

CLADOCERA CHYDORIDAE OF HIGH ALTITUDE WATER BODIES (SERRA DA MANTIQUEIRA), IN BRAZIL

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ABSTRACT

The diversity of species of Cladocera, Chydoridae in the water bodies belonging to the water management unity of Serra da Mantiqueira, was studied inside the BIOTA/FAPESP Program. A total of 21 water bodies were analyzed and the sampling was carried out between 9th and 11th September, 1999. Horizontal and vertical net hauls were taken at littoral and limnetic region in each lake. Most water bodies in Serra da Mantiqueira unity are small, shallow, and densely colonized by macrophytes. Most species of Cladocera found belong to the Chydoridae family, being typical inhabitants of the littoral zone, living associated with macrophytes. A total of 12 species were found, 9 of the subfamily Aloninae and 3 Chydorinae. In more than half of the water bodies the relative abundance of chydorids reached 100%, and they were dominant in most of the others, with few exceptions. *Alona rustica* was the most frequent species, occurring in 62% of the water bodies. The results evidenced the importance of the littoral zone as propitious habitats for the species of Chydoridae and contributing significantly to the diversity of Cladocera as a whole.

Key words: Cladocera, Chydoridae, zooplankton diversity.

RESUMO

Cladocera Chydoridae de corpos d'água de grande altitude (Serra da Mantiqueira)

A diversidade de espécies de Cladocera Chydoridae da unidade de gerenciamento dos recursos hídricos (UGRHI) da Serra da Mantiqueira foi estudada, como parte do Programa BIOTA/FAPESP. Foram analisadas amostras de 21 corpos d'água desta unidade de gerenciamento e as coletas foram realizadas no período de 9 a 11/9/99. Para a análise da comunidade zooplanctônica foram coletadas amostras por meio de arrastos horizontais e verticais na região limnética e na região litorânea. Os corpos d'água da UGRHI da Serra da Mantiqueira são pequenos, de pouca profundidade e densamente colonizados por macrófitas aquáticas. As espécies de Cladocera encontradas são típicas de região litorânea, vivendo associadas a macrófitas, isto é, representantes da família Chydoridae. Em relação à abundância relativa, esta família representou quase 100% do total de Cladocera da maior parte dos corpos d'água e, quanto à riqueza de espécies, representou mais da metade das espécies de Cladocera. A espécie *Alona rustica* foi a mais freqüente, ocorrendo em 62% dos corpos d'água. Os resultados obtidos comprovam que nos ambientes estudados a região litorânea desempenha papel importante, favorecendo o desenvolvimento de condições especiais para o crescimento de espécies de Chydoridae e contribuindo significativamente para a diversidade total dos Cladocera.

Palavras-chave: Cladocera, Chydoridae, diversidade do zooplâncton.

INTRODUCTION

For most aquatic ecosystems, the littoral region represents the interface or the contact zone with terrestrial ecosystems and plays an important role, sometimes functioning as a filter. This region is characterized by high productivity and heterogeneity of habitats, favoring the development of a diversified zooplankton community. Among the organisms inhabiting the littoral region the members of the family Chydoridae, belonging to the Cladocera group are represented by a major part of the species present. These organisms live usually associated with macrophytes, periphyton or sediment and they contribute significantly to the biomass and productivity of the water bodies. They occupy a key position in food chains converting organic matter used for its own growth and also making it available to higher trophic levels. They can also be indicators of the trophic state of the water bodies, because they quickly respond to the changes in environmental variables (Duigan & Kovach, 1991). They can also be used in the reconstruction of the past history of the aquatic ecosystem, considering that they have many fossil remains well preserved in the sediment (Whiteside, 1970).

The present work has analysed the diversity of species of the family Chydoridae in Serra da Mantiqueira, one of the 22 Water Resources Management Unities of São Paulo State.

MATERIAL AND METHODS

Twenty one water bodies were sampled, in the districts of Campos do Jordão and São José dos Alpes between 22°41.405'S and 22°46.229'S and between 45°25.156'W and 45°34.110'W (Fig. 1) at altitudes varying from 1,800 to 1,920 m.

