A checklist for the zooplankton of the Middle Xingu – an Amazon River system

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Received: March 11, 2015 – Accepted: May 22, 2015 – Distributed: August 31, 2015
(With 1 figure)

Abstract

A zooplankton checklist is presented for the Middle Xingu River, based on surveys conducted at four sites in the main channel and two fluvial lakes. A total of 175 taxa are listed, including 141 rotifers, 20 cladocerans, and five copepods. Rapids presented the greatest species richness, with up to 124 taxa, while Ilha Grande lake had 70 taxa, the lowest number. Non-planktonic benthic larvae were recorded frequently in the samples.

Keywords: clear water rivers, zooplankton, fluvial habitats, limnology.

Diversidade zooplanctônica do médio Rio Xingu – bacia amazônica

Resumo

Levantamentos realizados em dois lagos e no canal principal do médio Xingu objetivaram a listar a diversidade do zooplâncton. De um total de 175 táxons, 141 foram rotíferos, 20 cladóceros e 5 copépodes. As corredeiras foram os ambientes mais diversos com 124 táxons, enquanto que no Lago da Ilha Grande se registraram somente setenta táxons. Destaca-se a ocorrência de grupos de hábito não planctônico na coluna d'água do rio que indica o efeito perturbador da correnteza.

Palavras-chave: águas claras amazônicas, zooplâncton, ambientes fluviais, limnologia.

1. Introduction

Many inventories of the zooplankton diversity of the rivers of the Amazon basin are available, especially for the principal, white- and black-water tributaries. The principal studies have focused on the marginal várzea lakes of the Amazon and Negro floodplains (see Robertson and Hardy, 1984; Koste and Robertson, 1990; Brandorff, 1973; Brandorff and Andrade, 1978; Koste and Robertson, 1983; Carvalho, 1983; Hardy, 1980; Hardy et al., 1984; Robertson and Hardy, 1984; Santos-Silva et al., 1989; Waichman et al., 2002). However, studies of the composition of the zooplankton of clear-water rivers are scarce. The available studies include those of Bozelli (1992, 1994) and Bozelli et al. (2000) in the region of the Trombetas River, Koste (1972, 1974 a,b, 1989) on the Tapajós, and Brandorff et al. (1982) on the lower Nhamundá River. Given this, the present study provides a checklist of the zooplankton of two fluvial lakes and four sites in the main channel of the middle Xingu, a clear-water river in the southeastern Amazon basin.

2. Material and Methods

2.1. Study area

The present study was conducted along a 180 km stretch of the middle Xingu River in Pará, in the eastern Brazilian Amazon basin (Figure 1). This region is characterized by numerous waterfalls and rapids, as well as extensive areas of alluvial rainforest (Camargo et al., 2005).

The climate of the study area is of Köppen's A type, with variants Aw and Am (Critchfield, 1968). Mean annual temperatures in the study area oscillate between 17.5 °C and 24.5 °C, with relative humidity of 84-86%. Mean annual precipitation varies from 2066.8 mm to 2379.4 mm (Camargo et al., 2005).

Six environments were monitored in the present study. Two were located in lakes on river islands (Ilha Grande and Pimentel) and the other four (Boa Esperança, Arroz Cru, Caitucá and CNEC) in the main Xingu River. Ilha

Grande lake (3°34'47"S, 52°23'42"W) is semi-circular, with a depth of 0.5-2.5 m, and a total area of approximately 15,612 m^2. The bed of this lake is covered in slimy silt, sand, and leaf litter derived from the island's dense alluvial rainforest, and high concentrations of phytoplankton were associated with the reduced Secchi transparency (0.8-1.1 m) and high levels of dissolved oxygen (DO: 5.0-7.5 $mg.l^{-1}$), and the slightly acid water (pH = 5.9-6.7) with low conductivity, of 30 $uS.cm^{-1}$ (Estupiñan and Camargo, 2008). The second lake, Pimentel (3°25'46" S, 52º24'4" W), located on the river's Great Bend, is elliptical in shape, with a mean surface area of 1570 m^2, depths of between 0.8 and 3.0 m, with low pH (5.0-5.4) and Secchi transparency (0.90 0.98 m), and low DO (2 $mg.L^{-1}$) and reduced levels of chlorophyll, which determine its low levels of primary productivity (Estupiñan and Camargo, 2008). During the rainy season, the forest is flooded by the creeks that drain the area surrounding the lakes.

