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Geographical Distribution of Calanoida Species (Copepoda-Crustacea), at 22 UGRHi of São Paulo State - Brazil

Matsumura-Tundisi, T.[1], Tundisi, J.G.[2]

[1]International Institute of Ecology of São Carlos

[2]Feevale University, Novo Hamburgo, RS

Correspondence author: takako@iie.com.br

Abstract

Geographical distribution of Calanoida species (Copepoda-Crustacea) from São Paulo State were studied considering the 22 UGRHi (Management Units of Hydric Resources). Samplings were carried out from 250 water ecosystems including small lakes, reservoirs and rivers during the period of 1999 to 2001. Some species showed a large geographical distribution occurring in almost all water ecosystems registered in 22 UGTHi. Other species occurred only in the waters of some UGRHi showing a narrow range of geographical distribution. This behavioral difference showed by the species can be attributed to several environmental factors: climatological conditions, biogeochemical factors, inter specific competition for food, habitat and hydrogeochemical factors.

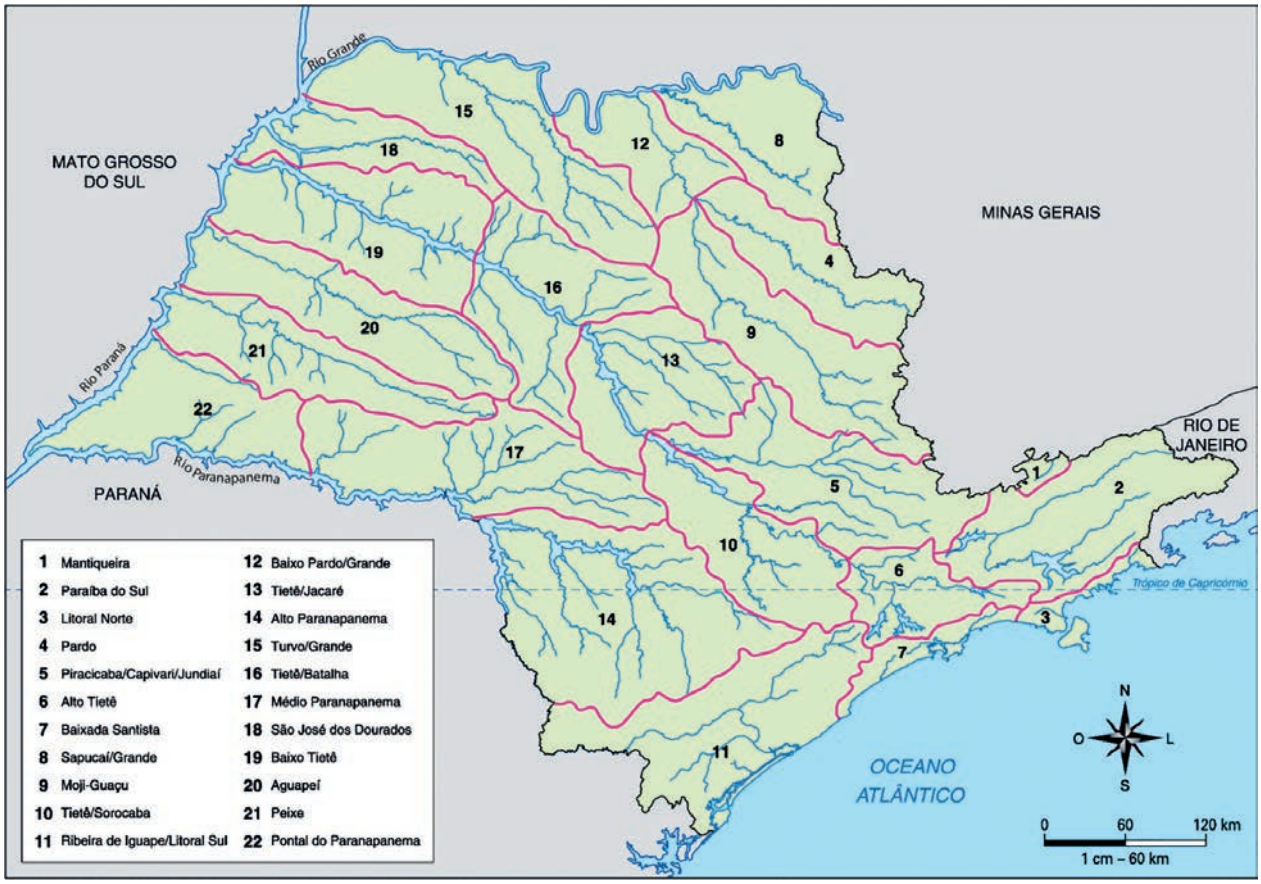
Keywords: eurioecious, stenoecious, climatological factors, biogeochemical factors, new species, interspecific competition.

Introduction

São Paulo State is separated by other States through three large rivers: Rio Grande at the north part making border with Minas Gerais State; Rio Paraná at the west part making border with Mato Grosso do Sul and Rio Paranapanema at the south part making border with Parana State. The fourth large river Tietê River across the center of São Paulo State from east to west direction to flow into Paraná River.

Based on watershed concept, São Paulo State was divided in 22 UGRHi (Management Units of Hydric Resources) where in each unit are include its hydric resources. Each unit has its number and the name of the main rivers contributors. The following Map shows the 22 UGRHi.

In each UGRHi there are some large dams constructed to the generation of hydroelectric power that will be shown in the Table 1.



Source: sanderlei.com.br/PT/Ensino-Fundamental/São-Paulo-Historia-Geografia-52

Table 1 – The main reservoirs belonging to each UGRHi of São Paulo State.

nº	UGRHi -Name	Dams construted
1	Mantiqueira	x
2	Paraiba do Sul	Paraibuna, Santa Branca,Jaguari, Funil
3	Litoral Norte	x
4	Pardo	Graminea (Caconde)
5	Piracicasba/Capivari/Jundiai	Atibaia,Atibainha, Salto Grande, Jacarei, Cachoeira
6	Alto Tietê	Guarapirang, Billings, Paiva Castro Aguas Claras, Pedro Beicht, Ponte Nova, Jundiai, Taiaçupeba, Biritiba, Paraitinga
7	Baixada Santista	x
8	Sapucaí/Grande	Estreito, Jaguara
9	Mogi Guaçu	Euclides da Cunha,Limoeiro
10	Tietê/Sorocaba	represa de Itupararanga
11	Ribeira de Iguape e Litoral Sul	França, Fumaça, Barra,Porto Raso, Alecrim, Serraria
12	Baixo Pardo/Grande	Volta Grande, Porto Colombia
13	Tietê/Jacaré	Barra Bonita, Bariri, Ibitinga,Lobo/Broa
14	Alto Paranapanema	Pirajui, Jurumrim
15	Turvo/Grande	Marimbondo, Agua Vermelha,Turvo
16	Tietê/Batalha	Promissão
17	Médio Paranapanema	Capivara, Xavantes
18	São Jose´dos Dourados	Jupiá,Ilha Solteira
19	Baixo Tietê	Nova Avanhandava, Três Imãos
20	Aguapeí	Porto Primavera
21	Peixe	Boa Esperança
22	Baixo ou Pontal do Paranapanema	Taquaruçu, Rosana

In 1998 a large Project on Biodiversity in Sao Paulo State was carried out financed by FAPESP (BIOTA/FAPESP) Matsumura-Tundisi, 2003, covering both terrestrial and aquatic organisms, aimed to explore the maximum biodiversity and to know the geographical distribution of the organisms through the construction of the maps using GPS. In the case of aquatic organisms, specifically zooplankton community 330 water bodies were studied including, small lakes, reservoirs, rivers, in such a way that in each UGRHi we have explored among 10 to 15 water bodies.

