Phytophilous cladocerans (Crustacea, Anomopoda and Ctenopoda) from Paranã River Valley, Goiás, Brazil

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ABSTRACT. A rapid assessment survey identified 39 phytophilous cladocerans species from littoral zones of rivers, permanent and temporary lagoons, and swamps of the Paranã River Valley, Goiás, Brazil, 22 are registered for the first time in Central Brazil. Aspects of the taxonomy of some of these species are discussed. Cluster analysis (UPGMA) revealed two phytophilous cladoceran assemblages, characterized by higher or lower richness and relative abundance of species of the families Daphniidae and Moinidae (filter feeders), in comparison with the dominant families Chydoridae and Macrothricidae (scraper feeders).
KEY WORDS. Cladocera; cluster analysis; phytophilous fauna; species richness.

RESUMO. **Cladóceros fitófilos (Crustacea, Anomopoda and Ctenopoda) do vale do Rio Paranã, Goiás, Brasil.** Através de amostragens rápidas, levantou-se as espécies de cladóceros fitófilos presentes em zonas litorâneas de rios, lagoas e brejos permanentes e temporários do vale do Rio Paranã, Goiás, Brasil. Foram encontradas 39 espécies, das quais 22 são registradas pela primeira vez na região central do Brasil. São discutidos aspectos da taxonomia de algumas dessas espécies. A análise de agrupamento (UPGMA) dos pontos de amostragem mostrou dois tipos de associações de espécies de cladóceros fitófilos, caracterizadas pela maior ou menor riqueza e abundância relativa das espécies das famílias Daphniidae e Moinidae (filtradoras), em contraste com as famílias dominantes Chydoridae e Macrothricidae, tipicamente raspadoras do substrato.
PALAVRAS-CHAVE. Análise agrupamento; Cladocera; fauna fitófila; riqueza de espécies.

Marginal zones of lentic or lotic environments, as well as swampy environments, are considered ecotones between terrestrial and aquatic environments, being characterized by communities marked by the presence of aquatic macrophytes. The submerged parts of macrophytes provides substrates for the development of periphyton, which acts as food resource and support a complex community of aquatic invertebrates (TAKEDA *et al.* 2003). This phytophilous fauna has been the focus of growing attention, as the comprehension of its role in the energy flow of aquatic ecosystems increases. The importance of this community in water quality evaluation is high, considering that marginal zone of aquatic environments has been subject to extensive morphological modifications deriving from human activities (MARGARITORA *et al.* 2003).

The water-land ecotone regions usually present a higher species richness than the open water environments. The higher complexity of microenvironments, generated by the presence of several species of macrophytes, seems to be the factor responsible for this increase in richness (NOGUEIRA *et al.* 2003).

Cladocerans comprise a major part of the diverse littoral community (DODSON & FREY 2001). Littoral species include truly filter feeders, such as some sidids (Ctenopoda) and some moinids and daphniids (Anomopoda Sars, 1865), as well scraper feeders, such as macrothricids and chydorids (Anomopoda). In the later case, animals typically feed by crawling along surfaces or through mud and scraping up or filtering food (FRYER 1968, 1974), being specialized in exploring the several microhabitats created by the submerged parts of the macrophytes. It cannot be attributed to a random event the fact that these two families correspond to about 60% of all known cladoceran species diversity (KOROVCHISNKY 1996).

The Paranã River basin has 5.940.382 ha, and it is a depression between the Central Goiano Plateau and the plateau representing the São Francisco and the Tocantins divide (13°20'-15°40'S, 46°35'-47°30'W) (SILVA & SCARIOT 2003). Like in most parts of the Central Brazilian Plateau, the cladoceran fauna of this region is still unknown (ELMOOR-LOUREIRO 2000).

As part of the PROBIO project "Assessment Survey of the Aquatic Biota with Conservation and Sustainable Use Intent of the Cerrado Biome (Paranã River Mountain Range and Valley)", this study aimed to survey the cladoceran species associated with macrophytes of permanent and temporary freshwater environments of this region.

