

**ZOOPLANKTON COMMUNITY COMPOSITION  
IN FLOODPLAIN LAKES OF CAURA RIVER, VENEZUELA**

YINETT M. REVEROL<sup>1,2</sup>, JOSÉ G. DELGADO<sup>3</sup>, CARLOS L. LÓPEZ<sup>4</sup>,  
AND LUZMILA SÁNCHEZ<sup>1</sup>

<sup>1</sup>*Departamento de Limnología, Fundación La Salle de Ciencias Naturales,  
Estación de Investigaciones Hidrobiológicas de Guayana “Dr. Enrique Vásquez  
León”. Apartado 51, San Félix, Estado Bolívar, Venezuela  
yreverol@hotmail.com, Fax: (58) (0286) 9311045*

<sup>2</sup>*Dirección Actual: Instituto para el Control y Conservación  
de la Cuenca del Lago de Maracaibo (ICLAM), División de Hidrobiología,  
Km 1, Carretera Vía Perijá, Sector Plaza Las Banderas,  
Maracaibo, Estado Zulia, Venezuela  
yreverol@hotmail.com*

<sup>3</sup>*Laboratorio de Evaluación de Recursos Pesqueros,  
Estación Local El Lago,  
Instituto Nacional de Investigaciones Agrícolas (INIA),  
Maracaibo, Estado Zulia, Venezuela  
jdelgado@inia.gob.ve, Telefax: (58) (261) 7642324*

<sup>4</sup>*Laboratorio de Zooplancton, Departamento de Biología,  
Facultad Experimental de Ciencias, Universidad del Zulia,  
Maracaibo, Estado Zulia, Venezuela*

*Abstract.* Four floodplain lakes (Chuapo, Naparaico, Brava and Aricagua) on the lower basin of the Caura River, Venezuela were analyzed regarding composition of the zooplankton. Samples were collected monthly from March 1998 to February 2000. At each site, composite water samples were filtered through a 60- $\mu$ m mesh plankton net, fixed in 10% formalin solution and preserved in 70% ethanol. Copepods were separated into adults and nauplii. A total of 101 species (68 rotifers and 33 cladocerans) were identified. The most abundant rotifer species were *Brachionus zanhiseri* var. *gessneri*, *B. zanhiseri* f. *reductus* and *Keratella americana*. *Bosminopsis deitersi* was the most dominant species among cladocerans. Nauplii and calanoids were the most abundant copepods. Mean abundance per lake was: Aricagua (390,18 org/L), Brava (261,03 org/L), Naparaico (193,21 org/L) and Chuapo (170,00 org/L). Total zooplankton abundance showed a strong seasonal trend in the floodplain lakes, increasing during low waters (dry season) and declining in rising waters (rainy season). We

observed a succession of frequent dominant species, instead of one dominant species. *Received: 29 March 2007, accepted: 17 March 2008.*

*Key words.* Zooplankton, Caura River, abundance, composition, floodplain lakes, Venezuela.

#### COMPOSICIÓN DE LA COMUNIDAD DEL ZOOPLANCTON EN LAGUNAS DE INUNDACIÓN DEL RÍO CAURA, VENEZUELA

*Resumen.* En este trabajo se analizó la composición del zooplancton en cuatro lagunas de inundación (Chuapo, Naparaico, Brava y Aricagua) de la cuenca baja del Río Caura, Venezuela. Las muestras se recolectaron mensualmente entre marzo de 1998 y febrero de 2000. En cada laguna se filtraron muestras de agua superficiales a través de una malla de 60  $\mu\text{m}$ , los organismos se fijaron en una solución de formalina al 10% y se preservaron en etanol al 70%. Los copépodos se separaron en nauplios y adultos. Se identificaron un total de 101 especies (68 de rotíferos y 33 de cladóceros). Los rotíferos más abundantes fueron *Brachionus zanhiseri* var. *gessneri*, *B. zanhiseri* f. *reductus* y *Keratella americana*. *Bosminopsis deitersi* fue la especie más dominante entre los cladóceros. Los nauplios y los calanoides fueron los copépodos más abundantes. La abundancia promedio por laguna fue: Aricagua (390,18 org/l), Brava (261,03 org/l), Naparaico (193,21 org/l) y Chuapo (170,00 org/l). La abundancia total del zooplancton mostró una marcada tendencia estacional en las lagunas de inundación, incrementándose durante los niveles bajos de agua (período de sequía) y disminuyendo cuando el nivel del agua se eleva (período lluviosa). Se observó una sucesión estacional de especies dominantes, en vez de una especie dominante de forma permanente. *Recibido: 29 marzo 2007, aceptado: 17 marzo 2008.*

*Palabras clave.* Zooplankton, Río Caura, abundancia, composición, laguna de inundación, Venezuela.

#### INTRODUCTION

In recent decades, several studies have been carried out in Venezuela on the taxonomy and abundance of zooplankton communities in various water bodies (Vásquez 1984a, b, Vásquez and Sánchez 1984, Zoopi de Roa *et al.* 1985, Médina and Vásquez 1988, Vásquez and Rey 1989, Vásquez and Rey 1992, Vásquez *et al.* 1998, Saunders and Lewis 1988a, b 1989, Hamilton *et al.* 1990, Reverol 2006). However, despite the importance of zooplankton in food web dynamics, few studies have addressed freshwater zooplankton dynamics in floodplains of Venezuelan rivers, especially in the extensive flooded areas of the Orinoco River Basin.

Floodplain lakes are strongly influenced by periodic fluctuations in water level. During periods of low water, these lakes function as lentic systems and are mostly isolated from the main river channel. During the rainy season, interaction with the river is at its maximum, and floodplain lakes act as lotic environments (Castillo 2000).

Several investigations conducted in floodplain lakes have shown that flood cycles are accompanied by fluctuations in physical, chemical and biological characteristics, including depth, turbulence, turbidity, oxygen level, nutrients, organic carbon concentration and biological production (Hamilton and Lewis 1987, Junk and Weber 1985, Castillo 2000). Zooplankton community structure, then, depends on several factors including morphometric and regional climatic conditions, which, in turn, govern important physical characteristics of water bodies, generally depending on the edaphic features and type of vegetation cover present (Sioli 1984, Hardy *et al.* 1984, Reverol 2006). The objective of the present work is to study the zooplankton community in four floodplain lakes of the Caura River, by analyzing the composition of the community during a two-year period.

