in the beginning to 70% at the end of the decomposition process (Gonçalves et al., unpublished data).

In total, 9 genera from the Tanypodinae (*Ablabesmyia*, *Labrundinia*) and Chironominae (*Polypedilum (Asheum)*, *Chironomus*, *Goeldichironomus*, *Parachironomus*, *Polypedilum*, *Tanytarsus* and *Rheotanytarsus*) sub-families were identified. *Rheotanytarsus* had the highest density at the end of the experiment (590 ind/100g DW) (Tab. I).

A gradual increase of the Chironomidae larvae throughout the detritus decomposition process of *N. ampla* was observed with a maximum of 1,822 ind/100gDW on the 16th day.

Table I: Taxonomic composition and functional trophic groups classification of the Chironomidae larvae throughout the detritus decomposition process of *Nymphaea ampla* (density (ind/100g DW) (P= predator, C-G= collector-gatherer, C-F= collector-filter, S= shredder).

Taxa	Functional Trophic Groups	Experiment Days 1	2	3	9	16
Chironomidae						
Tanypodinae						
Ablabesmyia	P	5	8	9	23	
Labrundinia	P					50
Chironominae						
Asheum	C-G	5	16	17	12	394
Chironomus	C-G				35	
Goeldichironomus	C-G		4			99
Parachironomus	P/ C-G		8			
Polypedilum	P/ C-G/S		8	17	46	295
Tanytarsus spp.	C-G			58	47	394
Rheotanytarsus	C-F		8	25	23	590
Total Density		10	52	126	186	1822
Genera Richness		2	6	5	6	6
H' Shannon-Wiener		0.693	1.712	1.407	1.701	1.58
Evenness		1	0.956	0.874	0.949	0.882

The Shannon-Wiener index values varied from H'= 0.69 on the 1st day up to H'= 1.58 on the last day of the experiment.

Four functional trophic groups were identified: predators, collector-gatherers, collector-filters and shredders. The collector-gatherers were dominant throughout the detritus decomposition process (Fig. 1). On the first sampling day, only collector-gatherers and predators were found, and on the following samples, a gradual increase on the functional trophic groups complexity was observed.

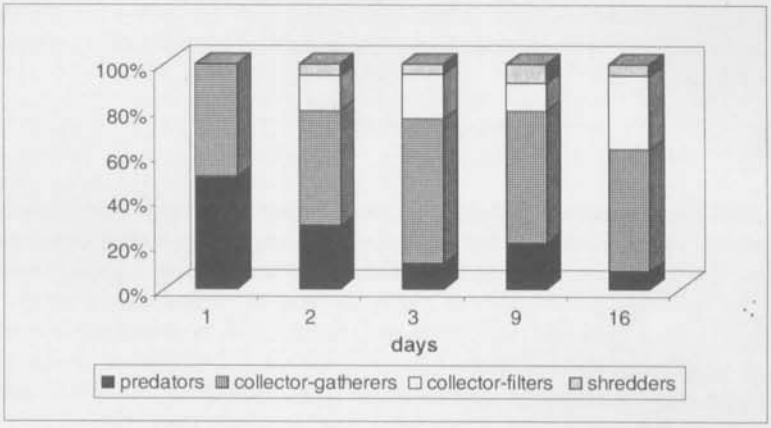

Figure 1: Functional trophic group classification of the Chironomidae larvae assemblage throughout the decomposition process of *Nymphaea ampla* detritus.

Discussion

The results obtained in this study show that the Chironomidae larvae have high density values throughout the detritus colonization process of *N. ampla* at the Jurubatiba lagoon. The predominance of the Chironomidae larvae during the process of vegetal organic matter decomposition in freshwater ecosystems has been widely observed (Wollheim & Lovvorn, 1996; Dvorák, 1996; Nessimian, 1997; Gonçalves et al., 2000).

According to Graça (2001) the invertebrates generally fragment direct or indirectly the vegetal detritus. The *taxa* found in this study fed on detritus (shredders), such as *Polypedilum*; fine and ultra fine organic matter particles stick to the detritus (collector-gatherers and collector-filters), as *Polypedilum* (*Asheum*) and *Rheotanytarsus*. These *taxa* are also a food resource for predators such as *Ablabesmyia* and *Labrundinia* larvae and another invertebrates (e.g., Odonata nymphs) and vertebrates (e.g., juvenile fishes). These trophic interactions suggest that the organisms respond to the changes occurred on the decomposing organic substrate through the substitution of the Chironomidae genera and, therefore, modifying the assemblage structure regarding the changes on the feeding habit of the present organisms.