MATERIAL AND METHODS

The Paranã River Basin (Fig. 1) is located in the Central Brazil, and the regional climate has two well-defined periods: a cool, dry winter (from May to September) and a warm, rainy summer (from October to April). Sample collection occurred during rapid sampling expeditions conducted throughout the wet season (2003 and 2005) and, in case of perennial water bodies, also in the dry season (2003 and 2004). Although 30 sampling points were defined for the PROBIO project, for the present work it was selected only the water bodies where an expressive macrophyte community existed or where other appropriate substrates for cladoceran colonization were present (*e.g.* submerged terrestrial plants) (Tab. I, Figs 2-5).

For specimens sampling, it was used a plankton net with mesh size of 130 µm, which was large enough to reduce the sediment in the samples, yet small enough to hold adult cladocerans (eventually, the youngest individuals could be lost). The net had its opening protected by a grating (1 cm mesh), in order to avoid the introduction of large fragments. The net was introduced among the macrophytes and the filtered content was fixed in 4% formalin. Animals were sorted and counted under a stereomicroscope. When few specimens were present, entire samples were counted, but when samples were very rich, successive sub-samples were examined until the cumulative richness remained stable (at least five sub-samples without the addition of new taxons). The relative abundance of each taxon was registered, with the intention of identifying the dominant species (approximately 50% of the relative abundance). Voucher specimens are deposited at the Laboratory of Zoology of Universidade Católica de Brasília.

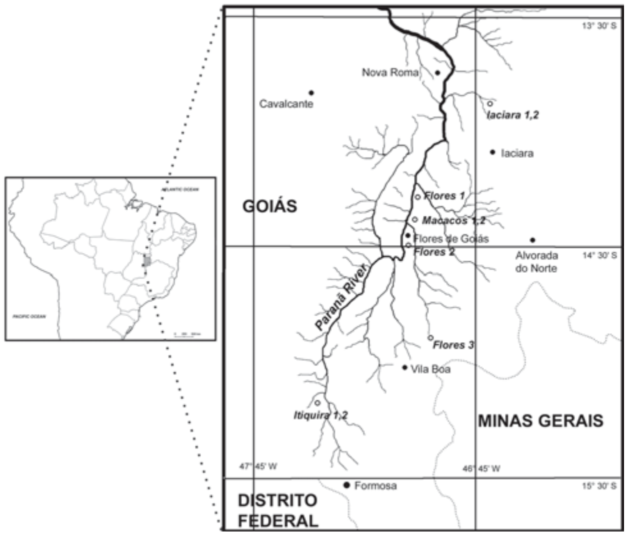
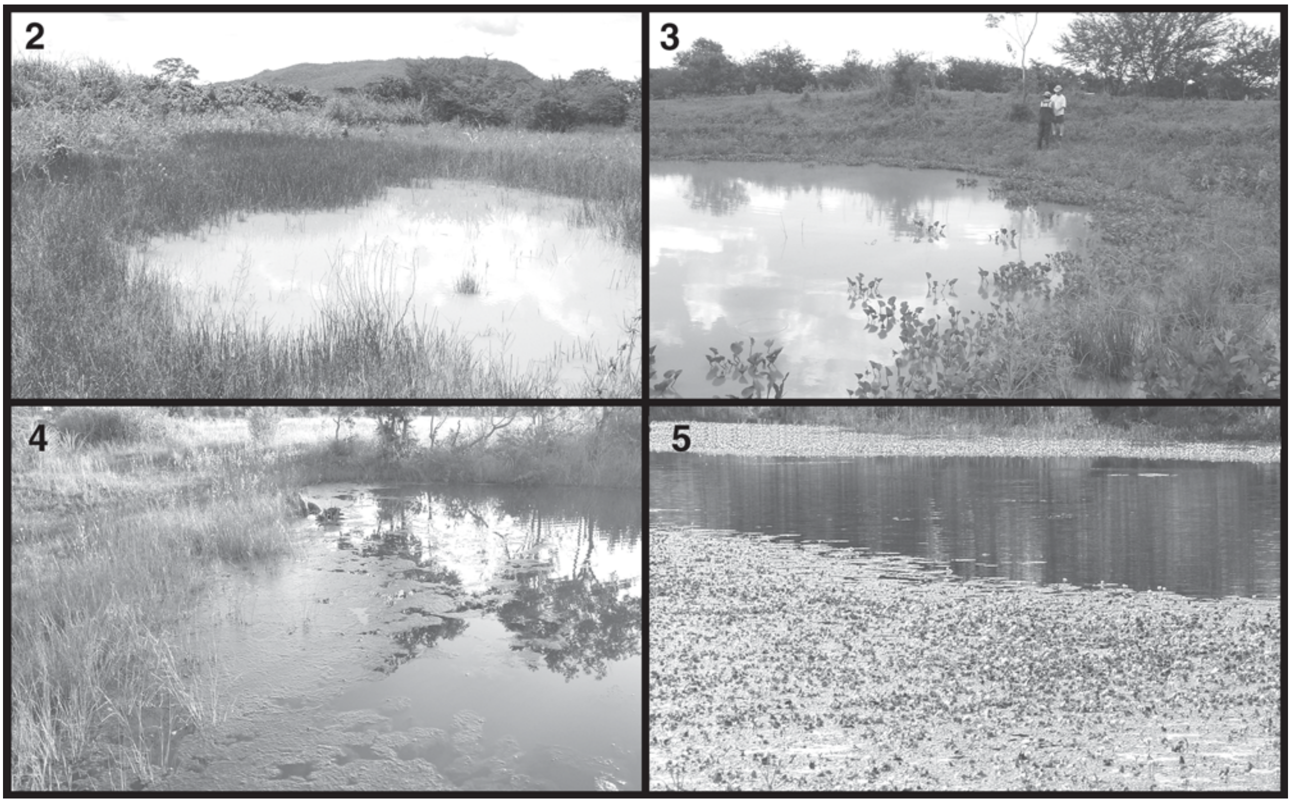