#### STUDY AREA

The study site was located in the Caura River Basin, one of the last major tropical watersheds still in virtually pristine conditions. The Caura River Basin is located in Bolívar State, southern Venezuela ( $3^{\circ}37'$  and  $7^{\circ}47'$  Lat. N and  $63^{\circ}23'$  y  $65^{\circ}35'$  Lat. W). The total surface drained by the basin is  $45,330 \text{ km}^2$  and resembles a trapezoid rectangle that stretches approximately 415 km from northwest to southeast and 130 km from east to west (Peña 1996, Reverol 2006). The Caura River is the second most important tributary on the right margin of the Orinoco River and discharges on average  $3,500 \text{ m}^3$  of water per second. According to Peña (1986) and Reverol (2006), maximum river discharge is between July and August and the minimum in February and March. The yearly water level pattern is unimodal (Peña 1996, Reverol 2006). The Caura River has been classified as a black water river by Sioli (1984), but not all of its characteristics fit this classification clearly. For example, dissolved organic carbon concentrations are very low, while pH and principal cation concentrations are high for a typical black water river.

The study examined the following floodplain lakes located in the lower Caura River basin: Chuapo ( $7^{\circ}03'30''$  N,  $65^{\circ}01'40''$  W), Naparaico ( $7^{\circ}31'28''$  N,  $65^{\circ}13'53''$  W), Brava ( $7^{\circ}33'05''$  N,  $65^{\circ}12'43''$  W) and Aricagua ( $7^{\circ}34'05''$

N, 65°09'04" W) (Fig. 1). Depth and area of the lakes vary throughout the year depending on the level of the Caura River. The lakes are surrounded by forest, and no floating meadows of macrophytes have been observed.

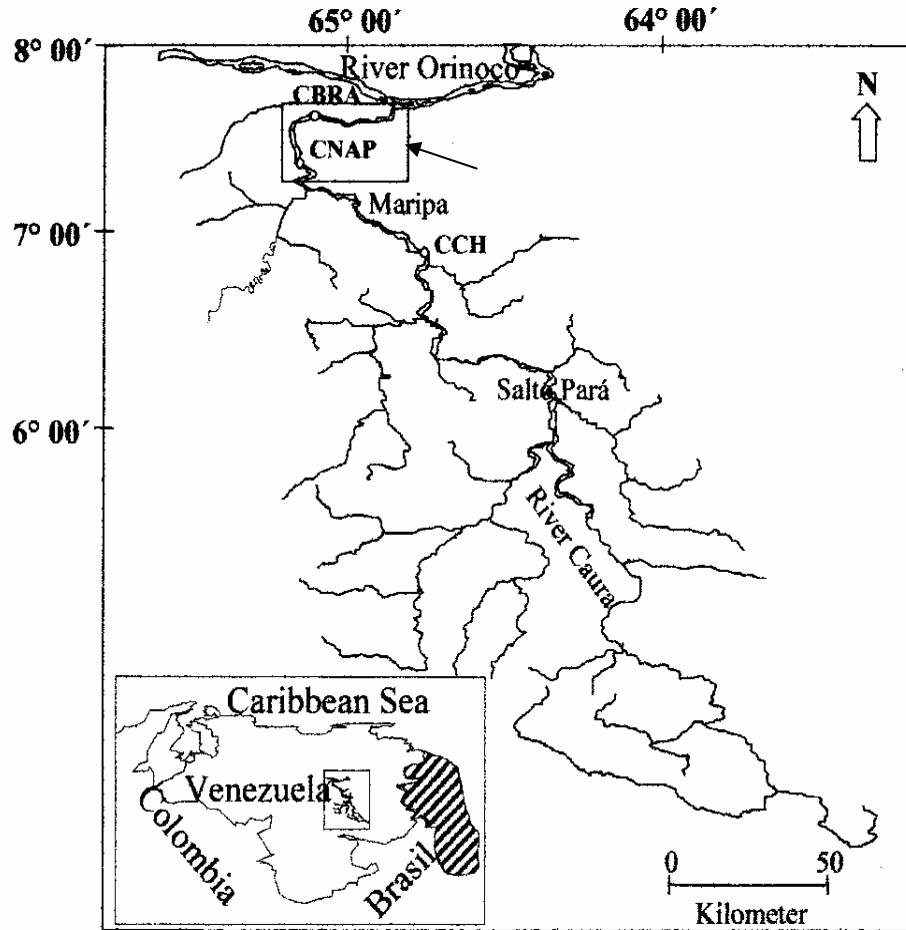


Figure 1a. The lower Caura River Basin and its floodplain, in Bolivar State, southeastern Venezuela.