On the river margin, Boa Esperança (3°34'46" S, 52°24'42" W) is located in the vicinity of Ilha Grande (Figure 1), while Arroz Cru (3°34'46" S, 52°24'42" W) is near Pimentel Island. The Caitucá marginal site (3°33'47" S, 51°24'42" W) is located in the large river bend (Cotubelo) deflection (Estupinãn and Camargo, 2008). The CNEC site (3°16'16" S, 51°24'42" W) is upstream from the larger waterfalls before the lower Xingu River. The pH of the river varied from 6.4 to 7.6 and conductivity was low (20-31 $uS.cm^{-1}$) which, together with the DO concentrations of 7.1-8.6 $mg.L^{-1}$ indicate highly that the water is highly oxygenated (Estupinãn and Camargo, 2008).

Every two months between August 2006 and June 2007, four zooplankton samples were collected at the surface and middle depths of the two lakes (Ilha Grande, Pimentel), while two angular sub-surface samples were collected from four stretches of the main channel of the Xingu River (Figure 1). The samples were collected with a 40 μ mesh plankton net equipped with a digital flowmeter in the river and by filtering 400 liters of water into a bucket in the lakes. The specimens collected were fixed and preserved in 4% formalin. Sorting and identification of specimens were carried out with a Wild-Leitz stereo-zoom dissecting microscope. Identification of the specimens was based on Cipólli and Carvalho (1973), Koste (1978), Paggi (1979), Robertson (1980), Brandorff et al. (1982), Koste and Robertson (1983), Koste et al. (1984), Reid (1985), Magalhães et al. (1988), Robertson et al. (1989), Santos-Silva et al. (1989), Koste and Robertson (1990), Korovchinsky (1992), Smirnov (1992), Paggi (1995), Segers (1995), Elmoor-Loureiro (1997), and Fernando (2002).

3. Results

This study recorded a total of 175 taxa, comprising 141 rotifers (80.6%), 20 cladocerans (11.4%), five copepods (2.9%), and nine (5.1%) bottom-dwelling protozoans, gastrotrichs and insects (Tables 1 and 2). In general, the fluvial habitats were the most diverse. The richness of taxa varied from 70 in Ilha Grande lake to 124 in the rapids. Despite being much smaller than Ilha Grande lake, Pimentel lake had a relatively high richness, with a total of 114 taxa.

The Rotifera was the most diverse group, accounting for approximately 80% of total taxon richness in each of the study environments (Table 1). Much less diverse were the Cladocera, with around 8% of the taxa, and the Calanoida and Copepoda, each with approximately 2% (Table 1).

Most of the rotifers (19.86%) belonged to the family Lecanidae. *Brachionus calyciflorus*, Pallas, 1866; *Testudinela*