Material and Methods

The Calanoida specimens were obtained through a standard net sampling with 70µm mesh size in horizontal hauls for a shallow water bodies and vertical hauls for deep water. In both cases the filtered water in the net was around 1 thousand liters. All the sampling sites were determined with GPS and after the analysis of the material at the laboratory identifying the Calanoida copepods at the level of species the metadata was sent to SinBiota (Instituto de Biodiversidade) to processing and producing the distribution map of Calanoida species at the 22 UGRHi of São Paulo State

Results

In the study of 250 water bodies (including small standing waters, rivers, large reservoirs), and 398 samplings carried out in São Paulo State, it was identified 12 species of Calanoida, one of them a new species described by Matsumura-Tundisi et al., 2010. They are: *Argyrodiaptomus furcatus* (SARS, 1901), *Argyrodiaptomus azevedoi* (WRIGHT, 1935), *Notodiaptomus iheringi* (WRIGHT, 1935), *Notodiaptomus cearensis* (WRIGHT, 1936) *Notodiaptomus henseni* (DAHL, 1894), *Notodiaptomus venezolanus deevoyorum* (BOWMAN, 1973), *Notodiaptomus spinuliferus* (DUSSART, MATSUMURA-TUNDISI, 1986; MATSUMURA-TUNDISI, 2008), *Notodiaptomus deitersi* (POPPE, 1891), *Notodiaptomus oliveirai* (MATSUMURA-TUNDISI, et al., 2015), *Odontodiaptomus paulistanus* (WRIGHT, 1936), *Pseudodiaptomus richardi* (DAHL, 1894), *Scolodiaptomus corderoi* (WRIGHT, 1936).

Geographical distribution of species

1. *Argyrodiaptomus furcatus*

This species (Figure 1a) was more frequent in the UGRHi of the northeast side of São Paulo State as can be seen in the Figure 1b.

The species were found mainly on the reservoirs of the following UGRHi: Sapucai/Grande (8); Pardo (4); Mogi Guaçu (9); Tetê/Sorocaba (10); Piracicaba/Capivi/Jundiai (5); Tietê/Jacaré (13); Alto Tietê (6); Paraiba do Sul (2) and in some reservoirs of River Paranapanema.

Argyrodiaptous furcatus was the only Calanoida species present in the Lobo/Broa reservoir (UGRHi-13).

Figure 1a – Characteristics of 5th leg of male of *Argyrodiaptomus furcatus.*

Figure 1b – Map of geographical distribution of *Argyrodiaptous furcatus* (SinBiota/FAPESP).

2. *Argyrodiaptomus azevedoi*

This species (Figure 2a) is restricted in the UGRHi that receive influence of River Paraná. They occurred in the following Unities located at the west part of the São Paulo State: São José dos Dourados (18); Baixo Tietê (19); Tietê/Batalha (16); Aguapei (20). Figure 2b shows the geographical distribution of this species in water boies os São Paulo State.

Figure 2a – Characteristics of 5th leg of male *Argyrodiaptomus azevedoi.*

Figure 2b – Map of geographical distribution of *Argyrodiaptous azevedoi* (SinBiota/ FAPESP).

3. *Notodiaptomus iheringi*

This species (Figure 3a) described by Wright, 1935 from the material coming from the northeast part of Brazil, probably dispersed to the South part at São Paulo State as has been stated Sendacz, Kubo, 1982 and Matsumura-Tundisi, Tundisi, 2003.

Currently as can be seen in the Figure 3b, the species are largely distributed occurring in the most UGRHi of São Paulo State, showing that the species has a strong plasticity supporting a great habitat variability.

Figure 3a – Characteristics of 5th leg of male of *Notodiaptomus iheringi*

Figure 3b – Map of geographical distribution of *Notodiaptomus iheringi* in São Paulo State (SinBiota/FAPESP).

4. *Notodiaptomus cearensis*

The species (Figure 4a) is very similar to *Notodiaptomus iheringi,* however is more larger than the last one, and also coming from the northeast part of Brazil.

Figure 4a – Characteristics of 5th leg of male of *Notodiaptomus cearensis.* Probably the species is coming from lower latitudes at northeast of Brazil.

Figure 4b – Map of geographical distribution of *Notodiaptomus iheringi* in São Paulo State (SinBiota/FAPESP).

5. *Notodiaptomus oliveirai*

Notodiaptomus oliveirai was observed at the first time in 1992-1993 in Barra Bonita reservoir by Espindola, 1994 as *Notodiaptomus* n sp. Furtheremore Matsumura-Tundisi et al., 2010 described as *Notodiaptomus oliveirai* (Figure 5a). Recently the species became the most abundant population of Barra Bonita reservoir dispersing also in the other water bodies belonging at 22 UGRH of São Paulo State as can be seen in the Figure 5b.

Figure 5a – Characteristics of 5th leg of male of *Notodiaptomus oliverai.*

Figure 5b – Map of geographical distribution of *Notodiaptomus oliveirai* in São Paulo State (SinBiota/FAPESP).

6. *Odontodiaptomus paulistanus*

This species (Figure 6a) described by Wright (1935) from the material collected in the water bodies of UGRH-Alto Tietê, never have been registered in other places of São Paulo State. At present study it has been registered only in UGRH Alto Tietê in the following reservoirs: Ribeirão do Campo,, Billings, Ponte Nova and Paiva Castro and in some lakes from UGRH 7 – Baixada Santista as can be seen in the Figure 6b.

Figure 6a – Characteristics of 5th leg of male of *Odontodiaptomus paulistanus.*

Figure 6b – Map of geographical distribution of *Odontodiaptomus paulistanus* in São Paulo State (SinBiota/FAPESP).