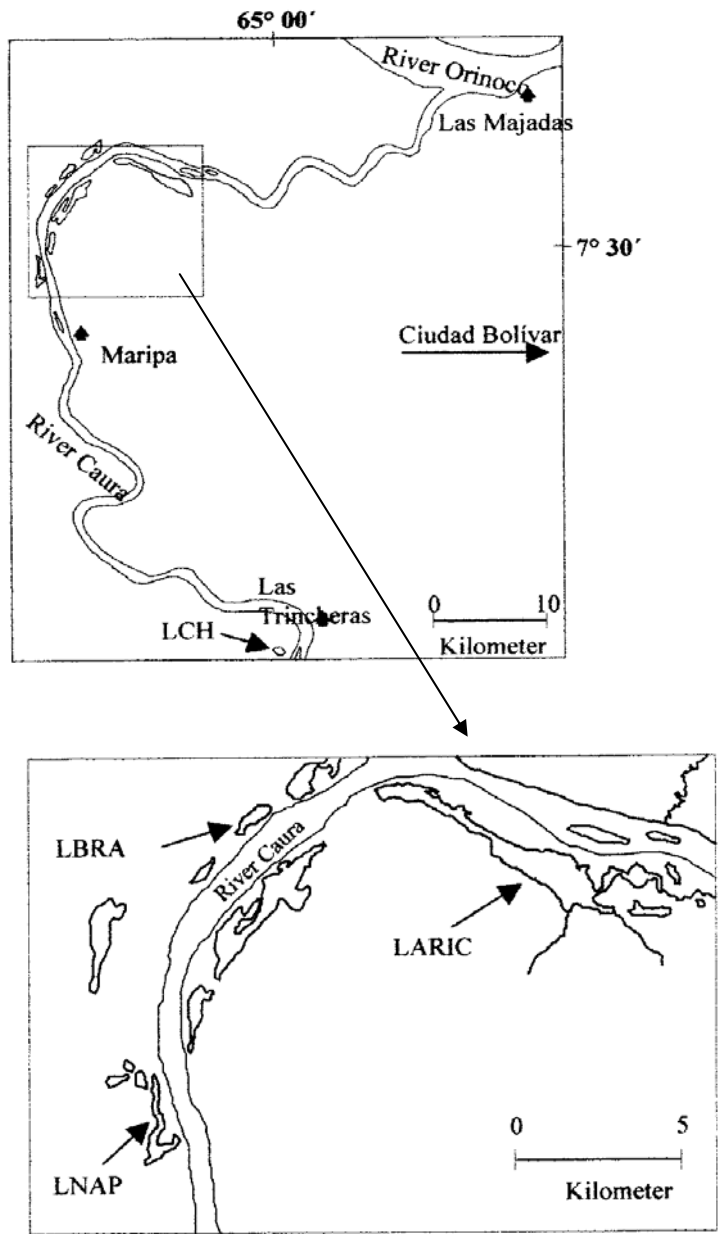


Figure 1b. The lower Caura River, showing Chuapo Lake (LCH), Brava Lake (LBRA), Naparaico Lake (LNAP), and Aricagua Lake (LARIC).

## MATERIALS AND METHODS

We sampled zooplankton monthly in each lake, from March 1998 to February 2000, during periods of low, rising, high and falling waters. Superficial water samples (~30-40 L) were taken in the pelagic zone and filtered with a 60  $\mu\text{m}$  mesh plankton net. Organisms were preserved in 10% formalin solution and 70% ethanol solution. Rose Bengal was added to facilitate separation of organisms from suspended matter. In general, organisms were identified to the lowest possible taxonomic level (genus or species), using an optical and stereoscopic microscope and specialized bibliography (Koste 1984, Pennak 1953, Rey and Saint-Jean 1968, 1969, Zoppi *et al.* 1985, Rey and Vásquez 1986a, b, Smirnov 1992, 1996, Korovchinky 1992, Vásquez *et al.* 1998). Nauplios and adult copepods were identified as calanoids, ciclopooids or harpacticoids only. Rotifers were counted in a Sedgewick-Rafter cell, whereas cladocerans and copepods were counted in Petri capsules, using 1 mL sub-samples. Samples were taken in the pelagic zone.

While collecting zooplankton, the following water measurements were made: depth, transparency, temperature, dissolved oxygen, pH, conductivity, turbidity and suspended solids. Temperature and dissolved oxygen were determined with a YSI 51B meter, pH with a Orion 210A meter, conductivity using a Lamotte Chemical DA-1 meter, and water transparency with a Secchi disc. Suspended solids were calculated as the difference between total and dissolved solids, and turbidity was determined by the Nephelometric method using a Hellige Turbidimeter. Geographic coordinates were noted using a GPS Magellan 5000 Professional.

To correlate zooplankton abundance with physical and chemical variables of the different stations, data were  $\log(x+1)$  transformed to obtain normality. Normality was verified by the Kolmogorov-Smirnov test (Steel and Torrie 1988). A correlation analysis was made to relate total zooplankton abundance with physical and chemical variables ( $P = 0.05$ ).

## RESULTS

Water temperature was similar among the four lakes. The pH values (5.70-7.11) were relatively acid. Water transparency was highest in the rainy season. Dissolved oxygen concentrations were high in all four lakes. Conductivity, alkalinity and turbidity were high in the dry season. Suspended solids were high in falling and low water, perhaps due to the sediment removed and plankton growth (Table 1).

Table 1. Values of physical and chemical variables in each floodplain lake.

Parameter	Lake Chuapo	Lake Naparaico	Lake Brava	Lake Aricagua	Mean
T (°C)	25.0 - 35.0	26.0 - 32.0	26.0 - 32.0	26.0 - 32.0	28.9
Z (m)	0.3 - 5.4	0.4 - 11.0	1.2 - 8.3	0.4 - 13.0	3.6
ZSD (m)	0.1- 1.8	0.3 - 1.4	0.4 - 1.6	0.2 -3.2	0.9
DO (mg/l)	2.2 - 7.80	1.8 - 7.8	2.2 -7.9	3.6 -9.0	5.4
SS (mg/l)	1.2 - 133.6	2.0 - 7.0	2.2 - 31.8	0.4 - 100.6	18.2
pH	5.8 - 7.1	5.7 - 6.5	5.7 - 6.7	5.8 - 6.9	6.3
Cond. (µS/cm <sup>-1</sup> )	5.0 - 27	0.6 - 20	4.1 - 14.0	6.0 -14.0	10.9
Alc. (mg/l)	1.1 - 6.0	1.0 - 6.0	1.0 - 4.0	1.4 - 4.2	2.9
Tur. (mg/l)	2.0 - 55	2.0 - 29.0	0.5 - 32.0	1.5 - 48.0	8.8

Z = depth, ZSD = transparency, Cond. = conductivity, T = temperature, DO = dissolved oxygen, Alc. = Alkalinity, Tur. = turbidity, and SS = suspended solids.

In the four lakes, 101 zooplankton taxa were recorded and consisted of 68 rotifer taxa and 33 cladoceran taxa (Table 2). Most frequent rotifer genera were *Lecane*, *Brachionus*, *Keratella*, *Filinia*, *Testudinella* and *Trichocerca*, and for cladocerans: *Bosminopsis*, *Moina*, *Diaphanosoma* and *Ceriodaphnia*. Among adult copepods, the calanoides and cyclopoides were most frequent.