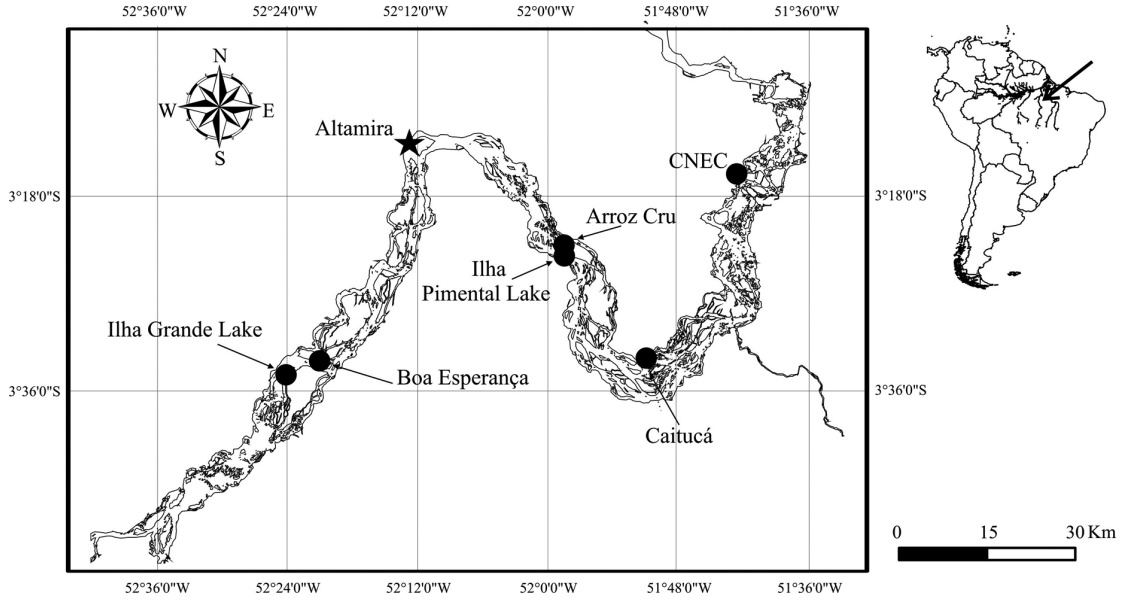

Figure 1. Map of the region with the localities in the main channel and island lakes.

Table 1. Zooplankton species recorded in different environments of the Middle Xingu River (2006-2007).

Group	Habitat	Environments and habitats			
		Island lakes		Main channel	
		Ilha Grande	Pimental	Rapids	Flow restricted waters
ROTIFERA					
GASTROPODIDAE					
Ascomorpha ecaudis (Perty, 1850)	Pl		X	X	
Ascomorpha saltans (Bartsch, 1870)	Pl	X	X		
Ascomorpha sp.	Pl		X		
Gastropus hyptopus (Ehrenberg, 1838)	NDT		X		X
Gastropus stylifer Imhof, 1891	NDT	X			
Gastropus sp.	NDT	X			
ASPLANCHNIDAE					
Asplanchna priodonta Gosse, 1850	Pl	X		X	
Asplanchna sieboldi (Leydig, 1845)	Pl		X		
Asplanchna silvestri Daday, 1902	Pl		X		
Asplanchna sp.	Pl	X	X	X	X
Harringia sp.	NDT	X			
BRACHIONIDAE					
Anuraeopsis fissa (Gosse, 1851)	Pl	X	X	X	X
Anuraeopsis navicula Rousselet, 1910	Pl	X	X	X	
Anuraeopsis siolli Koste, 1972	Pl		X		
Brachionus ahlstromi (Lindeman, 1939)	Pl			X	X
Brachionus angularis Gosse, 1851	Pl	X	X	X	X
Brachionus calyciflorus Pallas, 1866	Pl			X	X
Brachionus caudatus Barrois and Daday, 1894	Pl	X	X	X	X
Brachionus dolabratus Harring, 1915	Pl	X	X	X	X
Brachionus falcatus Zacharias, 1898	Pl	X	X	X	X
Brachionus gessneri Hauer, 1956	Pl	X	X	X	X
Brachionus mirabilis (Daday, 1897)	Pl		X		
Brachionus mirus Dady, 1905	Pl	X	X	X	X
Brachionus patullus (Müller, 1953)	Pl		X	X	X
Brachionus quadridentatus Hermann, 1783	NP	X	X	X	X
Brachionus zahniseri Ahlstrom, 1934	Pl	X	X	X	X
Keratella americana Carlin, 1943	Pl	X	X	X	X
Keratella cochlearis Gosse, 1851	Pl	X	X	X	X
Keratella lenzi Hauer, 1953	Pl	X	X	X	X
Keratella nhamunda (Koste and Robertson, 1983)	Pl				X
Notholca sp.	NDT			X	
Plathyias quadricornis Daday, 1905	NP		X	X	
Squatinella sp.	NDT				X
NOTOMATIDAE					
Cephalodella gibba (Ehrenberg, 1838)	NP		X	X	
Cephalodella intuta Myers, 1924	NP	X	X	X	X
Cephalodella mucronata Myers, 1924	NP				
Cephalodella sp.	NP		X	X	X
COLLOTHECIDAE					
Collotheca ambigua (Hudson, 1883)	NP	X			X
Collotheca tenuilobata (Anderson, 1889)	NP	X		X	X
Collotheca sp1.	NDT	X	X	X	X
Collotheca sp2.	NDT		X	X	X

