Diversity and distribution of the free-living freshwater Cyclopoida (Copepoda: Crustacea) in the Neotropics

*Silva, WM.**

Departamento Ciências do Ambiente, Campus Pantanal, Universidade Federal de Mato Grosso do Sul – UFMS, Av. Rio Branco, 1270, CEP 79304-020, Corumbá, MS, Brazil

*e-mail: wmsilvax@ig.com.br

Received March 26, 2008 – Accepted March 26, 2008 – Distributed November 30, 2008

(With 1 figure)

Abstract

Cyclopoida species from the Neotropics are listed and their distributions are commented. The results showed 148 species in the Neotropics, where 83 species were recorded in the northern region (above upon Equator) and 110 species in the southern region (below the Equator). Species richness and endemism are related more to the number of specialists than to environmental complexity. New researcher should be made on to the Copepod taxonomy and the and new skills utilized to solve the main questions on the true distributions and Cyclopoida diversity patterns in the Neotropics.

Keywords: Cyclopoida diversity, Copepoda, Neotropics, Americas, latitudinal distribution.

Diversidade e distribuição dos Cyclopoida (Copepoda:Crustacea) de vida livre de água doce nos Neotrópicos

Resumo

Foram listadas as espécies de Cyclopoida dos Neotrópicos e sua distribuição comentada. Os resultados mostram um número de 148 espécies, sendo que 83 espécies registradas na Região Norte (acima da linha do Equador) e 110 na Região Sul (abaixo da linha do Equador). A riqueza de espécies e o endemismo estiveram relacionados mais com o número de especialistas do que com a complexidade ambiental. Novos especialistas devem ser formados em taxonomia de Copepoda e utilizar novas ferramentas para resolver as questões sobre a real distribuição e os padrões de diversidade dos Copepoda Cyclopoida nos Neotrópicos.

Palavras-chave: diversidade dos Cyclopoida, Copepoda, neotrópicos, américas, distribuição latitudinal.

1. Introduction

Cyclopoids are the most abundant and successful Copepoda in freshwater and they inhabit all kinds of freshwater environments such as rivers, streams, pools, lakes, reservoirs, wetlands and temporary pools. The Cyclopoida group commonly represents the main component of the zooplanktonic biomass in tropical water bodies (Rocha, et al., 1995; Santos-Wisniewski and Rocha, 2007).

The freshwater cyclopoids are distributed in two subfamilies, Eucyclopinae and Cyclopinae. There are some genera with high diversity, some are distributed mainly in temperate zones such as *Cyclops* and *Diacyclops* and others in tropical zones represented principally *Mesocyclops* and *Thermocyclops*. In the Neotropical region, the tropical genera prevail, with some species different from those found in Africa and Australia, and there are also cosmopolitan while introduced species (Reid and Pinto-Coelho, 1994; Suárez-Morales et al., 1999).

Cyclopoida studies in the neotropical region are scarce and in all revisions genera new species have been added to the region lists (Gutierrez-Aguirre and Suárez-Morales, 2001; Suárez-Morales, et al., 2004; Silva and Matsumura-Tundisi, 2005). Revisions on the distribution of the Cyclopoida group in the neotropics have considered few genera, such as *Thermocyclops* (Reid, 1989) and *Mesocyclops* (Suárez-Morales and Gutierrez-Aguirre, 2001; Gutierrez-Aguirre and Suárez-Morales, 2001), and have been some local efforts such as Silva and Matsumura-Tundisi (2005) for *Themocyclops* in São Paulo State in Brazil and Suárez-Morales (2004) for *Eucyclops* in Mexico.

The aim of this work is to show the distribution of the free-living freshwater Cyclopoida group and its diversity in the neotropics, including South America, Central America and the Caribbean.

2. Material and Methods

The records of the *Cyclopoida* were obtained from a literature review on species in the world, in the neotropics and in some American countries and smaller localities, and from the Brazilian collections at UFSCar (Federal University of São Carlos, São Paulo State), IIE (International Institute of Ecology, São Carlos, São Paulo State), UFMS (Federal University of Mato Grosso

do Sul, Mato Grosso do Sul State) and the Biota data bank (www.biota.org.br).

3. Diversity and Distribution

Table 1 shows the species and their distributions based on Figure 1 of the South and North neotropical regions. These results showed 148 species in the neotropics, where 83 species were recorded in the North region and 110 species in the South, these species being distributed in six genera of the sub-family Eucyclopinae and 14 genera of the sub-family Cyclopinae.

3.1. Genus recorded in the Neotropics

Sub-Family Eucyclopinae Kiefer, 1927

Macrocyclops Claus, 1903

Genus with three species in the neotropics, two cosmopolitan *M. albidus* and *M. fuscus,* and one neotropical *M. albidus principalis. M. albidus* is the most common and widely distributed species, from Argentina to Mexico (Dussart and Dafaye, 1985). It inhabits littoral zones of lakes and reservoir.