Figure 1. Location of the Paranã River Valley and the sampling points (solid circles).

In order to compare the cladoceran fauna among the sampling points, a cluster analysis (UPGMA, mean character difference) was conducted using PAUP 4 (Swofford 1999). The data

Table I. Position and characterization of the phytophilous cladoceran sampling points in the Paranã River Valley, Goiás, Brazil.

Sampling points		Coordinates	Type of substrate
Iaciara 1	Temporary flood area, road GO110, Iaciara County	13°49'35.2"S; 46°38'54.5"W	Dense emergent macrophytes
Iaciara 2	Water pond for cattle, 100 m from point Iaciara 1	13°49'35.2"S; 46°38'54.5"W	Spaced emergent macrophytes
Itiquira 1	Natural lagoon with elevated water level created by a dam, near Salto de Itiquira, road GO116, Formosa County	15°09'15.8"S; 47°28'04.7"W	Dense submerged macrophytes
Itiquira 2	Temporary flood area, between point Itiquira 1 and road	15°09'15.8"S; 47°28'04.7"W	Submerged grass in decomposition
Flores 1	Temporary swamp between the Macacos and Correntes Rivers, road GO236, Flores de Goiás County	14°18'23.9"S; 46°57'34.0"W	Emergent and a few floating macrophytes
Flores 2	Flooded areas along the right (point Flores 2d) and left (point Flores 2e) margins of road GO114 way to Flores de Goiás	15°09'15.8"S; 47°28'04.7"W	Submerged macrophytes
Flores 3	Natural lagoon, BR020, near the intersection of road GO114, Flores de Goiás County	14°54'56.0"S; 46°57'02.9"W	Submerged and dense floating macrophytes
Macacos 1	Macacos River, Flores de Goiás County	14°27'42.9"S; 47°00'15.2"W	Spaced grass and phylamentous algae
Macacos 2	Backwater of Macacos River, Flores de Goiás County	14°27'42.9"S; 47°00'15.2"W	Submerged tree limbs and leaves



Figures 2-5. General aspects of the phytophilous cladoceran sampling points in water bodies of the Paranã River Valley, with predominant emerged macrophytes (2 – Iaciara 1; 3 – Iaciara 2) or submerged macrophytes (4 – Flores 2e; 5 – Flores 3).

matrix was constructed coding for presence (1) and absence (0) of each species in the samples using the software MacClade 3.04 (Maddison & Maddison 1992). For this analysis, data from the sampling repetitions were combined. For perennial water bodies, the Sørensen coefficient was calculated to estimate the similarity between community in dry and wet season.

