COMPARATIVE STUDY OF THE ZOOPLANKTON COMPOSITION OF SIX LACUSTRINE ECOSYSTEMS IN CENTRAL BRAZIL DURING THE DRY SEASON

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(With 2 figures)

ABSTRACT

Zooplankton community from six lacustrine ecosystems located in Federal District (Central Brazil) was studied based on samples collected during the dry season (July to September). A total of 71 taxa were recorded: 44 rotifers, 17 cladocerans and 10 copepods. The highest number of zooplankton species was recorded in oligotrophic Bonita Pond (32 species) and the lowest number in hypertrophic waste stabilisation ponds (7 species). This tendency of decreasing the diversity with increasing trophic level was consistent with a cluster analysis of the samples based on Sorensen index of similarity. From the overall similarity dendrogram, two groups of ecosystems were distinguished: one containing the natural ponds Bonita and Formosa and the other comprising the reservoirs Santa Maria, Descoberto and Paranoá. The role of morphometric features in determining the zooplankton community in such lacustrine ecosystems was also discussed.

Key words: zooplankton taxonomy, tropical zooplankton, trophic state.

RESUMO

Estudo comparativo da composição zooplanctônica de seis ecossistemas lacustres do Brasil Central na estação seca

A comunidade zooplanctônica de seis ecossistemas lacustres localizados no Distrito Federal (Brasil Central) foi estudada com base em amostras coletadas durante a estação seca (julho a setembro). Foi registrado o total de 71 taxas: 44 rotíferos, 17 cladóceros e 10 copépodos. O maior número de espécies zooplanctônicas foi encontrado no ambiente oligotrófico da Lagoa Bonita (32 espécies) e o menor número ocorreu nas águas hipertróficas das lagoas de estabilização de esgotos (7 espécies). Essa tendência de redução da diversidade com o aumento do estado trófico foi consistente com a análise de agrupamento das amostras baseada no índice de similaridade de Sorensen. Com base no dendrograma geral de similaridade, foram estabelecidos dois grupos de ecossistemas: um contendo as lagoas naturais Bonita e Formosa e o outro compreendendo os reservatórios de Santa Maria, Descoberto e Paranoá. O papel das características morfométricas na determinação da comunidade zooplanctônica destes ecossistemas lacustres é também discutido.

Palavras-chave: zooplankton taxonomy, tropical zooplankton, trophic state.

INTRODUCTION

Although many studies on zooplankton in Federal District (Central Brazil) are available, the large majority of them have been done in the eutrophic Paranoá Reservoir (Freitas, 1983; Pinto-Coelho, 1983; Giani, 1984; Elmoor-Loureiro, 1984; Branco, 1991). Only few researchers have

documented on the zooplankton fauna of other lacustrine ecosystems of this region (Elmoor-Loureiro, 1988, 1990; Reid, 1990), but most were dedicated to taxonomy of a single group of the zooplankton.

Since 1976, qualitative and quantitative information on the zooplankton community of the three large man-made lakes within Federal District has been collected by the Brasilia Water and Sewage Corporation (CAESB). However, these data have not yet been published and are incomplete as to what concern identification of the organisms.

In spite of the crescent concern about the deterioration of water quality in Federal District, little effort has been dedicated to improving the knowledge on the effects of eutrophication on zooplankton community.

The aim of the present study is to provide additional information on the species composition of the zooplankton and its relationship with environmental factors for the most important standing water bodies within Federal District. This paper summarises the results obtained during the International Training Course on Lake Zooplankton, carried out in the Institute of Animal Ecology, State University of Gent, Belgium.

STUDY AREA

The Federal District is a rectangular area of 5783 km^2 located in the highest region of the central plateau within Goiás State, Central-West Region of Brazil (Fig. 1). It was created to include the capital of Brazil, Brasilia, and its satellite cities. According to Kõppen, the climate of the region may be classified between Rainy Tropical Savannah (Aw) and Rainy Temperate with dry winter (Cwhl), with a marcant dry season (April to September) and rainy season (October to March).