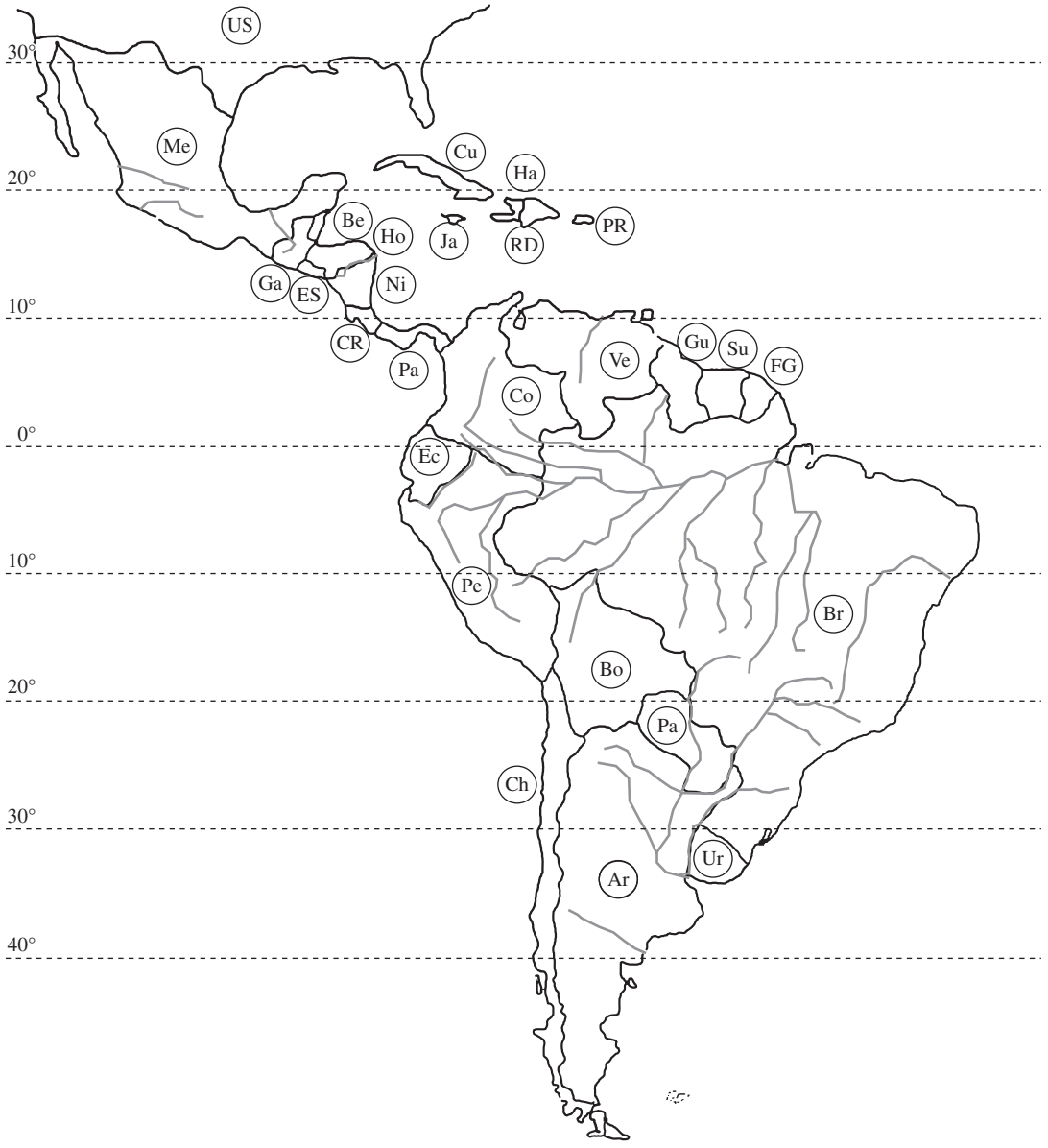

Figure 1. The Neotropic: Political division, hydrography and latitudinal division. Countries: South America: Ar: Argentina; Ur: Uruguay, Pa: Praguay, Ch: Chili; Br: Brazil; Bo: Bolivia; Pe: Peru; Co: Colombia; Ve: Venezuela; Gu: Guyana; Su: Suriname; FG: French Guyana; Central America: Pa: Panama; CR: Costa Rica; Ni: Nicaragua; Ho: Honduras; ES: El Salvador; Ga: Guatemala; Be: Belize; North America: Me: Mexico; Caribbean America: Cu: Cuba; Ha: Haiti; RD: Dominican Republic; Ja: Jamaica; PR: Puerto Rico; and US: United States.

Table 1. Species list of the Neotropical Cyclopoida and their distribution in the North (N) and South (S), in the latitudinal ranges 1: 0° to 9°; 2: 10° to 19°; 3: 20° to 29° and 4: up to 30° (illustrated in Figure 1) and comments where "*" indicates endemic notes, "**" indicates taxonomical notes and "***" indicates general comments.