7. *Notodiaptomus henseni*

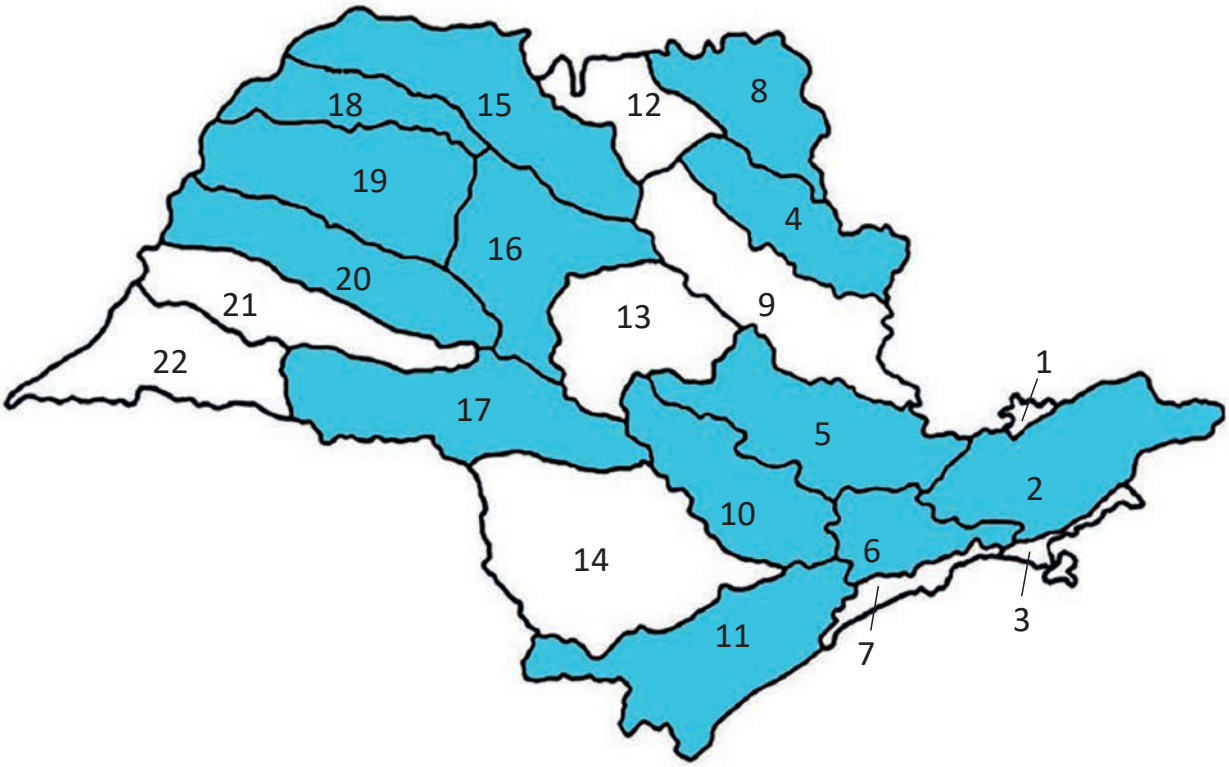
This species (Figure 7a) described by Dahl, 1891 from the material coming from Amazon it has been registered by the other authors such as Cipolli, Carvalho (1973) in the waters of Pará State, Matsumura-Tundisi in the lake José Maria (03°30'S lat. 40°W long).

The present study shows that the species there was restricted in the water of low latitudes it was introduced in some way to the water of more high latitudes (São Paulo State – 24°29'15''S) and has been adapted very well a new habitat enlarged their distribution in São Paulo State occurring in 13 UGRHi (Table 2).

Figure 7a – Characteristics of 5th leg of male of *Notodiaptomus henseni.*

Table 2 – Occurrence of *Notodiaptomus henseni* in the lakes and reservoirs of 13 UGRHi of São Paulo State.

Nº UGRHi	Name	Lakes & Reservoirs
2	Paraiba do Sul	Paraibuna
4	Pardo	Graminha
5	Piracicaba/Capivara/Jundiai	Paramirim,Atibainha
6	Alto Tietê	Aguas Claras, Taiaçupeba, Jundiai
8	Sapucaí/Grande	Jaguara, Sapucai, Igarapava, Volta Grande
10	Tietê/Sorocaba	Itupararanga
11	Ribeira do Iguape/Litoral Sul	Serraria,Alecrim, Cachoeira da França Fumaça, Barra
15	Turvo/Grande	Agua Vermelha, Turvo
16	Tietê/Batalha	Ibitinga, Bariri
17	Médio Paranapanema	Capivara
18	São José dos Dourados	Ilha Solteira,lagoa Estancia Semax
19	Baixo Tietê	Três Irmãos,Jupiá
20	Aguapeí	lago Country Clube(Rio Aguapeí), lago Pinopolis,lagoa Central (Rio Paraná)



Unidades de Gerenciamento de Recursos Hídricos – UGRHi

01 - Mantiqueira
02 - Paraíba do Sul
03 - Litoral Norte
04 - Pardo
05 - Piracicaba/Capivari/Jundiaí
06 - Alto Tietê
07 - Baixada Santista
08 - Sapucaí/Grande
09 - Mogi-Guaçu
10 - Tietê/Sorocaba
11 - Ribeira da Iguape/Litoral Sul
12 - Baixo Pardo/Grande
13 - Tietê/Jacaré
14 - Alto do Paranapanema
15 - Turvo/Grande
16 - Tietê/Batalha
17 - Médio Paranapanema
18 - São José dos Dourados
19 - Baixo Tietê
20 - Aguapeí
21 - Peixe
22 - Pontal do Paranapanema

Figure 7b – Map of geographical distribution of *Notodiaptomus henseni* in São Paulo State.