Pl = planktonic, NP = not planktonic, NDT = non determined.

Table 1. Continued...

Group	Habitat	Environments and habitats			
		Island lakes		Main channel	
		Ilha Grande	Pimental	Rapids	Flow restricted waters
Stephanoceros fimbriatus (Goldfuss, 1820)	NP			X	X
CONOCHLIDAE					
Conochilus dossuaris (Hudson, 1875)	NDT	X			X
EPIPHANIDAE					
Epiphanes clavatula (Ehrenberg, 1832)	Pl		X		
Epiphanes macrourus (Barrois and Daday, 1894)	Pl	X	X	X	X
Microcodides chlaena Gosse, 1886	NDT		X	X	
EUCHLANIDAE					
Euchlanis dilatata Ehrenberg, 1832	NP			X	X
Euchlanis incisa Carlin, 1939	NP		X		
Dipleuchlanis propatula (Gosse, 1886)	NP		X	X	X
FILINIDAE					
Filinia longiseta (Ehrenberg, 1834)	Pl	X	X	X	X
Filinia opoliensis (Zacharias, 1898)	Pl	X	X	X	X
Filinia pejleri Hutchinson, 1964	Pl	X	X	X	X
Filinia sp.	NDT		X	X	
HEXARTHRIDAE					
Hexarthra intermedia Wieszniewski, 1929	Pl	X	X	X	X
LECANIDAE					
Lecane arcuata (Ryce, 1891).	NP		X		
Lecane arculeata (Akubski, 1912).	NP				X
Lecane bulla (Gosse, 1886)	Pl/NP		X	X	X
Lecane clara (Bryce, 1892)	NP		X		
Lecane closterocerca (Schmarda, 1856)	NP	X	X	X	X
Lecane copeis (Harring and Myers, 1926)	NP			X	X
Lecane curvicornis (Murray, 1913)	Pl	X	X	X	X
Lecane hamata (Stockes, 1896)	NP		X	X	X
Lecane hornemanni (Ehrenberg, 1834)	NP			X	X
Lecane leontina (Turner, 1892)	NP		X	X	X
Lecane ludwigi (Eckstein, 1883)	NP		X	X	X
Lecane luna (O. F. Müller, 1776)	NP			X	X
Lecane lunaris Ehrenberg, 1832	NP		X	X	X
Lecane monostyla (Daday, 1897)	Pl/NP		X	X	
Lecane murrayi (Hauer, 1965)	NP			X	
Lecane nodosa (Hauer, 1937/38)	NP			X	X
Lecane obtusa (Murray, 1913)	NP			X	X
Lecane opias Harring and Myers, 1926	NP				X
Lecane papuana Murray, 1913	NP		X	X	X
Lecane proiecta (Hauer, 1956)	NP	X	X	X	X
Lecane pyriformis (Daday, 1905)	NP			X	X
Lecane ruttneri Hauer, 1938	NP				X
Lecane signifera (Jennings, 1896)	NP		X	X	X
Lecane stichaea Harring, 1913	NP			X	X
Lecane ungulata (Gosse, 1887)	NP			X	
Lecane sp1.	NDT		X	X	X
Lecane sp2.	NDT		X	X	X
Lecane sp3.	NDT		X		X

Pl = planktonic, NP = not planktonic, NDT = non determined.

Table 1. Continued...