The total management unity has a drainage basin of 642 km² and the main tributaries are the rivers Sapucaí, Sapucaí-Mirim, Prata and Paiol Grande stream. Because of the high altitude, the water temperatures are low and there is great change of slopes in the streams, creating rapid waters and small falls. Most water bodies sampled in this region are small lakes, reservoirs and streams, of small depth (varying from 0.5 a 5.5 m) and with plenty macrophyte vegetation at the

littoral zone. The small reservoirs were constructed for various uses such as hydroelectric generation (Santa Isabel and Fojo reservoir), fish farming (Horto Florestal ponds) and also for recreation. Some are located among the Atlantic Forest reserve of Horto Florestal whereas others as Lavrinhas 1 and Lavrinhas 2 reservoirs are in private properties.

Sampling was carried out during the period between 09th and 11th of September, 1999.

PHYSICAL AND CHEMICAL CHARACTERIZATION

For in situ chemical and physical analysis of the water a U10 Horiba water-quality checker was used, measuring, pH, conductivity, temperature oxygen. Transparency was evaluated by Secchi disk readings. Concentrations of chlorophyll *a*, suspended material, and nutrients were analyzed.

Quantitative and qualitative analyses of the family Chydoridae

Samples were taken by means of combined horizontal and vertical hauling in the limnetic and littoral regions near macrophyte banks. Volumes of at least 100 L in quantitative sampling and over 300 L in qualitative sampling were filtered in a 68 µm-mesh net. The samples were immediately preserved with a 4% neutralized formaldehyde. During the quantitative analysis a sub-sample with varying volume was analyzed (from 5 ml to the whole sample in the case of very low concentrations), whereas for the qualitative analysis the total sample was analyzed.

The preparations of the head shields for the visualization of the cephalic pores were performed according to the procedure described by Megard (1965). The organisms were identified using the following specialized literature: Bergamin, 1932; Edmondson, 1959; Scourfield & Harding, 1966; Smirnov, 1974, 1996; Young, 1998; Elmoor-Loureiro, 1997; Paggi, 1972; Duigan, 1992; Dumont & Silva-Briano, 1998; Rajapaksa & Fernando, 1987a; Duigan & Murray, 1987; Rajapaksa & Fernando, 1987b; Paggi, 1980; Smirnov, 1998; Frey, 1982; Alonso, 1987; Pennak, 1989; Olesen, 1996; Biraben, 1939; Olivier, 1962; Smirnov & Timms, 1983; Sinev 1999.



Fig. 1 — Map of São Paulo State showing the 22 Water Resources Management Unity, highlighting the unity Serra da Mantiqueira focused on this study. Source: <http://www.biota.org.br>.

RESULTS

Table 1 shows the results obtained for the physical and chemical variables analysed. The trophic state of the water bodies sampled varied from oligotrophic up to eutrophic, being Lavrinhas 2 the most eutrophic. It has the highest concentrations of nutrients and suspended matter, as a consequence of the large number of aquatic birds inhabiting it. The most oligotrophic was Fojo Reservoir. This water body is used for supplying water to Campos do Jordão City and it is well preserved. The Reservoir has low nutrient and chlorophyll *a* concentrations, as well as low conductivity.

A marginal pond to Fojo Reservoir was also sampled for biological communities. In general the pH of the various ponds was slightly acid (4.3 to 6.7), had high concentrations of dissolved oxygen (5.8 to 10.9 mg/L) and low values of suspended matter.

In relation to the relative abundance of organisms, the family Chydoridae represented almost 100% of the total of Cladocera in most water bodies (Fig. 2). Exceptions were the sampling station 1 of Itapeva Lake (limnetic region), lakes 3 and 4 of Horto Florestal and Vila Inglesa Lake where the species belonging to the family Bosminidae were the most abundant. Among the Chydoridae the species *Alona rustica* was the dominant in most water bodies.

The family Chydoridae had the highest richness of species. A total of 12 species were found among all the water bodies sampled, 9 species belonging to the subfamily Aloninae and 3 to the subfamily Chydorinae. Among the Aloninae, the most frequent species was *Alona rustica* that was found in 55% of the water bodies and among the Chydorinae, the species *Chydorus pubescens* occurring in 35% of them (Table 2).

The highest richness of species were found in a marginal pond near Fojo Reservoir followed by lake Pico Itapeva and Trutas Lake. The last lake is small, shallow, richly vegetated, 400 m² large. Seven species were found in this pond, 6 members of the subfamily Aloninae (*Acroperus harpae*, *Alona rustica*, *A. monacantha*, *Alona quadrangularis*, *Karualona* sp.) and one from the Chydorinae (*Chydorus pubescens*).

