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PROGRAMA DE PÓS-GRADUAÇÃO EM ECOLOGIA AQUÁTICA E PESCA**

BRENDA NATASHA SOUZA COSTA

**COMUNIDADE MICROZOOPLANCTÔNICA COMO INDICADORA DE
ALTERAÇÕES AMBIENTAIS EM UM POLO INDUSTRIAL E PORTUÁRIO
NA REGIÃO AMAZÔNICA**

BELÉM - PA

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Dissertação submetida ao Programa de Pós-Graduação em Ecologia Aquática e Pesca, da Universidade Federal do Pará como requisito parcial para obtenção do grau de Mestre em Ecologia Aquática e Pesca.

Orientadora: Dra. Lílian Lund Amado

Co-Orientador: Dr. Marcelo de Oliveira Lima

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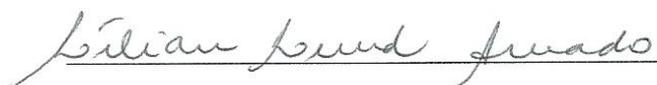
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Aprovada em 06 / 02 / 2015



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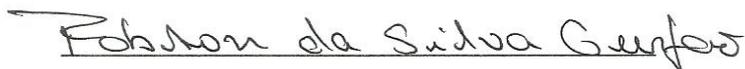
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BELÉM - PA

2015

INSTITUIÇÕES E FONTES FINANCIADORAS

MS - SECRETARIA DE VIGILÂNCIA EM SAÚDE



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“Esta atividade (obra ou projeto) é resultante do cumprimento de obrigação ambiental assumida pela Imerys Rio Capim Caulim em Termo de Ajustamento de Conduta lavrado perante o Ministério Público Estadual”.

Ao meu Pai (in memoriam) e minha Mãe, por todo apoio, esforço, dedicação, atenção, lições de esperança, companheirismo, carinho e amor que me proporcionaram, servindo de alicerce para que eu chegasse até aqui.

*"De repente, o que você chama de
fim, pode ser um novo começo."*

(Autor Desconhecido)

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RESUMO GERAL

Acordos governamentais nas décadas de 80 e 90 viabilizaram a instalação em Barcarena da área portuária e industrial de Vila do Conde, ocasionando um rápido e intenso crescimento populacional. O quadro resultou em danos ambientais aos ecossistemas aquáticos, afetando os organismos que nele habitam. Neste contexto, os organismos zooplanctônicos são considerados bons indicadores de alterações ambientais pelo seu curto ciclo de vida e adaptação a ambientes eutrofizados. Neste trabalho os objetivos foram identificar se há associação entre alterações na composição da comunidade em relação à proximidade com a área industrial e portuária de Vila do Conde (Município de Barcarena); se ocorrem espécies indicadoras de processos de alterações ambientais deste ambiente (Capítulo 1); caracterizar a comunidade zooplanctônica em quatro rios (Curuperê, Dendê, Murucupi e Arapiranga) avaliando a influência da ocupação territorial desordenada e o desenvolvimento industrial na degradação ambiental na área de estudo (Capítulo 2). Para o desenvolvimento do trabalho foram também utilizados dados físico-químicos e microbiológicos para avaliação da qualidade das águas. No primeiro capítulo, foram identificadas 64 espécies no rio Pará e que suas maiores densidades foram associadas aos meses mais chuvosos, fevereiro/2012 (962.400 org.m⁻³) e novembro/2012 (889.000 org.m⁻³) e na proximidade do complexo industrial e portuário. Estes últimos dados evidenciam a existência de fatores oriundos das atividades antropicas influenciando na densidade e composição da comunidade. O teste "IndVal" mostrou a espécie de rotífero *Filinia opoliensis* (IndVal=0,86, p=0,02) como possível bioindicadora da qualidade ambiental. No segundo artigo, a comunidade zooplanctônica foi composta por 149 táxons e as densidades dos organismos se diferenciaram entre os rios (r=0,275; p=0,001). O rio Arapiranga possui os menores valores médios (Média 76 ± DP 45,021), seguido do Curuperê-Dendê (Média 98 ± DP 34,245) e Murucupi (Média 190 ± DP 67,552). A análise indicadora de espécie (IndVal) indicou que as espécies *Keratella lenzi* e *Anureaopsis* sp1 possuem elevada fidelidade e especificidade aos rios Curuperê-Dendê e Murucupi, rios mais degradados. Este trabalho, de modo geral, contribui para a discussão sobre os impactos ambientais gerados pela instalação dos projetos industriais e portuários e a falta de investimentos em saneamento básico na Amazônia.

Palavras-Chave: Amazônia; Bioindicadores; Poluição

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ESTRUTURAÇÃO DA DISSERTAÇÃO

Esta dissertação foi elaborada no formato de artigos denominados de capítulos, seguindo as orientações de formatação do Programa de Pós-Graduação em Ecologia Aquática e Pesca da Universidade Federal do Pará, iniciando com um capítulo geral introdutório e os outros dois específicos.

O **Capítulo geral** trata de uma sucinta introdução a respeito do zooplâncton e estudo deste como ferramenta para a avaliação de impactos ambientais. Em seguida são apresentados os objetivos e a metodologia geral para a obtenção dos resultados.

O **Capítulo 1** aborda o uso da comunidade zooplanctônica como indicadora ambiental no complexo industrial e portuário do rio Pará. Nesse estudo foram discutidos aspectos como os efeitos sobre a comunidade zooplanctônica no rio Pará em relação a proximidade da área industrial e portuária bem como as oscilações associadas as variações sazonais locais.

O **Capítulo 2** enfoca na utilização do zooplâncton como Bioindicador de Degradação Ambiental associada a ocupação humana na região. Nesse estudo foram abordados os efeitos sobre a comunidade zooplanctônica associados a qualidade das águas superficiais e estágio de eutrofização dos rios Murucupi, Curuperê-Dendê e Arapiranga.

CAPÍTULO GERAL

INTRODUÇÃO

A cidade de Barcarena localiza-se no estado do Pará, região metropolitana de Belém. Atualmente esta possui uma população de aproximadamente 112 mil habitantes, densidade demográfica de 76 hab/km² e PIB de 2.522.044,00 mil reais (IBGE, 2014), sendo um dos principais municípios contribuintes para o desenvolvimento econômico do estado do Pará.

Acordos governamentais nas décadas de 80 e 90 viabilizaram a instalação em Barcarena da área portuária e industrial de Vila do Conde e atraíram empresas atuantes na produção, beneficiamento e exportação de caulim, alumina e alumínio. Após esse processo de implementação das indústrias, a região atraiu pessoas em busca de empregos e melhorias de vida, ocasionando um rápido e intenso crescimento populacional (PRESSLER, 2005).

A instalação de indústrias e movimentos de grandes massas populacionais resultaram em graves danos ambientais aos ecossistemas aquáticos. O funcionamento do porto de Vila do Conde e a falta de investimentos necessários para o aprimoramento das estruturas de saneamento básico e moradia na região levaram ao despejo direto e sem tratamento de efluentes domésticos e industriais nos rios locais. Este fato levou a alterações na qualidade das águas superficiais que essencialmente eram utilizadas pela população ribeirinha local para atividades de pesca de subsistência, lazer e consumo.

Além dessa carga de poluentes resultante do lançamento continuado de efluentes portuários e industriais, a área de Vila do Conde possui histórico de acidentes ambientais, decorrentes de falhas no controle dessas atividades. Esses eventos culminaram nos últimos anos com o lançamento de grandes quantidades de materiais líquidos e sólidos contendo substâncias tóxicas.

Nos anos de 2003 e 2009 houve o derramamento de grande quantidade de lama vermelha, a partir do rompimento das bacias de decantação da ALUNORTE que atingiram o rio Murucupi chegando ao furo do Arrozal, drenagem de grande volume d'água entre os rios Pará e São Francisco (LIMA et al., 2009). Também foram registradas sequências de derramamentos de materiais (sólidos e líquidos) das bacias de decantação do caulim ocorridos de 2003 a 2014, atingindo os igarapés Curuperê e Dendê chegando ao rio Pará (SANTOS et al., 2003; LIMA et al., 2009, 2011). Em ambos os casos ocorreram alterações ambientais (físicas, químicas e biológicas) de grandes proporções com efeitos sobre os meios bióticos e abióticos nos ambientes aquáticos, além de danos sociais com efeitos sobre a qualidade das águas de consumo

humano e riscos a saúde das populações a partir da exposição ambiental a contaminantes (IEC, 2007).

O lançamento de substâncias nesses ambientes acarreta diversas transformações nos ecossistemas aquáticos, provocando modificações que podem afetar desde os menores níveis biológicos (celular) até outros mais elevados (biosfera). Neste contexto, muitos organismos dos mais diferenciados tamanhos podem ter afetados seus ciclos de vida, nichos ecológicos e posições tróficas (ZAGATTO; BERTOLETTI, 2008).

A base da cadeia trófica aquática é geralmente constituída pela comunidade planctônica, organismos de extrema sensibilidade às modificações ambientais. Tal comunidade é composta principalmente pelo fitoplâncton e zooplâncton. Os primeiros são organismos fotossintetizantes responsáveis pela transformação de energia solar em energia química, pelo acúmulo de compostos nutrientes (por meio da fotossíntese) e pela produção do oxigênio utilizado na respiração dos organismos aquáticos. Já o zooplâncton, compreende consumidores primários que são, portanto, o elo na transferência da energia até os demais consumidores (DUSSART, 1964; SIPAÚBA-TAVARES; ROCHA, 2003).

Os organismos do plâncton têm como característica marcante, viver na coluna d'água, com reduzida capacidade de locomoção (SIPAÚBA-TAVARES; ROCHA, 2003). Devido ao seu curto ciclo de vida, os mesmos são considerados excelentes indicadores, uma vez que respondem de forma mais rápida as transformações química e física que possam acontecer no meio ao qual estão inseridos (COSTA; ESKINAZI-LEÇA; NEUMANN-LEITÃO, 2004).

Neste contexto, o zooplâncton pode responder de diferentes formas à alterações ambientais, podendo ocorrer desde modificações celulares, resultando em mutações, até modificações no nível de comunidade com alterações em sua composição, diversidade, e densidade, tais respostas podem propiciar a permanência e adaptação de espécies resistentes, denominadas oportunistas (MCLUSKY, 1989).

Pesquisas demonstram que o estudo da comunidade zooplânctônica é de grande relevância para investigações a respeito das alterações ambientais associadas aos lançamentos de efluentes domésticos e industriais, pois possibilitam respostas rápidas às transformações ocorridas no ambiente e evidenciam o grau de trofia que o ecossistema se encontra (PERBICHE-NEVES et al., 2013).

Apesar da importância da comunidade zooplânctônica como indicadora para estas regiões, estudos sobre a composição específica e densidade destes organismos são

relativamente escassos na região amazônica. Além disso, os trabalhos realizados não destacam as espécies potencialmente indicadoras dos processos de alterações em áreas impactadas, fato este que demonstra a relevância do presente estudo para o conhecimento e implementação de políticas públicas envolvendo a implantação e monitoramento de atividades portuárias e industriais na Amazônia.

OBJETIVOS

OBJETIVO GERAL

Determinar a estrutura da comunidade zooplanctônica e correlacionar às variáveis ambientais com a composição e densidade desses organismos em diferentes drenagens localizadas em uma área com influência de um complexo industrial e portuário na região Amazônica.

OBJETIVOS ESPECÍFICOS

- ✓ Identificar se há associação entre alterações na composição da comunidade zooplanctônica em relação à proximidade área industrial e portuária de Vila do Conde, município de Barcarena

- ✓ Avaliar a influência da ocupação territorial desordenada e o desenvolvimento industrial na degradação ambiental de três rios (Arapiranga, Curuperê-Dendê e Murucupi) localizados próximo a área industrial e portuária de Barcarena e no seu entorno.

MATERIAIS E MÉTODOS

ÁREA DE ESTUDO

O município de Barcarena está situado na mesorregião metropolitana de Belém, limitando-se ao norte pela baía de Guajará e o município de Belém, ao sul pelos municípios de Moju e Abaetetuba. Ao leste seu limite é feito pela baía de Guajará e município de Acará e a oeste pela baía do Marajó (SOUZA; LISBOA, 2005).

O município de Abaetetuba está inserido na microrregião de Cametá, mesorregião do Nordeste Paraense, é limitado ao sul com pelos municípios Igarapé Miri e Moju, e ao

norte pelo Rio Pará e o município de Barcarena. Sua limitação a oeste é feita pelos municípios de Igarapé Miri, Limoeiro do Ajuru e Muaná e a leste pelo o município de Moju (PARÁ, 2011) (Figura 1).

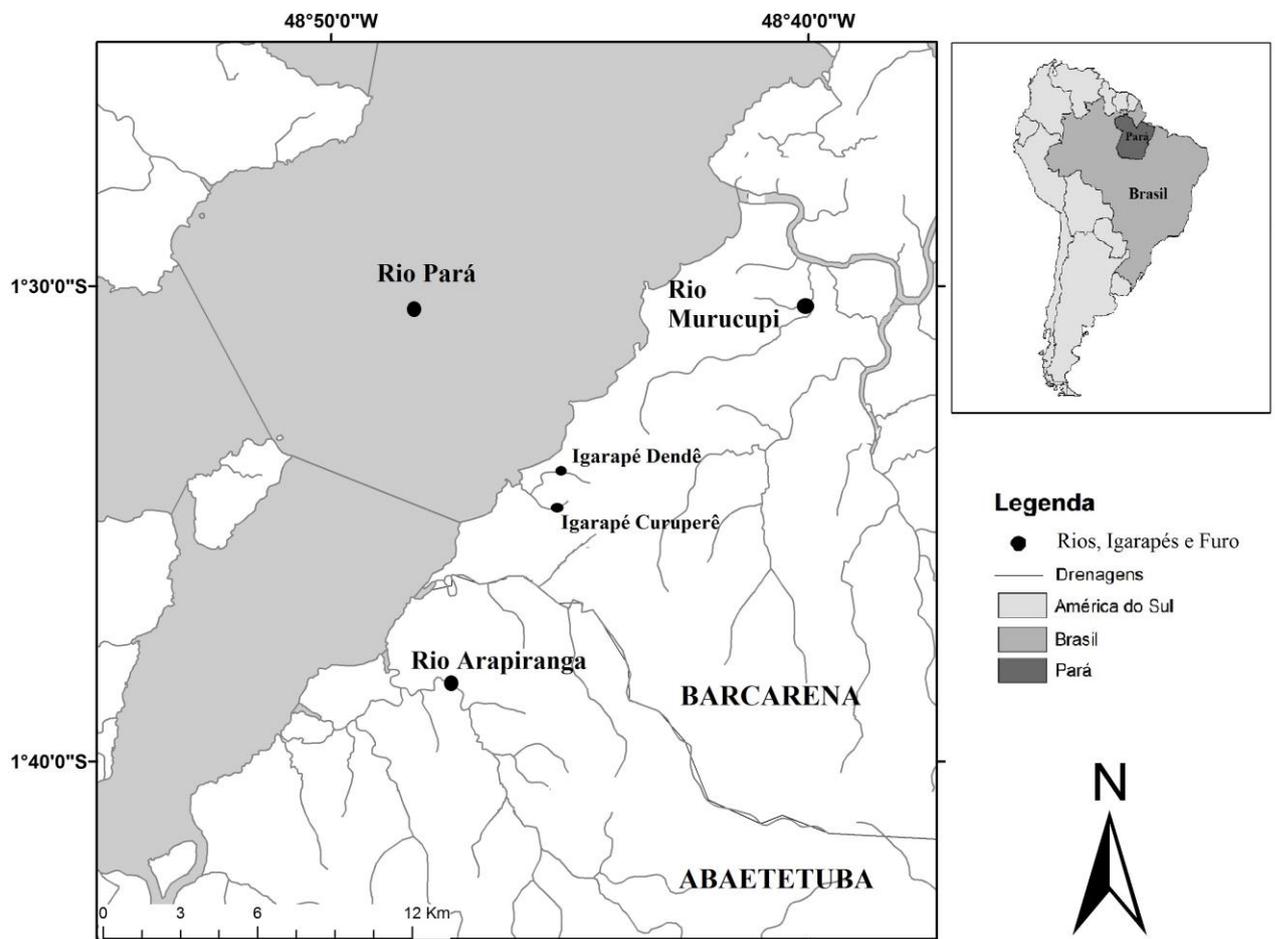


Figura 1. Mapa da área de estudo, evidenciando os rios Pará, Arapiranga, Curuperê-Dendê e Murucupi.

A região em estudo possui um clima quente e úmido, do tipo Am, de acordo com a classificação de Köppen, com temperatura média anual de 26°C. As menores temperaturas médias do ar ocorrem em fevereiro, e as mais elevadas ocorrem no mês de outubro (MORAES et al., 1998).

A variação sazonal da precipitação da região é caracterizada por uma estação chuvosa, compreendendo os meses de novembro a abril, e por uma estação menos chuvosa, correspondente aos meses de maio a outubro (INMET, 2014).

O rio Pará é o principal rio que banha as cidades de Barcarena e Abaetetuba. São observados também furos que cortam a porção continental da insular e rios que atravessam esses municípios e deságuam no rio Pará ou nestes furos (PARÁ, 2011).

As amostragens foram realizadas no ano de 2012, nos municípios de Abaetetuba e Barcarena, estado do Pará, compreendendo o pólo industrial e portuário instalado no distrito de Vila de Conde, município de Barcarena, e se estendendo até o rio Arapiranga (Figura 1).

DESENHO AMOSTRAL

O delineamento amostral e a localização dos pontos de amostragem obedeceram à malha proposta pelo projeto intitulado “Programa de Monitoramento e Controle em Saúde e Meio Ambiente em Áreas Industriais e Portuárias dos Municípios de Abaetetuba e Barcarena, estado do Pará”, o qual é resultante do cumprimento de obrigação ambiental assumida pela empresa Imerys Rio Capim Caulim em Termo de Ajustamento de Conduta lavrado perante o Ministério Público Estadual do Pará.

As coletas foram realizadas nos meses de fevereiro, maio agosto e novembro de 2012, compreendendo os períodos chuvoso e menos chuvoso, durante maré vazante das marés de sizígia (lua cheia) em quatro drenagens: rio Pará, rio Arapiranga, rio Curuperê-Dendê e rio Murucupi.

No rio Pará, foram definidas cinco estações de amostragens (P1 a P5, as quais foram distribuídas à montante, em frente e à jusante do complexo industrial. Nas demais drenagens, foram estabelecidas três estações de amostragens (cabeceira, intermediário e foz) distribuídas ao longo dos rios Arapiranga (A1, A2 e A3), Curuperê-Dendê (C1, C2 e C3) e Murucupi (M1, M2 e M3).

COLETA DOS DADOS

Variáveis Físico-Químicas

Foram realizadas *in situ* as medições das variáveis temperatura (T), potencial hidrogeniônico (pH), condutividade elétrica (EC), sólidos totais dissolvidos (TDS), salinidade (SAL) e oxigênio dissolvido (DO), utilizando um medidor multiparamétrico portátil (HI9828 - HANNA®) calibrado previamente. A transparência da água foi estimada pelo uso do disco de Secchi, com 30 cm de diâmetro.

As variáveis: turbidez (TRB), cor aparente (COLOR), sólidos totais em suspensão (SST) e demanda química de oxigênio (COD) foram determinadas por

Espectrofotometria de UV-VIS. Para a determinação da demanda bioquímica de oxigênio (BOD), utilizou-se a técnica de incubação por cinco dias (APHA; AWWA; WEF, 2012). As análises dos íons Nitrito (N-NO₂⁻), Nitrato (N-NO₃⁻), Nitrogênio Amoniacal (N-NH₄), Amônia (NH₃), fosfato (PO₄³⁻), Sulfato (SO₄²⁻), Dureza, Alcalinidade Total, Fluoreto (F⁻) e Cloreto (Cl⁻) realizadas por Cromatografia de Íons (ICS DUAL 2000-DIONEX).

Parâmetros Biológicos

As amostras para determinação da clorofila-*a*, foram obtidas por coleta direta na sub-superfície da água, com frascos de polipropileno de 250 mL, previamente esterilizados, os quais foram acondicionados e transportadas em caixas isotérmicas. A quantificação da clorofila-*a* ocorreu através do método espectrofotométrico e a absorbância foi obtida através dos comprimentos de ondas: 630 nm, 645 nm, 665 nm e 750 nm (PARSONS; STRICKLAND, 1963). Por problemas técnicos nas etapas de amostragem e transporte, não foi possível a obtenção de amostras para todos os pontos. Devido a isto os dados serão apresentados em médias para os períodos mais e menos chuvosos.

Para obtenção das amostras de *coliformes termotolerantes* foram utilizados sacos NASCOS® de 100 mL e as mesmas foram transportadas em caixas isotérmicas. A determinação dos Números Mais Prováveis (NMP) de *coliformes termotolerantes* foram realizadas por meio de cartelas QUANTI-TRAY em banho maria a temperatura constante de 44,5 °C.

As amostras destinadas ao estudo qualitativo da comunidade zooplancônica foram obtidas por meio de arrastos horizontais na sub-superfície da coluna de água, com o auxílio de uma rede de plâncton com malha de 64 µm. As amostras direcionadas ao estudo quantitativo foram adquiridas pela filtragem de 200 L de água com o auxílio de um balde graduado de 10 L. Posteriormente, o material coletado foi fixado em solução de formaldeído a 6% (BICUDO; BICUDO, 2006) e acondicionadas em frascos de polipropileno de 250 mL.

As análises qualitativas da comunidade zooplancônica foram realizadas a partir da sub-amostragem de uma alíquota de 6 mL em placas de petri, as quais foram visualizadas em microscópio óptico invertido (Axiovert 40C – Carl Zeiss) acoplado a um sistema de captura de imagem (AxioCamMRc). A identificação taxonômica dos

organismos foi realizada até o menor nível possível, através de bibliografias especializadas.

Para a estimativa da densidade total da comunidade zooplânctônica (org.m^{-3}) foram realizadas análises quantitativas, pelo método de sedimentação das sub-amostras, as quais foram observadas microscópio óptico invertido (Axiovert 40C – Carl Zeiss) em aumento de 200X, metodologia adaptada de Utermöhl (1958) (GARZIO; STEINBERG, 2013).