*Brachionus mirus*, *Brachionus caudatus*, *Brachionus falcatus*, and *Filinia* sp. were the most frequent rotifers in Lake Chuapo, whereas *Brachionus zanhiseri* var. *gessneri*, *Brachionus zanhiseri* f. *reductus*, and *Lecane elsa* were most frequent in Lake Naparaico. In Brava and Aricagua lakes, the most frequent rotifers were *B. zanhiseri* var. *gessneri*, *B. zanhiseri* f. *reductus*, and *Keratella americana*. Among cladocerans, *Bosminopsis deitersi* was the most abundant species in the four lakes (Table 3). The nauplius was the most frequent copepod group in each floodplain lake.

Total zooplankton abundance showed a strong seasonal trend in the floodplain lakes, increasing during low water and declining in rising waters (Fig. 2). Rotifers were the most abundant group (56.17%), followed by copepods (33.58%) and cladocerans (10.23%). Lake Aricagua had the greatest total abundance (390.18 org/L), followed by Lake Brava (261.03 org/L), Lake Naparaico (193.21 org/L), and Lake Chuapo (170 org/L). Total zooplankton abundance presented significant correlations with both physical and chemical variables (Table 4).

Table 2. List of taxa registered in the Caura River floodplain lakes, Bolivar State, southeastern Venezuela.

Taxon	Lake Chuapo	Lake Naparaico	Lake Brava	Lake Aricagua
ROTIFERA				
<i>Anaueropsis</i> sp.			x	
<i>Asplachna sieboli</i> (Leydig)	x			
<i>Beauchampiella eudactylota</i> (Gosse)	x	x	x	
<i>Brachionus zanhiseri</i> var. <i>gessneri</i> Hauer	x	x	x	x
<i>B. zanhiseri</i> f. <i>reductus</i> Hauer	x	x	x	x
<i>B. patulus</i> (O. F. Muller)				x
<i>B. variabilis</i> Hempel				x
<i>Brachionus</i> sp.		x		x
<i>B. gillardi</i> Hauer		x	x	
<i>B. mirus</i> Daday	x	x	x	x
<i>B. caudatus</i> Barrois y Daday	x	x		x
<i>B. quadridentatus mirabilis</i> (Daday)	x	x	x	x
<i>B. falcatus</i> Zacharias	x	x	x	x
<i>Cephalodella</i> sp1	x	x	x	x
<i>Conochilus</i> sp.	x	x	x	x
<i>Dipleuchnis</i> sp.		x		
<i>Dipleuchlanis propatula</i> (Gosse)		x		
<i>Euchlanis lyra</i> Ehrb		x		
<i>Euchlanis</i> sp.	x		x	x
<i>Epiphanes</i> sp.		x		x
<i>Filinia longiseta</i> (Ehrb)	x	x	x	x
<i>F. terminalis</i> (Plate)		x	x	x
<i>F. pejleri</i> Hutchinson			x	x
<i>Hexarthra intermedia</i> Wiszniewski		x	x	x
<i>Hexarthra</i> sp.	x			x
<i>Keratella americana</i> Carlin	x	x	x	x
<i>K. colchearis</i> (Gosse)			x	x
<i>K. lenzi</i> Hauer	x	x	x	x
<i>Lecane proiecta</i> Hauer	x	x	x	x

Table 2. Cont.

Taxon	Lake Chuapo	Lake Naparaico	Lake Brava	Lake Aricagua
<i>Lecane elsa</i> Hauer	x	x	x	x
<i>L. luna</i> (O. F. Muller)	x	x	x	x
<i>L. pertica</i> Harring & Myers			x	
<i>L. kutikova</i> Koste	x		x	x
<i>L. leontina</i> (Turner)	x	x	x	x
<i>L. levistyla</i> (Olofsson)		x		
<i>L. ludwigi</i> (Ekstein)		x	x	x
<i>L. nana</i> (Murrayi)				x
<i>L.(M) murrayi</i> (Hauer)			x	
<i>L (M) furcata</i> (Murrayi)		x		
<i>L (M) cornuta</i> (O. F. Muller)	x	x	x	x
<i>L (M) lunaris</i> (Ehrb)		x		
<i>L (M) quadridentata</i> (Ehrb)	x	x	x	x
<i>L (M) bulla</i> (Gosse)	x	x	x	x
<i>L (M) monostyla</i> (Daday)	x	x	x	x
<i>Lepadella latusinus</i> (Hilgendorf)		x		
<i>L. ovalis</i> (O. F. Muller)	x	x	x	x
<i>L. patella</i> (O. F. Muller)	x	x	x	x
<i>Macrochaetus</i> sp			x	
<i>Microdides</i> sp			x	
<i>Mytilina mucronata</i> (O. F. Muller)		x		x
<i>M. macrocera</i> (Jennings)	x	x	x	x
<i>M. ventralis f.r. macracantha</i> (Gosse)		x	.	x
<i>Notholca</i> sp	x	x		x
<i>Polyarthra</i> sp.	x	x	x	x
<i>Platyas quadricornis quadricornis</i> (Ehrb)	x	x	x	x
<i>P. quadricornis brevispinus</i> (Daday)	x	x	x	x
<i>Pleosoma</i> sp.		x	x	
<i>Rotífero</i> sp.1			x	
<i>Testudinella patina dendradena</i> (De Beauchamp)	x	x	x	x

Table 2. Cont.