Species of the family Bosminidae were the most abundant organisms in Itapeva Lake, however the family Chydoridae contributed with a larger number of species (6 species).

Species of Chydoridae were not found in Lakes 4 and 5 of Horto Florestal, the forest reserve of Campos do Jordão district, nor in Fonte da Hospedaria, a fountain. Cladocera in these lakes were dominated by species of the family Bosminidae. Riacho das Trutas (Trout stream) and Instituto de Pesca Stream, both lotic environments, had low Chydoridae species richness, 2 and 3 respectively.

DISCUSSION

The water bodies of Serra da Mantiqueira unity are mostly small, shallow and heavily colonized by macrophytes. The presence of abundant macrophytes creates adequate substrates for chydorids, typical inhabitants of the littoral region. Among all the families of Cladocera the Chydoridae had the highest richness of species and relative abundances for most lakes, evidencing its importance regarding freshwater invertebrates diversity. Only few lakes with no aquatic plants were not colonized by species of this family.

Despite the evident importance of the Chydoridae family in the zooplankton of the water bodies surveyed, its total richness at Serra da Mantiqueira unity is smaller than that found in other regions, as for example the Alto Tietê unity where a total of 21 species belonging to this family were recorded (Santos-Wisniewski *et al.*, in preparation). A greater heterogeneity of habitats is the probable cause for the high richness found in Alto Tietê, which comprises from small ponds up to very large reservoirs, very oligotrophic up to hyper-eutrophic water bodies, thus providing a number of different environments and opportunities to a variety of species having diverse requirements. At Serra da Mantiqueira Unity, on the other hand, the many small ponds are closely located and have more

similar conditions, perhaps the reason for the great similarity in the species composition, resulting lowest total richness.

Among the species found it was not possible to characterize any species assemblage that could be considered characteristic of a particular type of water body. The species *Alona rustica* was the most widespread regarding the spatial distribution in the area of study. It seems to be a tolerant species, occurring in environments from the very oligotrophic up to the eutrophic ones (Duigan, 1992).

Among the Chydoridae there is a number of species considered species-complex, of uncertain taxonomical position. Some of the species found in Serra da Mantiqueira fall in this category, as *Acroperus harpae* and *Chydorus sphaericus*. Several authors believe they are not cosmopolitan and that the forms occurring in different continents will probably be distinct species. Careful and detailed re-descriptions are under preparation for the species found in São Paulo State.

In this inventory, two species of the so called *Alona costata* group were found which are *Alona rustica* and *Alona setigera*. According to Sinev (1999) there exist 8 species belonging to the complex *Alona costata*: *Alona costata* in Europe; *Alona setigera* in Australia, Tasmânia and Indonesia; *Alona cheni* in India; *Alona rustica* in Europe and East Siberia (although already recorded in Brazil by Elmoor-Loureiro, 1997); *Alona hudeci* in Venezuela; *Alona bicolor* in North America, and two species *Alona fabricii* and *Alona muelleri* in Groenland. The species *Alona setigera* was recorded for Brazil for the first time by Santos-Wisniewski *et al.* (2001). This species initially described by Brehm (1931) as a variety of *Alona guttata* (*A. guttata setigera*) occurring in New Zealand. Smirnov & Timms (1983) registered this species in Australia, describing it as *Biapertura setigera*. Later on it was found a great similarity between *Alona setigera* and *Alona costata*, differing only in the number of head pores (two pores in *Alona setigera* and three in *Alona costata*) (Sinev, 1999), an argument against the distinction the genus *Biapertura* and *Alona*. Until recently *Alona setigera* was known only from New Zealand, Australia, Tasmania and Indonesia, the record of this species in Serra da Mantiqueira makes it the second record of the species in Brazil. A close check on its characteristics evidenced that *Alona setigera* is closely related to *Alona costata*.

TABLE 1

Values obtained for physical and chemical variables in the water bodies of Serra da Mantiqueira, in September, 1999. L = lake; R = reservoir; S = stream; Nt = total nitrogen; In. = inorganic; Pt = total phosphorus; IM = inorganic matter; OM = organic matter; Chl. = chlorophyll; Cond. = conductivity; DO = dissolved oxygen; and TSI = trophic state index.