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CAPÍTULO 1

Este Capítulo foi elaborado de acordo com as normas do periódico Ecological
Research

Microzooplankton as an Indicator of Environmental Quality at an Industrial Complex in the Brazilian Amazon

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ABSTRACT

The large volume of water of Pará river, together with governmental incentives, has attracted many industries to the city of Barcarena, Brazil. These activities have potential to cause changes in aquatic environments. In this context, zooplankton species are considered good indicators of environmental changes. In this paper, we have assessed whether there is association between changes in the community composition regarding proximity to the industrial and port area, and we have identified the potential bioindicators species in these environments. Five quarterly sampling points were selected along the Pará river (P1 to P5) in 2012. The zooplankton community in this region is composed by 64 species. The highest total densities were recorded in February and November, both during the rainy season, and at P3, located in front of the industrial and port complex, highlighting the existence of factors deriving from these activities. The IndVal test showed the rotifer *Filinia opoliensis* ($r=0.86$, $p=0.02$) like a possible bioindicator of the environmental quality in the study area. This paper contributes to the discussion on the impacts of the installation of industrial plants and large ports in the Amazon.

Keywords: Zooplankton; Pollution; Estuary; Rotifer

INTRODUCTION

In the Amazon region, estuaries are formed by the Amazon river basin, located in the northern part, and the Tocantins river basin, in the south. Together, these two water bodies constitute the world's largest river basin, over 7 million Km² long. The dynamics of these estuaries strongly influence both rivers due to the region's intense tidal regime (Barthem and Goulding 1997).

The Amazon River, approximately 6,990 km long, is one of the longest rivers in the world; the Apurímac river, located in southern Peru, is its starting point and its mouth is in the Atlantic Ocean between the states of Amapá and the north of Marajó Island, Pará State. The Tocantins River begins in the state of Goiás and its mouth is in the Amazon Gulf. This river is connected to the Amazon River, both biogeographically and ecologically, through its discharge into the Pará river. These rivers have a strong amplitude in their water levels throughout the year due to high rainfall rates that affect the entire basin (Gibbs 1967; Crist et al. 2012; Encyclopedia Britannica 2012).

The Pará River, approximately 300 km long and 20 km wide, is located in the central area of the Amazon Coastal Zone, which encompasses the states of Amapá, Pará, and Maranhão. It is formed by the discharge of countless rivers, forming several bays along the southern part of Marajó Island, such as Marajó Bay. As a result of the high discharge of its main tributaries (Tocantins, Guamá, and Acará-Moju rivers), this river has turbid, fresh waters, which become brackish when it is closer to the mouth in the Atlantic Ocean and depending on the regional seasonality (Barthem and Goulding 1997; Gregório and Mendes 2009).

Among the main cities on the banks of the Pará River are Abaetetuba and Barcarena. Factors such as the great availability of water from the rivers, the construction of the Vila do Conde harbour, and tax waivers have attracted companies to Barcarena over the past decades. These companies have implemented industrial processes for the production of fertilizers, pig iron, bauxite processing to produce alumina, aluminum ingots, and aluminum cables, kaolin processing, and manganese synthesizing. The products from this industrial complex, as well as rude ores and agricultural products (grains and oxen), are exported through Vila do Conde and other private ports in the region (Lima et al 2011). Since most of these industrial and port activities use the aquatic environment to discharge its effluents and they it is possible to trace back the origin of such effluents in time and space can be characterized as potential sources of pollution. These effluents may contain both inorganic and organic

contaminants which undergo changes in its concentrations (dilution) through bioprocessing, resulting in the increase, decrease, or even inactivation of these compounds' toxicity (Zagatto and Bertolletti 2008).

In addition to the continuous release of port and industrial effluents, the area of Vila do Conde has a history of environmental accidents deriving from failures in the industrial and port process control. Such events have culminated, over the last years, in the discharge of large amounts of liquid and solid materials containing toxic substances. Among the most prominent cases are the large red mud spill, in 2003 and 2009, due to the breach of ALUNORTE's tailing ponds, which affected the Murucupi river and reached Furo do Arrozal, a larger water drainage between the Pará and the São Francisco rivers (Lima et al 2009). Another important cause is the sequence of spills (both solid and liquid) from kaolin tailing ponds, from 2003 to 2014, into the Curuperê and Dendê streams, which reached the Pará River. In both cases, there were environmental impacts (physical, chemical, and biological) of great proportions with effects on the biotic and abiotic aquatic environments, and social damages due to the effect on the quality of waters for human consumption and risks to the health of populations due to environmental exposure to contaminants (Carneiro et al 2007).

These environmental damages are similar to the ones occurred in the city of Ajka (Hungary) in October, 2010. There, a tailing pond containing red mud breached and contaminated the soil and waters in the region. Torna creek and Marcal river were mainly affected and the flood reached rural settlements and agricultural areas. Studies in the area have shown that the sudden discharge of a large amount of red mud affected different biological levels. Some organisms manage to quickly re-establish and adapt; for others, however, the damage might be irreversible and lead to their local extinction (Gelencsér et al 2011; Ruyters et al 2011).

Anthropic activities contribute to the enrichment of the natural waters and to the eutrophication of aquatic environments by increasing nutrient content, organic matter, and turbidity, and decreasing the oxygen dissolved in surface waters (Uriarte and Villate 2004). Changes in the physical and chemical features of these environments might cause significant environmental changes that lead to shifts in the base of the food chain and result in trophic interactions that might affect all biological levels. Live organisms present in these aquatic environments might undergo changes in their life cycles, ecological niches, and trophic levels (Zagatto and Bertolletti 2008; Dutto et al. 2012).

The base of the food chain is mainly comprised by the planktonic community, which is sensitive to environmental changes, and have striking features such as living in water columns, subject to currents, and having limited locomotion (Sipaúba-Tavares and Rocha 2003). Plankton organisms are classified into phytoplankton and zooplankton, ichthyoplankton, and bacterioplankton. Zooplankton comprises consumers which are the link for energy transfer towards upper trophic levels (Dussart 1964; Sipaúba-Tavares and Rocha 2003). Due to their short life cycle, most plankton organisms can be considered excellent bioindicators of environmental impacts, since they respond more quickly to changes that might occur in the environment (Costa et al 2004).

Individuals of several taxonomic categories are found in the zooplankton, and they have different trophic levels, functions, and very distinctive features, which makes this community a diversified and complex biocenosis (Garrison 2010; Esteves 2011).

Zooplankton might respond to environmental changes in different ways. Studies show that these organisms might undergo changes ranging from cell modifications, resulting in mutations, to modifications at the community level, with changes in composition, diversity, and density. For this reason, environmental changes may cause different consequences in the zooplankton community, leading to the disappearance of some species or even to the permanence and adaptation of opportunistic species (Mclusky 1989; Uriarte and Villate 2004). Over the years, several studies have used changes in zooplankton communities as an important tool to assess the effects of anthropic activities and, consequently, of pollution in the aquatic system (Moraitou-Apostolopoulou and Ignatiades 1980; Marneffe et al. 1996; Uriarte and Villate 2004; Jiang et al. 2010).

In freshwater ecosystems, this community is comprised predominantly of Rotifera, Cladocera, Copepoda (Cyclopoida and Calanoida) and Protista (Dantas et al 2009). In impacted environments, there is an increase in the abundance of Cladocera, Rotifera, and Cyclopoida, while Calanoida adapts better to oligotrophic environments, and it might disappear in waters undergoing eutrophication (Perbiche-Neves et al 2013).

In this study, the zooplankton community was characterized at points distributed along the Pará river at different distances from the industrial and port complex, in order to obtain possible variations in the community along a contamination gradient. Our objectives were: (1) to identify whether there is an association between changes in the community composition and proximity to the industrial and port area of Vila do Conde,

municipality of Barcarena, and (2) if there are species that may be potential quality bioindicators of this environment.

MATERIALS AND METHODS

STUDY AREA

The studied sector of the Pará river is located in the municipalities of Barcarena and Abaetetuba, Pará State. Barcarena is situated in the metropolitan mesoregion of Belém, limited to the North by the Guajará bay and the city of Belém, and to the South by the cities of Moju and Abaetetuba. To the East, it is limited by the Guajará bay and the city of Acará, and to the West, by the Marajó bay. The city of Abaetetuba is inserted in the microregion of Cametá, mesoregion of Northeastern Pará, and is limited to the south by the cities of Igarapé Miri and Moju, and to the north by the Pará river and the city of Barcarena. It is limited to the west by the cities of Igarapé Miri, Limoeiro do Ajuru, and Muaná, and to the east by the city of Moju (Souza and Lisboa 2005).

The study region climate is hot and humid Köppen classification (Am), with a mean annual temperature of 26 °C. The mean annual rainfall ranges from 2,300 to 2,800 mm. The seasonal rainfall variation is characterized by a rainy season, from November to April, when the rainfall follows a rising trend and reaches its peak in March and April, and by a less rainy season, from May to October, when the rainfall decreases and reaches its minimum from September to October (Moraes et al 1998; INMET 2014). The monthly rainfall data of the study area were obtained via the National Institute of Meteorology (Instituto Nacional de Meteorologia, INMET) database.

SAMPLING

Sampling was carried out in February (rainy period), May (less rainy period), August (less rainy period), and November (rainy period) 2012. Sampling occurred during the spring ebbing tide (full moon). Five sampling stations were defined, and distributed upstream (P1 and P2), in front (P3), and downstream (P4 and P5) of the industrial and port complex, installed in the district of Vila do Conde (Figure 1).

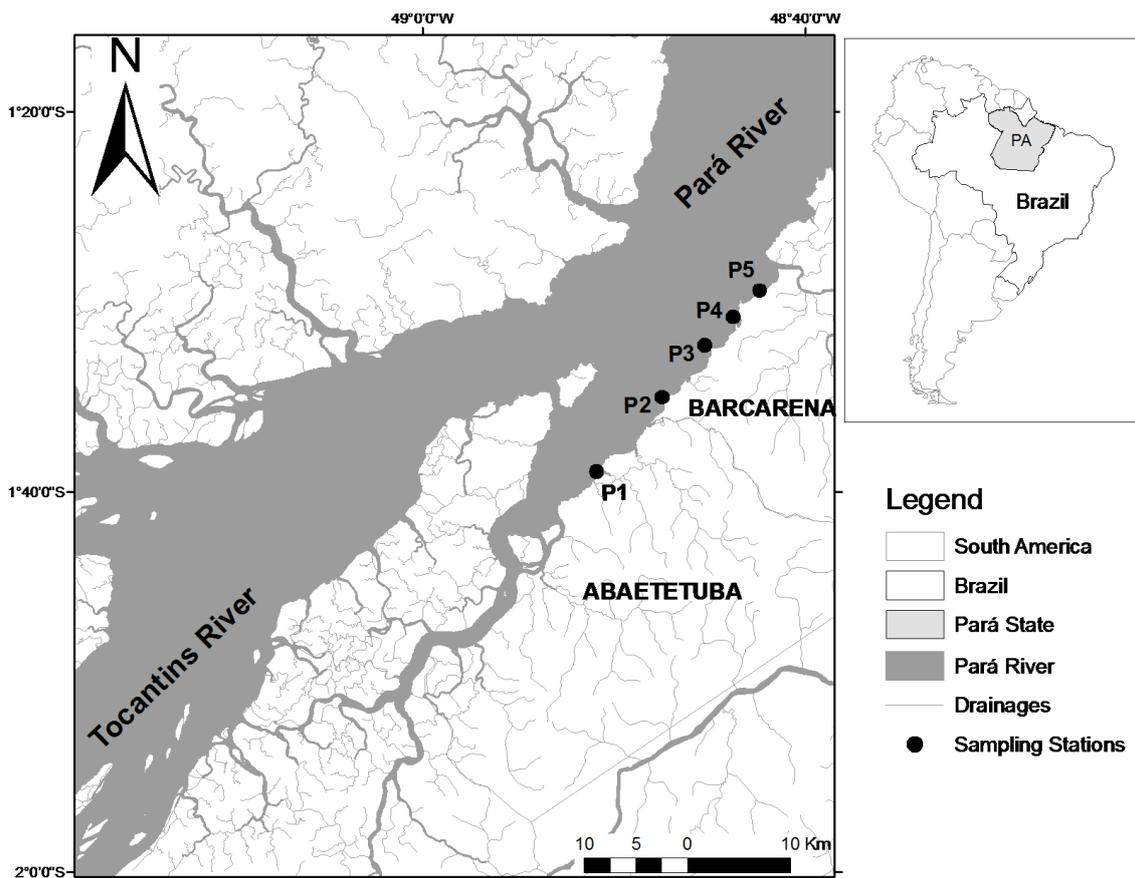


Figure 1. Study area in the Pará River, Barcarena and Abaetetuba cities, Pará, Brazil

Water sampling was performed at 0.3 m depth using previously washed 1000 mL polypropylene flasks. The samples for chlorophyll-*a* determination were obtained through direct collection of sub-surface water with 250 mL polypropylene flasks, properly sterilized, stored and transported in isothermal boxes. Samples for the qualitative study of the zooplankton community were obtained by horizontal trawling at the water column subsurface, with 64 μm mesh size a plankton net. Samplings for the quantitative study were obtained by filtering 200 L of water with a 10 L graduated stainless steel bucket. Samples were fixed in a 6% formaldehyde solution (Bicudo and Bicudo 2006) and stored in thermal boxes.

PHYSICOCHEMICAL ANALYSES

The following variables were measured *in situ*: temperature (T), hydrogenionic potential (pH), electrical conductivity (EC), total dissolved solids (TDS), salinity (SAL), and dissolved oxygen (DO), using a portable multi-parameter meter (HI9828 -

HANNA[®]) previously calibrated. Water transparency was estimated by using a Secchi disk, with 30 cm of diameter.

The variables turbidity (TRB), apparent color (COLOR), total suspended solids (TSS), and chemical oxygen demand (COD) were determined by UV-VIS Specter-photometry. To determine the biochemical oxygen demand (BOD), the five-day incubation technique was used (APHA et al 2012). Nitrite-N (N-NO_2^-), nitrate-N (N-NO_3^-), amonniacal nitrogen (N-NH_4), Ammonia (NH_3), phosphate (PO_4^{3-}), Sulfate (SO_4^{2-}), Hardness, Alkalinity, Fluoride (F^-), and Chloride (Cl^-) were determined by Ion Chromatography (ICS DUAL 2000-DIONEX).

ZOOPLANKTON AND CHLOROPHYLL-*a*

The qualitative analyses of the zooplankton community were carried out under an inverted optical microscope (Axiovert 40C – Carl Zeiss) coupled to an image capture system (AxiocamMRc). The taxonomic identification of the organisms was performed to the lowest possible level, through specialized bibliographies.

The density of the zooplankton community (org.m^{-3}), was estimated through the analysis of the subsample sedimentation method subsamples were counted using an inverted optical microscope (Axiovert 40C – Carl Zeiss) with 200 times magnification, adapted from Utermöhl (1958) (Garzio and Steinberg 2013).

The zooplankton taxa were classified based on their degree of occurrence as: very frequent ($\geq 70\%$), frequent ($< 70\%$ and $\geq 30\%$), infrequent ($< 30\%$ and $\geq 10\%$), and sporadic ($< 10\%$) (Mateucci and Colma 1982).

Chlorophyll-*a* samples were analyzed through the specter-photometric method and the absorbance obtained through wave lengths: 630 nm, 645 nm, 665 nm and 750 nm (Parsons and Strickland 1963). Due to technical problems at the sampling and transportation steps, it was not possible to obtain samples all the collection points. Therefore, the data was presented in averages for the each season.

STATISTICS

In order to test the difference in limnological features of the surface water between the collection points and seasonal periods, the Principal Component Analyses (PCA) was carried out (Legendre and Legendre 2012), using the Minitab 14 program.

In order to assess the similarity in community composition and density between the studied points and periods, we used the Bifactor Analysis of Similarity ANOSIM

(Clarke and Warwick 2011). An indicator species analysis (IndVal) was carried out to identify the typical species for each sampling point. This analysis combined density and frequency of occurrence for each species (Dufrêne and Legendre 1997). These analyses were calculated using the R.Project program available at <http://www.r-project.org>.

RESULTS

LIMNOLOGY

According to rainfall values from 2008 to 2012, two seasonal periods are evident for the study region. One is an intense rainy period, with increased rainfall from November to April (IA and IB, Figure 2), and the other is less intense, when the incidence of rain decreases from April onwards and encompasses the months of May to August (II, Figure 2). Comparison and distinction between seasonal periods were important, since temporal variations in the rainfall cycle were observed (Figure 2).

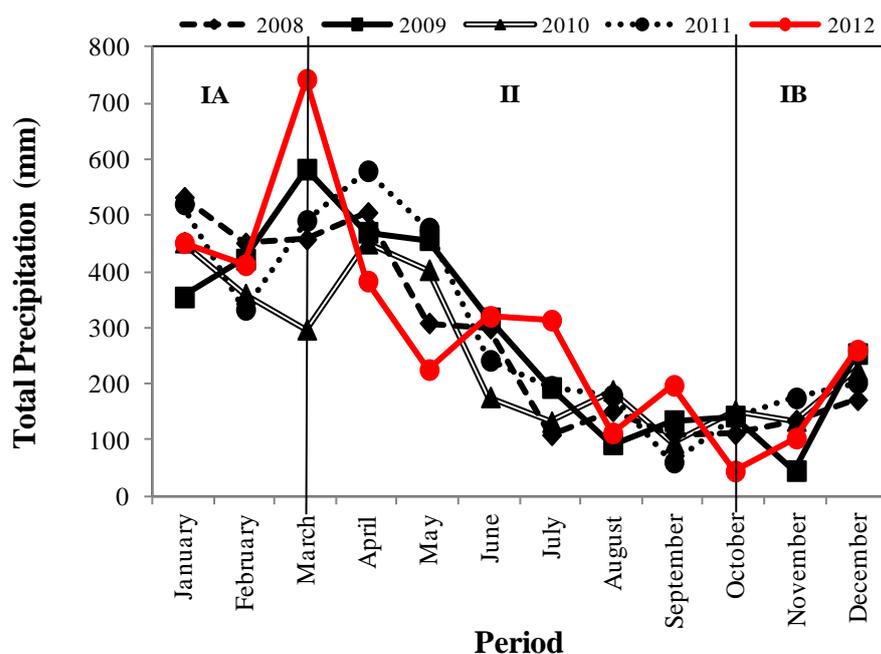


Figure 2. Rainfall from 2008 to 2012. IA and IB: Increase in Rainfall and; II: Decrease in Rainfall. Source: INMET 2014.

Chlorophyll-*a* concentrations were distinct between the seasons. In the rainy period, it was registered average concentrations of 5.3 mg.L^{-1} (3.8-7.7), values quite higher than in the less rainy period, which were 3.3 mg.L^{-1} (2.6-4.1).

The physicochemical values of the surface water are shown in Table 1 (Appendix I). The PCA for the physicochemical factors in the surface waters from the Pará River showed the formation of different groups within the studied months (Figure 3). Such

information emphasizes the fact that there are peculiar features that distinguish abiotic parameters in the sampling points and periods. Three groups were formed (A, B, C) and the sampling points P1, in February, and P4 and P5, in November, were characterized as *outliers*. In Figure 3, groups A, B, and C represent, respectively, the months of February, and the months of May and August combined. PC1 (31.9%) separated groups A and C (quadrants IV and II, respectively) from group B (quadrant I and III). PC2 (17.8%) only allowed between groups A and C.

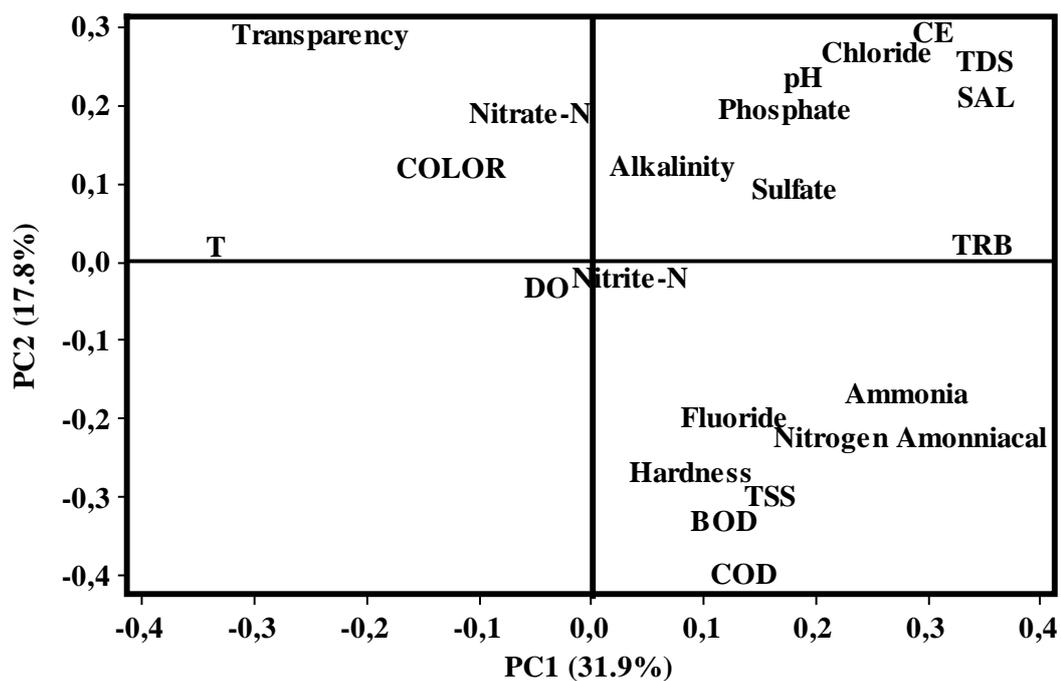
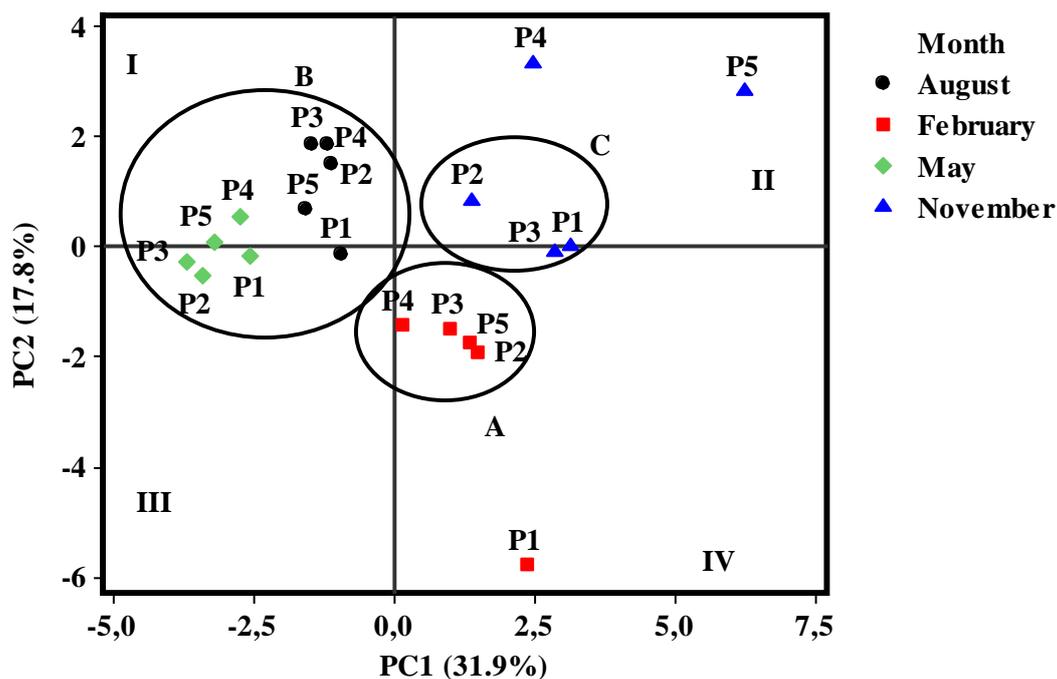


Figure 2. PCA for physicochemical variables in the Pará River in 2012. (A) Score plot for the first 2 components; (B) Loading plot for the first 2 components

ZOOPLANKTON COMMUNITY

The zooplankton community was composed by of 64 taxa, distributed in twenty genera, sixteen families, nine orders, nine classes, and seven phyla. The most representative family was Brachionidae, with 8 identified species, followed by

Trichocercidae, with 5 species; and Trochosphaeridae, Lecanidae, Bosminidae, with 4 species each. Table 2 (in Annex I) shows the information regarding all recorded species/groups.