Taxon	Lake Chuapo	Lake Naparaico	Lake Brava	Lake Aricagua
<i>Testudinella mucronata hauerensi</i> (Gillard)	x	x		
<i>T. tridentata amazonica</i> Thomasson		x	x	x
<i>T. ohlei</i> Koste	x	x	x	x
<i>Trichotria tetractis tetractis</i> (Ehrb)	x	x	x	x
<i>Trichocerca</i> sp.	x		x	x
<i>Trichocerca chattoni</i> De Beauchamp		x		
<i>Trichocerca cylíndrica</i> (Imhof)	x		x	
<i>Synchaeta</i> spp.	x	x	x	x
<i>Trochophaera</i> spp.		x	x	x
CLADOCERA				
<i>Alona</i> sp. 1	x	x	x	x
<i>Alona</i> sp. 2	x		x	x
<i>Alona</i> sp. 3	x	x	x	x
<i>Alona gutata</i> Sars	x		x	
<i>Alonella excisa</i> Fischer	x			
<i>Biapertura intermedia</i> (Sars)	x			x
<i>Bosminopsis brandorfi</i> Rey y Vásquez				
<i>Bosminopsis macaguensi</i> Rey y Vásquez	x	x		x
<i>Bosminopsis deitersi</i> Richard	x	x	x	x
<i>Bosmina</i> sp. 2	x	x	x	x
<i>Ceriodaphnia cornuta</i> Sars	x	x	x	
<i>Ceriodaphnia rigaudi</i>		x	x	x
<i>Chydorus euryotus</i> Sars	x	x		x
<i>Disparalona dadayi</i> (Birge)	x	x	x	x
<i>Dunhevedia</i> sp.		x		
<i>Dadaya</i> sp.	x			
<i>Daphnia gessneri</i> Herbst	x			x
<i>Diaphanosoma breviremi</i> Sars			x	x
<i>D. spinulosum</i> Herbst	x		x	x

Table 2. Cont.

Taxon	Lake Chuapo	Lake Naparaico	Lake Brava	Lake Aricagua
<i>D. brachyurum</i> Lievin		x		x
<i>Ephemeroporus tridentatus</i> (Bergamin)	x		x	
<i>Graptoleberis testudinaria</i> (Fisher)		x	x	
<i>Ilyocryptus spinifer</i> Herrick			x	
<i>Kurzia</i> sp.	x	x	x	
<i>Macrothrix</i> spp.				x
<i>Moina minuta</i> Hansen	x	x	x	x
<i>Moina</i> sp.	x		x	
<i>Moina reticulata</i> (Daday)	x	x	x	
<i>Moinodaphnia macleayi</i> (King)	x	x		x
<i>Oxiurella</i> spp.	x			
<i>Scapholeberis kingi</i> Sars	x			x
<i>Streblocerus</i> sp.	x	x		
<i>Cladocero</i> sp.	x			

Table 3. Most abundant zooplankton species in the hydrological phases of Caura River floodplain lakes.

Low Waters	Rising Waters	High Waters	Falling Waters
<i>Brachionus mirus</i> <i>B. caudatus</i> <i>Alona</i> sp.	<i>Bosminopsis deitersi</i>	LAKE CHUAPO <i>Bosminopsis deitersi</i>	<i>Brachionus falcatus</i> <i>Filinia</i> sp. <i>Moina</i> sp. Calanoids, Nauplii
<i>Brachionus zanhiseri</i> var. <i>gessneri</i> <i>Lecane elsa</i> <i>Trichocerca</i> sp.	<i>Brachionus zanhiseri</i> f. <i>reductus</i> <i>Brachionus zanhiseri</i> var. <i>gessneri</i> <i>Filinia</i> sp.	LAKE NAPARAICO <i>Filinia</i> sp. Nauplii	<i>Bosminopsis deitersi</i> <i>Brachionus zanhiseri</i> var. <i>gessneri</i>
<i>Keratella americana</i> <i>Bosminopsis deitersi</i>	<i>Brachionus zanhiseri</i> f. <i>reductus</i> <i>Brachionus zanhiseri</i> var. <i>gessneri</i> <i>Bosminopsis deitersi</i>	LAKE BRAVA <i>Bosminopsis deitersi</i>	<i>Brachionus zanhiseri</i> f. <i>reductus</i> <i>Brachionus zanhiseri</i> var. <i>gessneri</i> <i>Keratella americana</i>
<i>Brachionus falcatus</i> <i>Keratella americana</i>	<i>Bosmina</i> sp. <i>Moina minuta</i> Nauplii	LAKE ARICAGUA Calanoid copepods	<i>Brachionus zanhiseri</i> f. <i>reductus</i> var. <i>gessneri</i> <i>Brachionus caudatus</i> Nauplii