8. *Notodiaptomus deitersi*

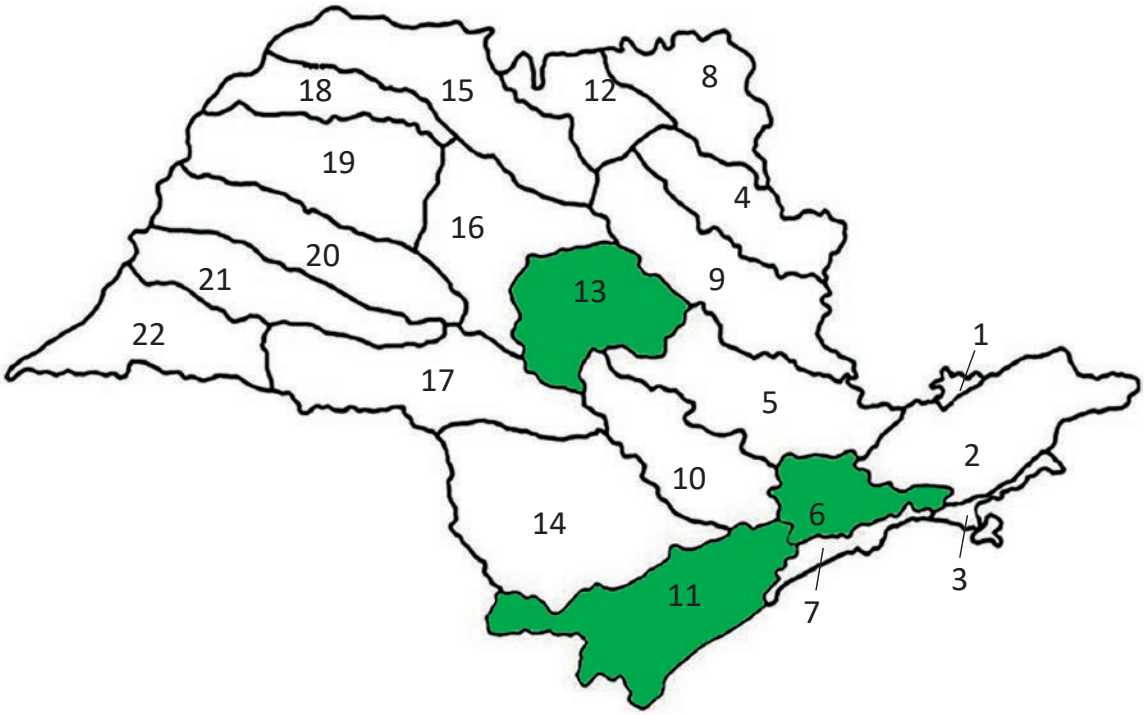
This species (Figure 8a) was recorded in the lakes of Pantanal Matogrossense (Recreio, Sá Mariana) located at 16º11'39''S lat. and 56º14'45''W long. (MATSUMURA-TUNDISI, 1986).

In the present work it was recorded only at three URGHi of São Paulo State (Alto Tietê, Tietê/Jacaré and Ribeira do Iguape/ Litoral Sul) (Table 3).

Figure 8a – Characteristics of 5th leg of male of *Notodiaptomus deitersi.*

Table 3 – Occurrence of *Notodiaptomus deitersi* in the lakes and reservoirs of 3 UGRHi of São Paulo State.

Nº UGRHi	Name	Lakes & Reservoirs
6	Alto Tietê	Paiva Castro
13	Tietê /Jacaré	Ibitinga
11	Ribieira do Iguape/Litoral Sul	Porto Raso, Barra



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05 - Piracicaba/Capivari/Jundiaí
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07 - Baixada Santista
08 - Sapucaí/Grande
09 - Mogi-Guaçu
10 - Tietê/Sorocaba
11 - Ribeira da Iguape/Litoral Sul
12 - Baixo Pardo/Grande
13 - Tietê/Jacaré
14 - Alto Paranapanema
15 - Turvo/Grande
16 - Tietê/Batalha
17 - Médio Paranapanema
18 - São José dos Dourados
19 - Baixo Tietê
20 - Aguapeí
21 - Peixe
22 - Pontal do Paranapanema

Figure 8b – Map of geographical distribution of *Notodiaptomus deitersi* in São Paulo State.

9. *Notodiaptomus spinuliferus*

This Calanoida was found at the first time in the sampling carried out in Ilha Solteira reservoir (UGRHi-18, São José dos Dourados) during the process of the Project "Typology of reservoirs of São Paulo State" and described as a new species by Dussart, Matsumra-Tundisi,1986 and carried out for rectification by Matsumura-Tundisi, 2008. In the present study it was observed that the species enlarged its occurrence occupying lakes and reservoirs from 9 UGRHi of São Paulo State as ca be seen in the Table 4.

Figure 9b shows the map of geographical distribution of *Notodiaptomus spinuliferus* in the waters of São Paulo State.

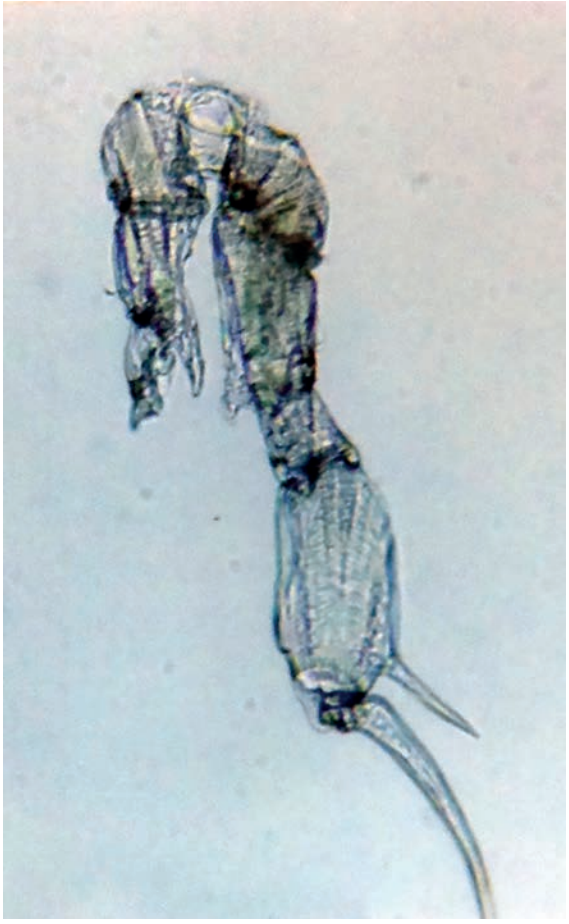
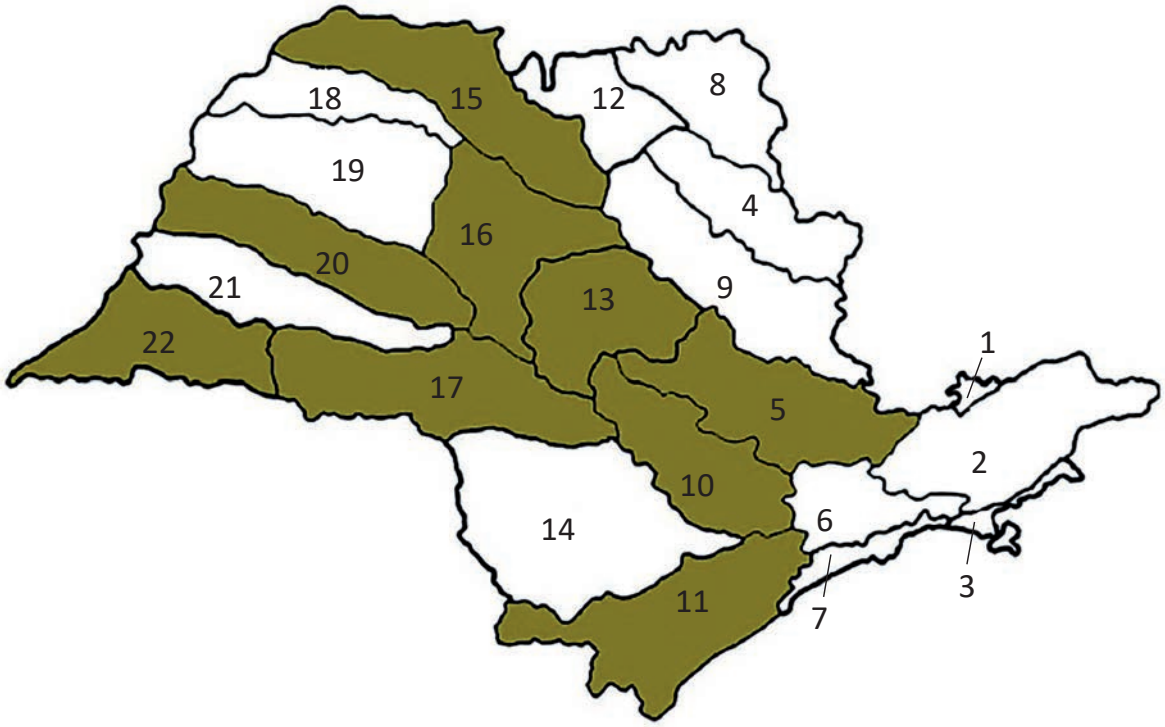