According to the frequency of occurrence, the taxa were classified as very frequent (20%), frequent (22%), infrequent (43%), and sporadic (15%). The taxa with presence above 70% were: *Brachionus mirus* (70%), *Filinia terminalis* (85%), Calanoida copepodites (95%), Cyclopoida sp1 (95%), Bdelloidea sp5 (95%), *Codonella cratera* (95%), Cyclopoida copepodites (100%), *Keratella americana* (100%), *Keratella cochlearis* (100%), Nauplius (100%), Bdelloidea sp2 (100%), and Tintinnina sp2 (100%).

Based on the similarity test (ANOSIM), we demonstrated that the composition of the zooplankton community is significantly different between the studied months ($r=0.529$; $p=0.001$). Such difference might be explained by the local seasonal periods; when the rainfall increases, an environment is formed and allows for the entering, permanence, and/or return of species which are more adapted to the new environmental conditions.

Seasonally, the highest densities were recorded in February (962,200 org.m⁻³) and November (888,600 org.m⁻³), both considered rainy seasons. Between the sampling points, the highest densities were recorded at P3, situated in front of the industrial and port complex (Figure 4).

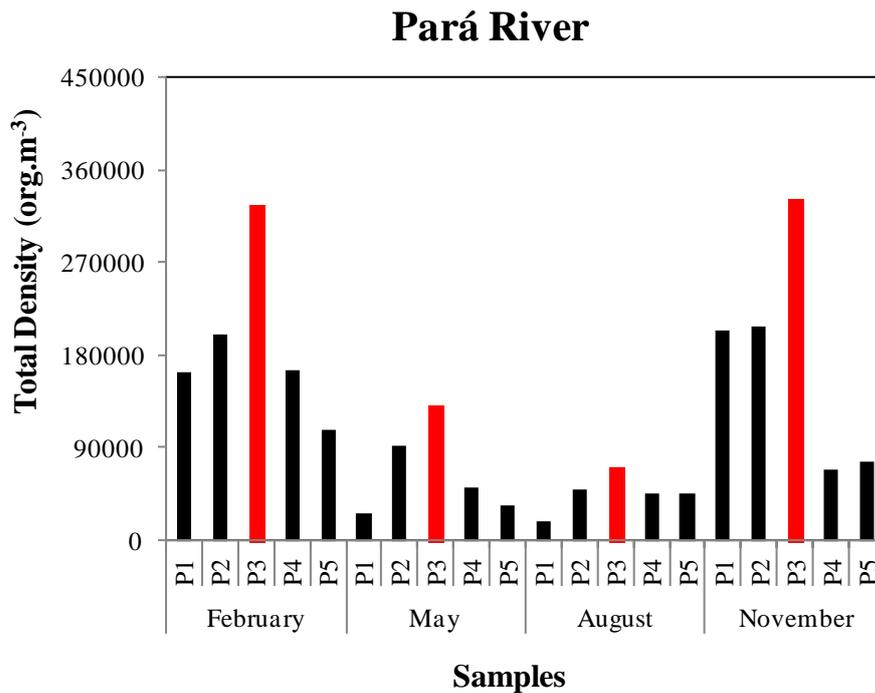


Figure 4. Total Density of zooplankton in the Pará River during 2012

BIOINDICATORS

The IndVal test showed that *Filinia opoliensis* (IndVal = 0.86, $p = 0.02$) has an elevated fidelity and specificity to the point in front of the industrial complex, and it might be a possible bioindicator of environmental quality.

The same test also highlighted *Moina minuta* (IndVal = 0.97, $p = 0.005$), *Filinia longiseta* (IndVal = 0.94, $p = 0.005$), *Brachionus caudatus* (IndVal = 0.82, $p = 0.025$), and *Bosminopsis deitersi* (IndVal = 0.81, $p = 0.05$) with specificity and fidelity to February and November, which corresponds to the period with highest rainfall.

DISCUSSION

During the rainy period, the rainfall increases, providing a favorable environment for microorganisms, and a higher primary production, since the soils in the region are more soaked and the carriage of nutrients and other substances occurs naturally by leaching process. During the less rainy period, the nutrient content in the leaching process decreases and, simultaneously, the water volume in the rivers lowers, with chances of increasing the concentration of substances associated to either anthropic or natural processes (Melão 1999; Navarro and Modenutti 2012).

Group A was comprised by all sampling points during February (except by P1) and characterizes by high values of Hardness ($12.70 \pm 0.95 \text{ mg.L}^{-1}$) and Fluoride ($0.06 \pm 0.01 \text{ mg.L}^{-1}$). Values which were differentiated from the others in all samples from 2012. This increase in hardness and fluoride concurs with the increase in rainfall. In periods with higher rainfall, there is an intensification of the nutrient leaching process, increase in concentrations of calcium and magnesium in the drainages, which explains the increase in the mean level of hardness in February. The increase of fluoride in the waters might be associated to leaching processes, if we consider that there would be an increase of this substance in the soil of the region, since it is well known in literature that industries that produce aluminum ingots through electrolytic processes might release fluoride-rich vapors that precipitate through rain. In the industrial and port area of Vila do Conde, there is a company that works with this type of production (Gomes 2007).

However, P1 during February 2012 (outliers) is correlated to the increase in BOD (20.35 mg.L^{-1}), COD (37.00 mg.L^{-1}), TSS (17.00 mg.L^{-1}), and ammoniacal nitrogen (0.38 mg.L^{-1}). These are the highest values of such parameters over the studied period. These results show that there was probably a competition for oxygen amongst organisms at this point, information which might be complemented by the decline in transparency (40 cm), the lowest in the entire sampling. The reduction of the euphotic layer leads to the increase in the competition for oxygen amongst microorganisms in the water column, mainly due to the low production of oxygen (Bezerra-Neto and Pinto-Coelho 2001).

Group C was formed by P1-P3 during November 2012 and is related to the increase in pH (7.74 ± 0.22), phosphate ($0.16 \pm 0.03 \text{ mg.L}^{-1}$), sulfate ($3.1 \pm 0.91 \text{ mg.L}^{-1}$), and turbidity ($14.8 \pm 2.95 \text{ UNT}$). The increase of these variables concurs with the beginning of the increased rainfall period in the region. At the beginning of the rainy season, nutrients and also a large amount of particulate material undergo leaching, which makes the waters in this region very soggy and, consequently, increases turbidity. With the increase in turbidity and pH, the environment tends to become more alkaline, and the phosphate and sulfate contents carried from the rocks in the leaching processes tend to become more stable. However, the increase in the levels of sulfate might be associated to the intensification of effluent discharge associated to red mud in the alumina production process. These effluents are highly alkaline and continuously neutralized with sulfuric acid (H_2SO_4) before the final discharge. Therefore, if rain

increases, the tailing ponds increase its volume, intensifying its discharge to relief the pressure in containment reservoirs (red mud). There is an alumina production company, in the studied area qich previous histories of environmental accidents show that during higher rainfall intensity, there is a greater accumulation of effluents in the tailing ponds, wich is discharged directly in the Pará river, near the points P3 and P4 (Santos et al 2003).

However, P4 and P5 were *outliers* from the November sampling. Point P5 is different due to the increase in conductivity ($109 \mu\text{S}\cdot\text{cm}^{-1}$), salinity ($0.05 \text{ mg}\cdot\text{L}^{-1}$), TDS ($55.00 \text{ mg}\cdot\text{L}^{-1}$), and chloride ($22.05 \text{ mg}\cdot\text{L}^{-1}$) while point P4 was characterizes by the decline in the DO ($5.29 \text{ mg}\cdot\text{L}^{-1}$). Since it is the beginning of the rainy period, and these points are the last towards the mouth and are located after the industrial area, there is greater accumulation of particulate material content. Thes increase in salinity may be associated to the ocean intrusion in this estuary during this period and by the proximity to the river mouth (Gregório and Mendes 2009).

Group B was related to the risc of temperature ($30.03\pm 0.21 \text{ }^\circ\text{C}$) and Transparency ($85.00\pm 15.09 \text{ cm}$) because the leaching process declines with the rainfall. The decline in particulate materials in the water column allowed light, penetration thus increasing transparency (Navarro and Modenutti 2012).

Zooplankton densities from the rainy season showed correlation to N-NO_3^- ($r= 0.75$; $p: 0.01$), which is easily carried by the rain and they benefits the phytoplankton growth ad biomass and consequently, the zooplankton. The lowest zooplankton density was recorded in May and August were correlated with COLOR ($r= 0.67$; $p: 0.04$), COD ($r= 0.62$; $p: 0.06$) and BOD ($r= 0.65$; $p: 0.04$), indicating a possible accumulation of anthropic substances and also the increase in turbidity due to a decline in the volume of river waters during this period (Wetzel 1993).

The point in front of the port (P3) was associated to phosphate and nitrate, important nutrients in zooplankton growth, since that it also causes primary production to intensify, and its input possibly benefits from the port and industrial activity. However, the increase in the concentration of sulfate and fluoride ions indicates possible influences from ALBRAS (one of the products of electrolytic plants is the increase in the fluoride levels in the water) and ALUNORTE industrial plants (the red mud effluent, highly alkaline, is daily neutralized with sulfuric acid (H_2SO_4) before it is discharged onto the Pará river) (Pinto-Coelho et al 2005).

These anthropic discharges increase turbidity and lower DO and transparency, variables that directly affect the zooplankton community. At Point 3 there was a negative correlation between zooplankton density and DO ($r = -0.98$; $p: 0.02$), and we might infer that, with the increase in the zooplankton population, there is a higher consumption of the oxygen in the water, which is also correlated to transparency ($r = -0.99$; $p: 0.01$) and turbidity ($r = 0.88$; $p: 0.12$), and this might be clearly explained by the large concentration of organisms in the environment, and the total suspended solids (Fantin-Cruz et al 2011).

However, our results indicate that these effects on the zooplankton community were more significant near the industrial and port complex, since, the zooplankton composition and density became similar upstream and downstream. Therefore, this pattern indicates that the Pará River still has self-depuration capacity, even though it receives a continuous discharge of contaminated effluents.

Little is known about the physiology of *Filinia opoliensis*; however, some studies highlight its easy development and adaptation to eutrophic environments (Lucinda et al 2004; Baião and Boavida 2005; Vitorio 2006).

The leaching process of nutrients intensifies during the period of highest rainfall, when the environment becomes appropriate for *Moina minuta*, *Filinia longiseta*, *Brachionus caudatus* and *Bosminopsis deitersi* to develop, since they are usually observed in environments rich in suspended material and organic matter (Mahar et al 2000; Costa et al 2004; Lucinda et al 2004).

Studies on the zooplankton community as a bioindicator of environmental impacts in industrial and port areas around the world are still rarely. Moreover, records for freshwater environments are still scarce, mainly in Amazonia, due to the fact that most of these investigations are carried out in marine areas. Developing research in freshwater environments is of extreme relevance, because industries and ports have been increasingly installed on the banks of large-volume rivers, such as the ones in the Amazon region, China, and India (Malik et al., 2013; Li et al., 2014; Yu et al., 2014). In these environments, the dilution and dispersion of pollutants is lower than in marine environments and the effects on the biotic environment are more immediate.

CONCLUSION

This study shows that the zooplankton community of the Pará River is influenced by the outflow of residues from activities developed at the industrial and port complex.

We observed that the proximity to the industrial and port area directly influences the composition and density of the zooplankton community. There is also a good association between the density of such microorganisms and the specific seasonality of the region. It is evident that the density of microorganisms is also higher in the periods of higher rainfall in the region.

We point out the rotifer *Filinia opoliensis* as a potential bioindicator of environmental quality and its presence in front of the urban complex is a indication that these anthropic activities are influencing the zooplankton community structure and that the Pará river might be already undergoing eutrophication process. Supplementary studies must be conducted to assess the presence of this species throughout the entire extension of the Pará River and in further areas in the river basins of the Tocantins and Amazonas. Such information is important to define the species as a bioindicator of environmental quality of the Amazon rivers.

The results also show the need for investments in public policies to improve effective monitoring, beginning with the deployment of port and industrial activities in Amazonia; it is evident that these are polluting activities and that even a large waters flow in the region may not endure the continuous discharge of contaminated effluents.

The intensification in primary production at point P3 makes it evident that there are factors deriving from these activities that influence zooplanktonic community density and composition (Chust et al 2014).

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CAPÍTULO 2

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Microzooplankton as an Indicator of Environmental Degradation in the Amazon

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ABSTRACT

Over the last years many studies have been developed to assess the extension of the impacts generated by the discharge of untreated domestic and industrial effluents into aquatic ecosystems. In the 1980's, large industries settled in the municipality of Barcarena, Brazilian Amazon, and immigration were not followed by the required investments to improve basic sanitation and housing structures in the region, compromising the quality of surface waters. In this study, the zooplankton communities of three rivers (Murucupi, Curuperê-Dendê, and Arapiranga) located near the industrial and port area of Barcarena and its surroundings were characterized. The physico-chemical and microbiological parameters for water quality assessment were also analyzed. For each river, three points were selected and samplings were performed quarterly over 2012. The zooplankton community of the three rivers was comprised of 149 taxa and the density of zooplankton organisms was different between the rivers; Arapiranga River has the lowest values (75847 org.m⁻³), followed by the Curuperê-Dendê (97931 org.m⁻³) and Murucupi (190597 org.m⁻³) rivers. IndVal showed that the species *Keratella lenzi* and *Anureaopsis* sp1 have an elevated fidelity and specificity to the Curuperê-Dendê and Murucupi rivers (more impacted). The species *Diffflugia distenda* and *Diffflugia* sp7 outstood in Arapiranga river (good conservation).

Keywords: Pollution; River; Rotifer

INTRODUCTION

The Industrial Revolution started in England in the 18th century causing great socio-economic changes with direct impacts both on the production mode and on the population quality of life (Raven & Stobart, 2005). Since then, the old agricultural economy gave way to a capitalist system focused on productivity (Veltmeyer, 2010).

In the 19th century, this industrialization process was no longer limited to England and became international, with company conglomerates being formed in several countries (Maitra, 2011). The creation of these industrial hubs caused the migration of people to places nearby and the formation of urban centers with high population density. However, the fast growth of these large cities was not followed by the required investments in infrastructure in most countries. Suburbs increased and were characterized by the lack of investments in basic sanitation and other minimum conditions to ensure quality of life (Silva & Silveira, 2006).

The precarious conditions of public services, social flows, and fast-track immigration processes generate impacts, which are not restricted to human health, but also extend to environmental compartments (Clark, 2005). The absence of solid residue management policies, the precarious cleaning mechanisms, and insufficient sewage systems contribute decisively to environmental degradation with damaging effects on the fauna and flora of terrestrial and aquatic ecosystems (Marale, 2012).

Throughout the years, many studies have been developed around the world to assess the extension of impacts generated by domestic and industrial effluents discharged into aquatic ecosystems. Toxic substances in the abiotic environment may accumulate and reach different trophic levels (Moon et al., 1994; Eschenhagen et al., 2003; Rocchetta et al., 2014). One example is the Mushim-chum estuary, located in the city of Chungju (South Korea), where there were point sources of domestic effluents and where metal analyses showed that the concentrations of Cd, Pb, and Zn were higher when compared to the amounts in other similar areas with no anthropic activities (Moon et al., 1994). Subsequent researches with bioindicators showed the occurrence of changes in lipid composition and increased oxidative stress of mollusks exposed to environments submitted to the discharge of domestic sewage (Rocchetta et al., 2014). At Port Harcourt (Nigeria), in another area for discharge of domestic and sanitary effluents, studies carried out on zooplankton observed the adaptation of these microorganisms to environments with high pollution rates (Davies, 2009).

After nearly two centuries, the same situation occurred in the Amazon region in the 1980's, when large companies were established in the municipality of Barcarena. This was initially associated to the government's position defending the need for regional development policies and strengthening of the mineral verticalization process of aluminum (Pressler, 2005). After large industries settled in the region, population growth quadrupled over the period ranging from 1980 to 1991, going from 20,000 to 90,000 inhabitants in only one decade. This immigration process, with the consequent population swelling in the areas surrounding these companies, was driven by the potential availability of jobs, mainly during the implementation phase (Lima, 2011). The fast growth in population density resulted in the creation of new districts (Vila dos Cabanos, Bairro Industrial, and Vila do Canaã) and in population increase in the existing ones (Vila do Laranjal and Vila do Conde). This mass population movement towards Barcarena was not followed by the required investments to improve basic sanitation and housing structures in the region. This precarious infrastructure resulted in the direct discharge of untreated domestic and industrial effluents into the local rivers changing the quality of surface waters used until then for subsistence fishing, leisure, and human consumption (Lima, 2011).

Studies show that bioindicators of exposure and effect are potential tools to assess the impact on the environment before the damage reaches higher trophic levels. Bioindicators have already been identified as organisms that respond preventively to the presence or absence of possible changes in the environment due to environmental impacts (Van Gestel & Van Brummelen, 1996).

Due to its short life cycle, many planktonic microorganisms may be considered excellent bioindicators of environmental impacts, since respond quickly to changes that occur in the aquatic environment (Costa, Eskinazi-Leça, & Neumann-Leitão, 2004). Among these microorganisms, zooplankton were characterized as primary consumers that work as a link for energy transfer to higher trophic levels and that respond differently to environmental changes (Dussart, 1964; Sipaúba-Tavares & Rocha, 2003). Previous studies showed that these microorganisms may be impacted from the cellular level, to community structure alteration with changes in their composition, diversity, and density. Such impacts may lead to local extinction of some of the planktonic taxa or even to the permanence and adaptation of opportunistic species (Mclusky, 1989; Uriarte & Villate, 2004).

Over the last years, several papers have used changes in zooplankton communities as an important tool to assess the effects of anthropic activities on marine and freshwater aquatic systems (Moraitou-Apostolopoulou & Ignatiades, 1980; Marneffe et al., 1996; Uriarte & Villate, 2004; Jiang et al., 2010).

In freshwater ecosystems, the zooplankton community is comprised predominantly of Rotifera, Cladocera, Copepoda (Cyclopoida and Calanoida), and Protista (Dantas, Almeida, Barbosa, Carmo, & Moura, 2009). According to the existing literature, there is an increase in abundance of Cladocera, Rotifera, and Cyclopoida in impacted environments, while Calanoida has a better adaptation to oligotrophic environments and disappears in waters with signs of eutrophication (Perbiche-Neves, Fileto, Laço-portinho, Troguer, & Serafim-Júnior, 2013). Nevertheless, there are records showing that the density and composition of these groups may be affected by regional climate changes that influence the higher exchange of nutrients between terrestrial and aquatic environments (Etilé et al., 2008).

In this paper, we developed studies to characterize the zooplankton community, assessing the influence of disorganized territorial occupation and industrial development on the environmental degradation of three rivers located near the industrial and port area of Barcarena and its surroundings. We show the results obtained from the characterization of the zooplankton community in four rivers (Curuperê, Dendê, Murucupi, and Arapiranga) located in the cities of Barcarena and Abaetetuba, both in the northern region of Brazil.

The Curuperê-Dendê and Murucupi rivers are located in the city of Barcarena, near the industrial and port area, whereas Arapiranga river is located in Abaetetuba, in an area located far from the potential impacts on the other rivers assessed (Souza & Lisboa, 2005).

MATERIALS AND METHODS

STUDY AREA

The Murucupi river begins in an environmental preservation area, limited by the districts of Vila de Itupanema and Vila dos Cabanos, Highway PA-483, and the residue tailing pond of the alumina producing industrial hub (red mud). In its natural course, it goes through Vila dos Cabanos, on its left bank, and Vila do Laranjal, on its right bank, discharging into Furo do Arrozal, a channel that interconnects the Pará and São Francisco rivers, after 10 km. Its riparian forests are quite devastated and there are large

stripped areas next to its sources, as well as impoundments for recreation. Areas for leisure were observed along its entire extension as were subsistence fishing activities, mainly by riverside dwellers that live along its banks (Faial, 2009). Historically, there are records of breaches in the red mud tailing ponds in 2003 and 2009, with discharge of solid materials and alkaline effluents directly into the Murucupi river. Discharge ducts or channels of untreated domestic and sanitary effluents were observed, deriving from Vila dos Cabanos and Vila do Laranjal (Santos et al., 2009; Lima et al., 2009).

The main sources of the Curuperê stream are located next to the residue tailing ponds of kaolin processing companies and, along its natural course, it runs along the left bank of the traditional communities of Curuperê, with a quilombola characteristics, and Canaã, which resulted from a resettlement after the industrial and port complex was installed. In its mouth into the Dendê stream, approximately 3 km away, it also passes through the community of Ilha São João. On its banks, the riparian forests have already been quite devastated and there are records of discharge of industrial effluents resulting from the kaolin processing in the period ranging from 1998 to 2014 (Carneiro et al., Lima et al., 2009; Lima, 2011). The Dendê stream begins in an environmental preservation area located near the industrial process of electrolytic reduction of alumina into aluminum ingot. In its natural course, it goes through Trevo do Peteca, Vila do Conde, on its right bank, and the communities of the Industrial District, São Jorge, Ilha São João, and Vila Maricá, on its left bank. Next to its mouth into the Pará river, approximately 7 km away, it runs along another area used for kaolin processing. On its margins, the riparian forests are quite devastated and the discharge of untreated domestic and sanitation effluents have been observed along its natural course.