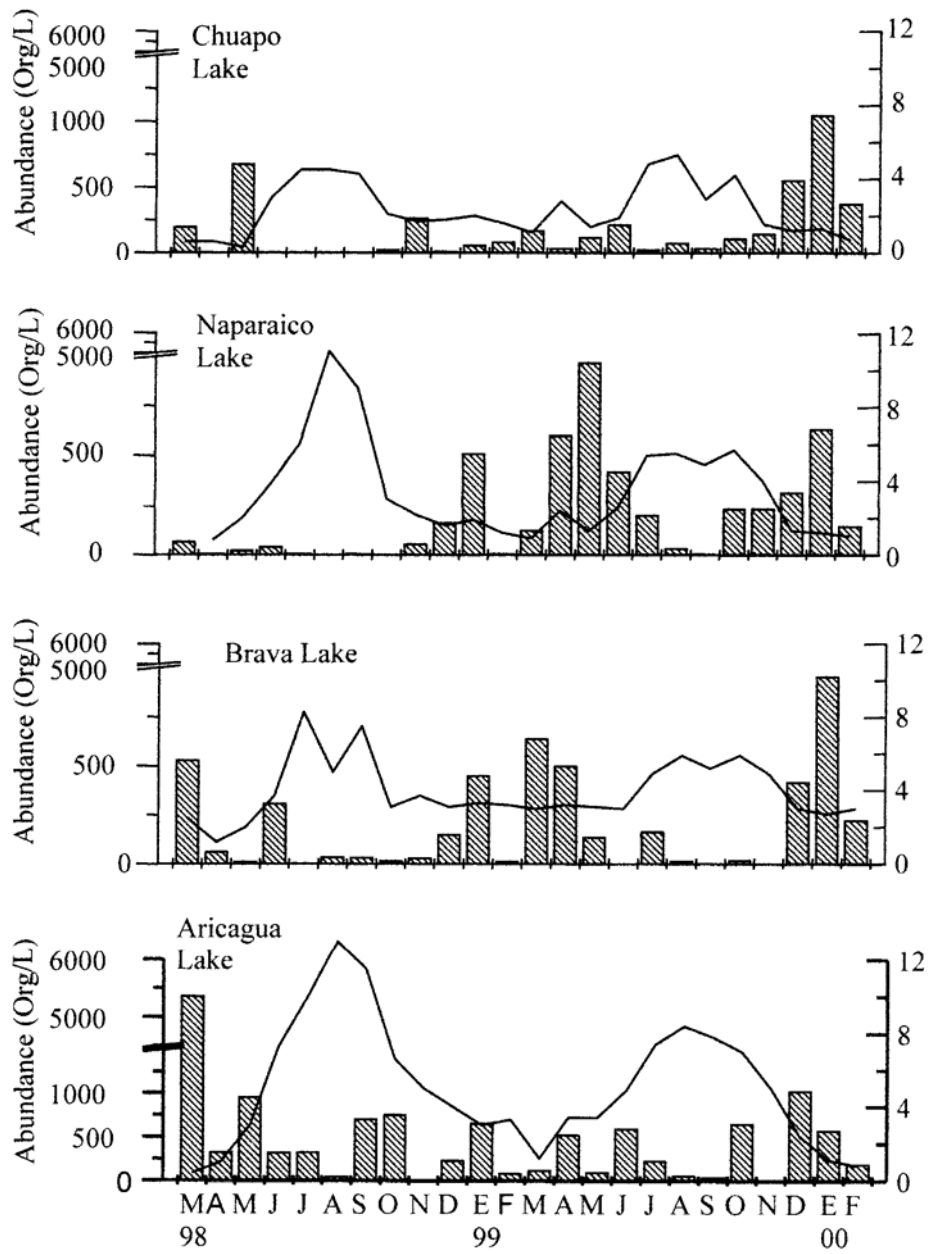


Figure 2. Temporal abundance patterns of total zooplankton in floodplain lakes of the lower Caura River Basin. The line indicates water depth of the lakes.

Table 4. Correlations of total zooplankton abundance with physical and chemical variables of the floodplain lakes ( $P < 0,05$ ).

Lake		Z (m)	ZSD (m)	pH	Cond. ( $\mu\text{Scm}/1$ )	T ( $^{\circ}\text{C}$ )	DO (mg/l)	Alc. (mg/l)	Tur. (mg/l)
Chuapo	<i>r</i>	-0,47		0,50		0,43	0,51		
	<i>P</i>	0,03	ns	0,01	ns	0,04	0,02	ns	ns
Brava	<i>r</i>		-0,48	0,50	-0,61		0,60	-0,41	
	<i>P</i>	ns	0,02	0,02	0,002	ns	0,002	0,046	ns
Aricagua	<i>r</i>			-0,56					0,71
	<i>P</i>	ns	ns	0,01	ns	ns	ns	ns	0,000
Naparaico		ns	ns	ns	ns	ns	ns	ns	Ns

Z = depth, ZSD = transparency; Cond. = conductivity, T = temperature, DO = dissolved oxygen, Alc. = alkalinity, Tur. = turbidity, and ns = not significant.

## DISCUSSION

The lakes analyzed in this study are bottom systems, with widely fluctuating water levels and acid pH. Dissolved oxygen concentration is high, indicating a well-oxygenated environment, without organic pollution or excessive organic matter decomposition.

Rotifers showed the greatest taxonomic richness in the four lakes, and similar results were obtained by Vásquez (1984a, b), Vásquez and Sánchez (1984), Robertson and Hardy (1984), Twombly and Lewis (1987), Paggi and De Paggi (1990), Sampaio and López (2000), Reverol (2006), and Neves *et al.* (2003). This pattern is common in tropical freshwater, whether in floodplain lakes, ponds, reservoirs, rivers, or streams.

*Brachionus* was the most frequent rotifer genus in the four lakes, and presented important peaks of abundance. However, some authors have reported a low presence of this genus in water bodies with low pH, nutrient concentrations and quantities of electrolytes (Vásquez 1984a), whereas others have mentioned a high presence, represented by species associations such as *B. zanhiseri* var. *gessneri*, *B. zanhiseri* f. *reductus* and *Keratella americana* (Sioli 1984, Vásquez 1989, Bozelli 1994).

Rotifers were the most abundant organisms recorded. The numerical dominance of this group in the zooplankton community in the majority of water bodies has been attributed to these organisms being r-strategists, or opportunists, of small size, with short life cycles and wide tolerance to a

variety of environmental factors (Robertson and Hardy 1984, Neves *et al.* 2003).

Among the cladocerans, the Chydoridae were the most representative, with the greatest number of species. Planktonic genera were the most abundant in the four lakes. However, in high water season, littoral genera such as *Alona*, *Allonella*, *Chydorus*, *Ephemeroporus* and *Iliocryptus* were observed, possibly due to the crawled vegetation and sediment removed during inundation. The majority of works on cladoceran communities are restricted to reports of planktonic genera. According to Dumont (1994), a factor which may determine this tendency is the application of inadequate sampling techniques.

In copepod populations, numerical predominance of young forms, especially nauplii, is the most common pattern, as observed by Paggi and de Paggi (1990), Vásquez and Rey (1992), Lima (1996), Nunes *et al.* (1996), Sampaio and Lopez (2000), Reverol (2006), and Neves *et al.* (2003) in different freshwater habitats, as well as in the present study. Among the factors which may determine the proportion of young to adult forms are predation intensity and the balance between predation by invertebrates and vertebrates (Dumont *et al.* 1994). According to Neves *et al.* (2003), the existence of young forms is of great importance for zooplankton community structure, with regard to population dynamics and also trophic aspects, since in early phases, organisms may occupy trophic niches different from those of adults.

Species richness of the four lakes is relatively high compared to tropical white water lakes (Twombly and Lewis 1987, Vásquez and Rey 1992), and low in comparison to black water lakes (Hardy *et al.* 1984, Neves *et al.* 2003). Table 5 compares species richness and abundance of zooplankton of the Caura floodplain lakes with some other tropical lakes. Neves *et al.* (2003) reported that rotifers and cladocerans presented the greatest species richness (71 rotifers and 29 cladocerans) and Hardy *et al.* (1984) determined that rotifers (175 species) predominated in Lake Camaleão, Brazil.