RESULTS AND DISCUSSION

A total of 39 cladoceran species were identified (Tab. II), of which 22 were registered for the first time for this region of Central Brazil – Distrito Federal/Goiás (cf. Elmoor-Loureiro 2000, Elmoor-Loureiro *et al.* 2004). Since the majority of these species possess an ample distribution, their occurrence in the Brazilian Midwest is predictable. No endemic species to this region were identified.

In the last two decades, several Neotropical species of cladocerans were the object of taxonomical reviews (*e.g.* Frey 1993, Sinev 1998, 2001a, b, Silva-Briano *et al.* 1999, Dumont & Silva-Briano 2000, Dumont *et al.* 2002, Kotov *et al.* 2002), supporting even more the idea that species once considered cosmopolitan, actually represent species complexes (Frey 1995, Korovchinsky 1996, Dumont 1997). The taxonomy of some of these complexes is not entirely elucidated, being the case of *Latonopsis australis*-group (Korovchinsky 1992), *Ephemeroporus barroisi*-group (Frey 1982) and *Simocephalus acutirostratus*-group (Orlova-Bienkowskaja 2001).

Several species identified in this study were the object of recent reviews, therefore, they were not included in Elmoor-Loureiro (2000), or were presented in different genera. These species are illustrated and aspects of their taxonomy are discussed below.

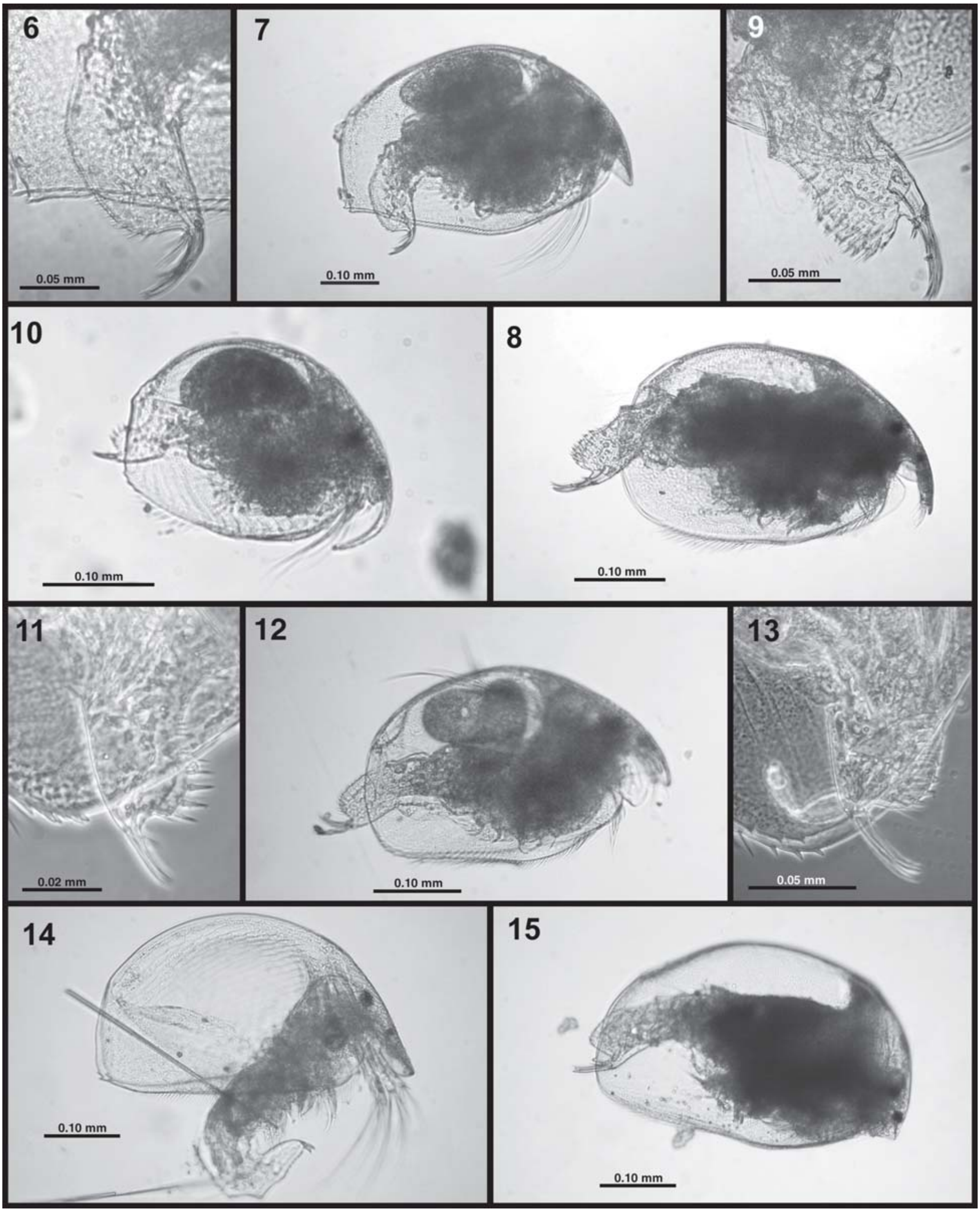
Alona dentifera (Sars, 1901) (Figs 6 and 7) was originally described in the *Alonella* genus, but was recently transferred to *Alona* Baird, 1843, particularly because of its trunk limbs characteristics, which are typically of the Aloninae type (Sinev *et al.* 2004). These authors, based on the detailed comparisons, also affirm that *Alonella brasiliensis* Bergamin, 1935 is a junior synonym of *A. dentifera*.