Arapiranga river begins in the city of Abaetetuba, northern region of Brazil, and discharges into the Pará river next to Vila de Beja. Along its banks, the riparian forests are more preserved when compared to other drainages nearby, such as the Murucupi river, the Curuperê stream, and the Dendê stream, mentioned above. Due to these peculiar characteristics, which indicate a good environmental preservation, and because it is located farther from the industrial and port area of Barcarena, Arapiranga river is considered as a control area, because no domestic sewage or industrial effluent discharges have been recorded on its banks.

REGIONAL CLIMATIC CHARACTERISTICS

Seasonal variation of rainfall is characterized by a rainy season, comprising, typically, November through April, and a less rainy season, which corresponds to May through October (INMET, 2014; Moraes, Maria, Carlos, & Costa, 1998). To confirm and characterize the rainflow cycle, data on monthly rainfall, maximum temperature, relative humidity, and wind speed in the study area were obtained from the National Institute of Meteorology (INMET) database.

SAMPLING

Sampling was carried out quarterly in February, May, August, and November, 2012, closing an annual cycle. All sampling occurred during the lowest ebbing tide (full moon). For all the rivers analyzed, three sampling stations were defined, which were distributed upstream (P1), in an intermediate area (P2), and downstream (P3) (Figure 1). The Curuperê and Dendê streams were studied due to their short extensions, and they were grouped into a single drainage called Curuperê-Dendê, with point P1 in Dendê, and points P2 and P3 in Curuperê.

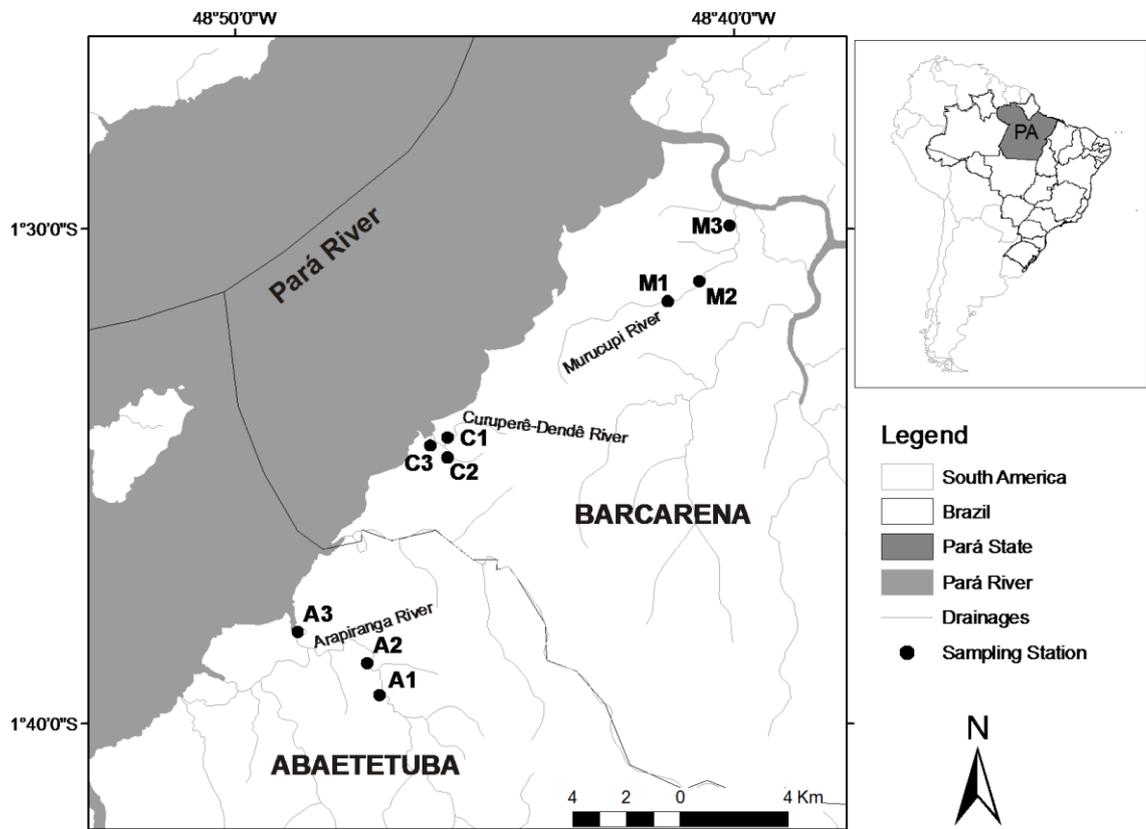


Figure 1. Study area in the Arapiranga (A), Curuperê-Dendê (C) and Murucupi (M) River, Barcarena and Abaetetuba, Pará, Brazil.

For the physico-chemical analyses of surface waters, previously washed 500-mL and 1000-mL polypropylene flasks were used. All samplings were performed at a depth of approximately 30 cm from the water surface. For the samples destined to *fecal coliform* determination, 100-mL NASCOS[®] bags were used and transported in isothermal boxes.

Samples used for the qualitative study of the zooplankton community were obtained by horizontal trawling at the water column subsurface, using a 64 µm plankton net. Samples for the quantitative study were obtained by filtering 200 L of water using a 10-L graduated stainless steel bucket. Subsequently, the material collected was fixed in a 6% formaldehyde solution (Bicudo & Bicudo, 2006) and stored in thermal boxes.

PHYSICO-CHEMICAL AND MICROBIOLOGICAL ANALYSES

The following variables were measured *in situ*: temperature (T), hydrogenionic potential (pH), electric conductivity (EC), total dissolved solids (TDS), salinity (SAL), and dissolved oxygen (DO), using a previously calibrated portable mutliparameter meter (HI9828 - HANNA[®]). Water transparency was estimated by using a Secchi disk, with 30 cm of diameter. The variables turbidity (TRB), apparent color (COLOR), total suspended solids (TSS), and chemical oxygen demand (COD) were determined by UV-VIS Espectrophotometry. To determine the biochemical oxygen demand (BOD), we used the five-day incubation technique (APHA, AWWA, & WEF, 2012). The nitrite-N (N-NO₂⁻), nitrate-N (N-NO₃⁻), nitrogen amonniacal (N-NH₄), Ammonia (NH₃), phosphate (PO₄³⁻), Sulfate (SO₄²⁻), Hardness, Total Alkalinity, Fluoride (F⁻), and Chloride (Cl⁻) were performed by Ion Chromatography (ICS DUAL 2000-DIONEX).

The Most Probable Numbers (MPN) of *fecal coliform*, used to calculate the Water Quality Index (WQI), were measured using QUANTI-TRAYS in water bath at a constant temperature of 44.5 °C.

WATER QUALITY INDEX (WQI)

WQI values were determined according to the criteria and equations elaborated by the Environmental Sanitation Technology Company (CETESB), Government of the São Paulo State, Brazil (Von Sperling, 2009). Based on this index, the waters were classified as Poor (WQI ≤ 19), Marginal (19 < WQI ≤ 36), Fair (36 < WQI ≤ 51), Good (51 < WQI ≤ 79), and Very Good (WQI > 79).

ZOOPLANKTON

The qualitative analyses of the zooplankton community were carried out via the sub-sampling of a 6-mL aliquot in Petri dishes, which were visualized under an inverted optical microscope (Axiovert 40C – Carl Zeiss) coupled to an image capture system (AxioCamMRc). The taxonomic identification of the organisms was performed to the lowest possible level.

Zooplankton density (org/m³) was estimated by quantitative analyses of the subsamples by the sedimentation method, using an inverted optical microscope (Axiovert 40C – Carl Zeiss) with 200 times magnification (Utermöhl, 1958) (Garzio & Steinberg, 2013).

Depending on the degree of occurrence of zooplankton organisms, they were classified as very frequent ($Fr \geq 70\%$), frequent ($30\% \leq Fr < 70\%$), infrequent ($10\% \leq Fr < 30\%$), and sporadic ($Fr < 10\%$).

STATISTICS

We applied multivariate analyses tools to test the differences in limnological characteristics of surface waters between the sampling points and the seasonal periods. After organizing and standardizing the data, a Principal Component Analysis (PCA) was performed (Legendre & Legendre, 2012). We used the program Minitab 14 in this stage.

In order to assess the similarity in organism composition and density between the points and periods of the rivers studied, a Non-Metric Multidimensional Scaling (NMDS) was used (Legendre & Legendre, 2012). In order to check significant differences between the groups ordered by NMDS, we used the Bifactor Analysis of Similarity ANOSIM (Clarke & Warwick, 2011). These analyses were calculated using the R.Project program available at <http://www.r-project.org>.

RESULTS

LIMNOLOGY

According to the values of total rainfall and wind speed in 2012, the period with the highest incidence of rain occurred from January to March (Figure 2-A). Soon after, the rains gradually decreased, from April to October, and its intensity increased again from November onwards. In the same figure, we can see that the wind speed in the

region increases gradually from January to April and then, it decreases, showing a nearly constant behavior from June to December.

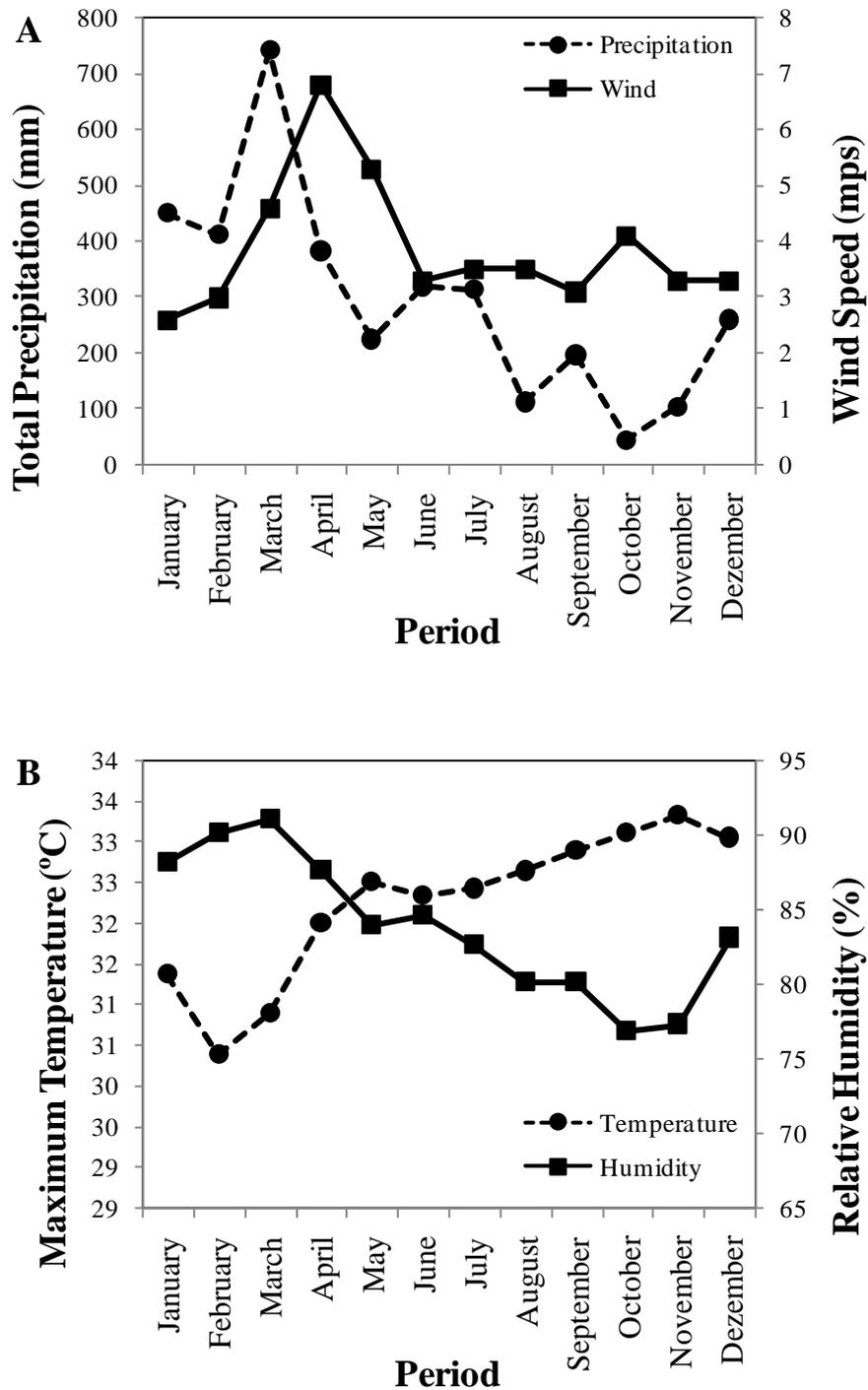


Figure 2. (A) Total Rainfall and Wind Speed; (B) maximum temperature and relative Humidity in 2012. Source: INMET, 2014.

However, the maximum temperature and relative humidity showed inverted patterns (Figure 2-B). The first four months of the year, period of lowest temperatures was also the period with the highest relative humidity rates. From May on, there was an inversion in this behavior and the region had higher temperatures and decreased humidity. Despite these oscillations, relative humidity was high throughout the year, with variations ranging from 74 to 91%.

Based on the Water Quality Index, we observed that Arapiranga is the only river that has waters classified as good in average. The Curuperê-Dendê and Murucupi rivers recorded fair waters in average; however, at many points along Murucupi, the WQI calculation classified waters as marginal, mainly in the points closer to the domestic and sanitary effluent discharge (Table 1 - supplementary material).

Data on the physico-chemical variables of the water are presented in Tables 2, 3 and 4 (supplementary material). PCA, Figure 3-A, generated based on the physico-chemical parameters of water measured for Arapiranga, Curuperê-Dendê, and Murucupi rivers, showed the formation of four different groups (A, B, C, and D). PC1 (20.3%) allowed for a good separation between groups C (quadrant III) and D (quadrant IV), while PC2 (15.7%) separated Group A (quadrant I) from groups C and D. The influences of the physico-chemical variables of the groups can be observed in Figure 3-B.

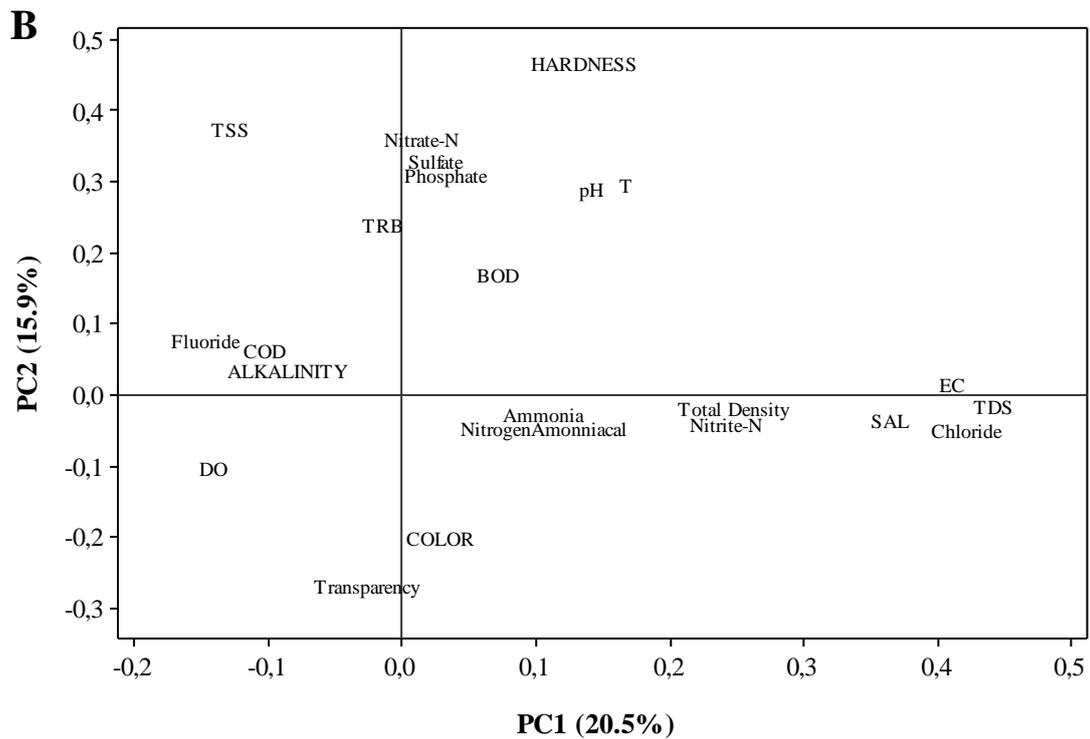
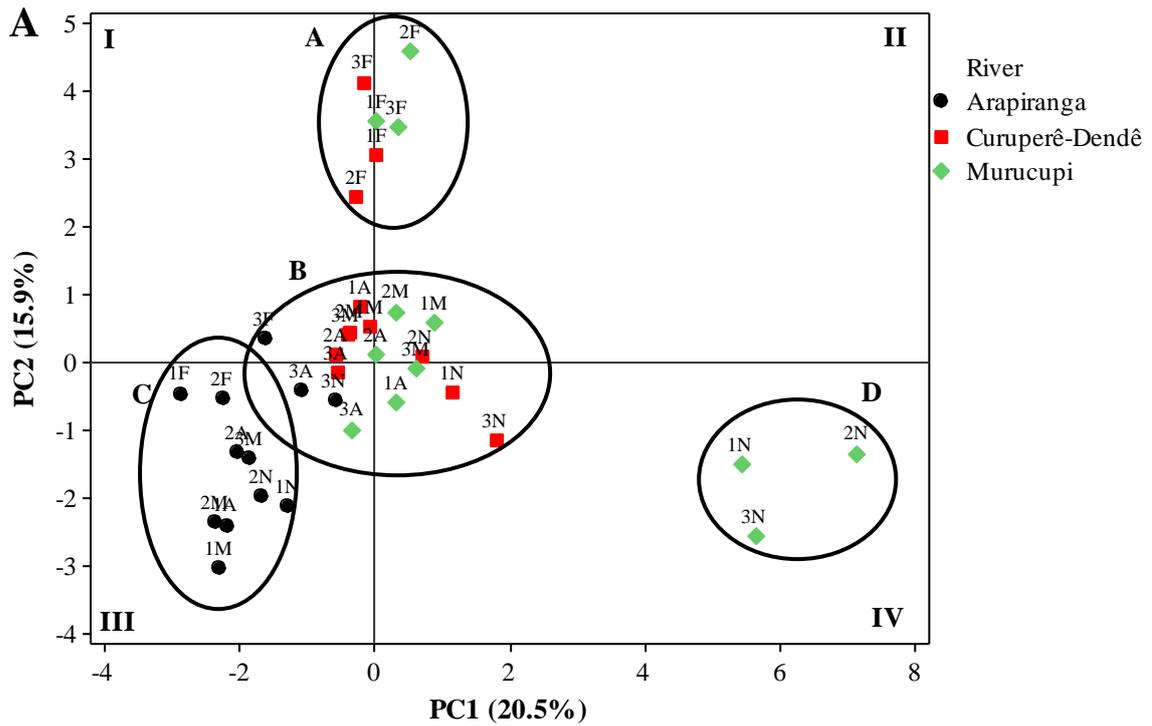


Figure 3. PCA for physicochemical variables in the Arapiranga, Curuperê-Dendê and Murucupi Rivers in 2012. (A) Score plot for the first 2 components; (B) Loading plot for the first 2 components

ZOOPLANKTON COMMUNITY

The zooplankton community in the three rivers was comprised of 149 taxa, distributed in thirty-four genera, twenty-four families, eleven orders, ten classes, and seven phyla. The most representative family was Diffugiidae (21 species), followed by Arcellidae (17 species); Brachionidae (15 species); Lecanidae (12 species); Trichotriidae (10 species); and Euglyphidae, Trichocercidae (both with 9 species). In Tables 5, 6, and 7 of the supplementary material, information is available regarding taxonomic composition and classification of the species/groups recorded in Arapiranga, Curuperê-Dendê, and Murucupi, respectively.

According to the frequency of occurrence, the taxa were classified as very frequent (14%), frequent (32%), infrequent (50%), and sporadic (66%). In Arapiranga river, the taxa present in all samples (100%) were Cyclopoida copepodites, Copepod nauplius, *Codonella cratera*, and *Keratella cochlearis*. In Curuperê-Dendê, the very frequent taxa (100%) were Cyclopoida copepodites, Copepod Nauplius, *Codenella* sp1, *Tintinnina* sp1, *Bdelloidea* sp2, *Keratella lenzi*, *Keratella cochlearis*, and *Keratella americana*. At Murucupi river, the samples with 100% of frequency of occurrence were Cyclopoida sp1, Cyclopoida Copepodite, Copepod Nauplius, *Bosminopsis deitersi*, Cladocera egg, *Bdelloidea* sp2, *Keratella lenzi*, *Keratella cochlearis*, and *Filinia terminalis*.

According to the similarity test, (ANOSIM), the composition and density of the zooplankton community is significantly different between the three rivers studied ($r=0.275$; $p=0.001$). Only Arapiranga river ($r=0.506$; $p=0.002$) was different between the months sampled. Spatially, the density of zooplankton organisms were different between the rivers (Figure 4), Arapiranga river has the lowest mean values ($75,847 \text{ org.m}^{-3}$), followed by Curuperê-Dendê ($97,931 \text{ org.m}^{-3}$) and Murucupi ($190,597 \text{ org.m}^{-3}$).