The drainage network of Federal District consists of four main hydrographic basins. The waterways which name the basins are: Descoberto River, in the west, with a drainage area of approximately 484 km^2; São Bartolomeu River, in the centerwest, with 2,864 Km^2; Maranhão River, (not represented in Fig. 1), in the north, with 750 Km^2 and Preto River, on the eastern boundary of the Federal District, with 1,344 Km^2 (UNDP/CAESB, 1990). Of the sampled water bodies, the waste stabilization ponds, Paranoá Reservoir, Santa Maria Reservoir and Bonita Pond are located within São Bartolomeu River Basin; Descoberto Reservoir is part of Descoberto River Basin and Formosa Pond is included in Maranhão River Basin outside the limits of Federal District (Fig. 1).

Three out of the four waste stabilization ponds of Federal District were constructed near the satellite city of Guará. They all are Australian Model, consisting basically of anaerobic cells followed by facultative and/or aerobic cells.

All waste stabilization ponds are considered hypertrophic ecosystems, with a dominance of blue-green algae and rotifers in the phytoplankton and zooplankton communities respectively (CAESB, unpublished data).

Paranoá Reservoir, located within the city limits of Brasilia, was constructed in 1959 for the purpose of recreation, landscaping, improvement of the microclimate of Brasilia, generating electric power and receiving sewage and rain water. The main land use of its drainage area (1,015 Km^2) is urban occupation. Paranoá Reservoir is a typical example of a tropical lacustrine ecosystem subjected to accelerated eutrophication due to sewage inflow mainly from Sewage Plants (UNDP/CAESB, 1990). The plankton of this ecosystem has been intensively studied in the last decade (Freitas, 1983; Pinto-Coelho, 1983; Giani, 1984; Starling, 1989; Branco, 1991). Summarising, it can be said that the phytoplankton, community is characterised by a monoculture of filamentous blue-green algae and frequent blooms of colonial blue-green *Microcystis aeruginosa*. The zooplankton community is numerically dominated by rotifers with 32 species whereas only 3 cladocerans and 1 cyclopoid copepod are present (Branco, 1991).

Santa Maria Reservoir was created in 1971 with the aim of supplying drinking water for the inhabitants of Brasilia. There is no impact of human activities on this reservoir as it is located entirely within an area reserved for conservation (Brasilia National Park). Since 1976, a monitoring program of water quality of this reservoir has been carried out by Brasilia Water and Sewage Corporation (CAESB). This reservoir has a very good water quality with phytoplankton largely composed of green algae (desmids mainly *Staurastrum* spp.) and zooplankton presenting high relative abundance of cladocerans (CAESB, unpublished data).