Figure 9a – Characteristics of 5th leg of male of *Notodiaptomus spinuliferus.*

Table 4 – Occurrence of *Notodiaptomus spinuliferus* in the lakes and reservoirs from 9 UGRHi of São Paulo State.

Nº UGRHi	Name	Lakes & Reservoirs
5	Piracicaba/Capivara/Jundiai	Atibainha
10	Tietê/Sorocaba	Itupararanga, Prainha, Hedberg
11	Ribeira do Iguape/Litoral Sul	Jurupara
13	Tietê/Jacaré	Barra Bonita
15	Turvo/Grande	Cestari, Santa Ana
16	Tietê/Batalha	Lago Laranja Azeda (Ibitinga), Bariri, Promissão
17	Médio Paranapanema	Taquaruçu, Capivara
20	Aguapeí	Lagoas: Pau da Onça, Marreco
22	Baixo(Pontal) Paranapanema	Rosana



Unidades de Gerenciamento de Recursos Hídricos – UGRHi

01 - Mantiqueira
02 - Paraíba do Sul
03 - Litoral Norte
04 - Pardo
05 - Piracicaba/Capivari/Jundiaí
06 - Alto Tietê
07 - Baixada Santista
08 - Sapucaí/Grande
09 - Mogi-Guaçu
10 - Tietê/Sorocaba
11 - Ribeira da Iguape/Litoral Sul
12 - Baixo Pardo/Grande
13 - Tietê/Jacaré
14 - Alto Paranapanema
15 - Turvo/Grande
16 - Tietê/Batalha
17 - Médio Paranapanema
18 - São José dos Dourados
19 - Baixo Tietê
20 - Aguapeí
21 - Peixe
22 - Pontal do Paranapanema

Figure 9b – Map of geographical distribution of *Notodiaptomus spinuliferus* in São Paulo State.

10. *Notodiaptomus venezoelanus deevoyorum*

The species (Figure 10) described by Kiefer, 1956 from the material collected from the lakes of Venezuela, it was recorded at the first time in Brazil in the lakes of Pantanal Matogrossense (Sá Mariana, Chacororé, Buritizal) by Matsumura-Tundisi, 1986.

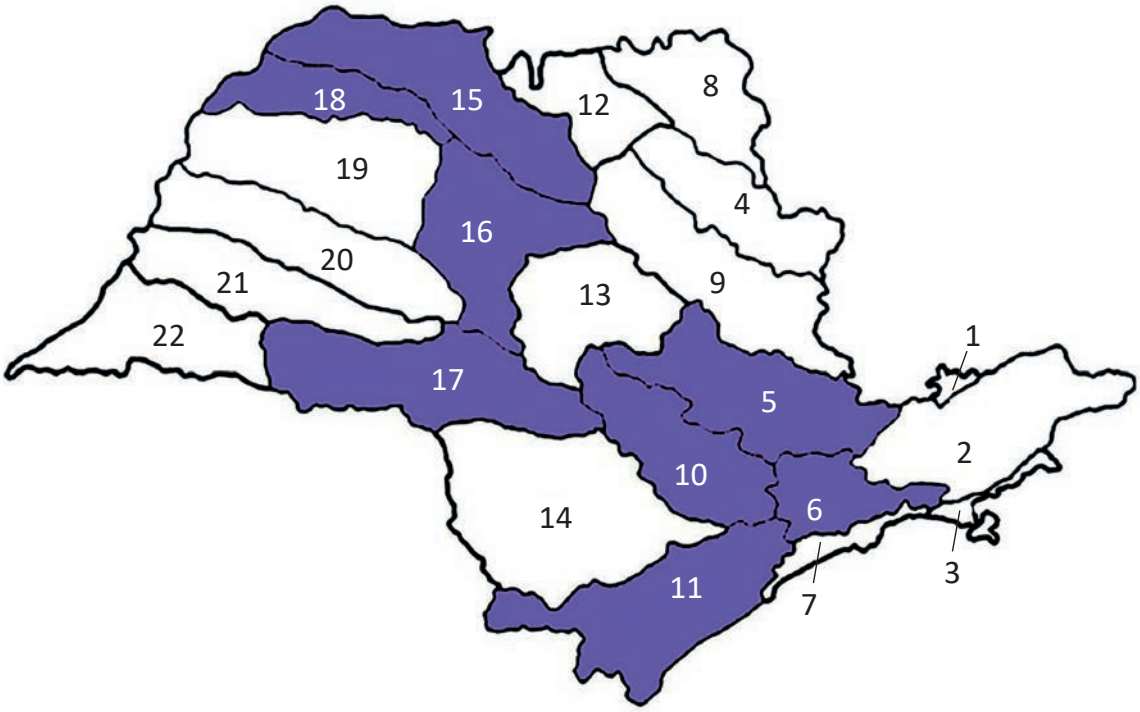
In the present investigation this species occurred I the lakes and reservoirs of São Paulo State at 24º29'15''S showing a large geographical distribution occupaying 8 UGRHi of São Paulo State (Table 4).

Figure 10b shows the map of geographical distribution of *Notodiaptomus venezoelanus deevoyorum* ocupaying 8 UGRHi of São Paulo State.

Figure 10a – Characteristics of 5th leg of male of *Notodiaptomus venezoelanus deevoyorum.*

Table 5 – Occurrence of *Notodiaptomus venezoelanus deevoyorum* in the lakes and reservoirs from 8 UGRHi of São Paulo State.