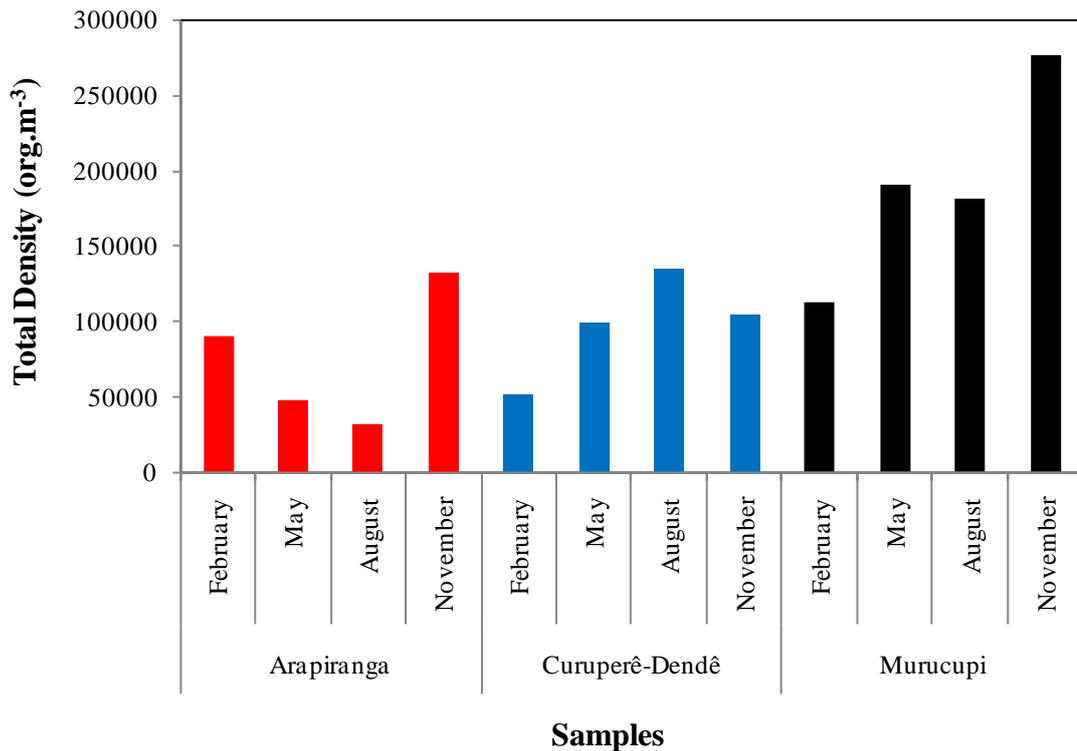


Figure 4. Total Density of the zooplanktonic community in the Arapiranga, Curuperê-Dendê and Murucupi Rivers in 2012.

In Arapiranga river, thecamoebas were positively correlated to COLOR ($r= 0.666$; $p= 0.018$), COD ($r= 0.618$; $p= 0.032$), BOD ($r= 0.698$; $p= 0.012$), and inversely correlated to TRB ($r= -0.785$; $p= 0.003$) and HARDNESS ($r= -0.591$; $p= 0.043$). In the Curuperê-Dendê river, they were correlated only to fluoride ($r= 0.777$; $p= 0.003$) and in Murucupi, there was no correlation with any physico-chemical variables.

Rotifers were correlated to Ammoniacal Nitrogen ($r= 0.863$; $p< 0.001$) and Ammonia ($r= 0.857$; $p< 0.001$) in Arapiranga river. In Curuperê-Dendê, there were influences on density associated with COD ($r= 0.826$; $p= 0.001$) and in Murucupi, we observed a good correlation with SAL ($r= 0.600$; $p= 0.039$). Cladocera were correlated to COLOR ($r= -0.817$; $p= 0.001$) and BOD ($r= 0.678$; $p= 0.015$) in Arapiranga and Curuperê-Dendê rivers, respectively.

BIOINDICATORS

The indicator species analysis (IndVal) indicated that *Keratella lenzi* ($t= 0.989$; $p= 0.005$) and *Anureaopsis* sp1 ($r= 0.736$; $p= 0.005$) have a high fidelity and specificity to

the Curuperê-Dendê and Murucupi rivers. The species *Diffflugia distenda* ($r= 0.663$; $p= 0.015$) and *Diffflugia* sp7 ($r= 0.577$; $p= 0.010$) outstood in Arapiranga river.

DISCUSSION

LIMNOLOGY

According to literature, there are scarce systematic studies that consider winds as direct dispenser factors of zooplankton, or that don't dismiss this possibility or associations to indirect factors that quickly change the limnological characteristics of aquatic ecosystems (Pineiro, Magalhães, Costa, Pereira, & Costa, 2013).

Zooplankton are sensitive to temperature changes, since their metabolism is directly affected by abrupt changes in temperature (Benndorf, Kranich, Mehner, & Wagner, 2001; Smith, Burns, Shearer, & Snell, 2012). However, it is not a determining factor for the area, because the variations are negligible throughout time, which is typical of tropical regions (Magalhães, Nobre, Bessa, Pereira, & Costa, 2011).

Group A of PCA allocated all points of the Curuperê-Dendê and Murucupi rivers in February. This grouping is related to the increase in the variables sulphate, nitrate, phosphate, pH, hardness, and turbidity (Figure 3B), which is related to the rainiest period in the region, causing the intensification of the leaching process of nutrients carried by rain waters towards aquatic ecosystems. This differentiation for these rivers might be associated to some peculiar characteristics, among which are: the fact that they present quite devastated riparian forests, the intense human occupation on their banks in precarious sanitary conditions, and the use of the river bed for recreation activities (Carvalho, Schlittler, & Tornisielo, 2000).

In February, the WQI of the Murucupi river varies from marginal (M1) to fair (M2 and M3), and fair in the Curuperê-Dendê river; confirming that the water quality has decreased in these environments, possibly due to the above-mentioned factors.

Group B comprised point 3 of Arapiranga river from February, May, and August, the three points (M1, M2, and M3) of the Murucupi river, from May and August, and all the points from Curuperê-Dendê referring to May, August, and November (C1, C2, and C3). Unlike the other groups, this group didn't have a strong influence from only one variable, showing a higher homogeneity. In group B, there was a higher number of points, most of which referred to the less rainy months. The absence of particularity in the physico-chemical variables in this group might be associated to the influence of the

Pará river on such drainages, since their main contributor is the tidal regime in this period (Gregório & Mendes, 2009).

In group C, all points of May and points 1 and 2 of February, August, and November referring to Arapiranga river are present. In this group, the relation occurred due to the increase in transparency, COD, and BOD, which might be benefiting from the process of decomposition of (humic) vegetables and by decreased pH and hardness. The combination of all these points is justified by the characteristics of this river, with a longer extension and a greater distance between its sources and the mouth in the Pará river. Closer to its sources, the riparian forests are more preserved, which increases the acid pH due to the high presence of humic substances (Yin et al., 2011).

Grouping D comprised November of the Mucurupi river; its waters ranged from Fair (next to the sources – M1 and M2) to Good (next to the mouth – M3), according to the WQI. November was correlated to conductivity, total dissolved solids, salinity, and chlorides. In this month, there is still a reduced volume of rains; therefore, the main influence in this period may be associated to a greater anthropic rate, mainly deriving from domestic and sanitary sewages, mostly near the sources. These effluents have many metallic, cationic, and anionic ions, which justifies the increase in the variables in this period (Oboh, Aluyor, & Audu, 2009).

ZOOPLANKTON COMMUNITY

According to Navarro & Modenutti (2012), the differentiation between the rivers, via the ANOSIM method, demonstrated the peculiarity of each environment, proving that anthropic activities may change the biota in aquatic ecosystems.

Arapiranga was the only river that showed differences in zooplankton community structure among the seasons. It is also the only river whose waters were classified as good due to the limited anthropic impact along its margins. This aspect allows for the striking natural parameters in the region, such as rainfall, to still exercise influence over the dynamics of this drainage, leading to the main changes in abiotic and biotic environments (Navarro & Modenutti, 2012). The Curuperê-Dendê and Murucupi rivers did not differentiate seasonally; this emphasized that the continuous discharge of domestic sewage in these rivers affects the natural processes of Amazon ecosystems, which causes the zooplankton community be more homogeneous in any period of the year.

Park & Marshall (2000) also observed the growth in zooplankton biomass as the trophic levels in the environment increase, which also occurred in the present study, where the highest densities were recorded in the Mucurupi river. In Figure 4, we can observe that density of thecamoebas showed slight seasonal variations, as well as variations between the drainages. The highest densities were recorded in Arapiranga river, with lower anthropic activities.

The dominance of this group in Arapiranga river is justified, according to Madoni (1994), by the preference of thecamoebas for low organic rate environments. Silva (2011) also observed the better development of these organisms in environments with a lower anthropic impact.

Rotifers were clearly influenced by geographical location and, therefore, showed distinctive patterns between the three drainages (Arapiranga, Curuperê-Dendê, and Murucupi). As in the studies of May & O'Hare (2005) and Wen et al. (2010), the lower density of this group in Arapiranga river, when compared to Murucupi and Curuperê-Dendê, suggests that the discharge of domestic sewages favors their presence in rivers with higher environmental impacts.

The highest densities of cladocera were recorded in the Murucupi river, this dominance was attributed mainly *Bosminopsis deitersi*. This group prevails in oligotrophic environments (Dantas-Silva & Dantas, 2013). However, their high density in Mucurupi, compared to the other rivers, is justified by its feeding characteristics; it has filtering habits, and it feeds more easily from nutrients available in eutrophicated environments, which leads to its higher proliferation and permanence in these locations (Panosso et al, 2003).

Similar to rotifers and cladocerans, copepods showed the same density pattern in the Murucupi river, and this group's composition was mainly represented by juvenile stages of Cyclopoida (nauplii and copepodites); these organisms are easily adapted to eutrophicated environments (Perbiche-Neves et al., 2013).

BIOINDICATORS

The dominance of the rotifers *Anuraeopsis* and *Keratella* in the Curuperê-Dendê and Murucupi rivers, which receive large amounts of domestic sewage discharges, corroborates the work of Haberman & Haldna (2014), who demonstrated that species of these genera are indicative of eutrophicated environment. The species *Diffugia distenda* outstood in Arapiranga river; as in our study, this species was indicated by Souza (2014)

for environments with non-eutrophicated conditions and is thus an indicator of good water quality.

CONCLUSION

Our study on Arapiranga, Curuperê-Dendê, and Murucupi rivers show that the effluents deriving from domestic activities influence the zooplankton community structure, which is different between the rivers.

Keratella lenzi and *Anureaopsis* sp1 proved to be potential bioindicators of eutrophicated waters, while *Diffugia distenda* and *Diffugia* sp7 are potential bioindicators of good quality environments, according to IndVal. These species should be used in the medium and long term in monitoring studies of environmental quality of rivers with similar characteristics to this region, and more in-depth studies may show its application to other Amazon rivers, with the same purpose.

Nevertheless, the density of these species already makes it evident that the discharge of untreated domestic and sanitary effluents is the probable source of changes in the zooplankton community structure in the area. According to these results, the Curuperê-Dendê, and Murucupi drainages are already in an advanced process of degradation, with its water quality compromised. As a counterpoint, the same results emphasize the environmental quality of Arapiranga river, considered good due to its still preserved riparian forests and the probably absence of impacts associated to the discharge of untreated effluents.

We emphasize that the presence of large industries in the Barcarena region indirectly brought environmental impacts associated to precarious public investments for the adequate treatment of domestic and sanitary effluents. This demonstrates that there is an immediate need for public policies for the construction of residue treatment systems, as well as the environmental recovery of the rivers already affected. On the other hand, quick measures that might keep the preservation of environmental quality of the waters of Arapiranga river must be taken in the city of Abaetetuba.

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CONSIDERAÇÕES FINAIS

Este trabalho demonstra que a comunidade zooplanctônica é influenciada pelo escoamento de resíduos a partir das atividades desenvolvidas no complexo industrial e portuário. A proximidade da área industrial e portuária influencia diretamente na composição e densidade da comunidade planctônica. Assim como os efluentes oriundos das atividades domésticas influenciam na dinâmica populacional desta comunidade.

Existe também boa associação entre a produção destes organismos com a sazonalidade da região. Fica evidenciado que a densidade zooplanctônica também foi maior nos períodos de maior volume de chuvas na região.

Destacamos a espécie *Filinia opoliensis* como potencial bioindicadora da qualidade ambiental em frente ao porto, e as espécies *Keratella lenzi* e *Anureaopsis* sp1 nas drenagens que recebem maior ecomento de efluentes domésticos. Suas presenças nesses ambientes é um bom indicativo de que essas atividades antrópicas estão influenciando na estruturação da comunidade zooplanctônica e o rio Pará, Curuperê-Dendê e Murucupi e que os mesmos já passam por processo de eutrofização.

Essas espécies podem ser usadas a médio e longo prazo em estudos de monitoramento da qualidade ambiental dos rios de características similares da região e estudos mais profundos poderão demonstrar sua aplicação com a mesma finalidade em outros rios da Amazônia.

Estudos complementares devem ser conduzidos para avaliação da presença de *Filinia opoliensis* em toda extensão do rio Pará e áreas mais distantes nas bacias hidrográficas dos rios Tocantins e Amazonas. Essas informações serão importantes para definição da espécie como bioindicadora da qualidade ambiental dos rios da Amazônia.

No entanto, a presença destas espécies já evidencia que o despejo de resíduos domésticos e sanitários sem tratamento são as prováveis fontes de alteração na estruturação da comunidade zooplanctônica em boa parte da área de estudo. Concordando com esses resultados, as drenagens Curuperê, Dendê e Murucupi já se encontram em processo avançado de degradação ambiental, com comprometimento da qualidade de suas águas. Como contraponto, os mesmos resultados enfatizam a qualidade ambiental do rio Arapiranga considerada como boa, devido suas características ainda preservadas de suas matas ciliares e a inexpressividade de impactos associados ao lançamento de efluentes domésticos e sanitários não tratados.

Ressaltamos que a presença de grandes indústrias na região de Barcarena trouxe indiretamente impactos ambientais associados a precariedades em investimentos públicos para o tratamento adequado dos efluentes domésticos e sanitários. Isso demonstra a necessidade imediata de políticas públicas para construção de sistemas de tratamento de resíduos, bem como a recuperação ambiental dos rios já afetados. Ao contrário também se deve tomar medidas rápidas que possam manter a preservação da qualidade ambiental das águas do rio Arapiranga na cidade de Abaetetuba.

Os resultados demonstram a necessidade de investimentos em políticas públicas para melhorar o acompanhamento efetivo desde a implantação de atividades portuárias e industriais na Amazônia, pois fica mais evidente que as mesmas são poluidoras e que mesmo o grande volume de águas da região pode não suportar o lançamento continuado de efluentes cujos tratamentos podem não ser eficazes.

APÊNDICE I (PRIMEIRO ARTIGO)

Table 1. Seasonal variation of physicochemical variables in the Pará River in 2012

Physicochemical Variables	February					May					August					November				
	P1	P2	P3	P4	P5	P1	P2	P3	P4	P5	P1	P2	P3	P4	P5	P1	P2	P3	P4	P5
T (°C)	29.52	29.66	29.59	29.55	29.64	29.85	30.11	30.46	30.02	30.08	30.10	29.90	29.80	29.80	30.20	28.99	29.22	28.96	29.54	29.05
pH	7.16	7.46	6.89	7.26	7.42	7.31	7.04	7.17	7.20	7.06	7.43	7.42	7.75	7.12	6.49	7.43	7.98	7.68	7.93	7.69
EC ($\mu\text{S}\cdot\text{cm}^{-1}$)	41.00	46.00	44.00	52.00	51.00	32.00	18.00	34.00	36.00	34.00	46.00	55.00	52.00	56.00	51.00	67.00	53.00	60.00	81.00	109.00
TDS ($\text{mg}\cdot\text{L}^{-1}$)	21.00	23.00	22.00	26.00	25.00	16.00	9.00	17.00	18.00	17.00	23.00	27.00	26.00	28.00	25.00	33.00	26.00	30.00	41.00	55.00
SAL ($\text{mg}\cdot\text{L}^{-1}$)	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.01	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.03	0.04	0.05
DO ($\text{mg}\cdot\text{L}^{-1}$)	7.26	9.19	7.18	6.54	5.26	5.58	7.00	8.26	5.84	6.26	7.08	9.78	8.94	5.71	6.65	7.81	7.29	6.67	5.29	5.98
Transparency (cm)	40.0	50.0	50.0	70.0	60.0	50.0	80.0	80.0	100.0	90.0	80.0	90.0	100.0	100.0	80.0	60.0	70.0	50.0	60.0	60.0
TRB (UNT)	11.25	8.25	9.25	8.00	12.25	6.00	4.50	4.50	4.50	4.50	6.50	4.50	3.50	4.00	5.50	16.00	12.00	15.00	12.00	19.00
COLOR (UC)	10.00	9.00	3.00	21.00	12.00	22.50	21.00	59.50	25.50	30.50	11.00	3.00	15.00	8.00	7.50	11.00	19.00	16.00	31.00	21.00
TSS ($\text{mg}\cdot\text{L}^{-1}$)	17.00	10.00	5.00	11.00	11.00	5.50	3.50	5.50	5.50	2.50	13.00	7.50	4.00	5.00	9.50	10.00	2.00	8.00	1.00	9.00
COD ($\text{mg}\cdot\text{L}^{-1}$)	37.00	15.00	12.00	17.00	17.00	12.00	14.00	19.00	10.00	12.00	13.00	9.00	9.00	12.00	9.00	14.00	13.00	16.00	13.00	14.00
BOD ($\text{mg}\cdot\text{L}^{-1}$)	20.35	8.25	6.60	9.35	9.35	7.80	9.10	12.35	6.50	7.80	5.00	5.00	4.00	7.00	4.00	6.00	8.00	10.00	5.00	13.00
N-NO ₂ ⁻ ($\text{mg}\cdot\text{L}^{-1}$)	0.03	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.03	0.03	0.03	0.01	0.02	0.02	0.02	0.03	0.01	0.02	0.02	0.03
N-NO ₃ ⁻ ($\text{mg}\cdot\text{L}^{-1}$)	0.85	0.81	0.94	0.89	0.83	0.36	0.35	0.37	1.76	0.72	0.95	1.93	1.62	2.53	1.65	0.94	0.83	0.88	0.67	0.72
N-NH ₄ ($\text{mg}\cdot\text{L}^{-1}$)	0.38	0.32	0.34	0.12	0.24	0.02	0.00	0.02	0.10	0.09	0.20	0.16	0.18	0.11	0.17	0.28	0.23	0.26	0.16	0.24
PO ₄ ³⁻ ($\text{mg}\cdot\text{L}^{-1}$)	0.09	0.21	0.20	0.05	0.08	0.11	0.08	0.11	0.04	0.06	0.12	0.18	0.12	0.15	0.17	0.13	0.20	0.14	0.17	0.18
SO ₄ ²⁻ ($\text{mg}\cdot\text{L}^{-1}$)	1.92	3.46	2.59	5.16	4.91	1.02	1.21	0.81	3.23	1.78	1.51	1.53	1.51	5.11	2.57	2.46	2.50	2.52	3.53	4.51
F ⁻ ($\text{mg}\cdot\text{L}^{-1}$)	0.05	0.06	0.05	0.06	0.06	0.03	0.07	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.08	0.08	0.07	0.03	0.03
Hardness ($\text{mg}\cdot\text{L}^{-1}$)	11.43	12.38	12.75	14.07	12.85	5.37	5.91	3.99	8.63	7.43	5.72	5.68	5.77	5.92	6.07	6.33	3.37	4.59	6.37	7.32
Alkalinity ($\text{mg}\cdot\text{L}^{-1}$)	16.00	16.00	16.00	16.00	17.00	15.00	20.00	20.00	10.00	20.00	20.00	20.00	20.00	18.00	20.00	30.00	15.00	25.00	20.00	17.00
Cl ⁻ ($\text{mg}\cdot\text{L}^{-1}$)	2.01	2.38	2.10	2.89	2.71	1.62	1.96	1.84	2.06	1.47	1.24	2.60	2.12	1.84	1.76	5.23	5.56	4.65	12.02	22.05
NH ₃ ($\text{mg}\cdot\text{L}^{-1}$)	0.31	0.27	0.28	0.10	0.20	0.01	0.00	0.01	0.08	0.07	0.16	0.13	0.15	0.09	0.14	0.23	0.19	0.21	0.13	0.20

Table 2. Classification and frequency of occurrence of zooplankton organisms in the Pará River in 2012.

Taxa	February					May					August					November					FR (%)	Classification	
	P1	P2	P3	P4	P5	P1	P2	P3	P4	P5	P1	P2	P3	P4	P5	P1	P2	P3	P4	P5			
Phylum: Rotifera																							
Class: Eurotatoria																							
Order: Flosculariaceae																							
Family: Hexarthridae																							
Genera: <i>Hexarthra</i>																							
<i>Hexarthra</i> sp. Schmarda, 1854				x	X					x			x	x					x	30	Frequente		
<i>Hexarthra</i> sp1 Schmarda, 1854	X		x											x						15	Infrequent		
Family: Trochosphaeridae																							
Genera: <i>Filinia</i>																							
<i>Filinia camasecla</i> Myers, 1938	X	x	x	x						x										25	Infrequent		
<i>Filinia longiseta</i> Ehrenberg, 1834	X	x	x	x	x							x				x	x	x	x	50	Frequente		
<i>Filinia opoliensis</i> Zacharias, 1898		x	x	x					x				x			x	x	x		40	Frequente		
<i>Filinia terminalis</i> Plate, 1886	x	x	x		x		x	x	x	x	x	x	x	x	x	x	x		x	85	Very Frequent		
Order: Ploima																							
Family: Asplanchnidae																							
Genera: <i>Asplanchna</i>																							
<i>Asplanchna</i> sp1 Gosse, 1850	x			x																10	Infrequent		
Family: Brachionidae																							
Genera: <i>Anuraeopsis</i>																							
<i>Anuraeopsis</i> sp1 Lauterborn, 1990		x																		5	Sporadic		
Genera: <i>Brachionus</i>																							
<i>Brachionus caudatus</i> Barrois & Daday, 1984	x	x	x	x	x							x				x	x			40	Frequente		
<i>Brachionus mirus</i> Daday, 1905		x	x	x	x		x		x			x	x	x	x	x	x		x	70	Very		

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Taxa	February					May					August					November					FR (%)	Classification
	P1	P2	P3	P4	P5	P1	P2	P3	P4	P5	P1	P2	P3	P4	P5	P1	P2	P3	P4	P5		
<i>Brachionus zahniseri gessneri</i> Hauler, 1956 Genera: <i>Keratella</i>								x	x							x		x			20	Infrequent
<i>Keratella americana</i> Carlin, 1943	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100	Very Frequent
<i>Keratella cochlearis</i> Gosse, 1851	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100	Very Frequent
<i>Keratella lenzi</i> Hauer, 1937		x			x	x	x									x	x				30	Frequente
<i>Keratella</i> sp1 Boy de St. Vicent, 1822 Family: Lecanidae Genera: <i>Lecane</i>																						
<i>Lecane bulla</i> Gosse, 1851			x										x					x			15	Infrequent
<i>Lecane lunaris</i> Ehnerberg, 1832	x		x																		10	Infrequent
<i>Lecane papuana</i> Murray, 1913 Genera: <i>Monostyla</i>			x	x	x											x	x	x	x	x	40	Frequente
<i>Monostyla elachis</i> Haring & Myers, 1926 Family: Trichocercidae Genera: <i>Trichocerca</i>	x				x						x					x	x	x	x		35	Frequente
<i>Trichocerca capucina</i> Wierzejski & Zacharias, 1893																		x			5	Sporadic
<i>Trichocerca gracilis</i> Tessin, 1890								x													5	Sporadic
<i>Trichocerca similis</i> Wierzejski, 1893			x										x								10	Infrequent
<i>Trichocerca</i> sp1 Lamarck, 1801										x						x	x	x			20	Infrequent
<i>Trichocerca jenningsi</i> Voigt, 1957 Order: Bdelloidea		x		x		x	x			x			x				x	x			40	Frequente
Bdelloidea sp1		x			x														x		15	Infrequent
Bdelloidea sp2	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100	Very

Table 2. Classification and frequency of occurrence of zooplankton organisms in the Pará River in 2012.