Group	Habitat	Environments and habitats			
		Island lakes		Main channel	
		Ilha Grande	Pimental	Rapids	Flow restricted waters
COLURELLIDAE					
Colurella uncinata (O.F. Muller, 1773)	NP		X	X	
Colurella sp.	NP		X	X	X
LEPADELLIDAE					
Lepadella amphitropis Harring, 1916	NP		X		X
Lepadella benjamini Harring, 1916	NP				X
Lepadella costata Wulfert, 1940	NP		X		
Lepadella cristata (Rousselet, 1893)	NP	X			
Lepadella donneri Koste, 1972	NP				X
Lepadella elliptica (Turner, 1892)	NP		X		
Lepadella latusinus Myers, 1934	NP		X	X	X
Lepadella patella (O. F. Müller, 1786)	NP	X	X	X	X
Lepadella rhomboides (Gosse, 1886)	NP		X		X
Lepadella sp.	NDT		X	X	X
Paracolurella logima (Myers, 1934)	NP		X		
TRICHOTRIIDAE					
Macrochaetus collinsi (Gosse, 1867)	NP		X	X	X
Macrochaetus sericus (Thorpe, 1893)	NP			X	
Macrotrachela zickendrahti (Richters, 1902)	NDT				X
Trichotria tetractis (Ehrenberg, 1830)	NDT		X	X	X
Trichotria sp.	NDT	X			
NOTOMATIDAE					
Monommata arndti Remane, 1933	NP		X		
Monommata maculata Harring and Myers, 1924	NP		X		
Eosphora anthadis (Harring and Myers, 1922)	NP		X	X	
MYTILINIDAE					
Mytilina macrocera (Jennings, 1894)	NP				X
Mytilina mucronata (Müller, 1773)	NP			X	
Mytilina ventralis (Ehrenberg, 1832)	N		X		
Mytilina sp.	NDT		X	X	X
SYNCHAETIDAE					
Ploesoma lenticulare Herrick, 1885	Pl/NP		X		
Ploesoma sp.	Pl/NP		X		
Polyarthra remata Skorikov, 1896	Pl	X	X		X
Polyarthra vulgaris Carlin, 1943	Pl	X	X	X	X
Proales sp.	Pl	X	X	X	X
Synchaeta stylata Wierzejski, 1893	NP	X		X	
Synchaeta sp.	NP			X	
PROALIDAE					
Ptygura libera Myers, 1934	NP	X	X	X	X
Ptygura melicerta Ehrenberg, 1832	NP			X	X
Ptygura sp.	NP		X		X
FLOSCULARIIDAE					
Sinantherina sp.	NDT				
TESTUDINELLIDAE					
Testudinela ahlstromi (Hauer, 1956)	NP		X	X	X
Testudinela ohlei (Koste, 1972)	NP		X	X	X

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Table 1. Continued...