Alona verrucosa Sars, 1901 (Figs 8 and 9), due to the presence of two median cephalic pores, was transferred to the *Biapertura* Smirnov, 1971. Sinev & Hollwedel (2002) presented this species once again in the *Alona* genus, following the tendency to abandon the *Biapertura* genus, now considered an artificial taxon.

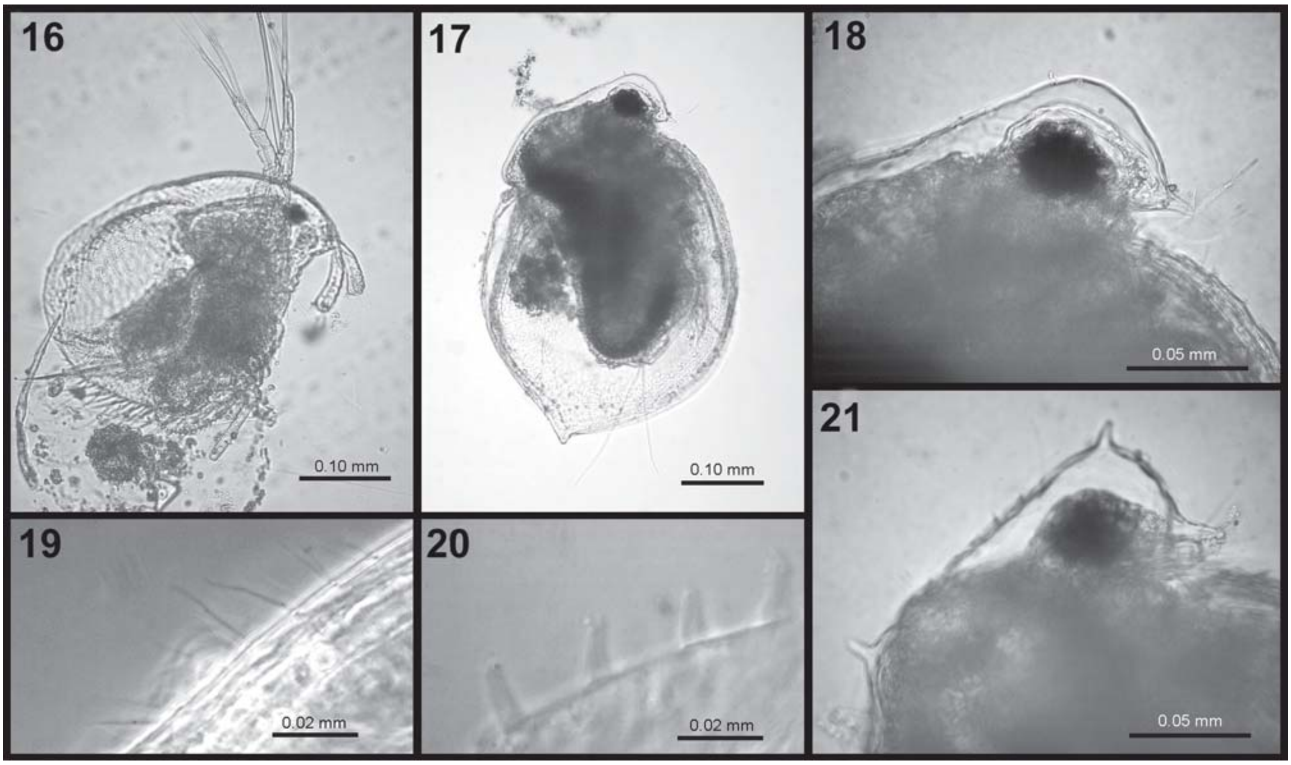
Alonella dadayi Birge, 1910 (Figs 10 and 11) is frequently cited in Brazil, however by different names, sometimes as *Dispa-*