Eucyclopinae species	N	S	Comments
Ectocyclops bromelicula Kiefer, 1935	1	1	-
Ectocyclops herbsti Dussart, 1984	1	1,2,3,4	-
Ectocyclops pharelatus (Koch, 1838)	1,2,3,4	1,2,3,4	-
Ectocyclops rubescens Brady, 1904	1	1,2,3	-
Ectocyclops strenkzei Herbst, 1959	-	3	*Recorded in Sao Paulo State in Brazil
Eucyclops breviramatus Loffer, 1963	-	1	*Recorded in Ecuador
Eucyclops ariguanabensis Brehm, 1948	2	-	*Recorded in Cuba
Eucyclops delachauxi Kiefer, 1925	-	2	*Recorded in Peru.
Eucyclops festivus Lindberg, 1955	3	-	*Recorded in Mexico
Eucyclops pseudoensifer Dussart, 1934	-	2,3	-
Eucyclops silvestrii (Brian, 1927)	-	1,2,3,4	-
Eucyclops alticola Kiefer, 1957	-	2	*Recorded in Titicaca Lake (Peru, Bolivia)
Eucyclops bondi Kiefer, 1934	2,3	-	-
Eucyclops demacedoi Lindberg, 1957		2	*Recorded in Peru.
Eucyclops elegans (Herrick, 1884)	4	2	***Those recorded in South America need revision.
Eucyclops ensifer Kiefer, 1936	1,2,3	1,2,3,4	-
Eucyclops leptacantus Kiefer, 1956	1,2	2	-
Eucyclops neotropicus Kiefer, 1936	-	1	*Recorded only in Pernambuco State in Brazil
Eucyclops neumani neumani (Pesta, 1927)	1	1, 3,4	-
Eucyclops neumani titicae Kiefer, 1957	-	2	*Recorded only in Titicaca Lake (Peru, Bolivia)
Eucyclops serrulatus (Fisher, 1851)	1,2,3	1,2,3,4	-
Eucyclops siolii Herbst, 1962	-	1	*Recorded only in Pará State in Brazil (Amazonian region)
Eucyclops solitarius Herbst, 1959	-	2,3	
Eucyclops sp. Herbst, 1959	-	2	**This species has no denomination
Eucyclops spertatus (Lilljeborg, 1901)	3,4		-
Eucyclops subciliatus Dussart, 1984	-	2,3	-
Eucyclops torresphilipi Suárez-Morales 2004	2	-	*Recorded only in Chiapa State in Mexico (Pacific coast)
Homocyclops ater (Herrick, 1882)	1,2,3,4	1,2,3,4	**Some author consider as *Macrocyclops*
Macrocyclops albidus (Jurine,1820)	1,2,3,4	1,2,3,4	-
Macrocyclops albidus principalis Herbst, 1962	1	1	-
Macrocyclops fuscus (Jurine,1820)	4	2	**In the southern region is species *incertae*
Paracyclops andinus Kiefer, 1957	-	2	*Recorded in Andes Mountain
Paracyclops hardingi Karaytug and Boxshall, 1998	-	2	*Recorded in Colombia
Paracyclops novenarius Reid, 1987	-	1	-
Paracyclops puncatus Karaytug and Boxshall, 1998	-	1	*Recorded in Northeast Brazil
Paracyclops reidae Karaytug and Boxshall, 1998	1	-	
Paracyclops rochai Karaytug and Boxshall, 1998	-	1	*Recorded in Northeast Brazil
Paracyclops uenoi Itô, 1962	-	3,4	-
Paracyclops carectum Reid, 1987	-	2	-
Paracyclops chiltoni (Thomson, 1882)	-	2,3	**Most of the species identified as *P. fimbriatus* in South America are *P. chiltoni.*
Paracyclops pilosus Dussart, 1983	1	-	*Recorded in French Guyana (Amazonian)
Paracyclops poppei (Rehberg, 1880)	1,2,3,4	-	-
Tropocyclops extensus Kiefer, 1931	3,4	-	-
Tropocyclops extensus longispina Kiefer, 1931	3,4	-	-

Table 1. Continued...