Group	Habitat	Environments and habitats			
		Island lakes		Main channel	
		Ilha Grande	Pimental	Rapids	Flow restricted waters
Testudinela patina (Hermann, 1783)	NP		X	X	X
Testudinela semiparva (Ternetz, 1892)	NP		X		
Testudinela tridentata Smirnov, 1931	NP			X	X
Testudinela sp.	NDT	X	X	X	X
TRICHOCERCIDAE					
Trichocerca agnatha Wulfert, 1939	NP	X			
Trichocerca bicristata (Gosse, 1887)	NP	X	X	X	X
Trichocerca bidens (Lucks, 1912)	NP		X	X	X
Trichocerca capucina Wierzejski and Zacharias, 1893	NP	X	X	X	X
Trichocerca chattoni (Beauchamp, 1907)	NP	X	X	X	X
Trichocerca collaris (Rousselet, 1896)	NP		X	X	X
Trichocerca gracilis (Tessin, 1890)	NP	X	X	X	
Trichocerca insiginis (Herrich, 1885)	NP	X	X	X	X
Trichocerca longiseta (Schrank, 1802)	Pl		X	X	X
Trichocerca myersi (Hauer, 1931)	NP	X		X	X
Trichocerca pusilla (Lauterborn, 1898)	NP	X	X	X	X
Trichocerca rousseleti (Voigt, 1901)	NP		X		
Trichocerca similis (Wierzejski, 1893)	Pl	X	X	X	X
Trichocerca stylata (Gosse, 1851)	NP	X		X	
Trichocerca tigris (O.F.M., 1786)	NP			X	
Trichocerca sp1.	Pl/NP	X		X	X
Trichocerca sp2.	Pl/NP		X	X	X
ORDEM BDELLOIDEA	NP	X	X	X	X
CLADOCERA					
CHYDORIDAE					
Acroperus sp.	NP				X
Alona cambouei Guerne and Richard, 1893	NP			X	
Alona guttata Sars, 1862	NP			X	
Alona poppei Richard, 1897	NP			X	X
Alona sp.	NP			X	X
Alonella dadayi Birge, 1910	NP		X	X	X
Alonella sp1.	NP		X	X	
Alonella sp2.	NP				X
Disparalona hamata (Birge, 1879)	NP				
Pleuroxus sp.	NP			X	
BOSMINIDAE					
Bosmina hagmanni Stingelin, 1904	Pl	X		X	X
Bosmina longirostris (O.F. Mueller, 1785)	Pl	X	X	X	X
Bosminopsis deitersi Richard, 1834	Pl	X	X	X	X
DAPHNIDAE					
Ceriodaphnia cornuta (Sars, 1886)	Pl	X			X
ILYOCRYPTIDAE					
Ilyocryptus spinifer (Herrich, 1884)	NP			X	X
MACROTHRICIDAE					

Pl = planktonic, NP = not planktonic, NDT = non determined.

Table 1. Continued...

Group	Habitat	Environments and habitats			
		Island lakes		Main channel	
		Ilha Grande	Pimental	Rapids	Flow restricted waters
Macrothrix spinosa King, 1853	NP			X	
Macrothrix superculeata Baird, 1843	NP	X		X	X
Macrothrix sp1.	NP				
Macrothrix sp2.	NP				X
MOINIDAE					
Moina minuta Hansen, 1899	Pl	X			X
COPEPODA					
Copepodito	Pl	X	X	X	X
Náuplio	Pl	X	X	X	X
CALANOIDA					
DIAPTOMIDAE					
Argyrodiaptomus sp.	Pl	X		X	
Notodiaptomus sp1.	Pl	X	X	X	X
Notodiaptomus sp2.	Pl		X	X	X
CYCLOPOIDA					
CYCLOPIDAE					
Thermocyclops sp1.	Pl	X			
Thermocyclops sp2.	Pl			X	
OTHER GROUPS					
PROTOZOA					
CENTROPYXIDAE					
Centropyxis spp.			X	X	X
EUGLYPHIDAE					
Euglypha spp.		X	X	X	X
VORTICELLIDAE					
Vorticella spp.		X	X	X	X
OSTRACODA			X	X	X
GASTROTRICHA					
Família Chaetonotidae		X			
INSECTA					
Acaro		X	X	X	X
Chaoboridae Famíly (larvae)		X	X	X	X
Chironomidae Famíly (larvae)			X	X	X
Odonata		X	X	X	X
UNIONICOLIDAE					
Unionicola spp.			X	X	

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tridentata Smirnov, 1931; *Lecane murrayi* (Hauer, 1965), and *Ilyocryptus spinifer* (Herrich, 1884) all occurred exclusively in the main channel, whereas *Brachionus mirabilis* (Daday, 1897), *Gastropus stylifer* Imhof, 1891; *Trichocerca rousseleti* (Voigt, 1901), and *Macrothrix superculeata* Baird, 1843 were found only in the lakes.

4. Discussion

The rotifers were the most diverse group of zooplankton recorded in the present study on the middle Xingu River in the southeastern Amazon basin, with approximately 80% of the organisms found in each study environment. A similar pattern has been recorded in the aquatic systems of

Table 2. Number of genera and taxa within zooplankton groups for the midd Xingu river habitats.