Table II. Cladoceran species from flooded areas and marginal zones of aquatic environments of the Paranã River Valley and mountain range. The first records of occurrence in Central Brazil are indicated by (*). Species that had a relative abundance close or superior to 50%, characterizing strong community dominance are indicated by (xx). (Flor) Flores, (Itiq) Itiquira, (Iaci) Iaciara, (Mac) Macacos.

Taxa	Wet season 2003					Dry season 2003-4		Wet season 2005				
	Itiq1	Itiq2	Mac1	Mac2	Flor1	Itiq1	Mac1	Iaci1	Iaci2	Flor2d	Flor2e	Flor3
Ctenopoda												
Sididae Baird, 1850												
Diaphanosoma brevireme Sars 1901	x	x					x		x			
Diaphanosoma spinulosum Herbst, 1967										x		
Latonopsis australis-group	x	x				x				x	x	xx
* *Pseudosida ramosa* (Daday, 1904)			x	x							x	
Anomopoda												
Daphniidae Straus, 1820												
Ceriodaphnia cornuta Sars, 1886				x		x	x	xx	xx			
* *Scapholeberis armata* (Herrick, 1882)				x								
* *Simocephalus acutirostratus*-group				x	xx				x			
* *Simocephalus latirostris* Stingelin, 1906			x			x						
Moinidae Goulden, 1968												
* *Moina reticulata* (Daday, 1905)				x								
Moina micrura Kurz, 1874									x			
* *Moinodaphnia macleayi* (King, 1853)		x		x				xx	x			
Ilyocryptidae Smirnov, 1992												
Ilyocryptus spinifer Herrick, 1882	x	x	x	x		x	x			x	x	x
Macrothricidae Norman & Brady, 1867												
Macrothrix elegans Sars, 1901	x	x	x	x	x	x	x			x	x	x
Macrothrix squamosa Sars, 1901	x		x		x	x	x					
Macrothrix paulensis (Sars, 1900)										x		
Streblocerus pygmaeus Sars, 1901	x										x	x
Chydoridae Stebbing, 1902												
* *Alona dentifera* (Sars, 1901)				x		x						
Alona guttata Sars, 1862	x											
* *Alona monacantha* Sars, 1901		x					x					
* *Alona ossiani* Sinev, 1998	x											
* *Alona verrucosa* Sars, 1901	x	x		x		x				x	x	x
Alonella dadayi Birge, 1910		x				x						x
* *Chydorus dentifer* Daday, 1905	x					x					x	x
Chydorus eurynotus Sars, 1901		x										
* *Chydorus nitidulus* (Sars, 1901)	x	x			x	x				x		
Chydorus pubescens Sars, 1901	x	x	x	x		x						x
Chydorus sp.				x		x					x	
* *Dadaya macrops* (Daday, 1898)				x	x							
* *Dunhevedia odontoplax* Sars, 1901					x					x		
Ephemeroporus barroisi-group		x				x				x	x	
* *Ephemeroporus hybridus* (Daday, 1905)		x	x	x						x	x	x
* *Ephemeroporus tridentatus* (Bergamin, 1931)				x	x		x			x		
Euryalona orientalis (Daday, 1898)				x								
* *Graptoleberis occidentalis* Sars, 1901	x											
* *Karualona mülleri* (Richard, 1897)	x	x		x	x	x		x		x	x	
* *Leydigiopsis megalops* Sars, 1901	x			x		x						
* *Nicsmirnovius cf incrediblis* (Smirnov, 1984)			x									
* *Notalona sculpta* (Sars, 1901)				x								
* *Oxyurella longicaudis* (Birge, 1910)					x			x	x			
Number of species	14	15	8	19	9	16	7	4	6	12	11	9