Nº UGRHi	Name	Lakes & Reservoirs
5	Piracicaba/Capivara/Jundiai	Igaratá
6	Alto Tietê	Taiaçupeba
10	Tietê/Sorocaba	Santa Branca, Paraibuna
11	Ribeira do Iguape/Litoral Sul	Porto Raso, Serraria, Barra
15	Turvo/Grande	Agua Vermelha
16	Tietê/Batalha	lago Laranja Azeda (Ibitinga), Bariri
17	Médio Paranapanema	Taquaruçu
18	São José dos Dourados	Ilha Solteira



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07 - Baixada Santista
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09 - Mogi-Guaçu
10 - Tietê/Sorocaba
11 - Ribeira da Iguape/Litoral Sul
12 - Baixo Pardo/Grande
13 - Tietê/Jacaré
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15 - Turvo/Grande
16 - Tietê/Batalha
17 - Médio Paranapanema
18 - São José dos Dourados
19 - Baixo Tietê
20 - Aguapeí
21 - Peixe
22 - Pontal do Paranapanema

Figure 10b – Map of geographical distribution of *Notodiaptomus venezoelaus deevoyorum* in São Paulo State.

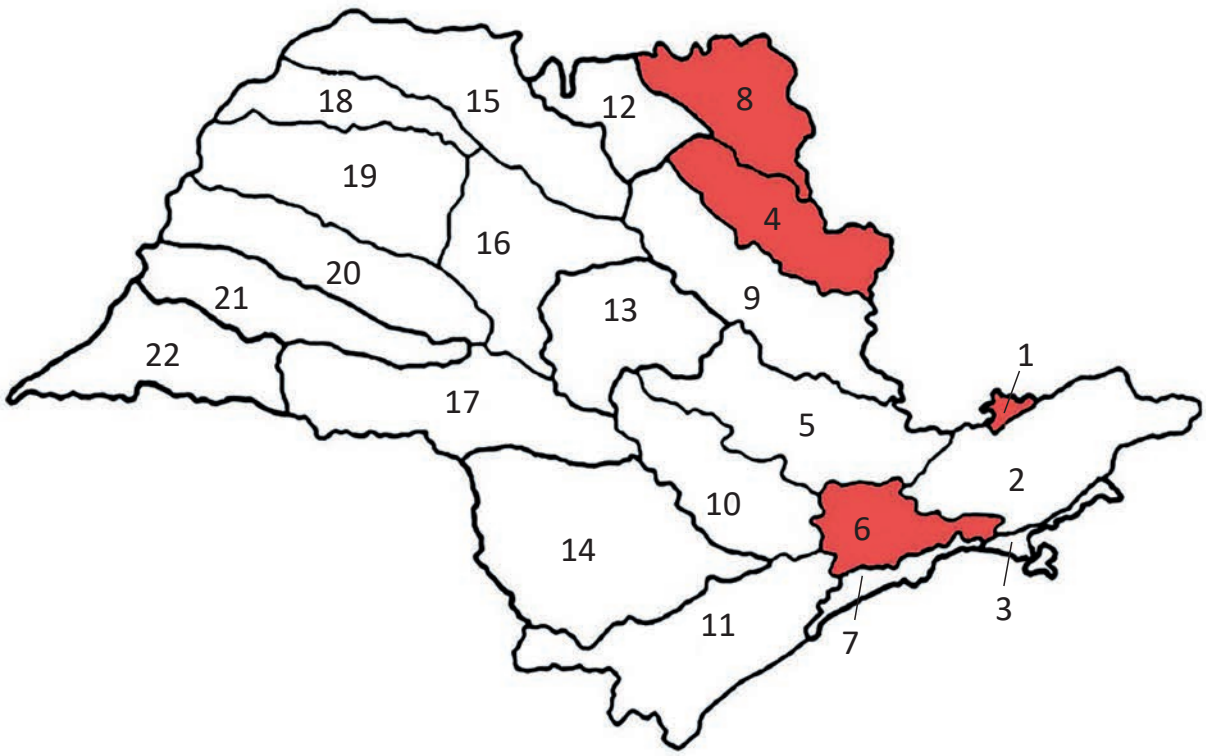
11. *Scolodiaptomus corderoi*

In the samplings made in 1979 (Typology of reservoirs of São Paulo State – TUNDISI, 1980) this species (Figure 11a) was present in the most of reservoirs belonging in the River Paraná basin, Rio Grande River basin and Rio Pardo basin, in large quantity (MATSUMURA-TUNDISI, TUNDISI, 2003). However recent studies showed the complete disappearance of this species from Barra Bonita reservoir that was present in abundance between 1983-1984 and from other reservoirs. The present data show the scarcity of ***Scolodiaptomus corderoi*** presence in the most water bodies of São Paulo State as can be seen in the table 6 occurring in some reservoirs from 4 (four) UGRHi: Mantiqueira, Pardo, Alto Tietê, Sapucai/Grande.

Figure 11a – Characteristics of 5th leg of male of *Solodiaptomus corderoi.*

Table 6 – Occurrence of *Scolodiaptomus corderoi* in the lakes and reservoirs from 4 UGRHi of São Paulo State.

Nº UGRHi	Name	Lakes & Reservoirs
1	Mantiqueira	Lago das Ninfeas, Horto
4	Pardo	Limoeiro
6	Alto Tietê	Aguas Claras, Guarapiranga
8	Sapuai/Grande	Jaguara, Volta Grande



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21 - Peixe
22 - Pontal do Paranapanema

Figure 11b – Map of geographical distribution of *Scolodiaptomus corderoi* in São Paulo State.

12. *Pseudodiaptomus richardi*

This is a brackish water species (Figure 12a) found only in UGRHi 7 (Baixada Santista) where the Rio Aguapei that flows to the Atlantic Ocean suffers the influence of the seas. Table 7 and Figure 12b show the occurrence of *Pseudodiaptomus richard* only in the UGRHi Baixada Santista.