Group	Genera	Taxa
ROTIFERA	38	141
Monogononta	38	141
Bdelloidea	-	1
CLADOCERA	11	20
COPEPODA	3	5
Cyclopoida	1	2
Calanoida	2	3
Total	52	166

white- (77%) and black-water (40%) rivers in the Amazon basin (Table 3), as well as other systems (see Green, 1972; Dumont, 1983; Neves et al., 2003; Paggi and José de Paggi, 1990; Sampaio and López, 2000).

The distinct composition of the zooplankton found in the two lakes studied here reflect their different limnological characteristics, such as the much larger surface area of the Ilha Grande lake in comparison with Pimentel, which in turn is subject to a considerable input of organic matter from the surrounding forest, which also shelters the lake from the sun. Pimentel lake is also connected more extensively to the main river, with the water being

Table 3. Taxonomic richness for the zooplankton of different Amazon environments.

Environment	Water category	Rotifera	Cladocera	Copepoda	Main source
Amazon-Solimões system	Whites	110		17	Robertson and Hardy (1984)
Calado Lake	Whites		8		Robertson and Hardy (1984)
Camaleão Lake	Whites	175			Koste et al. (1984)
Castanho Lake	Whites		16		Robertson and Hardy (1984)
Jacaretinga Lake	Whites		12		Robertson and Hardy (1984)
Redondo Lake	Whites		5		Robertson and Hardy (1984)
Manacuri Lake	Whites		16		Robertson and Hardy (1984)
Branco river	Whites	11	1		Robertson and Hardy (1984)
Madeira river	Whites	60		7	Robertson and Hardy (1984)
Maracá-Roraima Island	Whites	159			Koste and Robertson (1990)
Cuiabá river marginal lakes	Whites	79	30	6	Neves et al. (2003)
Acre river Amapá lake, Pirapora lake	Whites	38	6	2	Keppeler (2003)
Amapá lake	Whites	30	5	3	Keppeler and Hardy (2004)
Negro river	Blacks	50	7	18	Robertson and Hardy (1984)
Cristalino lake	Blacks		6		Robertson and Hardy (1984)
Tarumã-Mirim lake	Blacks		12		Robertson and Hardy (1984)
Guedes lake	Blacks		7		Robertson and Hardy (1984)
Caju lake	Blacks		5		Robertson and Hardy (1984)
Prato lake	Blacks		3		Robertson and Hardy (1984)
Utinga-Pará system Bolonha lake	Blacks	30	19	7	Melo et al. (2006)
Tapajós river	Clears	127		8	Robertson and Hardy (1984)
Paroni lake	Clears	76			Koste (1974a)
Tocantins river	Clears	21	5-7	14	Robertson and Hardy (1984)
Tauá lake	Clears	6			Robertson and Hardy (1984)
Paulo pool	Clears	3			Robertson and Hardy (1984)
Lower Nhamundá river	Clears	145			Brandorff et al. (1982)
Trombetas river Macaco lake	Clears	48			Koste (1989)
Batata lake (impacted by bauxite waste)	Clears	98	10	7	Bozelli et al. (2000)
Xingu river (lentic waters / rapids)	Clears	55-87	10-16	1-2	**This study**
Ilha Grande lake	Clears	56	6	3	**This study**
Pimental kake	Clears	97	5	4	**This study**

filtered by the surrounding forest before draining into the lake (Estupiñan and Camargo, 2008). The considerable phytoplankton biomass and high primary productivity recorded in Ilha Grande lake (Costa et al., 2008) may have determined the low zooplankton richness recorded in this lake. The higher zooplankton diversity recorded in Pimentel lake appears to have been related to specific characteristics of this environment, such as the low current velocity, given that reproductive populations of planktonic organisms are restricted to the slow-flowing lower reaches of these areas (Ward, 1994).

Acknowledgements

The present study was supported by the project "A trophic model for the management of the middle Xingu River", financed by ANEL. The authors wish to thank the anonymous reviewers for comments on an earlier version of this paper.

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