Figures 6-15. Chydoridae cladoceran species found in water bodies in the Paranã River Valley. (6-7) *Alona dentifera*; (8-9) *Alona verrucosa*; (10-11) *Alonella dadayi*; (12-13) *Karualona mülleri*; (14) *Graptoleberis occidentalis*; (15) *Nicsmirnovius* cf *incredibilis*.



Figures 16-21. Cladoceran species found in water bodies in the Paranã River Valley. (16) *Macrothrix squamosa*; (17-19) *Ceriodaphnia cornuta*, fine haired form; (20-21) *Ceriodaphnia cornuta*, coarse haired form.

ralona dadayi (*e.g.* Elmoor-Loureiro 1998), other times as *Phryxura dadayi* (*e.g.* Lima *et al.* 2003). The proposed synonymy between *Disparalona* Fryer, 1968 and *Phryxura* Müller, 1867 was rejected by the suppression of the latter name (Iczn 2001). Independently of this fact, Smirnov (1996) suggested the reallocation of this species in the *Alonella* Sars, 1862 genus until further studies are conducted. In fact, some details of *A. dadayi* morphology suggest that it does not belong to *Disparalona*, such as its not elongated shape, the better development of the labral plate and absence of the robust seta on gnathobase of trunk limb 3 directed along food groove.

Dumont & Silva-Briano (2000) discussed the particular characteristics the *Alona karua*-group (or *Biapertura karua*-group), concluding that all the species should be transferred to the new genus *Karualona*, and showing that each one has a restricted distribution to one continent. In Brazil, *Karualona mülleri* (Richard, 1897) (Figs 12 and 13) was reported from the Pantanal of Mato Grosso (Hollwedel *et al.* 2003), creating the possibility that previous reports of *Alona karua* in Brazil were actually this species.

Sars (1901) described *Graptoleberis occidentalis* (Fig. 14) as a subspecies of *Graptoleberis testudinaria* (Fischer, 1851). However, the growing evidences of the non-cosmopolitanism of Chydoridae sustain the separation of the two species, already in use by Paggi (1995).

Alona incredibilis Smirnov, 1984 is distributed throughout the Amazon, and was recently transferred to the *Nicsmirnovius* Chiambeng & Dumont, 1999 genus (Kotov 2003), based on its head pore arrangement, postabdomen and trunk limbs characteristics. The observed specimens (Fig. 15) presented few differences in relation to *Nicsmirnovius incredibilis*, demanding additional studies to confirm the identification.

Macrothrix squamosa Sars, 1901 (Fig. 16) has been presented as a junior synonym of *Macrothrix spinosa* King, 1853 (Smirnov 1992). However, evidences of the non-cosmopolitan distribution of species belonging to this genus (Silva-Briano *et al.* 1999, Dumont *et al.* 2002) raise doubts about the synonymy between *M. spinosa*, originally described from Australian specimens, and *M. squamosa*, from the Neotropics. The proposed synonymy was based on superficial similarities, such as the general aspect of the carapace, antennule, and postabdomen. However, the taxonomical revisions of *Macrothrix laticornis* group (Silva-Briano *et al.* 1999) and *Macrothrix rosea-triserialis* group (Dumont *et al.* 2002) revealed the importance of the trunk limbs morphology in defining species. Thus, until *M. spinosa* and *M. squamosa* could be properly studied, it is recommended that they be treated as separate species.

Even so references of the occurrence of *Ceriodaphnia cornuta* Sars, 1886 (Figs 17-21) exist for almost all Brazilian regions

(Elmoor-Loureiro 2000), this is the first record of its hairy morphs from Brazil. According to Berner (1985), such hairy morphs are common and found primarily in littoral habitats. I observed two different patterns: fine haired specimens, generally associated with the *rigaudi* form (Figs 17-19) and coarse haired specimens (pilosity similar to spines), generally found in the *cornuta* form (Figs 20 and 21).