According to Bowen et al. (1998) the *Polypedilum* larvae indicate advanced stages of the ecological succession process, thus assuming an important role on the assemblage composition during the detritus decomposition. This numeric participation can be measured through the increase of these organisms density, which was observed in this experiment not only for the *Polypedilum* but also to the *Polypedilum* (*Asheum*) and *Tanytarsus* larvae. Despite most of the Chironomidae genera showing defined feeding habits (Merritt & Cummins, 1984), it has been reported that these organisms tend to show generalist and opportunist feeding habits, especially the collector-gatherers that not rarely use the periphyton organisms as food supply (Nessimian, 1997).

The results obtained by Gonçalves (1999) when studying *N. ampla* and *Typha domingensis* decomposition processes, showed that the detritus from *N. ampla*

decomposed c. 24 times faster than the detritus from *T. domingensis*. This rapid decomposition characterizes the detritus from *N. ampla* as an unstable substrate, due to the constant physical, chemical and biological changes occurred to the environment. When comparing the results obtained from the Chironomidae larvae assemblage colonization in the present study and the data from Gonçalves et al. (2000), a decrease on density and diversity (c. 50%) of *N. ampla* detritus was observed. It was also observed by Botts (1997) when comparing the colonization in other types of organic substrates (trunk and leaf), where the more unstable substrates (faster decomposition) decreased the density and diversity of the Chironomidae larvae.

The studies that have conservation, rehabilitation and managing of freshwater ecosystems as main goals have showed the need to investigate the ecological processes that maintain the biodiversity in the watershed, therefore allowing the establishment of proper politics and strategies (Primack & Rodrigues, 2001; Wood et al. 2001; O'Connel & Yallop, 2002; Sheldon et al., 2002; Souza et al., 2002). Furthermore, the results obtained in this study represent a progress on the knowledge of the organic matter decomposition process and degradative ecological succession, and also the importance of the Chironomidae larvae diversity in tropical ecosystems, especially to the lacustrine complex located inside the Parque Nacional da Restinga de Jurubatiba.

Acknowledgments

We are grateful to MSc. Anderson Medeiros dos Santos for his help in the field experiment and our colleagues in NUPEM (Ecological Research Center of Macaé) for the logistical infrastructure in the field. Grants obtained from CNPq as a scholarship for the authors are appreciated.

References

Allan, D.J. 1995. Stream Ecology: structure and function of running waters. Chapman & Hall, Londres. 388 p.

Batzer, D.P. & Wissinger, A.S. 1996. Ecology of insect communities in nontidial wetlands. Annu. Rev. Entomol., 41:75-100.

Begon, M., Harper, J.L. & Townsend, C.R. 1996. Ecology: individuals, populations and communities. 3rd ed. Blackwell Science, Cambridge. 1068 p.

Botts, P.S. 1997. Spatial pattern, patch dynamics and successional change: Chironomidae assemblages in a Lake Erie coastal wetland. Freshwater Biol., 37:277-286.

Bowen, K.L., Kaushik, N.K. & Gordon, A.M. 1998. Macroinvertebrate communities and biofilm chlorophyll on woody debris in two Canadian oligotrophic lakes. Arch. Hydrobiol.,141:257-281.

Callisto, M., Serpa-Filho, A., de Oliveira, S.J. & Esteves, F.A. 1996. Chironomids on leaves of *Typha domingensis* in a lagoons of Rio de Janeiro State (Brazil). Stud. Neotrop. Fauna & Environ., 31:51-53.

Callisto, M., Barbosa, F. A., Moreno, A. 2001. The influence of *Eucalyptus* plantations on the macrofauna associated to *Salvinia auriculata* in Southeast Brazil. Braz. J. Biol., 61(4): 1-12.

Dvorák, J. 1996. An example of relationships between macrophytes, macroinvertebrates and their food resources in a shallow eutrophic lake. Hydrobiologia, 339:27-36.

Esteves, F.A. 1998. Fundamentos de Limnologia. Interciência - FINEP, Rio de Janeiro. 575p.

Furtado, A. 1994. Contribuição das macrófitas aquáticas *T. domingensis* (Typhaceae) e *Eleocharis* cf. *fistulosa* (Cyperaceae) para o estoque de nutrientes e energia na lagoa Imboacica (Macaé-RJ). Rio de Janeiro, UFRJ, 104p (Dissertação).

Gessner, M.O., Chauvet, E. & Dobson, M. 1999. A perspective on leaf litter breakdown in stream. Oikos, 85:377-384.

Gonçalves Jr, J.F., Fonseca, J.J. & Callisto, M.F.P. 1998. Population dynamic of *Heleobia australis* (Gastropoda) in a coastal lagoon (Rio de Janeiro, Brazil). Verh. Int. Verein. Limnol., 26:2056-2057.

Gonçalves Jr., J.F. 1999. Colonização por invertebrados em detritos de Macrófitas aquáticas (*Typha domingensis* e *Nymphaea ampla*) na lagoa Jurubatiba (Cabiúnas), Macaé, RJ. Rio de Janeiro. UFRJ. 60 p (Dissertação).