Site	NO ₃ ⁻ (µg/L)	NH ₄ ⁺ (µg/L)	Nt (µg/L)	PO ₄ in. (µg/L)	Pt (µg/L)	IM (mg/L)	OM (mg/L)	Chlor. (µg/L)	Cond. (µSi/cm ²)	DO (mg/L)	Carlson indices	
											TSI (Chlor)	TSI (Pt)
Fojo R.	37.7	44.6	274.3	0.8	3.4			0.5	12.0	9.2	23.2	21.2
Lambaris L.	67.7	30.6	224.1	4.6	6.4	3.4	2.6	0.0	120.0	8.0		30.3
Ninfóides L.	12.0	15.5	388.9	2.6	27.4	1.2	7.0	14.4	70.0	6.8	56.7	50.9
H. Florestal 1 L.	57.1	30.6	374.1	2.4	21.3			9.8	80.0	7.0	53.0	47.3
H. Florestal 2 L.	38.7	40.7	311.4	5.6	6.6	10.0	9.0	4.1	70.0	5.8	44.5	30.7
H. Florestal 3 L.	12.2	37.6	410.0	2.3	25.5	8.4	13.6	13.4	60.0	7.4	56.0	49.8
H. Florestal 4 L.	123.0	68.3	436.1	21.0	21.9	1.2	5.2	1.7	110.0	7.8	35.8	47.7
H. Florestal 5 L.	117.5	63.7	443.2	19.7	25.2	1.6	6.4	6.3	110.0	8.3	48.7	49.7
Sta. Isabel R.	19.1	8.1	368.9	2.3	30.0	0.8	3.0	25.8	70.0	10.9	62.4	52.2
Trutas S.	46.4	407.3	567.2	34.8	102.4	0.6	2.2	1.6	50.0	7.7	35.2	69.5
Tundra L.	59.7	15.9	218.2	2.7	5.0	3.2	2.6	1.3	64.0	7.8	33.1	26.9
Lavrinhas 1 L.	52.8	30.3	269.1	2.8	5.6	2.0	4.3	1.9	120.0	7.4	36.9	28.4
Lavrinhas 2 L.	9.6	10.0	1219.5	13.0	181.0	30.0	108.0	234.1	50.0	9.8	84.1	77.6
Inst. Pesca S.	70.1	7.7	231.9	2.0	4.0	0.4	1.6	0.3	90.0	10.2	19.7	23.6
Pico Itapeva R.	8.4	19.0	295.8	1.1	5.9	1.7	2.0	8.1	40.0	9.5	51.0	29.3
Hípica 1 L.	42.7	13.9	283.4	1.5	6.6	1.0	1.8	1.1	60.0	8.9	31.1	30.8
Hípica 2 L.	29.0	13.9	198.0	1.4	4.1	4.0	3.7	4.5	150.0	6.9	45.3	24.1
Vila Inglesa L.	65.3	96.7	422.4	1.7	13.8	3.0	5.0	0.8			28.9	41.2