Taxa	February					May					August					November					FR (%)	Classification
	P1	P2	P3	P4	P5	P1	P2	P3	P4	P5	P1	P2	P3	P4	P5	P1	P2	P3	P4	P5		
Bdelloidea sp3	x					x	x	x										x			25	Infrequent
Bdelloidea sp5	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	95	Very Frequent
Bdelloidea sp8		x	x				x	x	x												25	Infrequent
Bdelloidea sp.																	x				5	Sporadic
Phylum: Lobosa																						
Class: Testacealobosa																						
Order: Arcellinida																						
Family: Arcellidae																						
Genera: <i>Arcella</i>																						
<i>Arcella</i> sp. Ehrenberg, 1832										x								x			10	Infrequent
<i>Arcella vulgaris</i> Ehrenberg, 1830			x					x													10	Infrequent
Family: Centropyxidae																						
Genera: <i>Centropyxis</i>																						
<i>Centropyxis aculeata</i> Ehrenberg, 1838	x		x							x		x							x		25	Infrequent
Family: Diffugiida																						
Genera: <i>Diffugia</i>																						
<i>Diffugia elegans</i> Penard, 1890	x	x															x	x			20	Infrequent
<i>Diffugia pyriformes</i> Perty, 1849			x																x		10	Infrequent
<i>Diffugia</i> sp. Leclerc, 1815	x											x		x			x		x		25	Infrequent
Family: Lesquereusiidae																						
Genera: <i>Lesquereusia</i>																						
<i>Lesquereusia</i> sp. Schlumberger, 1845										x											5	Sporadic
Genera: <i>Netzelia</i>																						
<i>Netzelia wailesi</i> Ogden, 1980	x		x																		10	Infrequent
Phylum: Cercozoa																						

Table 2. Classification and frequency of occurrence of zooplankton organisms in the Pará River in 2012.

Taxa	February					May					August					November					FR (%)	Classification	
	P1	P2	P3	P4	P5	P1	P2	P3	P4	P5	P1	P2	P3	P4	P5	P1	P2	P3	P4	P5			
Class: Imbricatea																							
Order: Euglyphida																							
Family: Euglyphidae																							
Genera: <i>Euglypha</i>																							
<i>Euglypha acanthophora</i> Ehrenberg, 1841		x																			5	Sporadic	
Phylum: Ciliophora																							
Class: Polihymenophorea																							
Order: Oligotrichida																							
Tintinnina sp1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100	Very Frequent	
Tintinnina sp4					x	x														x	15	Infrequent	
Family: Codonellidae																							
Genera: <i>Codonella</i>																							
<i>Codonella cratera</i> Leidy, 1877	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	95	Very Frequent	
Phylum: Arthropoda																							
Class: Branchiopoda																							
Order: Diplostraca																							
Neonate of cladocera		x									x					x	x	x			25	Infrequent	
Family: Bosminidae																							
Genera: <i>Bosmina</i>																							
<i>Bosmina hagmanni</i> Stingelin, 1904		x	x										x			x					20	Infrequent	
<i>Bosmina longirostris</i> Müller, 1785			x													x	x	x			20	Infrequent	
<i>Bosmina</i> sp. Baird, 1845			x																		5	Sporadic	
Genera: <i>Bosminopsis</i>																							
<i>Bosminopsis deitersi</i> Richard, 1895	x	x	x	x							x	x				x	x	x			45	Frequente	
Family: Sididae																							

Table 2. Classification and frequency of occurrence of zooplankton organisms in the Pará River in 2012.

Taxa	February					May					August					November					FR (%)	Classification																					
	P1	P2	P3	P4	P5	P1	P2	P3	P4	P5	P1	P2	P3	P4	P5	P1	P2	P3	P4	P5																							
Genera: <i>Diaphanosoma</i>																																											
<i>Diaphanosoma birgei</i> Korinek, 1981																																											
Family: Daphniidae																																											
Genera: <i>Ceriodaphnia</i>																																											
<i>Ceriodaphnia cornuata</i> Sars, 1885																																											
Family: Moinidae																																											
Genera: <i>Moina</i>																																											
<i>Moina minuta</i> Hansen, 1899																						x	x	x	x	x						x	x		x	x	x	x	x	x	x	65	Frequente
Class: Maxillopoda																																											
Nauplii																						x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100	Very Frequent
Order: Cyclopoida																																											
Copepodite of Cyclopoida																						x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100	Very Frequent
Cyclopoida sp1																						x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	95	Very Frequent
Cyclopoida sp2																																x		x								10	Infrequent
Order: Calanoida																																											
Calanoida sp1																								x		x			x			x	x	x	x		x		x	x	x	55	Frequente
Calanoida sp2																						x												x								10	Infrequent
Copepodite of Calanoida																						x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	95	Very Frequent
Phylum: Mollusca																																											
Class: Gastropoda																																											
Larva of Gastropoda																						x	x						x												x	20	Infrequent
Class: Bivalvia																																											
Larva of Bivalve																						x	x	x	x	x									x							30	Frequente

Table 2. Classification and frequency of occurrence of zooplankton organisms in the Pará River in 2012.

Taxa	February					May					August					November					FR (%)	Classification	
	P1	P2	P3	P4	P5	P1	P2	P3	P4	P5	P1	P2	P3	P4	P5	P1	P2	P3	P4	P5			
Phylum: Annelida																							
Class: Polychaeta																							
Polichaeta					x																x	10	Infrequent

APÊNDICE II (SEGUNDO ARTIGO)

Table 1. Water Quality Index in Arapiranga, Curuperê-Dendê, and Murucupi rivers in 2012.

Rivers	February			May			August			November			Mean	Classification
	Pt 01	Pt 02	Pt 03	Pt 01	Pt 02	Pt 03	Pt 01	Pt 02	Pt 03	Pt 01	Pt 02	Pt 03		
Arapiranga	49	48	59	50	46	57	57	55	65	52	52	62	54	Good
Curuperê-Dendê	47	50	50	48	59	51	36	42	42	49	57	51	49	Regular
Murucupi	30	37	45	33	36	44	44	39	56	40	39	52	41	Regular

Table 2. Seasonal variation of physicochemical variables in the Arapiranga River in 2012.

Physico Chemical Variables	February			May			August			November		
	P1	P2	P3	P1	P2	P3	P1	P2	P3	P1	P2	P3
T (°C)	25,96	26,94	28,22	26,00	27,00	28,00	26,70	26,86	29,06	26,86	26,99	28,53
pH	5,13	5,50	6,41	4,94	4,18	5,84	5,50	5,45	6,63	5,45	5,35	6,40
EC ($\mu\text{S.cm}^{-1}$)	18,00	20,00	39,00	14,00	17,00	26,00	18,00	16,00	40,00	26,00	27,00	72,00
TDS (mg.L^{-1})	9,00	10,00	20,00	7,00	8,00	13,00	9,00	8,00	20,00	13,00	13,00	36,00
SAL (mg.L^{-1})	0,01	0,01	0,02	0,00	0,01	0,01	0,01	0,01	0,02	0,01	0,01	0,03
DO (mg.L^{-1})	6,60	6,79	9,36	3,92	4,34	2,53	6,12	5,45	6,40	7,81	7,19	8,39
Transparency (cm)	70,00	50,00	50,00	70,00	50,00	60,00	110,00	90,00	80,00	60,00	60,00	50,00
TRB (UNT)	27,60	14,40	19,20	6,00	8,00	8,00	20,00	23,00	23,00	16,00	15,00	18,00
COLOR (UC)	14,00	14,00	7,00	46,00	56,00	43,00	25,00	21,00	29,00	38,00	30,00	23,00
TSS (mg.L^{-1})	23,00	12,00	16,00	4,00	11,00	10,00	9,00	15,00	12,00	6,00	4,00	7,00
COD (mg.L^{-1})	34,00	30,00	12,00	28,00	73,00	40,00	11,00	14,00	14,00	24,00	22,00	24,00
BOD (mg.L^{-1})	8,00	9,00	6,00	10,00	42,00	18,00	5,00	3,00	5,00	10,00	9,00	6,00
N-NO ₂ ⁻ (mg.L^{-1})	0,02	0,06	0,05	0,05	0,02	0,02	0,04	0,06	0,02	0,04	0,03	0,02
N-NO ₃ ⁻ (mg.L^{-1})	0,42	0,63	0,72	0,17	0,26	0,21	0,53	0,97	2,39	0,73	0,59	0,77
N-NH ₄ (mg.L^{-1})	0,12	0,11	0,10	0,03	0,10	0,08	0,08	0,09	0,17	0,41	0,09	0,05
P-PO ₄ ³⁻ (mg.L^{-1})	0,07	0,10	0,04	0,04	0,03	0,04	0,09	0,03	0,04	0,02	0,05	0,03
SO ₄ ²⁻ (mg.L^{-1})	1,84	1,94	1,91	0,31	0,30	0,36	0,53	0,68	1,53	1,20	1,05	1,82
F ⁻ (mg.L^{-1})	2,13	2,10	1,87	0,01	0,01	0,02	0,01	0,02	0,03	0,02	0,01	0,03
Hardness (mg.L^{-1})	4,93	5,02	6,97	0,88	1,51	2,58	2,28	4,77	4,64	2,58	2,64	5,69
Alkalinity (mg.L^{-1})	5,00	5,00	20,00	20,00	17,50	30,00	35,00	30,00	40,00	6,00	6,00	15,00
Cl ⁻ (mg.L^{-1})	2,13	2,10	1,87	1,39	1,24	1,11	1,68	1,28	4,61	1,76	1,67	1,49
NH ₃ (mg.L^{-1})	0,10	0,09	0,08	0,03	0,08	0,07	0,07	0,08	0,14	0,34	0,07	0,04

Table 3. Seasonal variation of physicochemical variables in the Curuperê-Dendê River in 2012.

Physico Chemical Variables	February			May			August			November		
	P1	P2	P3	P1	P2	P3	P1	P2	P3	P1	P2	P3
T (°C)	29,19	29,16	29,65	29,41	28,81	28,88	28,64	28,54	28,56	27,78	28,39	28,23
pH	6,28	7,28	7,40	7,70	7,67	7,75	6,74	7,14	6,98	6,30	6,50	6,30
EC ($\mu\text{S.cm}^{-1}$)	62,00	57,00	57,00	47,00	45,00	50,00	64,00	54,00	56,00	94,00	89,00	90,00
TDS (mg.L^{-1})	31,00	28,00	29,00	23,00	22,50	25,00	32,00	27,00	28,00	47,00	45,00	45,00
SAL (mg.L^{-1})	0,03	0,03	0,03	0,02	0,02	0,02	0,03	0,02	0,02	0,04	0,04	0,04
DO (mg.L^{-1})	6,28	7,65	7,00	5,31	5,42	5,85	3,23	3,94	3,95	8,77	8,96	8,91
Transparency (cm)	40,00	70,00	45,00	60,00	70,00	70,00	80,00	70,00	100,00	70,00	60,00	60,00
TRB (UNT)	10,00	6,00	10,00	5,00	5,00	6,00	3,50	4,00	4,50	16,00	21,00	18,00
COLOR (UC)	16,00	20,00	19,00	24,00	24,00	32,00	25,20	28,00	34,50	22,00	15,00	25,00
TSS (mg.L^{-1})	14,00	16,00	20,00	4,00	5,00	6,00	4,00	3,00	3,50	8,00	6,00	8,00
COD (mg.L^{-1})	21,00	24,00	24,00	24,00	14,00	18,00	65,00	28,00	28,00	22,00	27,00	20,00
BOD (mg.L^{-1})	12,00	19,00	12,00	13,00	8,00	8,00	20,00	16,00	14,00	18,00	16,00	16,00
N-NO ₂ ⁻ (mg.L^{-1})	1,53	0,11	2,33	0,64	0,24	0,49	6,27	5,25	5,34	0,68	0,59	0,63
N-NO ₃ ⁻ (mg.L^{-1})	0,04	0,01	0,01	0,02	0,02	0,02	0,03	0,01	0,03	0,26	0,19	0,13
N-NH ₄ (mg.L^{-1})	1,01	0,03	0,13	1,17	0,17	0,22	0,29	0,16	0,22	0,76	0,43	8,93
P-PO ₄ ³⁻ (mg.L^{-1})	0,72	0,56	0,99	0,72	1,19	1,04	1,02	0,16	0,62	0,82	0,87	0,06
SO ₄ ²⁻ (mg.L^{-1})	67,60	54,06	62,76	4,77	3,93	4,75	10,03	11,79	11,13	5,89	5,67	6,12
F ⁻ (mg.L^{-1})	0,36	0,24	0,33	0,97	0,16	1,04	1,20	0,33	0,43	0,18	0,15	0,07
Hardness (mg.L^{-1})	12,45	11,97	13,56	6,04	5,80	6,02	4,43	4,91	5,00	6,05	5,53	7,36
Alkalinity (mg.L^{-1})	40,00	20,00	20,00	15,00	20,00	10,00	60,00	40,00	40,00	20,00	15,00	15,00
Cl ⁻ (mg.L^{-1})	4,11	3,36	3,88	3,86	3,07	3,53	3,88	2,54	2,65	6,78	5,96	6,48
NH ₃ (mg.L^{-1})	1,01	0,03	0,13	1,17	0,17	0,22	0,29	0,16	0,22	0,76	0,43	8,93

Table 4. Seasonal variation of physicochemical variables in the Murucupi River in 2012.

Physico Chemical Variables	February			May			August			November		
	P1	P2	P3	P1	P2	P3	P1	P2	P3	P1	P2	P3
T (°C)	27,55	28,56	30,14	26,91	27,89	29,11	28,52	28,86	29,62	28,15	28,22	29,14
pH	6,06	6,36	6,80	7,61	7,46	7,05	6,87	6,20	6,35	6,03	6,25	6,69
EC ($\mu\text{S.cm}^{-1}$)	61,00	70,00	55,00	69,00	68,00	45,00	67,00	61,00	41,00	209,00	215,00	252,00
TDS (mg.L^{-1})	30,00	35,00	28,00	34,00	34,00	23,00	34,00	31,00	21,00	104,00	108,00	126,00
SAL (mg.L^{-1})	0,03	0,03	0,02	0,03	0,02	0,02	0,03	0,03	0,02	0,10	0,40	0,12
DO (mg.L^{-1})	2,04	2,52	5,56	2,26	4,95	6,35	4,85	3,83	5,47	3,32	3,54	5,58
Transparency (cm)	20,00	20,00	50,00	40,00	40,00	60,00	70,00	40,00	80,00	70,00	70,00	70,00
TRB (UNT)	58,00	48,00	32,00	19,00	18,00	18,00	22,00	28,00	22,00	13,00	12,00	10,00
COLOR (UC)	25,00	22,00	27,00	12,00	21,00	30,00	50,00	58,00	47,00	33,00	14,00	64,00
TSS (mg.L^{-1})	30,00	22,00	26,00	13,00	13,00	9,00	9,00	17,00	12,00	4,00	2,00	3,00
COD (mg.L^{-1})	32,00	12,00	20,00	34,00	42,00	33,00	20,00	29,00	10,00	12,00	17,00	16,00
BOD (mg.L^{-1})	21,44	8,04	13,40	22,78	28,14	22,11	13,40	19,43	6,70	8,04	11,39	10,72
N-NO ₂ ⁻ (mg.L^{-1})	6,57	15,77	6,79	3,11	2,82	1,00	2,17	1,20	1,21	0,61	0,65	0,56
N-NO ₃ ⁻ (mg.L^{-1})	0,06	0,05	0,07	0,20	0,20	0,16	0,04	0,09	0,09	0,12	0,11	0,19
N-NH ₄ (mg.L^{-1})	0,04	0,11	0,19	0,92	0,55	0,06	0,20	0,16	1,14	1,13	0,25	0,57
P-PO ₄ ³⁻ (mg.L^{-1})	0,53	0,62	0,67	0,02	0,03	0,05	0,21	0,03	0,07	0,17	0,15	0,11
SO ₄ ²⁻ (mg.L^{-1})	3,92	7,18	7,36	2,79	2,42	1,48	1,53	1,19	1,43	7,46	8,00	1,46
F ⁻ (mg.L^{-1})	0,03	0,07	0,05	0,04	0,04	0,03	0,02	0,02	0,02	0,03	0,03	0,02
Hardness (mg.L^{-1})	8,59	11,85	11,65	3,85	4,48	5,37	4,54	4,59	3,74	8,09	8,38	3,32
Alkalinity (mg.L^{-1})	5,00	10,00	10,00	20,00	30,00	30,00	20,00	40,00	35,00	10,00	10,00	12,00
Cl ⁻ (mg.L^{-1})	11,25	9,93	6,36	9,40	7,55	3,24	4,60	2,86	2,69	42,43	45,45	42,89
NH ₃ (mg.L^{-1})	0,03	0,09	0,16	0,75	0,45	0,05	0,17	0,13	0,94	0,93	0,20	0,47

Table 5. Classification and frequency of occurrence of zooplankton organisms in the Arapiranga River in 2012.

Taxa	February			May			August			November			FR (%)	Classification
	A1	A2	A3	A1	A2	A3	A1	A2	A3	A1	A2	A3		
Phylum: Rotifera														
Class: Eurotatoria														
Order: Flosculariaceae														
Family: Hexarthridae														
Genera: <i>Hexarthra</i> Schmarda, 1854														
<i>Hexarthra</i> sp.														
<i>Hexarthra</i> sp1														
Family: Trochosphaeridae														
Genera: <i>Filinia</i> Bory de St. Vincent, 1824														
<i>Filinia camasecla</i> Myers, 1938	x		x										17	Infrequent
<i>Filinia longiseta</i> Ehrenberg, 1834	x	x	x				x	x		x	x		58	Frequent
<i>Filinia opoliensis</i> Zacharias, 1898			x										8	Sporadic
<i>Filinia terminalis</i> Plate, 1886	x	x	x						x	x	x	x	58	Frequent
Order: Ploima														
Family: Asplanchnidae														
Genera: <i>Asplanchna</i> Gosse, 1850														
<i>Asplanchna</i> sp1				x									8	Sporadic
<i>Asplanchna</i> sp2														
Family: Brachionidae														
Genera: <i>Anuraeopsis</i> Lauterborn, 1990														
<i>Anuraeopsis</i> sp1														
<i>Anuraeopsis</i> sp2														

Table 5. Classification and frequency of occurrence of zooplankton organisms in the Arapiranga River in 2012.

Taxa	February			May			August			November			FR (%)	Classification	
	A1	A2	A3	A1	A2	A3	A1	A2	A3	A1	A2	A3			
<i>Anuraeopsis</i> sp3	x										x		17	Infrequent	
Genera: <i>Brachionus</i> Pallas, 1766															
<i>Brachionus calyciflorus gigantea</i> Koste & Shiel, 1987											x		8	Sporadic	
<i>Brachionus caudatus</i> Barrois & Daday, 1984	x		x				x	x	x			x	50	Frequent	
<i>Brachionus caudatus personatus</i> Ahlstrom, 1940											x		8	Sporadic	
<i>Brachionus gessneri</i> Hauer, 1956	x	x									x		33	Frequent	
<i>Brachionus mirus</i> Daday, 1905	x		x						x	x	x	x	50	Frequent	
<i>Brachionus urceolaris</i> Müller, 1773	x	x	x					x		x	x	x	58	Frequent	
<i>Brachionus zahniseri gessneri</i> Hauer, 1956															
Genera: <i>Keratella</i> Bory de St. Vincent, 1822															
<i>Keratella americana</i> Carlin, 1943	x	x	x	x		x		x	x	x	x	x	83	Very Frequent	
<i>Keratella cochlearis</i> Gosse, 1851	x	x	x	x	x	x	x	x	x	x	x	x	100	Very Frequent	
<i>Keratella lenzi</i> Hauer, 1937	x	x	x		x			x	x	x	x	x	75	Very Frequent	
<i>Keratella</i> sp1															
Genera: <i>Platylas</i> Harring, 1913															
<i>Platylas quadricornis</i> Ehrenberg, 1832												x	8	Sporadic	
Family: Euchlanidae															
Genera: <i>Dipleuchlanis</i> Beauchamp, 1910															
<i>Dipleuchlanis propatula</i> Gosse, 1886					x								8	Sporadic	
Family: Lecanidae															
Genera: <i>Lecane</i> Nitzsch, 1827															
<i>Lecane curvicornis</i> Murray, 1913															
<i>Lecane ludwigi</i> Eckstein, 1883															
<i>Lecane proiecta</i> Hauer, 1956											x	x	x	25	Infrequent

Table 5. Classification and frequency of occurrence of zooplankton organisms in the Arapiranga River in 2012.

Taxa	February			May			August			November			FR (%)	Classification
	A1	A2	A3	A1	A2	A3	A1	A2	A3	A1	A2	A3		
<i>Lecane pusilla</i> Harring, 1914														
<i>Lecane</i> sp1														
Genera: <i>Monostyla</i> Ehrenberg, 1830														
<i>M onostyla cornuta</i> Müller, 1786														
<i>Monostyla bulla</i> Gosse, 1851														
<i>Monostyla decipiens</i> Murray, 1913					x				x				17	Infrequent
<i>Monostyla elachis</i> Harring & Myers, 1926	x		x								x	x	33	Frequent
<i>Monostyla lunaris</i> Ehrenberg, 1832														
<i>Monostyla scutata</i> Harring & Myers, 1926	x												8	Sporadic
<i>Monostyla</i> sp1								x					8	Sporadic
Family: Lepadellidae														
Genera: <i>Lepadella</i> Bory de St. Vincent, 1826														
<i>Lepadella rottenburgi</i> Lucks 1912						x			x				17	Infrequent
<i>Lepadella</i> sp.					x								8	Sporadic
<i>Lepadella</i> sp1						x							8	Sporadic
Family: Mytilinidae														
Genera: <i>Mytilina</i> Bory de St. Vincent, 1826														
<i>Mytilina macrocera</i> Jennings, 1894														
Family: Synchaetidae														
Genera: <i>Polyarthra</i> Ehrenberg, 1834														
<i>Polyarthra</i> sp1											x	x	17	Infrequent
<i>Polyarthra</i> sp2														
Genera: <i>Synchaeta</i> Ehrenberg, 1832														
<i>Synchaeta</i> sp1														

Table 5. Classification and frequency of occurrence of zooplankton organisms in the Arapiranga River in 2012.