Gonçalves, J.F.Jr.; Esteves, F.A. & Callisto, M. 2000. Succession and diversity of Chironomidae in detritus of *Typha domingensis* in a coastal lagoon (Parque Nacional da Restinga de Jurubratiba, State of Rio de Janeiro, Brazil). Verh. Internat. Verein. Limnol. 27: 2374-2377.

Graça, M.A.S. 2001. The role of invertebrates on leaf litter decomposition in streams – a review. Int. Rev. Hydrobiol., 86(4-5):383-393.

Hanlon, R.D.G. 1982. The breakdown and decomposition of allochthonous and autochthonous plant litter in an oligotrophic lake (Llyn Frongoch). Hydrobiologia, 88:281-288.

Humphries, P. 1996. Aquatic macrophytes, macroinvertebrate associations and water levels in a lowland Tasmanian river. Hydrobiologia, 321:219-233.

Huszar, V.L.M. & Reynolds, C.S. 1997. Phytoplancton periodicity and sequences of dominance in an Amazonian flood-plain lake (Lago Batata, Pará, Brazil): responses to gradual environmental change. Hydrobiologia, 346:169-181.

Johnson, R.K.; Wiederholm, T. & Rosenberg, D.M. 1995. Freshwater biomonitoring using individual organisms, population, and species assemblages of benthic macroinvertebrates. In: Rosenberg, D.M. & Resh , V.H. (ed.). Freshwater biomonitoring and benthic macroinvertebrates. Chapman and Hall, New York. 540p.

Lawton, J.H. & Jones, C.G. 1993. Linking species and ecosystem perspectives. Tree, 8(9):311-313.

Magurran, A. E. 1991. Ecological diversity and its measurement. Chapman & Hall, London. 178 p.

Menezes, C.F.S., Esteves, F.A. & Anésio, A.M. 1993. Influência da variação artificial do nível d' água da represa do Lobo (SP) sobre a biomassa e produtividade de *Nymphoides indica* (L.) O Kuntze e *Pontederia cordata* L. Acta Limnol. Bras., 6:163-172.

Merritt, R.W. & Cummins, K.W. 1984. Introduction to aquatic insect of North America. 2nd ed. Kendall/Hunt Publishing Company, Iowa.720p.

Nessimian, J.L. 1997. Categorização funcional de macroinvertebrados de um brejo de dunas do Estado do Rio de Janeiro. Braz. J. Biol., 57(1): 135-145.

Odum, E.P. 1969. The strategy of ecosystem development. Science, 164: 262-270.

O'Connell, M. & Yallop, M. 2002. Research needs in relation to the conservation of biodiversity in the UK. Biol. Conserv., 103:115-123.

Palma-Silva, C. 1998. Crescimento e produção de *Typha domingensis* Pers na Lagoa Imboassica. In: Esteves, F.A. (ed.). Ecologia das lagoas costeiras do Parque Nacional da Restinga de Jurubatiba e do Município de Macaé (RJ). NUPEM, Macaé. 442p.

Primack, R.B. & Rodrigues, E. 2001. Biologia da Conservação. Editora, Londrina. 328p.

Sheldon, F., Boulton, A.J. & Puckridge J.T. 2002. Conservation value of variable connectivity: aquatic invertebrate assemblages of channel and floodplain habitats of a central Australian arid-zone river, Cooper Creek. Biological Conservation, 103:13-31.

Smock, L.A. & Stoneburner, D.L. 1980. The response of macroinvertebrates to aquatic macrophyte decomposition. Oikos, 35:397-403.

Souza, F.L., Cunha, A.F., Oliveira, M.A., Pereira, G.A.G., Pinheiro, H.P. & Reis, S.F. 2002. Partitioning of molecular variation at local spatial scales in the vulnerable neotropical freshwater turtle, *Hydromedusa maximiliani* (Testudines, Chelidae): implication for the conservation of aquatic organisms in natural hierarchical systems. Biol. Conserv., 104:119-126.

Trivinho-Strixino, S. & Strixino, G. 1993. Estrutura da comunidade de insetos aquáticos associados à *Pontederia lanceolata mittal*. Braz. J. Biol., 53(1):103-111.

Wallace, J.B., Eggert, S.L.Meyer, J.L. Webster, J.R. 1997. Multiple trophic levels of a forest stream linked to terrestrial litter inputs. Science, 277:102-104.

Wetzel, R.G. 1993. Limnología. Fundação Calouste Gulbenkain, Lisboa. 919p.
Wood, P.J., Greenwood, S.A. & Gunn, J. 2001. The effects of amenity management for angling on the conservation value of aquatic invertebrate communities in old industrial ponds. Biol. Conserv., 102:17-29.
Wollheim, W.M. & Lovvorn, J.R. 1996. Effects of macrophyte growth forms on invertebrates communities in saline lakes of the Wyoming High Plains. Hydrobiologia, 323:83-96.

Received: 21 October 2002
Accepted: 25 February 2003