Eucyclopinae species	N	S	Comments
Tropocyclops federensis Reid, 1991	-	2	-
Tropocyclops nananae Reid, 1991	-	2	-
Tropocyclops piscinalis Dussart, 1984	-	2	-
Tropocyclops prasinus aztequei Lindberg, 1955	3	-	-
Tropocyclops prasinus meridionalis (Kiefer, 1931)	1,2,3,4	1,2,3,4	-
Tropocyclops prasinus mexicanus Kiefer, 1938	1,2,3,4	1	-
Tropocyclops prasinus peruviana Lindberg, 1955		2	-
Tropocyclops prasinus prasinus (Fischer, 1860)	1,2,3,4	1,2,3,4	-
Tropocyclops rarus Dussart, 1983	-	1	*Recorded in French Guyana (Amazonian)
Tropocyclops schubarti dispar Herbst, 1952	-	1	*Recorded in Pará state in Brazil (Amazonian)
Tropocyclops schubarti Kiefer, 1935	-	2,3,4	-
Cyclopinae species	**N**	**S**	**Comments**
Acanthocyclops robustus (G.O. Sars, 1863)	1,3,4	1,2,3,4	-
Acanthocyclops vernalis (Fisher, 1853)	1,3,4	1,2,3,4	-
Acanthocyclops michaelseni (Mrázek, 1901)	-	4	*Recorded in southern Argentina
Acanthocyclops scottsbergi Lindberg, 1949	-	4	*Recorded in Patagonia
Allocyclops botosaneanui Plesa, 1981	3	-	*Recorded only in Cuba
Allocyclops silvaticus Rocha and Bjornberg, 1988	-	1	*Recorded in Northeast Brazil
Apocyclops panamensis (Marsh, 1913)	1,2,3,4	-	-
Apocyclops procerus (Herbst, 1955)	1	1,2,3	-
Apocyclops distans (Kiefer, 1956)	1	1	-
Apocyclops viduus (Kiefer, 1933)	2	-	*Recorded in Aruba
Bryocyclops campaneri Rocha and Bjornberg, 1987	-	3	-
Bryocyclops campaneri Bjornberg, 1985	-	3	-
Hesperocyclops herbsti Rocha and Bjornberg, 1987	-	3	-
Hesperocyclops improvisus Herbst, 1984	2	-	*Recorded in Antilles
Mesocyclops aspericornis Daday, 1906	1,2,3,4	1,2,3,4	-
Mesocyclops longisetus longisetus (Thiébaud, 1912)	1,2,3,4	1,2,3,4	-
Mesocyclops longisetus curvatus Dussart, 1987	1,2,3	1,2,3,4	-
Mesocyclops longisetus araucanus Loffler, 1961	-	3	*Recorded only in Chile
Mesocyclops ogunnus Onabamiro, 1957	2	2,3	***Introduced species from Africa
Mesocyclops thermocyclopoides Harada, 1931	1	1	***Some recorded are doubtful
Mesocyclops venezuelanus Dussart, 1987	1,2,3	-	-
Mesocyclops reidae Petkovski, 1986	3,4	-	-
Mesocyclops meridianus Kiefer, 1926	-	1,2,3,4	-
Mesocyclops pseudomeridianus Defaye and Dussart,1984	1	-	*Recorded in French Guyana
Mesocyclops meridionalis Dussart and Frutos, 1986	-	4	*Recorded in Argentina
Mesocyclops brasilianus Kiefer, 1933	-	1	**Only the original record was plotted because the others recorded do not confer with original drawings, and are doubtful.
Mesocyclops chaci Fiers, 1996	2,3	-	*Recorded only in Yucatan (Mexico)
Mesocyclops yutsil Reid, 1996	2,3	-	*Recorded only in Yucatan (Mexico)
Mesocyclops intermedius Pesce, 1985	2,3	-	*Recorded in Caribean
Mesocyclops pescei Petkovski, 1986	2	-	*Recorded in Bahamas
Mesocyclops annulatus diversus Herbst, 1962	-	1	-
Mesocyclops annulatus annulatus Wierzejski, 1892	-	1,2,3,4	-
Mesocyclops paranaensis Dussart and Frutos, 1986	-	4	*Recorded in Argentina
Mesocyclops ellipticus Kiefer, 1936	1	1,2,3	
Mesocyclops varius Dussart, 1987	2	-	*Recorded in Guatemala
Mesocyclops edax (S.A. Forber, 1891)	2,3,4	-	-
Metacyclops subequalis Dussart, 1984	1	-	-
Metacyclops curtipinosus Dussart, 1984	1	-	-
Metacyclops hartmanni Herbst, 1960	3	-	-
Metacyclops paludolicola (Herbst, 1959)	-	3	-
Metacyclops paludolicola dentatus Plesa, 1981	3	-	*Recorded in Cuba
Metacyclops oremaris Rocha, 1994	-	3	-
Metacyclops grandis Kiefer, 1935	-	4	-
Metacyclops leptopus mucubaijensis Kiefer, 1956	1	-	-

Table 1. Continued...

Cyclopinae species	N	S	Comments
Metacyclops brauni Herbst, 1962	-	1	*Recorded in Amazonia
Metacyclops campestris Reid, 1987	-	2	-
Metacyclops cushae Reid, 1991	-	1	*Recorded in Northeast Brazil
Metacyclops hirsutus Rocha, 1994	-	3	-
Metacyclops leptopus (Kiefer, 1927)	1	1,2	-
Metacyclops mendocinus (Wierjski, 1982)	1,2,3	1,2,3,4	-
Metacyclops laticornis (Lowndes, 1934)	-	2,3,4	-
Metacyclops mendocinus venozuelanus (Kiefer, 1956)	1	1	-
Metacyclops rudis Plesa, 1981	3	1	-
Metacyclops tredecimus (Lowndes, 1934)	1	4	-
Microcyclops alius (Kiefer, 1935)	1,2,3	1,2,3,4	-
Microcyclops anceps anceps (Richard, 1897)	1,2,3,4	1,2,3,4	-
Microcyclops anceps pauxensis Herbst, 1962	1	1	-
Microcyclops anceps minor Dussart, 1984	1	-	*Recorded in Venezuela
Microcyclops ceibaensis (Marsh, 1919)	1,2,3,4	1,2,3,4	-
Microcyclops diversus Kiefer, 1935	1,2	4	-
Microcyclops dubitailis Kiefer, 1934	1,2	1	-
Microcyclops elongatus (Lowndes, 1934)	-	4	-
Microcyclops finitimus Dussart, 1984	1	1,2,3	-
Microcyclops furcatus (Daday, 1904)	-	4	-
Microcyclops varicans subaequlis (Kiefer, 1928)	1	1	-
Microcyclops varicans varicans (G.O. Sars, 1863)	1,2,3	1,2,3	-
Microcyclops sp. Varella et al., 1978	-	4	***This species has no denomination
Muscocyclops bidentatus Reid, 1987	-	2	*Recorded only in the Federal District of Brazil
Muscocyclops operculatus (Chappius, 1917)	-	1,2,3	-
Muscocyclops therasiae Reid, 1987	-	2	*Recorded only in the Federal District of Brazil
Neutrocyclops brevifurca (Lowndes, 1934)	1,2,3,4	1,2,3,4	-
Ponticyclops boscoi Reid, 1987	-	2	*Recorded only in the Federal District of Brazil
Thermocyclops tenuis (Marsh, 1910)	1,2,3,4	1,3,4	-
Thermocyclops decipiens (Kiefer, 1929)	1,2,3,4	1,2,3,4	-
Thermocyclops minutus (Lowndes, 1934)	1	1,2,3,4	-
Thermocyclops inversus Kiefer, 1936	1,2,3,4	1,2,3	-
Thermocyclops brehmi (Kiefer, 1927)	-	4	-
Thermocyclops crassus (Fischer, 1853)	-	2	-
Thermocyclops hastatus antilhensis Herbst, 1986	-	2	*Recorded in the Antilles
Thermocyclops iguapensis Silva and Matsumura-Tundisi, 2005	-	3	*Recorded in the Atlantic basin in São Paulo state in Brazil
Thermocyclops tenuis longifurcatus Pesce, 1985	-	1	*Caribbean
Thermocyclops parvus Reid, 1987	4	-	*Florida
Yancyclops ferrarii Reid, 1988	-	1	*Amazonian