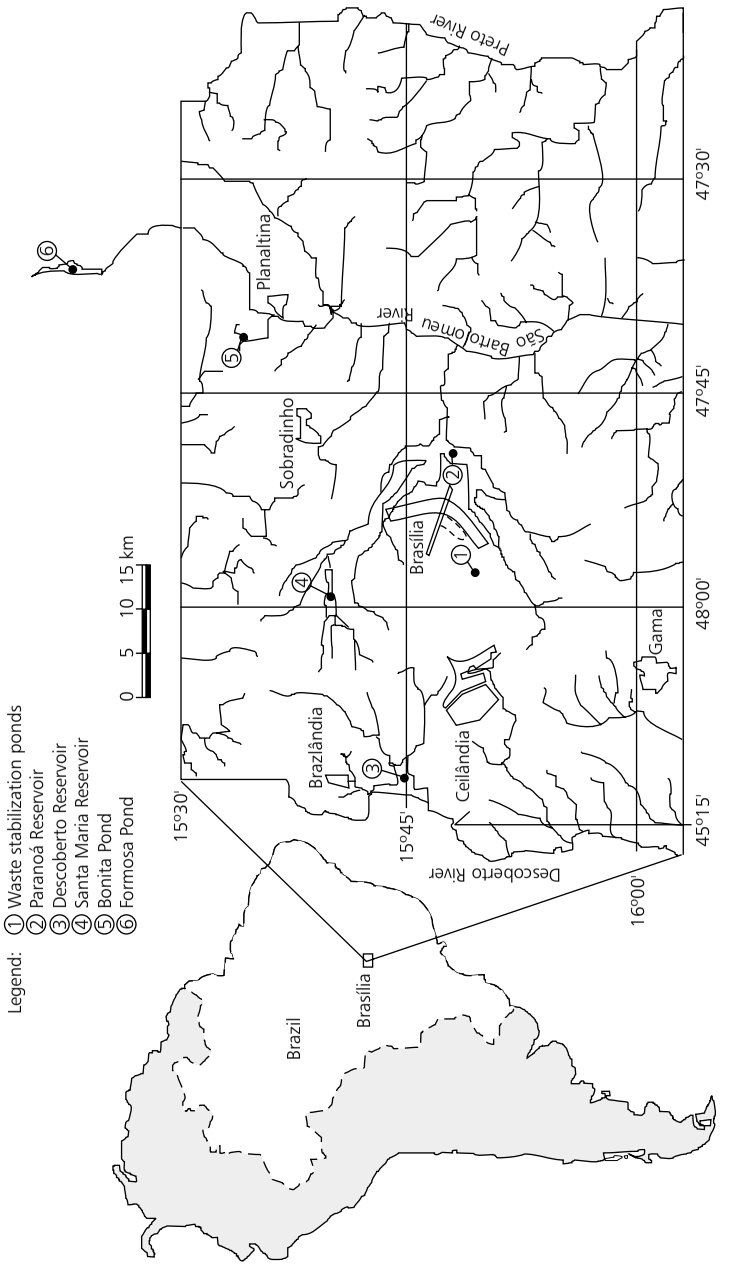

Fig. 1 — Location of the studied water bodies in the Federal District.

Descoberto Reservoir is another artificial lake created for drinking water supply purpose. Agriculture, cattle breeding and silviculture are the most important activities within its drainage area (482 Km^2). Based on data from Limnological Monitoring Program started in 1976 by CAESB, Descoberto Reservoir may be considered as a mesotrophic ecosystem. The phytoplankton community is highly diverse (52 genera recorded) and generally dominated by *Coelastrum*, *Scenedesmus*, *Staurastrum*, *Cryptomonas*, *Peridinium* and *Gymnodiniun.* Only 5 microcrustaceans are present in the reservoir and rotifers species are found in relatively high numbers (CAESB, unpublished data).

Bonita Pond is the largest natural lacustrine ecosystem in Federal District. It was formed by upwelling of freatic water and is characterised by a massive presence of macrophytes (mainly Mayacaceae and Lentibulariaceae) which cover all bottom and emerge near the shore forming extensive beds. Bonita Pond is located within an area reserved for conservation ('Águas Emendadas' Ecological Reserve) and is therefore not submitted to any kind of human impact. Consequently, the water quality is excellent and this ecosystem is considered oligotrophic (Leite, 1990). Although it has never been monitored by CAESB, some information on its planktonic community is available. The presence of 102 taxa of desmids belonging to 20 different genera (Leite, *op. cit.*) and the occurrence of one species of copepod (Reid, 1990) has been recorded.

Formosa Pond is the only studied ecosystem located outside Federal District, in Goiás State near Planaltina de Goiás City. It is a natural large pond of about 10 Km long and maximum width of 1 Km, with some shallow areas covered by macrophytes. Agriculture represents the main land use in its drainage basin and recreation has contributed to the deterioration of the water quality of the pond. From this mesotrophic ecosystem, only some microcrustaceans have been recorded (Elmoor-Loureiro, 1988; Reid, 1990).

MATERIAL AND METHODS

All zooplankton samples used in this study were collected during the dry season (July to September) of 1991. The sampling methodology differed among ecosystems according to their specific morphometric characteristics.

For reservoirs, water samples (2-4 liters) from different areas of the pelagic zone (at 1 m depth) and from a vertical profile (0, 1, 3, 5, 10 and 15 m in case of Descoberto and Santa Maria and also 20 and 25 m for Paranoá) in the deeper point of each reservoir were collected using a Van Dorn bottle and concentrated in a 45 μm plankton sieve. A total number of 10, 25 or 33 samples were collected and poured together to form composite samples for Santa Maria, Descoberto and Paranoá Reservoir respectively. For waste stabilization ponds, a total of 8 integrated water samples (0-1 m) were collected with a PVC tube sampler (2 m of length and 5.5 cm of diameter), concentrated and poured together as described above. Zooplankton from Bonita and Formosa Ponds were sampled with a 20 cm diameter and 45 μm mesh size plankton net, through successive horizontal and vertical hauls in the limnetic zone. All zooplankton samples were mixed with boiling distilled water before preservation with formalin 5% to minimise contraction of illoricate rotifers.