Taxa	February			May			August			November			FR (%)	Classification
	A1	A2	A3	A1	A2	A3	A1	A2	A3	A1	A2	A3		
<i>Synchaeta</i> sp2														
<i>Synchaeta</i> sp3														
Family: Testudinellidae														
Genera: <i>Testudinella</i> Bory de St. Vincent, 1826														
<i>Testudinella patina</i> Hermann, 1783														
Family: Trichocercidae														
Genera: <i>Trichocerca</i> Lamarck, 1801														
<i>Trichocerca bicristata</i> Gosse, 1887								x					8	Sporadic
<i>Trichocerca capucina</i> Wierzejski & Zacharias, 1893											x		8	Sporadic
<i>Trichocerca gracilis</i> Tessin, 1890														
<i>Trichocerca jenningsi</i> Voigt, 1957			x										8	Sporadic
<i>Trichocerca pusilla</i> Jennings, 1903								x					8	Sporadic
<i>Trichocerca ruttneri</i> Donner, 1953		x											8	Sporadic
<i>Trichocerca similis grandis</i> Hauer, 1965														
<i>Trichocerca similis</i> Wierzejski, 1893			x							x		x	33	Frequent
<i>Trichocerca</i> sp1														
Family: Trichotriidae														
Genera: <i>Trichotria</i> Bory de St. Vincent, 1827														
<i>Trichotria tetractis</i> Ehrenberg, 1830			x										8	Sporadic
Order: Bdelloidea														
Bdelloidea sp2	x	x	x	x	x	x				x	x	x	83	Very Frequent
Bdelloidea sp3	x	x	x	x	x	x			x	x	x		83	Very Frequent
Bdelloidea sp4										x		x	17	Infrequent
Bdelloidea sp5	x		x						x	x		x	42	Frequent

Table 5. Classification and frequency of occurrence of zooplankton organisms in the Arapiranga River in 2012.

Taxa	February			May			August			November			FR (%)	Classification
	A1	A2	A3	A1	A2	A3	A1	A2	A3	A1	A2	A3		
Bdelloidea sp7								x					8	Sporadic
Bdelloidea sp8	x		x								x		25	Infrequent
Bdelloidea sp 13	x										x		17	Infrequent
Bdelloidea sp14	x			x			x	x					33	Frequent
Bdelloidea sp15											x		8	Sporadic
Phylum: Lobosa														
Class: Testacealobosa														
Order: Arcellinida														
Family: Arcellidae														
Genera: <i>Arcella</i> Ehrenberg, 1832														
<i>Arcella braziliensis</i> Cunha, 1913						x							8	Sporadic
<i>Arcella costata angulosa</i> Playfair, 1918														
<i>Arcella costata</i> Ehrenberg, 1847				x	x								17	Infrequent
<i>Arcella crenulata</i> Deflandre, 1928														
<i>Arcella discoides</i> Ehrenberg, 1871		x						x					17	Infrequent
<i>Arcella gibbosa</i> Pénard, 1890														
<i>Arcella hemisphaerica gibba</i> Deflandre, 1928														
<i>Arcella hemisphaerica hemisphaerica</i> Perty, 1852					x		x		x				25	Infrequent
<i>Arcella megastoma</i> Pénard, 1913					x								8	Sporadic
<i>Arcella rotundata alta</i> Playfair, 1918														
<i>Arcella rotundata aplanata</i> Deflandre, 1928														
<i>Arcella</i> sp.											x		8	Sporadic
<i>Arcella</i> sp1														
<i>Arcella</i> sp4														

Table 5. Classification and frequency of occurrence of zooplankton organisms in the Arapiranga River in 2012.

Taxa	February			May			August			November			FR (%)	Classification
	A1	A2	A3	A1	A2	A3	A1	A2	A3	A1	A2	A3		
<i>Arcella vulgaris</i> Ehrenberg, 1830			x	x	x	x	x	x					50	Frequent
<i>Arcella vulgaris undulata</i> Deflandre, 1928					x								8	Sporadic
<i>Arcella vulgaris wailesi</i> Deflandre, 1928											x		8	Sporadic
Family: Centropyxidae														
Genera: <i>Centropyxis</i> Stein, 1857														
<i>Centropyxis aculeata</i> Ehrenberg, 1838	x	x		x		x	x	x	x	x	x	x	83	Very Frequent
<i>Centropyxis cassis</i> Wallich, 1864		x	x		x	x		x	x				50	Frequent
<i>Centropyxis ecornis</i> Ehrenberg, 1841						x							8	Sporadic
<i>Centropyxis</i> sp1								x					8	Sporadic
Genera: <i>Cyclopyxis</i> Deflandre, 1929														
<i>Cyclopyxis kahli</i> Deflandre, 1929		x			x			x					25	Infrequent
Family: Diffugiidae														
Genera: <i>Diffugia</i> Leclerc, 1815														
<i>Diffugia achlora</i> Pénard, 1902														
<i>Diffugia acuminata</i> Ehrenberg, 1838														
<i>Diffugia brevicolla</i> Cash & Hopkinson, 1909														
<i>Diffugia</i> cf. <i>minuta</i> Rampi, 1950														
<i>Diffugia corona</i> Wallich, 1864														
<i>Diffugia cylindrus</i> Odgen, 1983														
<i>Diffugia distenda</i> Odgen, 1983		x				x		x	x	x	x		50	Frequent
<i>Diffugia elegans</i> Penard, 1890		x	x	x	x	x		x		x	x		67	Frequent
<i>Diffugia kempnyi</i> Stepánek, 1953						x							8	Sporadic
<i>Diffugia litophila</i> Pénard, 1902														
<i>Diffugia penardi</i> Hopkinson, 1909					x								8	Sporadic

Table 5. Classification and frequency of occurrence of zooplankton organisms in the Arapiranga River in 2012.

Taxa	February			May			August			November			FR (%)	Classification
	A1	A2	A3	A1	A2	A3	A1	A2	A3	A1	A2	A3		
<i>Diffugia pyriformes</i> Perty, 1849						x							8	Sporadic
<i>Diffugia</i> sp. Leclerc, 1815		x	x	x	x	x	x		x		x		67	Frequent
<i>Diffugia</i> sp1		x			x	x	x				x	x	50	Frequent
<i>Diffugia</i> sp2														
<i>Diffugia</i> sp3														
<i>Diffugia</i> sp4		x											8	Sporadic
<i>Diffugia</i> sp7				x	x			x	x				33	Frequent
<i>Diffugia</i> sp10														
<i>Diffugia</i> sp11														
<i>Diffugia</i> sp13														
Family: Lesquereusiidae														
Genera: <i>Lesquereusia</i> Schlumberger, 1845														
<i>Lesquereusia</i> sp1				x	x	x							25	Infrequent
<i>Lesquereusia</i> sp12														
Genera: <i>Netzelia</i> Odgen, 1979														
<i>Netzelia</i> sp.	x	x											17	Infrequent
<i>Netzelia wailesi</i> Ogden, 1980					x	x			x		x		33	Frequent
Phylum: Cercozoa														
Class: Imbricatea														
Order: Euglyphida														
Family: Ccyphoderidae														
Genera: <i>Cyphoderia</i> Schlumberger, 1845														
<i>Cyphoderia</i> sp1														
Family: Euglyphidae														

Table 5. Classification and frequency of occurrence of zooplankton organisms in the Arapiranga River in 2012.

Taxa	February			May			August			November			FR (%)	Classification
	A1	A2	A3	A1	A2	A3	A1	A2	A3	A1	A2	A3		
Genera: <i>Euglypha</i> Dujardin, 1840														
<i>Euglypha acanthophora</i> Ehrenberg, 1841		x		x			x						25	Infrequent
<i>Euglypha denticulata</i> Brown, 1912						x					x		17	Infrequent
<i>Euglypha filifera</i> Pénard, 1890												x	8	Sporadic
Genera: <i>Trinema</i> Dujardin, 1838														
<i>Trinema</i> sp1						x					x		17	Infrequent
Phylum: Ciliophora														
Class: Polihymenophorea														
Order: Oligotrichida														
Tintinnina sp1	x	x	x	x		x	x	x	x	x	x	x	92	Very Frequent
Tintinnina sp3							x						8	Sporadic
Tintinnina sp6														
Tintinnina sp11														
Family: Codonellidae														
Genera: <i>Codonella</i> Haeckel 1873														
<i>Codonella cratera</i> Leidy, 1877	x	x	x	x	x	x	x	x	x	x	x	x	100	Very Frequent
Phylum: Arthropoda														
Class: Branchiopoda														
Order: Diplostraca														
Neonato de cladocera	x	x	x				x	x	x			x	58	Frequent
Ovo de cladocera	x	x	x		x		x	x	x				58	Frequent
Family: Bosminidae														
Genera: <i>Bosmina</i> Baird, 1845														

Table 5. Classification and frequency of occurrence of zooplankton organisms in the Arapiranga River in 2012.

Taxa	February			May			August			November			FR (%)	Classification
	A1	A2	A3	A1	A2	A3	A1	A2	A3	A1	A2	A3		
<i>Bosmina hagmanni</i> Stingelin, 1904	x	x	x					x			x	x	50	Frequent
<i>Bosmina longirostris</i> Müller, 1785	x	x	x					x	x		x	x	58	Frequent
<i>Bosmina</i> sp.														
Genera: <i>Bosminopsis</i> Richard, 1895														
<i>Bosminopsis deitersi</i> Richard, 1895	x	x	x	x	x		x	x	x	x	x	x	92	Very Frequent
Family: Chydoridae														
Genera: <i>Alonella</i> Fryer 1968														
<i>Alonella dadayi</i> Birge, 1910		x		x									17	Infrequent
Family: Sididae														
Genera: Diaphanosoma														
<i>Diaphanosoma birgei</i> Korinek, 1981														
Family: Daphniidae														
Genera: Ceriodaphnia														
<i>Ceriodaphnia cornuata</i> Sars, 1885	x	x	x										25	Infrequent
Family: Macrothricidae														
Genera: <i>Macrothrix</i> Baird, 1843														
<i>Macrothrix</i> sp1														
Family: Moinidae														
Genera: Moina														
<i>Moina minuta</i> Hansen, 1899	x	x	x						x	x		x	50	Frequent
Class: Maxillopoda														
Nauplio de Copepoda	x	x	x	x	x	x	x	x	x	x	x	x	100	Very Frequent
Order: Cyclopoida														
Copepodito de Cyclopoida	x	x	x	x	x	x	x	x	x	x	x	x	100	Very Frequent

Table 5. Classification and frequency of occurrence of zooplankton organisms in the Arapiranga River in 2012.

Taxa	February			May			August			November			FR (%)	Classification
	A1	A2	A3	A1	A2	A3	A1	A2	A3	A1	A2	A3		
Cyclopoida sp1	x		x	x	x	x	x	x	x	x	x	x	92	Very Frequent
Cyclopoida sp2														
Cyclopoida sp3														
Cyclopoida sp4														
Cyclopoida sp5														
Order: Calanoida														
Calanoida sp1	x	x	x	x	x			x	x	x	x		75	Very Frequent
Copepodito de Calanoida	x	x	x					x		x	x	x	58	Frequent
Order: Haparticoidea														
Copepodito de Haparticoidea														
Haparticoidea sp1				x	x				x				25	Infrequent
Haparticoidea sp2														
Class: Malacostraca														
Order: Isopoda														
Isopoda														
Phylum: Mollusca														
Class: Gastropoda														
Larva de Gastropoda	x		x					x	x			x	42	Frequent
Class: Bivalvia														
Larva de Bivalve	x	x	x						x		x		42	Frequent
Phylum: Annelida														
Class: Polychaeta														
Poliqueta									x				8	Sporadic

Table 6. Classification and frequency of occurrence of zooplankton organisms in the Curuperê-Dendê River in 2012.

Taxa	February			May			August			November			FR (%)	Classification
	C1	C2	C3	C1	C2	C3	C1	C2	C3	C1	C2	C3		
Phylum: Rotifera														
Class: Eurotatoria														
Order: Flosculariaceae														
Family: Helarthridae														
Genera: <i>Helarthra</i> Schmarda, 1854														
<i>Helarthra</i> sp.														
<i>Helarthra</i> sp1														
Family: Trochosphaeridae														
Genera: <i>Filinia</i> Bory de St. Vincent, 1824														
<i>Filinia camasecla</i> Myers, 1938		x											8	Sporadic
<i>Filinia longiseta</i> Ehrenberg, 1834				x			x	x		x		x	42	Frequent
<i>Filinia opoliensis</i> Zacharias, 1898							x			x	x		25	Infrequent
<i>Filinia terminalis</i> Plate, 1886		x	x	x	x	x	x	x	x	x	x	x	92	Very Frequent
Order: Ploima														
Family: Asplanchnidae														
Genera: <i>Asplanchna</i> Gosse, 1850														
<i>Asplanchna</i> sp1		x			x						x		25	Infrequent
<i>Asplanchna</i> sp2														
Family: Brachionidae														
Genera: <i>Anuraeopsis</i> Lauterborn, 1990														
<i>Anuraeopsis</i> sp1		x		x		x	x			x			42	Frequent
<i>Anuraeopsis</i> sp2							x						8	Sporadic

Table 6. Classification and frequency of occurrence of zooplankton organisms in the Curuperê-Dendê River in 2012.

Taxa	February			May			August			November			FR (%)	Classification	
	C1	C2	C3	C1	C2	C3	C1	C2	C3	C1	C2	C3			
<i>Anuraeopsis</i> sp3															
Genera: <i>Brachionus</i> Pallas, 1766															
<i>Brachionus calyciflorus gigantea</i> Koste & Shiel, 1987															
<i>Brachionus caudatus</i> Barrois & Daday, 1984		x		x				x			x	x	x	50	Frequent
<i>Brachionus caudatus personatus</i> Ahlstrom, 1940	x	x			x		x				x		x	50	Frequent
<i>Brachionus gessneri</i> Hauer, 1956									x					8	Sporadic
<i>Brachionus mirus</i> Daday, 1905			x	x	x		x	x	x	x	x	x	x	75	Very Frequent
<i>Brachionus urceolaris</i> Müller, 1773	x		x	x	x	x	x	x	x	x	x			83	Very Frequent
<i>Brachionus zahniseri gessneri</i> Hauler, 1956															
Genera: <i>Keratella</i> Bory de St. Vincent, 1822															
<i>Keratella americana</i> Carlin, 1943	x	x	x	x	x	x	x	x	x	x	x	x	x	100	Very Frequent
<i>Keratella cochlearis</i> Gosse, 1851	x	x	x	x	x	x	x	x	x	x	x	x	x	100	Very Frequent
<i>Keratella lenzi</i> Hauer, 1937	x	x	x	x	x	x	x	x	x	x	x	x	x	100	Very Frequent
<i>Keratella</i> sp1															
Genera: <i>Platyias</i> Harring, 1913															
<i>Platyias quadricornis</i> Ehrenberg, 1832															
Family: Euchlanidae															
Genera: <i>Dipleuchlanis</i> Beauchamp, 1910															
<i>Dipleuchlanis propatula</i> Gosse, 1886															
Family: Lecanidae															
Genera: <i>Lecane</i> Nitzsch, 1827															
<i>Lecane curvicornis</i> Murray, 1913								x		x				17	Infrequent
<i>Lecane ludwigi</i> Eckstein, 1883															
<i>Lecane proiecta</i> Hauer, 1956		x	x								x	x	x	42	Frequent

Table 6. Classification and frequency of occurrence of zooplankton organisms in the Curuperê-Dendê River in 2012.

Taxa	February			May			August			November			FR (%)	Classification
	C1	C2	C3	C1	C2	C3	C1	C2	C3	C1	C2	C3		
<i>Lecane pusilla</i> Haring, 1914							x			x	x		25	Infrequent
<i>Lecane</i> sp1				x									8	Sporadic
Genera: <i>Monostyla</i> Ehrenberg, 1830														
<i>M onostyla cornuta</i> Müller, 1786											x		8	Sporadic
<i>Monostyla bulla</i> Gosse, 1851							x	x					17	Infrequent
<i>Monostyla decipiens</i> Murray, 1913							x	x					17	Infrequent
<i>Monostyla elachis</i> Haring & Myers, 1926				x								x	17	Infrequent
<i>Monostyla lunaris</i> Ehrenberg, 1832									x				8	Sporadic
<i>Monostyla scutata</i> Haring & Myers, 1926														
<i>Monostyla</i> sp1														
Family: Lepadellidae														
Genera: <i>Lepadella</i> Bory de St. Vincent, 1826														
<i>Lepadella rottenburgi</i> Lucks 1912				x					x		x		25	Infrequent
<i>Lepadella</i> sp.														
<i>Lepadella</i> sp1												x	8	Sporadic
Family: Mytilinidae														
Genera: <i>Mytilina</i> Bory de St. Vincent, 1826														
<i>Mytilina macrocera</i> Jennings, 1894														
Family: Synchaetidae														
Genera: <i>Polyarthra</i> Ehrenberg, 1834														
<i>Polyarthra</i> sp1								x					8	Sporadic
<i>Polyarthra</i> sp2										x			8	Sporadic
Genera: <i>Synchaeta</i> Ehrenberg, 1832														
<i>Synchaeta</i> sp1														

Table 6. Classification and frequency of occurrence of zooplankton organisms in the Curuperê-Dendê River in 2012.

Taxa	February			May			August			November			FR (%)	Classification
	C1	C2	C3	C1	C2	C3	C1	C2	C3	C1	C2	C3		
<i>Synchaeta</i> sp2				x			x	x			x		33	Frequent
<i>Synchaeta</i> sp3										x	x		17	Infrequent
Family: Testudinellidae														
Genera: <i>Testudinella</i> Bory de St. Vincent, 1826														
<i>Testudinella patina</i> Hermann, 1783									x				8	Sporadic
Family: Trichocercidae														
Genera: <i>Trichocerca</i> Lamarck, 1801														
<i>Trichocerca bicristata</i> Gosse, 1887	x			x			x			x		x	42	Frequent
<i>Trichocerca capucina</i> Wierzejski & Zacharias, 1893					x								8	Sporadic
<i>Trichocerca gracilis</i> Tessin, 1890					x	x						x	25	Infrequent
<i>Trichocerca jenningsi</i> Voigt, 1957		x		x				x		x	x	x	50	Frequent
<i>Trichocerca pusilla</i> Jennings, 1903														
<i>Trichocerca ruttneri</i> Donner, 1953														
<i>Trichocerca similis grandis</i> Hauer, 1965					x			x	x				25	Infrequent
<i>Trichocerca similis</i> Wierzejski, 1893	x			x		x	x			x		x	50	Frequent
<i>Trichocerca</i> sp1	x												8	Sporadic
Family: Trichotriidae														
Genera: <i>Trichotria</i> Bory de St. Vincent, 1827														
<i>Trichotria tetractis</i> Ehrenberg, 1830														
Order: Bdelloidea														
Bdelloidea sp2	x	x	x	x	x	x	x	x	x	x	x	x	100	Very Frequent
Bdelloidea sp3				x		x	x	x	x	x	x	x	67	Frequent
Bdelloidea sp4														
Bdelloidea sp5				x	x	x	x	x	x	x	x	x	75	Very Frequent

Table 6. Classification and frequency of occurrence of zooplankton organisms in the Curuperê-Dendê River in 2012.

Taxa	February			May			August			November			FR (%)	Classification
	C1	C2	C3	C1	C2	C3	C1	C2	C3	C1	C2	C3		
Bdelloidea sp7														
Bdelloidea sp8	x	x		x	x	x		x	x				58	Frequent
Bdelloidea sp 13			x										8	
Bdelloidea sp14							x		x	x			25	Infrequent
Bdelloidea sp15				x		x				x			25	Infrequent
Phylum: Lobosa														
Class: Testacealobosa														
Order: Arcellinida														
Family: Arcellidae														
Genera: <i>Arcella</i> Ehrenberg, 1832														
<i>Arcella braziliensis</i> Cunha, 1913														
<i>Arcella costata angulosa</i> Playfair, 1918				x		x	x						25	Infrequent
<i>Arcella costata</i> Ehrenberg, 1847				x							x		17	Infrequent
<i>Arcella crenulata</i> Deflandre, 1928														
<i>Arcella discoides</i> Ehrenberg, 1871		x		x	x		x		x				42	Frequent
<i>Arcella gibbosa</i> Pénard, 1890	x												8	
<i>Arcella hemisphaerica gibba</i> Deflandre, 1928	x												8	
<i>Arcella hemisphaerica hemisphaerica</i> Perty, 1852	x	x	x	x		x	x	x	x				67	Frequent
<i>Arcella megastoma</i> Pénard, 1913		x											8	
<i>Arcella rotundata alta</i> Playfair, 1918	x												8	
<i>Arcella rotundata aplanata</i> Deflandre, 1928	x	x		x									25	Infrequent
<i>Arcella</i> sp.	x	x							x		x		33	Frequent
<i>Arcella</i> sp1														
<i>Arcella</i> sp4								x					8	

Table 6. Classification and frequency of occurrence of zooplankton organisms in the Curuperê-Dendê River in 2012.