Total zooplankton abundance patterns of the Caura River lakes coincide with those reported by Carvalho (1983), Vásquez (1984b), Hardy *et al.* (1984), Saunders and Lewis (1988a, c 1989), Vásquez and Rey (1989, 1992), Paggi and de Paggi (1990), Astiz and Alvarez (1998), and Reverol (2006), for tropical environments, where rotifers are the most abundant group, followed

Table 5. Species richness and mean abundance of zooplankton from tropical floodplain lakes.

Lakes	Species Number			Abundance (org/L)			Author
	Rot	Cla	Cop	Rot	Cla	Cop	
Souza Lima (Brasil)	71	29	6	-	-	-	Neves <i>et al.</i> (2003)
Parque Atalai (Brasil)	60	9	6	-	-	-	Neves <i>et al.</i> (2003)
Camaleão (Brasil)	175	14	7	74.22	5.61	22.16	Hardy <i>et al.</i> (1984)
La Orsinera (Venezuela)	8	4	3	199.00	18.80	379.00	Twombly & Lewis (1987)
Playa Blanca (Venezuela)	4	4	-	331.10	12.20	104.80	Vásquez & Rey (1992)
La Orsinera (Venezuela)	10	5	-	215.10	5.60	119.20	Vásquez & Rey (1992)
Chuapo	38	25	-	85.88	24.93	59.77	This study
Naparaico	52	17	-	170.26	9.71	12.98	This study
Brava	48	18	-	148.61	50.05	62.36	This study
Aricagua	48	18	-	158.75	17.71	201.77	This study

Rot = rotifers, Cla = cladocerans, and Cop = copepods.

by copepod-nauplii and cladocerans. In this study, we observed a succession of frequent dominant species, instead of one dominant species. Similar results were observed by Hardy *et al.* (1984), Medina and Vásquez (1988), and Vásquez (1989), for tropical environments.

In conclusion, zooplankton communities of the Caura floodplain lakes are characterized by high species richness and abundance, and little anthropogenic stress. This study indicates the necessity for conserving the floodplain lakes of Caura River, which seem to contain a significant diversity of aquatic invertebrates.

#### ACKNOWLEDGMENTS

We thank Marlenis Villarroel, José Montoya, Jorge Medina and Malvis Calzadilla for help in the field and laboratory. We also thank Marilín Grillet for the excellent administration of the project. This study was funded by the Fundación La Salle de Ciencias Naturales and FUNDACITE-Guayana, Venezuela.

#### LITERATURE CITED

- ASTÍZ, S., AND H. ÁLVAREZ. 1998. El zooplancton en el alto y medio Río Orinoco, Venezuela. *Acta Científica Venezolana* 49: 5–18.
- BOZELLI, R. L. 1994. Zooplankton community density in relation to water level fluctuations and inorganic turbidity in an Amazonian Lake “Lago Batata”, State of Para, Brazil. *Amazoniana* 13: 17–32.
- CARVALHO, M. L. 1983. Efeitos da flutuacao do nível da água sobre a densidade e composicao do zooplancton em um lago de várzea da amazonia, Brasil. *Acta Amazonica* 13: 715–724.
- CASTILLO, M. M. 2000. Influence of hydrological seasonality on bacterioplankton in two neotropical floodplain lakes. *Hydrobiologia* 437: 57–69.
- DUMONT, H. J. 1994. On the diversity of Cladocera in the tropics. *In* H. J. Dumont, J. Green, H. Masudire (eds.), *Studies on the ecology of tropical zooplankton*. *Hydrobiologia* 272: 27–38.
- HAMILTON, S. K., S. J. SIPPEL, W. M. LEWIS, AND J. F. SAUNDERS. 1990. Zooplankton abundance and evidence for its reduction by macrophyte mats in two Orinoco floodplain lakes. *J. Plankton Research* 12: 345–363.
- HAMILTON, S. K., AND W. LEWIS. 1987. Causes of seasonality in the chemistry of a lake on the Orinoco River Floodplain, Venezuela. *Limnol. Oceanogr.* 32: 1277–1290.

- HARDY, E. R., B. ROBERTSON, AND W. KOSTE. 1984. About the relationship between the zooplankton and fluctuating water levels of Lago Camaleao, a Central Amazonian várzea lake. *Amazoniana* 9: 43–52.
- JUNK, W. J., AND G. E. WEBER. 1985. Amazonian floodplains: A limnological perspective. *Verh. Int. Ver. Limnol.* 26: 149–157.
- KOROVCHINSKY, N. M. 1992. Sididae and Holopediidae. Guides to the identification of the Macroinvertebrates of the Continental waters of the world. SPB Academic Publishin, The Netherlands, 83 pp.
- KOSTE, W. 1978. Rotatoria. Die Rädertier Mittleleuropas. Bestimmungswerk begründet von Max Voigt. Borntraeger, Stuttgart, 234 pp.
- LIMA, D. 1996. Community structure of the zooplankton and phytoplankton of Lake Recreio-Barão de Melgaço Pantanal, Mato Grosso. Masters Thesis, Federal University of São Carlos, São Carlos, 206 pp.
- MEDINA, M. L., AND E. VÁSQUEZ. 1988. Estudio de los rotíferos de una laguna de inundación de aguas negras del Bajo Caroní, Venezuela. *Mem. Soc. Cien. Nat. La Salle* 48: 105–119.
- NEVES, I. F., O. ROCHA, K. F. ROCHE, AND A. A. PINTO. 2003. Zooplankton community structure of the two marginal lakes of the River Cuiabá (Mato Grosso, Brazil) with analysis of Rotifera and Cladocera diversity. *Braz. J. Biol.* 63: 329–343.
- NUNES, M. A., F. A. LANSAC-TÔHA, C. C. BONECKER, M. C. ROBERTO, AND L. RODRÍGUEZ. 1996. Composition and abundance of the zooplankton in two lakes of the Horto Florestal Dr. Luiz Teixeira Mendes, Maringá, Paraná. *Acta Limnol. Brasil.* 8: 207–219.
- PAGGI, J., AND S. JOSÉ DE PAGGI. 1990. Zooplankton de ambientes lóticos e lénticos do río Paraná. *Acta Limnol. Brasil.* 3: 685–719.
- PEÑA, O. 1996. Hidrografía. In J. Rosales and O. Huber (eds), *Ecología de la Cuenca del Río Caura, Venezuela. I. Caracterización General*. *Scientia Guaianae* 6: 29–33.
- PENNAK, R. W. 1953. *Fresh-water Invertebrates of the United States*. The Ronald Press Company, USA, 769 pp.
- REVEROL, Y. 2006. Caracterización de las comunidades zooplanctónicas en la cuenca baja del río Caura y lagunas de su planicie de inundación, estado Bolívar, Venezuela. Masters Thesis, Departamento de Biología, Facultad Experimental de Ciencias, Universidad del Zulia, Maracaibo, Venezuela, 115 pp.
- REY, J., AND E. VÁSQUEZ. 1986a. Cladocères de quelques corps d’eaux du bassin moyen de l’Orinoque (Vénézuéla). *Annls. Limnol.* 22: 137–168.
- REY, J., AND E. VÁSQUEZ. 1986b. *Bosminopsis macaguensis* n. sp. et *Alona ovata* n. sp. (Crustacea, Cladocera), Cladocères nouveaux du Vénézuéla. *Annls. Limnol.* 22: 219–229.
- REY, J., AND L. SAINT-JEAN. 1968. Les Cladocères (Crustacès, Branchiopodes) du Tchad. (Prèrière note). *Cah. O.R.S.T.O.M., sèr. Hydrobiol.* 2: 78–118.
- REY, J., AND L. SAINT-JEAN. 1969. Les Cladocères (Crustacès, Branchiopodes) du Tchad. (Deuxième note). *Cah. O.R.S.T.O.M., sèr. Hydrobiol.* 3: 20–42.