The samples were completely searched through for zooplankton organisms (except protozoans and *Chaoborus* larvae) using a stereoscopic binocular microscope. Cladocera and Copepoda were placed in slides with a drop of glycerin, dissected using a stereoscopic microscope and examined under composed microscope. Rotifers were put on slides, mastax preparation with natrium-hypochlorite were made whenever necessary and specimens were examined under composed microscope.

Identifications are based on the following works: Brooks (1957), Lindberg (1957), Herbst (1962), Goulden (1968), Flõssner (1972), Smirnov (1974, 1991), Koste (1978), Paggi (1979), Korinék (1981), Idris (1983), Lieder (1983), Dussart (1984), Reid (1985, 1990) and Matsumura-Tundisi (1986).

A cluster analyses of the samples basing on Sorensen's index of similarity (Sorensen, 1948) was performed.

RESULTS AND DISCUSSION

A list of the zooplankton organisms present in the samples is provided in Tables 2, 3 e 4. A total of 71 taxa were recorded, 41 of them

belonging to the Rotifera, 17 to Cladocera and 10 to Copepoda. The highest number of species was obtained in the sample from Bonita Pond (32 species) and the lower number was found in the waste stabilization ponds (7 species). Paranoá Reservoir (19 species), Descoberto Reservoir (18 species) Formosa Pond (18 species) and Santa Maria Reservoir (14 species) represented an intermediate situation between these two extremes. As can be seen in Table 1, there is also an obvious gradient of water quality conditions among the studied ecosystems, from the oligotrophic Bonita Pond to the hypertrophic Sewage Ponds. From this general picture it is possible to observe a tendency of decreasing diversity with increasing trophic level. Such relationship is well documented in literature and is related to the extreme restrictive environmental conditions associated with the eutrophication process (Sladecék, 1983). However, it should be kept in mind that the results from Bonita Pond and, in a lesser extend from Formosa Pond, are influenced by the records of typical littoral species. Differences in sampling methods applied in the ecosystems are believed not to have any implications in qualitative studies such as the present one.

Bonita Pond is largely colonised by submerged and emerging macrophytes which almost completely occupy its surface area. Although the samples were taken in the open water, they included a considerable number of littoral rotifers (*Macrochaetus longipes, Lecane leontina, L. signifera, L. bulla, L. crenata, L. lunaris, L. pertica, Tetrasiphon hydrocora, Notommata* sp., *Cephalodella mucronata* and *Floscularia melicerta)* and cladocerans (Chydoridae and Macrothricidae) which comprised over 70% of the total zooplankton taxocoenosis found for this ecosystem. Similar to Bonita Pond, the presence of macrophyte beds in Formosa Pond also influence the zooplankton composition by including typical littoral Rotifera (genera *Lecane* and *Notommata)* and Cladocera (Fam. Chydoridae). However, as Formosa Pond is comparatively less colonised by macrophytes, the contribution of such species was lower comprising about 50% of total zooplankton species recorded. In contrast with the natural ponds, the zooplankton communities of the three studied reservoirs and of the sewage ponds were found to be essentially limnetic with the inclusion of a single littoral rotifer, *Ptygura* sp. and the cladoceran *Disparalona dadayi* in the sample from Santa Maria Reservoir.

The only ecosystem of the region studied before is Paranoá Reservoir (Pinto-Coelho, 1983; Branco, 1991). Our study does not add any zooplankton to the list given in Branco (*op. cit*). On the contrary, 16 of the 32 rotifer species recorded by this author were not found in the present study. This is mainly a result of differences in sampling effort and clearly demonstrates the necessity of extended sampling in order to cover the entire species spectrum present in an ecosystem.