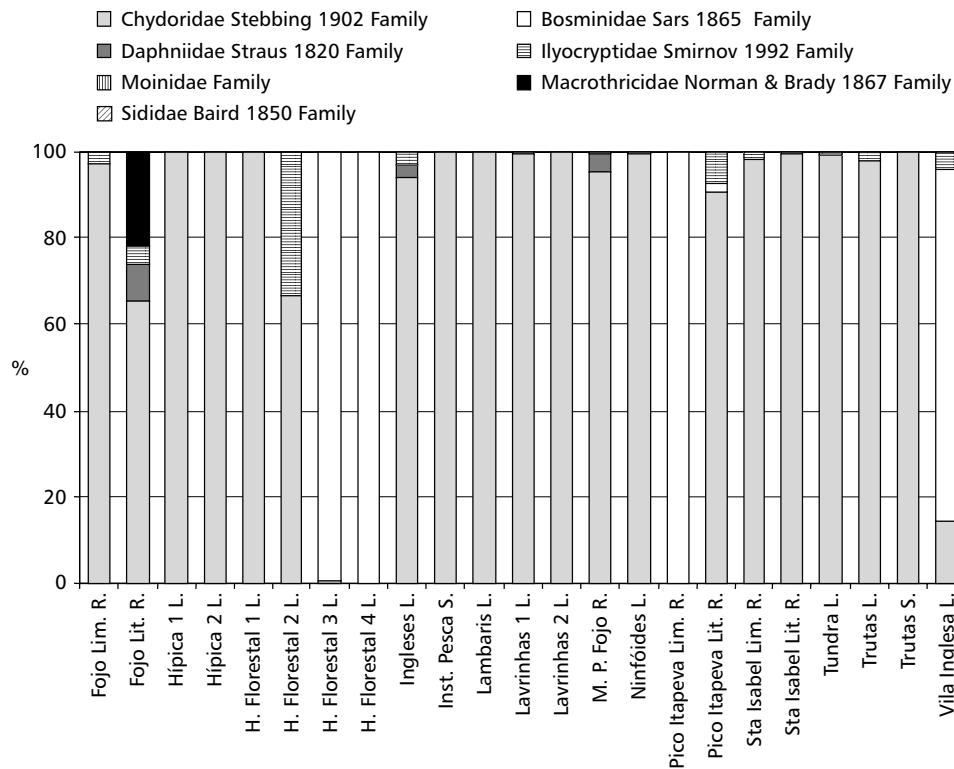


Fig. 2 — Relative abundance of Cladocera families in the water bodies of Serra da Mantiqueira unity.

TABLE 2
Occurrence of the Cladocera Chydoridae species in the water bodies of Serra da Mantiqueira unity.

	Fojo R.	Hípica 1 L.	Hípica 2 L.	H. Florestal 1 L.	H. Florestal 2 L.	H. Florestal 3 L.	H. Florestal 4 L.	H. Florestal 5 L.	Inst. Pesca S.	Lambaris L.	Lavrinhas 1 L.	Lavrinhas 2 L.	M. P. Fojo R.	Nimfóides L.	Pico Itapeva R.	Sta Isabel R.	Trutas L.	Trutas S.	Tundra L.	Vila Inglesa L.
Chydoridae Family																				
Aloninae Subfamily																				
<i>Acroperus harpae</i>	+									+			+			+	+		+	
<i>Alona affinis</i>											+	+					+			
<i>Alona guttata tuberculata</i>	+									+	+	+		+	+		+			+
<i>Alona intermedia</i>		+	+		+												+	+		+
<i>Alona karua</i>					+								+	+		+	+		+	+
<i>Alona monacantha</i>													+				+			
<i>Alona quadrangularis</i>	+				+							+	+		+					
<i>Alona rustica</i>	+	+	+	+	+				+	+			+	+	+	+				+
<i>Alona setigera</i>										+	+	+				+	+	+	+	
<i>Camptocercus daday</i>		+	+						+					+	+					+
Chydorinae Subfamily																				
<i>Alonella chlathratula</i>											+									
<i>Alonella dadayi</i>				+	+	+								+	+					
<i>Chydorus pubescens</i>													+		+	+				+

It can be concluded that chydorids were representative of the invertebrate fauna at Serra da Mantiqueira unity and made up an important fraction of the zooplankton community in these high altitude lakes of Brazil.

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REFERENCES

- ALONSO, M., 1987, Morphological differentiation of two new *Ephemeroporus* species (Cladocera, Chydoridae) belonging to the *barroisi* complex: *E. margalefi* and *E. epiaphantoi*, in Spain. *Hydrobiologia*, 145: 131-46.
- BERGAMIN, F., 1932, *Estudo sistemático dos Cladocera das águas do município de São Paulo*. Tese de Doutorado, Faculdade de Medicina de São Paulo. Empresa Graphica da Revista dos Tribunaes, São Paulo, 58p.
- BIRABEN, M., 1939, Los Cladoceros de la familia Chydoridae. *Physis*, XVII: 651-70.
- BREHM, V., 1931, Cladoceran aus Neuseeland. *Arch. Hydrobiol.*, 23: 491-501.
- DUIGAN, C. A., 1992, The ecology and distribution of the littoral freshwater Chydoridae (Branchiopoda, Anomopoda) of Ireland, with taxonomic comments on some species. *Hydrobiologia*, 241: 1-70.
- DUIGAN, C. A. & KOVACH, W. L., 1991, A study of the distribution and ecology of littoral freshwater Chydorid (Crustacea, Cladocera) communities in Ireland using multivariate analyses. *J. Biogeogr.*, 18: 267-280.
- DUIGAN, C. A. & MURRAY, D. A., 1987, A contribution to the taxonomy of *C. sphaericus* sens. lat. (Cladocera, Chydoridae). *Hydrobiologia*, 145: 113-24.
- DUMONT, H. J. & SILVA-BRIANO, M., 1998, A reclassification of the anomopod families Macrothricidae and Chydoridae, with the creation of a new suborder, the Radopoda (Crustacea: Brachiopoda). *Hydrobiologia*, 384: 119-49.
- EDMONDSON, W. T., 1959, *Freshwater Biology*. Second edition. John Wiley & Sons. Inc., USA, 1248p.
- ELMOOR-LOUREIRO, L. M. A., 1997, *Manual de identificação de cladóceros límnicos do Brasil*. Universa, Brasília, 156p.