Eucyclops Claus, 1893

Genus with high diversity and with few studies on its taxonomy. *E. serrulatus* is the most common species being is described as a cosmopolitan and in the neotropics is distributed from Argentina to Mexico (Dussart and Dafaye, 1985; Rocha and Botelho, 1998; Suárez-Morales, 2004). Another 22 species present in the neotropical region are *E. ensifer, E. leptacanthus, E. neotropicus, E. neumani neumani, E. neumani titicae, E. solii, E. solitarius, E. subciliatus, E.* sp., *E. speratus, E. delachauxi, E. silvestrii, E. bondi, E. ariguanabensis, E. festivus, E. demacedoi, E. pseudoensifer, E. elegans, E. torresphilipi, E. conrowae, E. ariguanabensis, E. breviramatus.*

Tropocyclops Kiefer, 1927

Genus that includes small organisms and the most common planktonic Cyclopoida species in the neotropics, with *T. prasinus* including *T. prasinus prasinus* (cosmopolitan), *T. prasinus meridionalis* and *T. prasinus mexicanus* (Reid, 1989; Rocha and Botelho, 1998). This species complex is distributed from Argentina to Mexico, *T. prasinus meridionalis* restricted to South America and *T. prasinus mexicanus* is restricted to Amazon, Central and North American sites. South America presents a high diversity with 10 endemic species, *T.prasinus aztequei, T. prasinus peruviana, T. extensus, T.extensus longispina,T. schubarti, T. schubart dispar, T. rarus, T. federensis, T. nanae* and *T. piscinalis.*

Paracyclops Claus, 1893

The genus *Paracyclops* has 28 species recorded in the world with eleven occurring in the neotropical region, and around 9 are American (Karaytug, 1999). In the neotropics the species *P. poppei* while *P. chiltoni* are considered cosmopolitan species, the first one being restricted to North America and the Caribbean zone and the second is restricted to South America and commonly misidentified as *P. fimbriatus* which does not exist in the Americas (Karaytug, 1999).

The other species recorded in the neotropics are *P. pilosus, P. novenarius, P. andinus, P. carectum, P. rochai, P. reidae, P. hardingi, P. uenoi, P. puncatus.*

Ectocyclops Brady, 1904

The genus *Ectocyclops* presents five species, one cosmopolitan, *E. pharelatus* and four species from South America and the Caribbean region, *E. bromelicula, E. herbsti, E. rubescens* and *E. strenkzei* (Dussart and Dafaye, 1985 and Rocha and Botelho, 1998).

Homocyclops (Herrick, 1882)

This genus is monospecific, with only one species, *Homocyclops ater,* which is an American species and its distribution in the neotropics is from Argentina to Mexico (Rocha and Botelho, 1998).

Sub-Family Cyclopinae Kiefer, 1927

Acanthocyclops G.O. Sars, 1863

This genus in the neotropics is represented by two cosmopolitan species and two endemic ones. *A. robustus* and *A. vernalis* are cosmopolitan and they are so close that they include a complex robustus-vernalis (Dodson, 1984). These species have been recorded in Eurasia, Australia and America. In the neotropics, they have been recorded from Argentina to Mexico (Reid, 1985; Dussart and Dafaye, 1985; Rocha and Botelho, 1998, Silva, 2003; Silva and Matsumura-Tundisi, 2002), and *A. robustus* is the most common form recorded in the neotropics. *A. michaelseni* and *A. scottsbergi* are both endemic to the south of Argentina and Chile.

Allocyclops Kiefer, 1932

Genus represented by two species in the neotropical region, one in the Cuba, *A. botosaneanui* (Dussart and Dafeyae, 1985) and another in Brazil, *A. silvaticus* (Rocha and Botelho, 1998).

Apocyclops Lindberg, 1942

Genus represented by four species in the neotropics (Dussart and Dafaye, 1985), *A. panamensis* (Central America and Caribbean), *A. viduus* (Aruba), *A. procerus* and *A. distans* (South America).