When considering the entire list of taxa found during the present study, 20 out of 44 species of Rotifera represent new records for Federal District (indicated with the symbol * in Table 2). For the microcrustaceans, only the Cladocera *Bosmina (Bosmina) longirostris, Bosmina (Neobosmina) hagmanni, Bosmina (Neobosmina) tubicens, Ceriodaphnia cornuta, Diaphanosoma birgei* and *Moina micrura* (Elmoor-Loureiro, 1984, 1988, 1990, *in litt.)* and the Copepoda *Thermocyclops decipiens* and *Trichodiaptomus coronatus* (Reid, 1989, 1990) have been previously reported from Federal District.

From the general zooplankton similarity dendrogram (Fig. 2), two groups of ecosystems can be distinguished, one containing the natural ponds Bonita and Formosa and the other comprising the three studied reservoirs Santa Maria, Descoberto and Paranoá. The waste stabilization ponds show a low similarity with any of the other ecosystems. As can also be seen in this figure, the dendrogram obtained basing on rotifers, only, which comprised 62% of the recorded species, showed the same pattern of ecosystems groupment. For the cladocerans, all water bodies except the waste stabilization ponds had rather similar zooplankton taxocoenosis. When the copepods are considered, relatively high similarity was found between Bonita Pond, Formosa Pond and Descoberto Reservoir only, probably resulting from the co-occurrence of calanoid copepods species in these ecosystems

From these results, it seems that not trophic state itself but the general ecological type of the ecosystem (which also includes trophic state) explains the zooplankton composition.

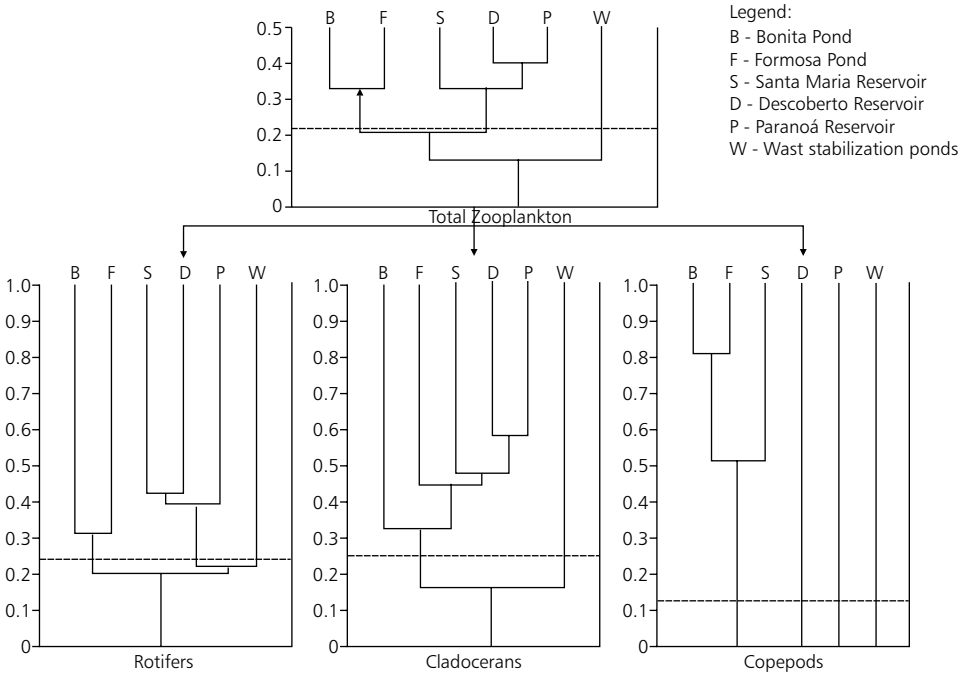

Fig. 2 — Dendrogram based on Sorensen Similarity Index for zooplankton species present in the sampled ecosystems. Dotted line indicates mean values for all samples.

TABLE 1

Morphometric and limnological data from Bonita Pond (5), Formosa Pond (6), Santa Maria Reservoir (4), Descoberto Reservoir (3), Paranoá Reservoir (2) and waste stabilization ponds (1) during dry season.