The most frequent species were *Ilyocryptus spinifer* Herrick, 1882, *Karualona mülleri*, and *Alona verrucosa*, which were found in more than 50% of the samples. *Latonopsis australis*, *Chydorus pubescens* Sars, 1901, and *Ephemeroporus hybridus* (Daday, 1905), occurred in 50% of the samples.

In a few samples, the species *Ceriodaphnia cornuta*, *Moinodaphnia macleayi* (King, 1853), *Simocephalus acutirostratus*-group and *Latonopsis australis* were particularly abundant, with an estimated relative abundance of nearly 50% (Tab. II).

Comparison of the communities between wet and dry seasons was only possible in two perennial sampling points (points Itiquira 1 and Macacos 1). A small variation in total richness was verified, but the species composition of the communities were variable (Sørensen coefficient between wet and dry season for point Itiquira 1 = 0.65; point Macacos 1 = 0.40).

Some of the observed species cannot be considered to be truly phytophilous, given that they are typical filter feeders from the planktonic community, this being the case of *Diaphanosoma brevireme* Sars, 1901, *Diaphanosoma spinulosum* Herbst, 1967, and *Moina micrura* Kurz, 1874. These species were found in environments where emergent macrophytes were present, or where open water occurred among the plants, which suggests that their occurrence in the samples was accidental. An alternative hypothesis would be the occurrence of a migration from the limnetic zone, as a strategy to escape from predators, already verified in other species (Stansfield *et al.* 1997).

Higher species richness occurred in environments where submerged macrophytes (points Itiquira 1 and Flores 2), or flooded terrestrial vegetation (point Macacos 2) were predominant. These substrates seem to support a greater variety of microhabitats than emergent or floating macrophytes, favoring exploration by a larger number of species.

The cluster analysis of the sampling points (Fig. 22) indicates the existence of two types of associations of phytophilous cladoceran species in the aquatic environments of the Paranã River Valley. The first association (group A) is related to environments with the predominant presence of emergent macrophytes (points Iaciara 1, Iaciara 2, Macacos 1, and Flores 1), which leads to the occurrence of open water among the substrates (Figs 2 and 3). In this association, a greater number and relative abundance of species of the families Daphniidae and Moinidae (filter feeders) occur than in the second type of association. This is not caused only by the presence of planktonic species, but also by the typical filter feeders from the littoral zone, for example *Moinodaphnia macleayi* and the *Simocephalus* species (Fryer 1991).

The second association (group B) occurs in environments

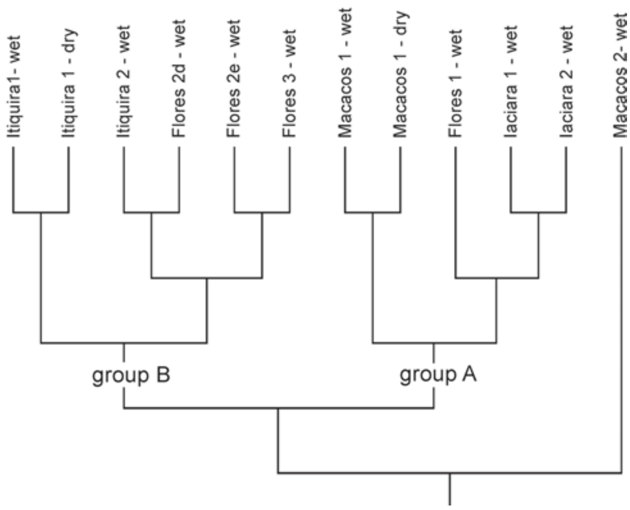


Figure 22. Similarity dendrogram of the phytophilous cladoceran species between the sampling points, during different periods.

that are dominated by submerged macrophytes (Figs 4 and 5), being characterized by a greater richness and elevated relative abundance of the families Chydoridae and Macrothricidae, typically substrate scraper feeders.

The point Macacos 2 is distinguished from the two previous associations (Fig. 22), and it has the highest number of species (Tab. II). The considerable mass of free water between the abundant submerged material (shrubs and tree limbs) created a peculiar and intermediate condition between the two previously described types of environments, which could explain its higher richness.

The results of the cluster analysis, however suggestive, must be considered as preliminary, given that sampling effort was punctual and the abundance of the present taxa was not considered.

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