Bryocyclops Kiefer, 1927

The species from this genus are essentially Afro-Asian (Dussart and Dafaye, 1985), with two species in the neotropics restricted to South America, the species *B. campaneri* and *B. Caroli.*

Diacyclops Kiefer, 1927

The species of this genus is absent in most of the neotropical region, and are found mainly in the southern region of the Atlantic coast, in spite of this genus being the largest of the Cyclopidae group (Stoch, 2001). In the neotropics there are nine species, six of which are restricted to the north region: *D. bernardi, D. hispidus, D. chakan, D. pilosus, D. ecabensis, D. puuc* and three species restricted to the south above 40° S, *D. andinus, D. bicuspidatus* and *D. urugaiensis*.

Hesperocyclops Herbst, 1984

Hesperocyclops is an American genus, with two species, *H. herbsti* and *H. improvisus* (Rocha and Botelho, 1998).

Mesocyclops G. O. Sars, 1914

Most of the species from this genus have been recorded in the tropical region and it is one of the most studied groups, including revisions of African (Van de Velde, 1984), American (Suárez-Morales and Gutierrez-Aguire, 2001) and Australian (Holyska, 2000) species. Suárez-Morales and Gutierrez-Aguirre (2001) listed the 21 species and sub-species of *Mesocyclops* recorded in the neotropics, where one is pan-tropical, *M. aspericornis*, two neotropical *M.*, *M. longisetus longisetus* and *M. longisetus curvatus*, two introduced species from the Afro-Asian region, *M. ogunnus* (the *M. kieferi* recorded in Brazil was a misidentification corrected by Matsumura-Tundisi and Silva, 2002 as *M. ogunnus*) and *M. thermocyclopoides*, and other species endemic or restricted to some regions of the neotropics such as *M. venezuelanus, M. reidae, M. longisetus longisetus, M. longisetus curvatus, M. meridianus, M. pseudomeridianus, M. meridionalis, M. ellipticus, M. brasilianus* (note: In the revision of the *Mesocyclops* species in São Paulo State and in Samuel Reservoir in Rondônia State in Brazil, *M. meridianus* was identified as *M. brasilianus*), *M. edax, M. evadomingoi* with six species are endemic to islands, *M. cahci, M. yutsil, M. intermedius, M. pescei, M. annulatus diversus, M. longisetus araucanus* and species from the South above 40° S *M. annulatus annulatus* and *M. paranaensis.*

Metacyclops Kiefer, 1927

The species from this genus present a high endemism and all species recorded in the neotropics are American species. In the neotropics 18 species were recorded including the endemic species *M. subequalis, M. curtipinosus, M. hartmanni, M. paludolicola, M. paludolicola dentatus, M. oremaris, M. grandis, M. leptopus mucubaijensis, M. brauni, M. campestri, M. cushae, M. hirsutus, M. tredecimus* and *M. rudis.* The most widely distributed *Metacyclops* species in the the neotropics are *M. leptopus, M. mendocinus*, *M. laticornis, M. mendocinus venozuelanus*, the latter one having been

recorded in Venezuela and Brazil although in Brazil it is na incertae species (Rocha and Botelho, 1998).

Microcyclops Claus, 1893

The species of this genus present a low degree of endemism with many species recorded in more than one hydrographic basin. There are 12 recorded species in the neotropics (Dussart and Dafaye, 1985; Rocha, 1998; Rocha and Botelho, 1998): *M. alius, M. anceps anceps, M. anceps pauxensis, M. anceps minor, M. ceibaensis, M. diversus, M. dubitailis, M. elongates, M. finitimus, M. furcatus, M. varicans subaequlis, M. varicans varicans.*

Muscocyclops Kiefer, 1937

The species from this genus are all restricted to South America and are composed of three species: *M. bidentatus, M. operculatus, M. therasiae.* These species inhabit wet fields and organic soil (Rocha and Botelho, 1998).

Neutrocyclops (Lowndes, 1934)

This genus is monospecific, including only one species, *N. brevifurca,* distributed in the whole neotropical region.

Ponticyclops Reid, 1987

This genus is monospecific, including only one species, *P. boscoi,* recorded in the central Brazilian region.

Thermocyclops Kiefer, 1927

This genus, one of the most common in the planktonic environment, in the neotropics consists of eleven species (Silva and Matsumura-Tundisi, 2005). *Thermocyclops tenuis* is the most widely distributed species in the neotropics, but many records are probably erroneous (Reid, 1989). *Thermocyclops decipiens,* a pan-tropical species, is the most abundant in the neotropics followed by *T. minutus* a South American species. *T. inversus* is a species distributed between tropics in the Americas. The other *Thermocyclops* species are more geographically restricted, being: *T. brehmi, T. crassus, T. hastatus antilhensis, T. iguapensis, T. tenuis longifurcatus, T. parvus*.

Yancyclops Reid, 1988

This genus is monospecific, including only one species, *Y. ferrarii,* recorded in the northern region of Brazil, in the Amazonian region.

4. Discussion

The diversity and distribution of the Neotropical species is very likely linked to the pilocene events. Suárez-Morales (2004) observed that in the colonization of the Yucatán Peninsula in Mexico, South American species predominate. This way, the freshwater cyclopoid dispersion in the Neotropics should be starting from South American equatorial and tropical to the temperate zones and North America.