Parameter	Ecosystems					
	(5)	(6)	(4)	(3)	(2)	(1)
Surface area (Km^2)	1.2	< 6	6	17	38	0.02
Volume (x 10^6 m^3)	1.9	–	58	120	498	–
Maximum depth (m)	–	3.5	< 4	20	40	1
Mean depth (m)	1.8	–	9.7	7	13	1
Retention time (days)	–	–	550	100	299	20
Transparency (cm)	200	150	208	190	70	11
Dissolved oxygen ($mg.L^{-1}$)	8.0	–	6.0	7.4	7.3	5.0
Conductivity ($\mu S.cm^{-1}$)	< 05	6.2	8.0	10	45	600
pH	5.3	6.3	7.3	7.1	7.5	9.0
Ammonia ($\mu g.L^{-1}$)	< 10	21	115	–	–	–
Total Nitrogen ($mg.L^{-1}$)	–	–	0,6	0.6	1.9	35
Orthophosphate ($\mu g.L^{-1}$)	< 10	< 02	5.8	–	–	–
Total Phosphorous ($\mu g.L^{-1}$)	< 10	28	10	14	41	6000
Chlorophyll-a ($\mu g.L^{-1}$)	–	–	12	2.6	61	–

(Compiled from Leite (1990); UNDP/CAESB (1990) and CAESB, unpublished data.)

TABLE 2

Occurrence of Rotifera taxa in samples from Bonita Pond (5), Formosa Pond (6), Santa Maria Reservoir (4), Descoberto Reservoir (3), Paranoá Reservoir (2) and waste stabilisation ponds (1).

Family/Species	Ecosystems					
	(5)	(6)	(4)	(3)	(2)	(1)
Order Monogononta:						
Fam. Brachionidae						
Brachionus angularis (Gosse, 1871)	+			+		+
Brachionus calyciflorus (Pattas, 1766)	+	+	+	+	+	+
Brachionus quadridentatus f. mirabilis (Daday, 1897) *		+				
Keratella americana (Carlin, 1943)		+	+	+	+	
Keratella cochlearis (Gosse, 1851)				+	+	
Keratella quadrata (O. F. Muller, 1786) *	+					
Keratella tropica (Apstein, 1907)					+	
Anuraeopsis fissa fissa (Gosse, 1851)					+	
Anuraeopsis navicula (Rousselet, 1910)				+		
Fam. Trichotriidae						
Macrochaetus Longipes (Myers, 1934)*	+					
Fam. Lecanidae						
Lecane leontina (Turner, 1892) *	+	+			+	
Lecane signifera (Jennings, 1896)	+	+				
Lecane bulla (Gosse, 1886) *	+					
Lecane crenata (Harring, 1913) *	+	+				
Lecane lunaris (Ehrenberg, 1832) *	+					
Lecane pertica (Harring & Myers, 1922)*	+					
Fam. Notommatidae						
Tetrasiphon hydrocora (Ehrenberg, 1834)*	+					
Notommata allantois (Wulfert, 1935)*		+				
Notommata copeus (Ehrenberg, 1834)*		+				
Notommata sp.*1,* sp.*2,* sp.*3*	+					
Cephalodella mucronata (Myers, 1924)*	+					
Fam. Trichocercidae						
Trichocerca capucina (Wierzejski & Zacharias, 1893)					+	
Trichocerca pusilla (Lauterborn, 1898)			+	+	+	
Trichocerca similis (Wierzejski, 1898)					+	
Trichocerca stylata (Gosse, 1851) *				+		
Fam. Gastropodidadae						
Ascomorpha saltans (Bartsch, 1870)*			+			
Fam. Synchaetidae						
Synchaeta pectinata (Ehrenberg, 1832)*					+	
Polyarthra remata (Skorikov, 1896) *				+		
Polyarthra vulgaris (Carlin, 1943)			+		+	

TABLE 2 (*Continued*)

Family/Species	Ecosystems					
	(5)	(6)	(4)	(3)	(2)	(1)
Fam. Asplanchnidae						
Asplanchna girodi (De Guerne, 1888)					+	
Asplanchna sieboldi (Leydig, 1854) *						+
Fam. Flosculariidae						
Floscularia melicerta (Ehrenberg, 1832) *	+					
Ptygura sp.		+	+	+		
Gen. spec.	+					
Fam. Conochilidae						
Conochilus dossuarius (Hudson, 1875)					+	
Conochilus hippocrepis (Schrank, 1830) *		+				
Conochilus unicornis (Rousselet, 1892)				+	+	
Fam. Hexarthridae						
Hexarthra intermedia brasiliensis (Hauer, 1953)			+			
Fam. Filiniidae						
Filinia longiseta (Ehrenberg, 1834)						+
Fam. Trochosphaeridae						
Horaella thomassoni (Koste, 1973)					+	
Fam. Collothecidae						
Collotheca sp.	+			+		
Order Digononta:						
Gen. spec.						+