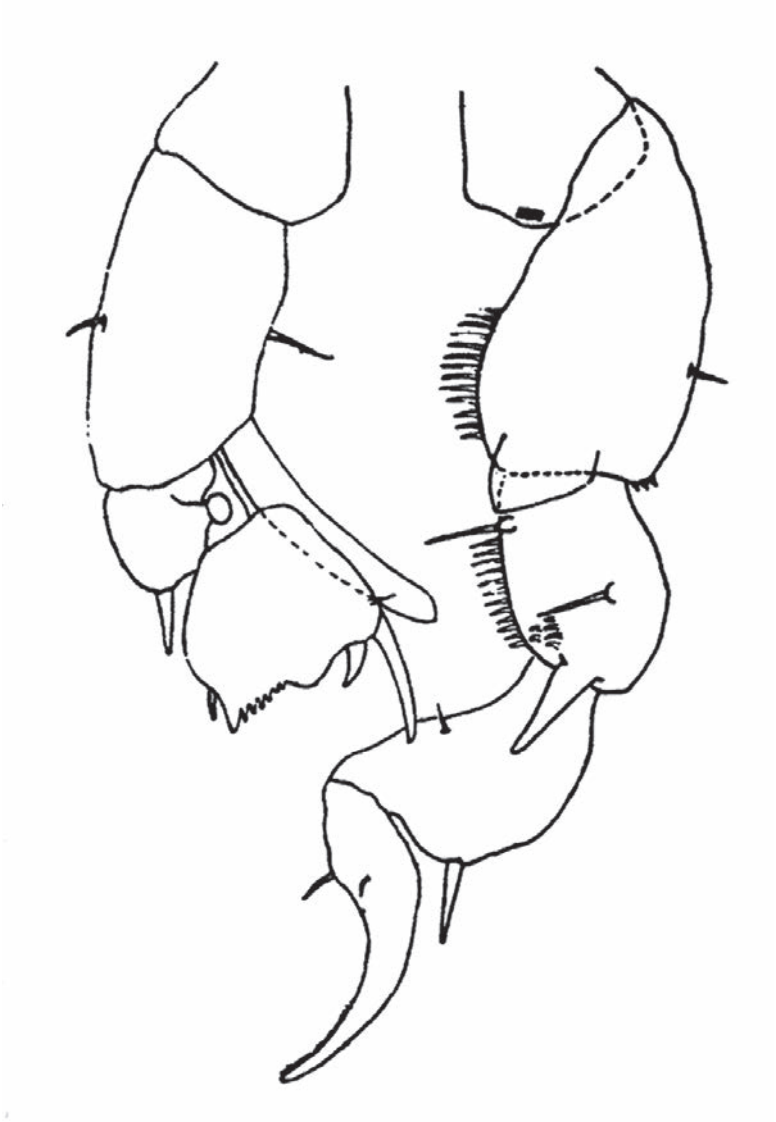
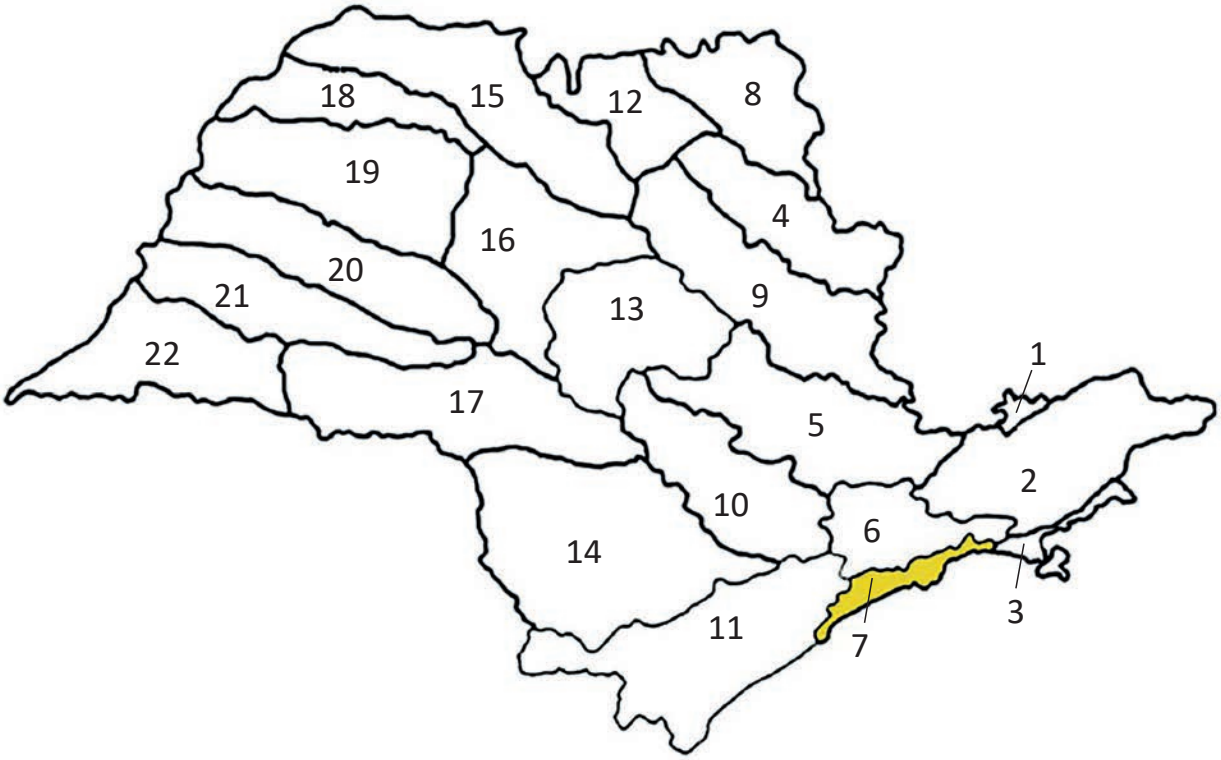


Figure 12a – Characteristics of 5th leg of male of *Pseudodiaptomus richardi.* Source: Sars, 1901.

Table 7 – Occurrence of *Pseudodiaptomus richardi* in the lakes and reservoirs in 1(one) UGRHi of São Paulo State.

Nº UGRHi	Name	Lakes & Reservoirs
7	Baixada Santista	Aguapei (Itanhaen)



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10 - Tietê/Sorocaba
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12 - Baixo Pardo/Grande
13 - Tietê/Jacaré
14 - Alto Paranapanema
15 - Turvo/Grande
16 - Tietê/Batalha
17 - Médio Paranapanema
18 - São José dos Dourados
19 - Baixo Tietê
20 - Aguapeí
21 - Peixe
22 - Pontal do Paranapanema

Figure 12b – Map of geographical distribution of *Pseudodiaptomus richardi* in São Paulo State.

Discussion

The twelve species of Calanoida identified in the freshwater continental ecosystems of São Paulo State (rivers, lakes and reservoirs) can be grouped as those that have large tolerance to environmental factors (climatological, habitats, chemical, physical, hydrogeological) as eurioecious species, and those that present a narrow tolerance to these factors as stenoecious species.

Of the identified Calanoida, five species, *Notodiaptomus iheringi, Notodiaptomus*

oliveirai, Notodiaptomus spinuliferus, Notodiaptomus henseni and *Notodiaptomus venezoelanus deevoyorum* can be considered as eurioecious species. These tolerate an ample spectra of environmental factors with a presence in more than 50% of the UGRHi of São Paulo State, under the influence of the main rivers that limit the frontiers of the major UGRHi: Rio Grande, Rio Paraná, Rio Paranapanema, Rio Tietê and Rio Pardo.