The distribution showed a high number of species of Cyclopoida in the Southern region. In fact, these results were expected, because the south is bigger than the north in area and environmental diversity. Seventeen species are present in the whole neotropical region, which represents 10.8% of the total species. The high number of endemic versus the low number of widely distributed species for Cyclopoid a has been found in all recent taxonomic studies such as Kiefer (1981); Van-de-Velde (1984); Reid (1989) and Karaytug (1999) and Suárez-Morales (2002); Suárez-Morales et al. (2004). This fact has high evolutionary significance, because it shows that the speciation of Cyclopida is bigger than supposed some time ago. Endemism in the neotropics should be much higher than recorded; nowadays endemism is directly linked to the amount of research carried out at a given site. Reid, (1987; 1989; 1991) for central Brazil, Holynska, 2000 for Australia and Suárez-Morales et al. (2004) for the Yucatán Peninsula (Mexico), Silva and Mastsumura-Tundisi (2005) for São Paulo State (Brazil) give examples of endemism and discuss its relationship with research.

Amazonian sites are examples of less-understood environments, with thousands of different freshwater environments, in a giant area certainly having dozens (a conservative estimate) of endemic and new species of freshwater Cyclopoida.

Moreover, even with the well-studied Cyclopoida groups, such as *Mesocyclops*, there are many doubts about distribution, because of imprecise descriptions or morphological confusion (Suárez-Morales, 2001). Nowadays, new skills have been useful in taxonomy; Silva and Matsumura-Tundisi, 2004, found differences between *Mesocylops longisetus longisetus* from the United States and *M. longisetus longisetus* from Brazil using cytogenetic techiniques. This kind of study helps to understand distribution patterns and the speciation process has occurred in the neotropics. In the latter there are three variations for *M. longisetus*: *M. longisetus longisetus* var. north, *M. longisetus longisetus* var. south and *M. longisetus curvatus.*

Silva and Matsumura-Tundisi (2005), using molecular biology, observed that the genera *Themocyclops* and *Mesocyclops* are closely related genera, and that the morphological differences are not supported. This result alerts evolutionary researchers that the study of these genera might not have to be done alone, but together, and their distribution might be interrelated.

On the other hand, human activities usually represent a strong forcing function driving distribution and diversity. Tundisi et al. (1995) discuss the formation of hundreds of hydropower dams in Brazil, which is a country poor in natural lakes, and that before hydropower, the Cyclopoida species was adapted in marginal lakes with strong interannual pulses. Nowadays, there are hundreds of cascades of interlinked reservoirs multiplying environments for plankton. Silva and Matsumura-Tundisi (2002) and Nogueira et al. (2004), observed that in the cascade

systems, the Cyclopoida species are usually similar, differing in abundance among reservoirs, and that abundance is often related to the trophic state of the system and the retention time. This anthropic process might be homogenizing the systems and promoting extinction.

Concluding, in the last twenty years has been great improvement in the taxonomical knowledge of freshwater Cyclopoida with an emphasis on the impact of their distribution and diversity. Moreover, greater effort should be made to solve taxonomical doubts including the use of morphological, molecular and cytogenetic skills and in the geographical areas with a high deficit of studies.

References

DODSON, S., 1984. Morphological analysis of Wisconsin (USA) species of the *Acanthocyclops vernalis* group (Copepoda:Cyclopoida). *J. crustac. biol.,* vol. 14, no. 1, p. 113-131.

DUSSART, BH. and DAFAYE, D., 1985. *Répertoire Mondial des Cycloppoides.* Paris: Editors du CNRS. 236 p.

GUTIERREZ-AGUIRRE, MA., and SUÁREZ-MORALES, E. 2001. Distribution and taxonomy of the tropical tropical american *Mesocyclops* Sars, 1914 (Copepoda, Cyclopoida). *Crustaceana,* vol. 74, no. 5 p. 477-487.

GUTIERREZ-AGUIRRE, MA., and SUÁREZ-MORALES, E., 2002. A new species of *Mesocyclops* (Copepoda, Cyclopoida, Cyclopidae) from Southeastern Mexico. *J. Limnol.,* vol. 60, no. 2, p. 143-154.

HOLYNSKA, M., 2000. Revision of the Australian species of the genus *Mesocyclops* Sars, 1914 (Copepoda: Cyclopidae). *Annales zoologici.,* vol. 50, no. 3, p. 363-447.

KARAYTUG, S., 1999. *Copepoda:* Cyclopoida. *Genera* Paracyclops, Ochridacyclops *and key to the Eucyclopinae*. In *Guides to the identification of the microinvertebrates of the continental waters of the world.* DUMONT, HJF. (Ed.). Belgium: University of Gent. 217 p.

MATSUMURA-TUNDISI, T. and SILVA, WM., 2002. Occurrence of *Mesocyclops ogunnus* Onabamito, 1957 (Copepoda, Cyclopoida) in waterbodies of São Paulo State, identified as *Mesocyclops kieferi* Van de Velde, 1984. *Braz. J. Biol. = Rev. Bras. Biol.,* vol. 62, no. 4a, p. 615-620.

NOGUEIRA, MG., JORCIN, A., VIANNA, NC. and BRITTO, YC. 2004. *Reservatórios em cascata e os efeitos na limnologia e organização das comunidades bióticas (fitoplâncton,zooplâncton e zoobentos): Um estudo de caso no rio Paranapanema (SP/PR).* In: NOGUEIRA, MG., HENRY, R. & JORCIN, A. (eds.). Ecologia de reservatórios: Impactos potenciais, ações de manejo e sistemas em cascata. São Carlos: Rima, p. 435-459.