- ROBERTSON, B. A., AND E. R. HARDY. 1984. Zooplankton of Amazonian lakes and rivers. Pp. 337–352, in H. Sioli and W. Junk (eds.), *The Amazon: Limnology and landscape ecology of a mighty tropical river and its basin*. Dr. W. Junk Publishers, Boston, MA.
- SAMPAIO, E. V., AND C. M. LÓPEZ. 2000. Zooplankton community composition and some limnological aspects of an oxbow lake of the Paraopeba River, São Francisco River Basin, Minas Gerais, Brazil. *Arch. Biol. Technol.* 43: 285–293.
- SAUNDERS, J. F., AND W. M. LEWIS JR. 1988a. Zooplankton abundance in the Caura River, Venezuela. *Biotropica* 20: 206–214.
- SAUNDERS, J. F., AND W. M. LEWIS JR. 1988b. Dynamics and control mechanisms in a tropical zooplankton community (Lake Valencia, Venezuela). *Ecological Monographs* 58: 337–353.
- SAUNDERS, J. F., AND W. M. LEWIS JR. 1988c. Zooplankton abundance and transport in a tropical white-water river. *Hydrobiologia* 162: 147–155.
- SAUNDERS, J. F., AND W. M. LEWIS JR. 1989. Zooplankton abundance in the lower Orinoco River, Venezuela. *Limnol. Oceanogr.* 34: 397–409.
- SIOLI, H. 1984. *The Amazon limnology and landscape ecology of a mighty tropical river and its basin*. Dr. W. Junk Publishers, Boston, 763 pp.
- SMIRNOV, N. N. 1992. *The Macrothricidae of the World. Guides to identification of the Macroinvertebrates of the Continental waters of the world*. SPB Academic Publishing, The Netherlands, 143 pp.
- SMIRNOV, N. N. 1996. *Cladocera: The Chydorinae and Sayciinae (Chidaridae) of the World. Guides to identification of the Macroinvertebrates of the Continental waters of the world*. SPB Academic Publishing, The Netherlands, 197 pp.
- STEEL, R. G. D., AND J. H. TORRIE. 1988. *Bioestadística: Principios y Procedimientos*. McGraw Hill, México.
- TWOMBLY, S., AND W. M. LEWIS JR. 1987. Zooplankton abundance and species composition in Laguna La Orsinera, a Venezuelan floodplain lake. *Arch. Hydrobiol. Suppl.* 79: 87–107.
- VÁSQUEZ, E. 1984a. Estudio de las comunidades de rotíferos del Orinoco Medio, Bajo Caroní y algunas lagunas de inundación. *Mem. Soc. Cienc. Nat. La Salle* 44: 95–108.
- VÁSQUEZ, E. 1984b. El zooplancton de la sección baja de un río de aguas negras (río Caroní) y de un embalse hidroeléctrico (Macagua), Venezuela. *Mem. Soc. Cienc. Nat. La Salle* 44: 109–129.
- VÁSQUEZ, E. 1989. The Orinoco River: A review of hydrological research. *Regulated River: Research y Management* 3: 381–392.
- VÁSQUEZ, E., AND J. REY. 1989. A longitudinal study of zooplankton along the Lower Orinoco River and its Delta (Venezuela). *Anns. Limnol.* 25: 107–120.
- VÁSQUEZ, E., AND J. REY. 1992. Composition, abundance and biomass of zooplankton in orinoco floodplain lakes, Venezuela. *Anns. Limnol.* 28: 3–18.
- VÁSQUEZ, E., AND L. SÁNCHEZ. 1984. Variación estacional del plancton en dos sectores del río Orinoco y una laguna de inundación adyacente. *Mem. Soc. Cienc. Nat. La Salle* 44: 11–31.

- VÁSQUEZ, E., M. J. PARDO, E. ZOPPI DE ROA, AND C. LÓPEZ. 1998. Rotifer fauna from Venezuela. *Amazoniana* 15: 11–24.
- ZOPPI DE ROA, E., F. MICHELANGELLI, AND L. SEGAVIA. 1985. Cladocera (Crustacea, Branchipoda) de sabanas inundables de Mantecal, Estado Apure, Venezuela. *Acta Biol. Venez* 12: 43–55.