The other species such as *Argyrodiaptomus azevedoi, Odontodiaptomus paulistanus,, Notodiaptomus deitersi, Scolodiaptomus corderoi* and *Psedodiaptomus richardi* are stenoecious species, once their occurrence was registered in a few UGRHi.

As discussed by Hutchinson (1967) most of the species of Calanoida, specially Diaptomidae have wide tolerance of soft and moderately hard waters. The response of the species of Diaptomidae to environmental factors specially what Hutchinson (op.cit.) describes as "chemical ecology of Calanoida" is from field evidences of distribution rather than to experimental work in the laboratory. The endemicity of Calanoida species is well known from these field samples, therefore. Baily (1969) hás shown a strong correlation between Calanoida distribution in Australian freshwaters ecosystems and the ionic composition of waters specially the HCO_3^- + CO_3^-/clorate. Thus there are many evidences that hydrogeochemical factors such as the ionic composition of the water, the eutrophication and acidification processes are key factors, together with temperature that affect the distribution and survival of Calanoida species. These facts could explain why the copepods Calanoida from Northern hemisphere do not occur in the Southern hemisphere or vice versa. Many authors that studied the Diaptomidae from South hemisphere, since 1891 (POPPE, 1891 described the Diaptomidae from Brasilian material as "*Diaptomus" deitersi*), described all the Calanoida found as "*Diaptomus"* until 1958, when Brehm, 1958, classified the different "*Diaptomus"* in several genera.

In response to eutrophication changes in the composition of phytoplankton are expected. Cyanobacteria blooms are more frequent or permanent components of the phytoplankton community and given the fact that many species of cyanobacteria can produce toxins, it is probably another factor that affects the distribution of the Copepoda.

Several reservoirs in São Paulo State changed trophic status in the last 20 years (MATSUMURA-TUNDISI, TUNDISI, 2003; TUNDISI, MATSUMNURA-TUNDISI, 2013) a fact that can explain the changes observed in the zooplankton composition as regards Calanoida.

As Margalef (1966) pointed out, there is a constant interaction between plants and animals and this regulates the speed of phytoplankton and zooplankton succession. Quality of food which is different at each stage of succession has a strong influence on zooplankton development and evolution. Food availability changes, therefore, from smaller particles at the early stages of succession to larger particles at latter stages of succession and this can affect the Copepoda Calanoida distribution. Rietzler et al. (2002) proposed that changes in particle size and availability was one

of the factors that caused the change of *Argyrodiaptomus furcatus* to *Notodiaptomus iheringi* at Lobo/Broa reservoir.

The production of resting eggs by Copepoda Calanoida is another factor that can explain the wider geographical distribution of some species and the limited distribution of other species. As stated by Hutchinson (op. cit.) Diaptomidae can produce active and resting eggs The conditions under which the resting eggs hatch is relatively unknown but evidence from Lob/Broa reservoir a shallow ecosystem, with a high level of organic matter can explain the presence of *Argyrodiaptomus furcatus* the unique species of Calanoida present in this reservoir until 1986. On that time occurred the invasion of *Notodiaptomus iheringi* in competition with *A. furcatus*. The conditions of the reservoir also were undergoing becoming more eutrophic. Then it is possible to explain that the distribution of *Argyrodiaptomus furcatus* occurs only at the water ecosystems belonging at the UGRHi located in the northeast part of São Paulo State.

Other possible effect on the Copepoda Calanoida composition is the introduction of exoctic species of fishes in the reservoirs of São Paulo State. As shown by Matsumura-Tundisi & Tundisi (2003) major changes in zooplankton Copepoda Calanoida composition occurred mainly from 1980 to 1990. This was exactly the period during which at least 13 species of fishes from Amazon basin and other basins were introduced. The presence of *Notodiaptomus cearensis* in the present data and only in the UGRHi, influenced by River Tietê, could be explained by the transportation of this species native from lower latitudes by fishes to São Paulo State, where they found ideal conditions for their adaptation, reproduction and development.

The disappearance or the reduction of the geographic distribution of some species can be attributed to changes in the environmental conditions described above. Eutrophication, changes in the ionic composition or predation can be factors that limit the distribution or contribute for the changes in species composition. As Margalef (op. cit.) pointed out new empty spaces are continually produced in places where ecosystems are altered completely. Direct reactions of organisms to environmental change is most useful when the environment is altered in an unpredictable way. Reservoirs, lakes and rivers respond to environmental changes from the watershed inputs or the human activities in na unpredictable way depending on soil uses, the water uses, the load of nutrients and suspended material. Therefore a change in composition of Copepoda Calanoida should be expected under these dynamic and not so organized environmental conditions. These events may explain the retraction of the occurrence of *Scolodiaptomus corderoi* and *Notodiaptomus conifer* in the reservoirs os São Paulo State. Both species were present in 1979 in several reservoirs as related by Matsumura-Tundisi, Tundisi, 2003. At present *Scolodiaptomus corderoi* occurred in the reservoirs belonging at only three UGRHi, and *Notodiaptomus conifer* disappeared completely.

As stated by Matsumura-Tundisi, Tundisi (2003), during the decades of 1980

and 1990, eutrophication, acidification, the load of nutrients, suspended material and ionic composition changed drastically in several reservoirs of São Paulo State.For example in Barra Bonita reservoir amonium content (μgL^{-1}) had an increase of 200%; conductivity changed from 100μScm^{-1} in 1979 to 370 μScm^{-1} in 2002 and the presence of sulphate íon (SO_4^{--}) was detected during 2002 sampling.

Several books and papers reported extensive changes in the limnological conditions of the reservoirs in São Paulo State in the last 20 years (TUNDISI, MATSUMURA-TUNDISI, 2013). This would favor the expansion in the distribution of some species and the reduction in the geographical distribution of other species.

As Margalef (1966) pointed out nature is a channel of information. The genetic channel is replicable individual structures. Then the genetic channel of information should probably be the response of the Copepoda Calanoida community to changes in the environment. The appearance of new species as *Notodiaptomus oliveirai,* would also be a consequence of this response. Due to the dynamic and rapid changes in the environmental conditions and the effect of man activities the genetic channel has been enlarged more rapidly than the ecological channel. The cultural channel of information was very much enlarged, too. This explain the changes and the appearance of new species in the zooplankton community of Copepoda Calanoida.

Reservoirs are complex systems. They are dynamic and variable ecosystems responding rapidly to the impacts of human activities (“the cultural channel”, sensu Margalef, 1966). Effects of intraspecific competition, predation and changing environmental conditions would be responsible for the composition and succession of zooplankton community (PIANKA, 1999). The response of the Copepoda Calanoida populations dwelling in the reservoirs of São Paulo State can be a good example of the impact of man on the ecosystem structure and function.

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