REID, JW. and PINTO-COELHO, R., 1994. An Afro-Asian continental copepod, *Mesocyclops ogunnus*, found in Brazil: with a new key to the species of *Mesocyclops* in South America and a review of intercontinental introductions of copepods. *Limnologica,* vol. 24, no. 4, p. 359-368.

REID, JW., 1985. Chave de identificação e lista de referencias para as espécies continentais sulamericanas de vida livre da ordem Cyclopoida (Crustácea, Copepoda). *Bolm Zool*., Univ. de S. Paulo, vol. 9, p. 17-143.

-, 1991. some species of Tropocyclops (Crustacea, Copepoda) from Brazil, with a key to American species. *Bijdragen tot de Dierkunde*. no. 61, vol. 1, p. 3-15.

-, 1987. The cyclopoids copepods of a wet campos marsh in central Brazil. *Hydrobiologia,* vol. 153, no. 2, p. 121-138.

-, 1989. The distributions of species of the genus *Thermocyclops* (Copepoda, Cyclopoida) in the western hemisphere, with a description of *T. parvus*, new species. *Hydrobiologia,* vol. 175, no. 2, p. 149-174.

ROCHA, CEF., 1998. New morphological characters useful for the taxomomy of the genus Microcyclops (Copepoda, Cyclopoida). *J. Mar. Syst*., vol. 15, no. 1-4, p. 425-431.

ROCHA, CEF., and BOTELHO, MCJ., 1998. Maxillopoda-Copepoda. Cyclopoida. In YOUNG, PS. (Ed.). *Catalogue of crustacean of Brazil.* Rio de Janeiro: Museu Nacional. (Série Livros, n° 6).

ROCHA, O., SENDACZ, S.,MATSUMURA-TUNDISI,T., 1995. Composition, biomass and productivity of zooplankton in natural lakes and reservoirs of Brazil. In *Limnology in Brazil.* Rio de Janeiro: ABC/SBL. p. 151-166.

SANTOS-WINIESWSKI, MJ. and ROCHA, O., 2007. Spatial distribution and secondary production of Copepoda in a tropical reservoir. *Braz. J. Biol. = Rev. Bras. Biol.,* vol. 67, no. 2, p. 223-233.

SILVA, WM. and MATSUMURA-TUNDISI, T. 2002. Distribution and abundance of Cyclopoida populations in a cascade of reservoirs of the Tietê River (São Paulo State, Brazil). *Verh. Internat. Limnol*. vol. 28, p. 667-70.

-, 2004. Cytogenetics of the freshwater cyclopoid *Mesocyclops longisetus longisetus* (Crustacea, Copepoda) from São Carlos, São Paulo, Brazil. *Biota Neotropica*, vol. 4, no. 2: http://www.biotaneotropica.org.br/v4n2/pt/abstract?short-communication+bn03604022004.

-, 2005. Taxonomy, ecology and geographic distribution of the species of the genus *Thermocyclops* Kiefer, 1927 (Copepoda, Cyclopoida) in São Paulo State, Brazil, with description of a new species. *Braz. J. Biol. = Rev. Bras. Biol.,* vol. 65, no. 3, p. 533-540.

SILVA, WM., 2003. *Diversidade dos Cyclopoida (Copepoda, Crustacea) de água doce do Estado de São Paulo:* taxonomia, ecologia e genética. São Carlos: UFSCAR. 154 p. [Tese de Doutorado].

STOCH, F., 2001 How many species of Diacyclops? New taxonomic characters and species richness in a freshwater cyclopid genus (Copepoda, Cyclopoida). *Hydrobiologia,* vol. 453/454, no. 1, p. 225-231.

SUÁREZ-MORALES, E., 2004. A new species of *Eucyclops* Claus (Copepoda: Cyclopoida) fromSoutheast Mexico with a key for the identification of the species recorded in Mexico. *Zootaxa*, vol. 617, p. 1-18.

SUÁREZ-MORALES, E. and GUTIERREZ-AGUIRRE, MA., 2001. *Morfología y taxonomia de los Mesocyclops (Crustacea: Copepoda: Cyclopoida) de Mexico.* Mexico: Consejo Nacional de Ciencia y Tecnología (CONACYT) y El Colegio de la frontera sur (ECOSUR). 202 p.

SUÁREZ-MORALES, E., MACLELLAND, J. and REID, JW. 1999. The copepods of coastal saline ponds of the Cayaman Islands with special reference to the occurrence of Mesocyclops ogunnus Onabamiro, an apprentely introduced Afro-Asian cyclopoid. *Gulf Research Reports*, vol. 11, p. 51-55.

SUÁREZ-MORALES, E., REID, JW., FIERS, F., and ILIFFE, TM. 2004. Historical biogeography and distribution of the freshwater cyclopine copepods (Copepoda, Cyclopoida, Cyclopinae) of the Yucatan Peninsula, Mexico. *J. Biogeogr*., vol. 31, no. 7, p. 1051-1063.

VAN-DE-VELDE, I., 1984. Revision of the african species of the genus *Mesocyclops* Sars, 1914 (Copepoda, Cyclopoida). *Hydrobiologia*, vol. 109, no. 1, p. 183-199.