Thus, Bonita and Formosa Ponds as shallow and small natural ecosystems, characterised by an abundance of macrophytes, low levels of nutrients and acid water (Tables 2, 3 and 4) have similar zooplankton communities. A distinct community is established in the larger and deeper man-made lakes which are characterised by a scarcity of submerged and emerging macrophytes, a well developed pelagic zone, a neutral to slightly alkaline pH and a moderate to high trophic state. Peculiar communities composed by few but resistant species are found in the alkaline and extremely highly productive water of the shallow sewage ponds.

Although the present study has contributed increasingly to the knowledge of the zooplankton species occurring in Federal District, data on seasonal fluctuation and relative abundance of the zooplankton community are still lacking for almost all of the studied ecosystems.

Such additional information is necessary to obtain a better understanding of the responses of the zooplankton community to man-induced modifications of the water quality.

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TABLE 3
Occurrence of Cladocera taxa in samples from Bonita Pond (5), Formosa Pond (6), Santa Maria Reservoir (4), Descoberto Reservoir (3), Paranoá Reservoir (2) and waste stabilisation ponds (1).

Family/Species	Ecosystems					
	(5)	(6)	(4)	(3)	(2)	(1)
Fam. Bosminidae						
Bosmina (Bosmina) longirostris (O. F. Muller, 1785)					+	
Bosmina (Neobosmina) hagmani (Stigelin, 1904)		+	+	+	+	
Bosmina (Neobosmina) tubicens (Brehm, 1953)		+	+			
Bosminopsis deitersi (Richard, 1895)	+					
Fam. Chydoridae						
Alona intermedia (Sars, 1862)	+					
Alona rustica (Scott, 1895)	+					
Ephemeroporus barroisi (Richard, 1894)	+	+				
Chydorus eurynotus (Sars, 1901)	+	+				
Disparalona acutirostris (Birge, 1879)	+					
Disparalona dadayi (Birge, 1910)	+		+			
Fam. Daphniidae						
Ceriodaphnia cornuta (Sars, 1886)	+		+			
Daphnia gessneri (Herbst, 1967)				+		
Fam. Macrothricidae						
Ilyocriptus spinifer (Herrick, 1982)	+					
Macrothrix paulensis (Sars, 1900)	+					
Streblocerus pygmaeus (Sars, 1901)	+					
Fam. Moinidae						
Moina micrura (Kurz, 1874)			+	+		+
Fam. Sididae						
Diaphanosoma birgei (Korinek, 1981)		+			+	

TABLE 4
Occurrence of Copepoda taxa in samples from Bonita Pond (5), Formosa Pond (6), Santa Maria Reservoir (4), Descoberto Reservoir (3), Paranoá Reservoir (2) and waste stabilisation ponds (1).

Family/Species	Ecosystems					
	(5)	(6)	(4)	(3)	(2)	(1)
Order Cyclopoida:						
Fam. Cyclopidae						
Mesocyclops sp.	+	+				
Metacyclops mendocinus (Wierzejski, 1893)						+
Microcyclopsanceps pauxensis (Herbst, 1962)			+			
Microcyclops finitimusi (Dussart, 1984)	+					
Thermocyclops decipiens (Kiefer, 1929)					+	
Tropocyclops schubarti (Kiefer, 1935)			+			
Gen. spec.				+		

TABLE 4 (*Continued*)

Family/Species	Ecosystems					
	(5)	(6)	(4)	(3)	(2)	(1)
Order Calanoida:						
Fam. Diaptomidae						
Notodiaptomus jatobensis (Wright, 1935)				+		
Notodiaptomus spinuliferus (Dussart & Matsumur -Tundisi, 1986)		+				
Trichodiaptomus coronatus (Sars, 1901)	+	+		+		

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