- FREY, D. G., 1982, Relocation of *Chydorus barroisi* and related species (Cladocera, Chydoridae) to a new genus and description of two new species. *Hydrobiologia*, 86: 231-269.
- MEGARD, R., 1965, A Chemical technique for disarticulating the exoskeletons of Chydorid Cladocera. *Crustaceana*, 9: 208-211.
- OLESEN, J., 1996, External morphology and phylogenetic significance of dorsal/neck organ in the Conchostraca and head pores of the cladoceran family Chydoridae (Crustacea, Branchiopoda). *Hydrobiologia*, 330: 213-326.
- OLIVIER, S. R., 1962, Los cladoceros argentinos. *Rev. del Museo de La Plata República Argentina*, p. 173-329.
- PAGGI, J. C., 1980, Aportes al conocimiento de la fauna Argentina de cladoceros. II: *Euryalona fasciculata* Daday 1905 y *Euryalona occidentalis* Sars 1901. *Rev. Asoc. Cienc. Nat. Litoral*, 11: 145-60.
- PAGGI, J. C., 1972, Nota sistemática acerca de algunos cladoceros del género *Chydorus* Leach, 1843, de la República Argentina. *Physis*, Tomo XXXI, 82: 223-236.
- PENNAK, R. W., 1989, *Freshwater invertebrates of the United States: Protozoa to Mollusca*. 3. ed. John Wiley & Sons, Inc., New York, 628p.
- RAJAPAKSA, R. & FERNANDO, C. H., 1987a, A description of *Euryalona orientalis* (Daday, 1898), with a consideration of the other species in the genus *Euryalona* (Cladocera: Chydoridae). *Hydrobiologia*, 150: 75-90.
- RAJAPAKSA, R. & FERNANDO, C. H., 1987b, Redescription and assignment of *Alona globulosa* Daday 1898 to a new genus *Notoalona* and a description of *Notoalona freyi* sp. nov. *Hydrobiologia*, 144: 131-53.
- SCOURFIELD, D. J. & HARDING, J. P., 1966, *A key to the British Freshwater Cladocera with notes on their ecology*. Freshw. Biol. Association. Scientific Publication, n. 5. 3. ed. 55p.
- SINEV, A. Y., 1999, *Alona costata* Sars, 1862 versus relates palaeotropical species the first example of close relations between species with a different number of main head pores among Chydoridae (Crustacea: Anomopoda). *Arthropoda Selecta*, 8(3): 131-148.
- SMIRNOV, N. N., 1998, A revision of the genus *Camptocercus* (Anomopoda, Chydoridae, Aloninae) *Hydrobiologia*, 386: 63-83.
- SMIRNOV, N. N., 1996, *Cladocera: the Chydorinae and Sayciinae (Chydoridae) of the world*. Guides to the identification of the microinvertebrates of the continental waters of the world. SPB Academic Publishing, Netherlands., 197p.
- SMIRNOV, N. N., 1974, *Fauna of the U.S.S.R. Crustacea. Chydoridae*. Vol. 1, n. 2. Israel Program for Scientific Translations, Jerusalem, 644p.
- SMIRNOV, N. N. & TIMMS, B. V., 1983, A revision of the Australian Cladocera (Crustacea). *Records of the Australian Museum*. Supplement 1, 132p.
- WHITESIDE, M. C., 1970, Danish Chydorid Cladocera: modern ecology and core studies. *Ecol. Monogr.*, 40: 79-118.
- WISNIEWSKI, M., ROCHA, O. & MATSUMURA-TUNDISI, T., 2001, First record of *Alona setigera* Brehm, (Cladocera, Chydoridae) in the neotropical region. *Rev. Bras. Biol.* 61(4): 701-702. São Carlos.
- YOUNG, P. S., 1998, *Catalogue of Crustacea of Brazil*. Série livros 6, Museu Nacional, Rio de Janeiro, 717p.