Taxa	February			May			August			November			FR (%)	Classification
	C1	C2	C3	C1	C2	C3	C1	C2	C3	C1	C2	C3		
<i>Arcella vulgaris</i> Ehrenberg, 1830	x	x	x	x		x	x	x	x				67	Frequent
<i>Arcella vulgaris undulata</i> Deflandre, 1928	x			x		x	x						33	Frequent
<i>Arcella vulgaris wailesi</i> Deflandre, 1928	x	x											17	Infrequent
Family: Centropylidae														
Genera: <i>Centropylis</i> Stein, 1857														
<i>Centropylis aculeata</i> Ehrenberg, 1838	x			x		x		x		x		x	50	Frequent
<i>Centropylis cassis</i> Wallich, 1864			x	x		x		x		x			42	Frequent
<i>Centropylis ecornis</i> Ehrenberg, 1841	x	x		x		x					x	x	50	Frequent
<i>Centropylis</i> sp1														
Genera: <i>Cyclopylis</i> Deflandre, 1929														
<i>Cyclopylis kahli</i> Deflandre, 1929				x				x				x	25	Infrequent
Family: Diffugiidae														
Genera: <i>Diffugia</i> Leclerc, 1815														
<i>Diffugia achlora</i> Pénard, 1902								x					8	Sporadic
<i>Diffugia acuminata</i> Ehrenberg, 1838								x	x				17	Infrequent
<i>Diffugia brevicolla</i> Cash & Hopkinson, 1909														
<i>Diffugia</i> cf. <i>minuta</i> Rampi, 1950	x	x						x					25	Infrequent
<i>Diffugia corona</i> Wallich, 1864	x			x		x							25	Infrequent
<i>Diffugia cylindrus</i> Odgen, 1983												x	8	Sporadic
<i>Diffugia distenda</i> Odgen, 1983			x										8	Sporadic
<i>Diffugia elegans</i> Penard, 1890	x		x			x				x			33	Frequent
<i>Diffugia kempnyi</i> Stepánek, 1953						x							8	Sporadic
<i>Diffugia litophila</i> Pénard, 1902														
<i>Diffugia penardi</i> Hopkinson, 1909	x			x									17	Infrequent

Table 6. Classification and frequency of occurrence of zooplankton organisms in the Curuperê-Dendê River in 2012.

Taxa	February			May			August			November			FR (%)	Classification
	C1	C2	C3	C1	C2	C3	C1	C2	C3	C1	C2	C3		
<i>Diffflugia pyriformes</i> Perty, 1849														
<i>Diffflugia</i> sp. Leclerc, 1815	x		x				x	x				x	42	Frequent
<i>Diffflugia</i> sp1								x		x			17	Infrequent
<i>Diffflugia</i> sp2		x		x									17	Infrequent
<i>Diffflugia</i> sp3														
<i>Diffflugia</i> sp4														
<i>Diffflugia</i> sp7														
<i>Diffflugia</i> sp10	x												8	Sporadic
<i>Diffflugia</i> sp11							x			x			17	Infrequent
<i>Diffflugia</i> sp13				x						x			17	Infrequent
Family: Lesquereusiidae														
Genera: <i>Lesquereusia</i> Schlumberger, 1845														
<i>Lesquereusia</i> sp1		x				x		x					25	Infrequent
<i>Lesquereusia</i> sp12				x									8	Sporadic
Genera: <i>Netzelia</i> Odgen, 1979														
<i>Netzelia</i> sp.														
<i>Netzelia wailesi</i> Ogden, 1980											x	x	17	Infrequent
Phylum: Cercozoa														
Class: Imbricatea														
Order: Euglyphida														
Family: Cyphoderidae														
Genera: <i>Cyphoderia</i> Schlumberger, 1845														
<i>Cyphoderia</i> sp1														
Family: Euglyphidae														

Table 6. Classification and frequency of occurrence of zooplankton organisms in the Curuperê-Dendê River in 2012.

Taxa	February			May			August			November			FR (%)	Classification
	C1	C2	C3	C1	C2	C3	C1	C2	C3	C1	C2	C3		
Genera: <i>Euglypha</i> Dujardin, 1840														
<i>Euglypha acanthophora</i> Ehrenberg, 1841						x							8	Sporadic
<i>Euglypha denticulata</i> Brown, 1912							x			x			17	Infrequent
<i>Euglypha filifera</i> Pénard, 1890				x									8	Sporadic
<i>Euglypha</i> sp1														
Genera: <i>Trinema</i> Dujardin, 1838														
<i>Trinema</i> sp1							x			x			17	Infrequent
Phylum: Ciliophora														
Class: Polihymenophorea														
Order: Oligotrichida														
Tintinnina sp1	x	x	x	x	x	x	x	x	x	x	x	x	100	Very Frequent
Tintinnina sp3				x		x							17	Infrequent
Tintinnina sp6										x			8	Sporadic
Tintinnina sp11														
Family: Codonellidae														
Genera: <i>Codonella</i> Haeckel 1873														
<i>Codonella cratera</i> Leidy, 1877	x	x	x	x	x	x	x	x	x	x	x	x	100	Very Frequent
Phylum: Arthropoda														
Class: Branchiopoda														
Order: Diplostraca														
Neonato de cladocera		x			x		x	x	x	x		x	58	Frequent
Ovo de cladocera	x	x			x		x	x	x	x	x	x	75	Very Frequent
Family: Bosminidae														
Genera: <i>Bosmina</i> Baird, 1845														

Table 6. Classification and frequency of occurrence of zooplankton organisms in the Curuperê-Dendê River in 2012.

Taxa	February			May			August			November			FR (%)	Classification
	C1	C2	C3	C1	C2	C3	C1	C2	C3	C1	C2	C3		
<i>Bosmina hagdmani</i> Stingelin, 1904	x	x						x	x			x	42	Frequent
<i>Bosmina longirostris</i> Müller, 1785	x	x									x	x	33	Frequent
<i>Bosmina</i> sp.														
Genera: <i>Bosminopsis</i> Richard, 1895														
<i>Bosminopsis deitersi</i> Richard, 1895	x	x	x	x	x		x	x	x	x	x	x	92	Very Frequent
Family: Chydoridae														
Genera: <i>Alonella</i> Fryer 1968														
<i>Alonella dadayi</i> Birge, 1910			x										8	Sporadic
Family: Sididae														
Genera: Diaphanosoma														
<i>Diaphanosoma birgei</i> Korinek, 1981	x							x				x	25	Infrequent
Family: Daphniidae														
Genera: Ceriodaphnia														
<i>Ceriodaphnia cornuata</i> Sars, 1885														
Family: Macrothricidae														
Genera: <i>Macrothrix</i> Baird, 1843														
<i>Macrothrix</i> sp1														
Family: Moinidae														
Genera: Moina														
<i>Moina minuta</i> Hansen, 1899	x	x	x		x			x		x	x	x	67	Frequent
Class: Malloppoda														
Nauplio de Copepoda	x	x	x	x	x	x	x	x	x	x	x	x	100	Very Frequent
Order: Cyclopoida														
Copepodito de Cyclopoida	x	x	x	x	x	x	x	x	x	x	x	x	100	Very Frequent

Table 6. Classification and frequency of occurrence of zooplankton organisms in the Curuperê-Dendê River in 2012.

Taxa	February			May			August			November			FR (%)	Classification
	C1	C2	C3	C1	C2	C3	C1	C2	C3	C1	C2	C3		
Cyclopoida sp1	x	x		x	x	x	x	x		x	x		75	Very Frequent
Cyclopoida sp2	x			x			x			x	x		42	Frequent
Cyclopoida sp3	x	x								x			25	Infrequent
Cyclopoida sp4														
Cyclopoida sp5														
Order: Calanoida														
Calanoida sp1						x							8	Sporadic
Copepodito de Calanoida	x	x		x			x	x		x	x	x	67	Frequent
Order: Haparticoidea														
Copepodito de Haparticoidea														
Haparticoidea sp1	x									x			17	Infrequent
Haparticoidea sp2						x					x		17	Infrequent
Class: Malacostraca														
Order: Isopoda														
Isopoda										x			8	Sporadic
Phylum: Mollusca														
Class: Gastropoda														
Larva de Gastropoda	x		x	x		x	x	x	x	x	x	x	83	Very Frequent
Class: Bivalvia														
Larva de Bivalve	x	x							x		x	x	42	Frequent
Phylum: Annelida														
Class: Polychaeta														
Poliqueta	x		x	x				x					33	Frequent

Table 7. Classification and frequency of occurrence of zooplankton organisms in the Murucupi River in 2012.

Taxa	February			May			August			November			FR (%)	Classification
	M1	M2	M3	M1	M2	M3	M1	M2	M3	M1	M2	M3		
Phylum: Rotifera														
Class: Eurotatoria														
Order: Flosculariaceae														
Family: Helarthridae														
Genera: <i>Helarthra</i> Schmarda, 1854														
<i>Helarthra</i> sp.														
<i>Helarthra</i> sp1									x		x		17	Infrequent
Family: Trochosphaeridae														
Genera: <i>Filinia</i> Bory de St. Vincent, 1824														
<i>Filinia camasecla</i> Myers, 1938		x								x	x		25	Infrequent
<i>Filinia longiseta</i> Ehrenberg, 1834			x		x					x	x	x	42	Frequent
<i>Filinia opoliensis</i> Zacharias, 1898		x							x		x		25	Infrequent
<i>Filinia terminalis</i> Plate, 1886	x	x	x	x	x	x	x	x	x	x	x	x	100	Very Frequent
Order: Ploima														
Family: Asplanchnidae														
Genera: <i>Asplanchna</i> Gosse, 1850														
<i>Asplanchna</i> sp1		x				x							17	Infrequent
<i>Asplanchna</i> sp2		x											8	Sporadic
Family: Brachionidae														
Genera: <i>Anuraeopsis</i> Lauterborn, 1990														
<i>Anuraeopsis</i> sp1		x		x	x	x	x	x		x	x		67	Frequent
<i>Anuraeopsis</i> sp2														

Table 7. Classification and frequency of occurrence of zooplankton organisms in the Murucupi River in 2012.

Taxa	February			May			August			November			FR (%)	Classification
	M1	M2	M3	M1	M2	M3	M1	M2	M3	M1	M2	M3		
<i>Anuraeopsis</i> sp3	x												8	Sporadic
Genera: <i>Brachionus</i> Pallas, 1766														
<i>Brachionus calyciflorus gigantea</i> Koste & Shiel, 1987														
<i>Brachionus caudatus</i> Barrois & Daday, 1984			x	x	x	x	x	x		x	x	x	75	Very Frequent
<i>Brachionus caudatus personatus</i> Ahlstrom, 1940	x	x								x	x	x	42	Frequent
<i>Brachionus gessneri</i> Hauer, 1956							x	x	x			x	33	Frequent
<i>Brachionus mirus</i> Daday, 1905	x	x	x				x	x	x	x	x	x	75	Very Frequent
<i>Brachionus urceolaris</i> Müller, 1773	x			x		x	x	x		x	x		58	Frequent
<i>Brachionus zahniseri gessneri</i> Hauler, 1956			x	x		x	x			x	x		50	Frequent
Genera: <i>Keratella</i> Bory de St. Vincent, 1822														
<i>Keratella americana</i> Carlin, 1943			x	x	x	x	x	x	x	x	x	x	83	Very Frequent
<i>Keratella cochlearis</i> Gosse, 1851	x	x	x	x	x	x	x	x	x	x	x	x	100	Very Frequent
<i>Keratella lenzi</i> Hauer, 1937	x	x	x	x	x	x	x	x	x	x	x	x	100	Very Frequent
<i>Keratella</i> sp1								x					8	Sporadic
Genera: <i>Platyias</i> Haring, 1913														
<i>Platyias quadricornis</i> Ehrenberg, 1832	x					x							17	Infrequent
Family: Euchlanidae														
Genera: <i>Dipleuchlanis</i> Beauchamp, 1910														
<i>Dipleuchlanis propatula</i> Gosse, 1886														
Family: Lecanidae														
Genera: <i>Lecane</i> Nitzsch, 1827														
<i>Lecane curvicornis</i> Murray, 1913	x										x		17	Infrequent
<i>Lecane ludwigi</i> Eckstein, 1883				x									8	Sporadic
<i>Lecane proiecta</i> Hauer, 1956										x	x	x	25	Infrequent

Table 7. Classification and frequency of occurrence of zooplankton organisms in the Murucupi River in 2012.

Taxa	February			May			August			November			FR (%)	Classification
	M1	M2	M3	M1	M2	M3	M1	M2	M3	M1	M2	M3		
<i>Lecane pusilla</i> Harring, 1914							x						8	Sporadic
<i>Lecane</i> sp1			x	x		x			x				33	Frequent
Genera: <i>Monostyla</i> Ehrenberg, 1830														
<i>M onostyla cornuta</i> Müller, 1786	x												8	Sporadic
<i>Monostyla bulla</i> Gosse, 1851	x		x	x		x	x	x					50	Frequent
<i>Monostyla decipiens</i> Murray, 1913	x			x						x			25	Infrequent
<i>Monostyla elachis</i> Harring & Myers, 1926														
<i>Monostyla lunaris</i> Ehrenberg, 1832														
<i>Monostyla scutata</i> Harring & Myers, 1926														
<i>Monostyla</i> sp1														
Family: Lepadellidae														
Genera: <i>Lepadella</i> Bory de St. Vincent, 1826														
<i>Lepadella rottenburgi</i> Lucks 1912	x												8	Sporadic
<i>Lepadella</i> sp.				x							x		17	Infrequent
<i>Lepadella</i> sp1								x					8	Sporadic
Family: Mytilinidae														
Genera: <i>Mytilina</i> Bory de St. Vincent, 1826														
<i>Mytilina macrocera</i> Jennings, 1894				x									8	Sporadic
Family: Synchaetidae														
Genera: <i>Polyarthra</i> Ehrenberg, 1834														
<i>Polyarthra</i> sp1							x	x	x	x	x	x	50	Frequent
<i>Polyarthra</i> sp2														
Genera: <i>Synchaeta</i> Ehrenberg, 1832														
<i>Synchaeta</i> sp1							x	x		x			25	Infrequent

Table 7. Classification and frequency of occurrence of zooplankton organisms in the Murucupi River in 2012.

Taxa	February			May			August			November			FR (%)	Classification
	M1	M2	M3	M1	M2	M3	M1	M2	M3	M1	M2	M3		
<i>Synchaeta</i> sp2						x		x	x			x	33	Frequent
<i>Synchaeta</i> sp3														
Family: Testudinellidae														
Genera: <i>Testudinella</i> Bory de St. Vincent, 1826														
<i>Testudinella patina</i> Hermann, 1783	x			x	x		x	x					42	Frequent
Family: Trichocercidae														
Genera: <i>Trichocerca</i> Lamarck, 1801														
<i>Trichocerca bicristata</i> Gosse, 1887	x	x	x							x	x		42	Frequent
<i>Trichocerca capucina</i> Wierzejski & Zacharias, 1893	x						x		x	x	x		42	Frequent
<i>Trichocerca gracilis</i> Tessin, 1890														
<i>Trichocerca jenningsi</i> Voigt, 1957									x	x			17	Infrequent
<i>Trichocerca pusilla</i> Jennings, 1903														
<i>Trichocerca ruttneri</i> Donner, 1953														
<i>Trichocerca similis grandis</i> Hauer, 1965							x	x	x				25	Infrequent
<i>Trichocerca similis</i> Wierzejski, 1893				x		x	x	x		x	x		50	Frequent
<i>Trichocerca</i> sp1							x	x			x		25	Infrequent
Family: Trichotriidae														
Genera: <i>Trichotria</i> Bory de St. Vincent, 1827														
<i>Trichotria tetractis</i> Ehrenberg, 1830				x									8	Sporadic
Order: Bdelloidea														
Bdelloidea sp2	x	x	x	x	x	x	x	x	x	x	x	x	100	Very Frequent
Bdelloidea sp3	x	x		x		x	x	x	x	x	x		75	Very Frequent
Bdelloidea sp4	x		x				x						25	Infrequent
Bdelloidea sp5	x		x			x	x		x			x	50	Frequent

Table 7. Classification and frequency of occurrence of zooplankton organisms in the Murucupi River in 2012.

Taxa	February			May			August			November			FR (%)	Classification
	M1	M2	M3	M1	M2	M3	M1	M2	M3	M1	M2	M3		
Bdelloidea sp7	x	x	x							x			33	Frequent
Bdelloidea sp8	x						x	x		x	x	x	50	Frequent
Bdelloidea sp 13	x	x	x	x						x			42	Frequent
Bdelloidea sp14		x								x			17	Infrequent
Bdelloidea sp15	x	x	x	x				x	x		x	x	67	Frequent
Phylum: Lobosa														
Class: Testacealobosa														
Order: Arcellinida														
Family: Arcellidae														
Genera: <i>Arcella</i> Ehrenberg, 1832														
<i>Arcella braziliensis</i> Cunha, 1913														
<i>Arcella costata angulosa</i> Playfair, 1918														
<i>Arcella costata</i> Ehrenberg, 1847					x								8	Sporadic
<i>Arcella crenulata</i> Deflandre, 1928					x								8	Sporadic
<i>Arcella discoides</i> Ehrenberg, 1871					x		x		x				25	Infrequent
<i>Arcella gibbosa</i> Pénard, 1890														
<i>Arcella hemisphaerica gibba</i> Deflandre, 1928		x	x	x									25	Infrequent
<i>Arcella hemisphaerica hemisphaerica</i> Perty, 1852					x		x		x				25	Infrequent
<i>Arcella megastoma</i> Pénard, 1913					x								8	Sporadic
<i>Arcella rotundata alta</i> Playfair, 1918					x				x				17	Infrequent
<i>Arcella rotundata aplanata</i> Deflandre, 1928														
<i>Arcella</i> sp.					x		x	x	x	x	x	x	58	Frequent
<i>Arcella</i> sp1	x												8	Sporadic
<i>Arcella</i> sp4														

Table 7. Classification and frequency of occurrence of zooplankton organisms in the Murucupi River in 2012.

Taxa	February			May			August			November			FR (%)	Classification
	M1	M2	M3	M1	M2	M3	M1	M2	M3	M1	M2	M3		
<i>Arcella vulgaris</i> Ehrenberg, 1830	x	x	x	x				x	x			x	58	Frequent
<i>Arcella vulgaris undulata</i> Deflandre, 1928					x								8	Sporadic
<i>Arcella vulgaris wailesi</i> Deflandre, 1928														
Family: Centropylidae														
Genera: <i>Centropylis</i> Stein, 1857														
<i>Centropylis aculeata</i> Ehrenberg, 1838	x	x	x	x			x	x		x	x	x	75	Very Frequent
<i>Centropylis cassis</i> Wallich, 1864	x	x		x				x			x		42	Frequent
<i>Centropylis ecornis</i> Ehrenberg, 1841	x												8	Sporadic
<i>Centropylis</i> sp1		x		x									17	Infrequent
Genera: <i>Cyclopylis</i> Deflandre, 1929														
<i>Cyclopylis kahli</i> Deflandre, 1929														
Family: Diffugiidae														
Genera: <i>Diffugia</i> Leclerc, 1815														
<i>Diffugia achlora</i> Pénard, 1902														
<i>Diffugia acuminata</i> Ehrenberg, 1838	x												8	Sporadic
<i>Diffugia brevicolla</i> Cash & Hopkinson, 1909				x									8	Sporadic
<i>Diffugia</i> cf. <i>minuta</i> Rampi, 1950														
<i>Diffugia corona</i> Wallich, 1864														
<i>Diffugia cylindrus</i> Odgen, 1983				x	x			x					25	Infrequent
<i>Diffugia distenda</i> Odgen, 1983									x		x		17	Infrequent
<i>Diffugia elegans</i> Penard, 1890	x							x			x		25	Infrequent
<i>Diffugia kempnyi</i> Stepánek, 1953											x		8	Sporadic
<i>Diffugia litophila</i> Pénard, 1902											x		8	Sporadic
<i>Diffugia penardi</i> Hopkinson, 1909											x		8	Sporadic

Table 7. Classification and frequency of occurrence of zooplankton organisms in the Murucupi River in 2012.

Taxa	February			May			August			November			FR (%)	Classification
	M1	M2	M3	M1	M2	M3	M1	M2	M3	M1	M2	M3		
<i>Diffflugia pyriformes</i> Perty, 1849														
<i>Diffflugia</i> sp. Leclerc, 1815	x			x			x		x		x		42	Frequent
<i>Diffflugia</i> sp1			x					x					17	Infrequent
<i>Diffflugia</i> sp2														
<i>Diffflugia</i> sp3										x		x	17	Infrequent
<i>Diffflugia</i> sp4														
<i>Diffflugia</i> sp7														
<i>Diffflugia</i> sp10														
<i>Diffflugia</i> sp11														
<i>Diffflugia</i> sp13														
Family: Lesquereusiidae														
Genera: <i>Lesquereusia</i> Schlumberger, 1845														
<i>Lesquereusia</i> sp1														
<i>Lesquereusia</i> sp12														
Genera: <i>Netzelia</i> Odgen, 1979														
<i>Netzelia</i> sp.														
<i>Netzelia wailesi</i> Ogden, 1980														
Phylum: Cercozoa														
Class: Imbricatea														
Order: Euglyphida														
Family: Ccyphoderidae														
Genera: <i>Cyphoderia</i> Schlumberger, 1845														
<i>Cyphoderia</i> sp1	x						x						17	Infrequent
Family: Euglyphida														

Table 7. Classification and frequency of occurrence of zooplankton organisms in the Murucupi River in 2012.

Taxa	February			May			August			November			FR (%)	Classification
	M1	M2	M3	M1	M2	M3	M1	M2	M3	M1	M2	M3		
Genera: <i>Euglypha</i> Dujardin, 1840														
<i>Euglypha acanthophora</i> Ehrenberg, 1841				x			x		x		x		33	Frequent
<i>Euglypha denticulata</i> Brown, 1912	x												8	Sporadic
<i>Euglypha filifera</i> Pénard, 1890					x								8	Sporadic
<i>Euglypha</i> sp1														
Genera: <i>Trinema</i> Dujardin, 1838														
<i>Trinema</i> sp1														
Phylum: Ciliophora														
Class: Polihymenophorea														
Order: Oligotrichida														
Tintinnina sp1	x	x	x	x		x	x	x	x	x	x	x	92	Very Frequent
Tintinnina sp3	x			x									17	Infrequent
Tintinnina sp6												x	8	Sporadic
Tintinnina sp11	x			x			x	x					33	Frequent
Family: Codonellidae														
Genera: <i>Codonella</i> Haeckel 1873														
<i>Codonella cratera</i> Leidy, 1877	x	x	x	x			x	x	x	x	x	x	83	Very Frequent
Phylum: Arthropoda														
Class: Branchiopoda														
Order: Diplostraca														
Neonato de cladocera	x	x	x	x		x	x		x	x	x	x	83	Very Frequent
Ovo de cladocera	x	x	x	x	x	x	x	x	x	x	x	x	100	Very Frequent
Family: Bosminidae														
Genera: <i>Bosmina</i> Baird, 1845														

Table 7. Classification and frequency of occurrence of zooplankton organisms in the Murucupi River in 2012.

Taxa	February			May			August			November			FR (%)	Classification
	M1	M2	M3	M1	M2	M3	M1	M2	M3	M1	M2	M3		
<i>Bosmina hagmanni</i> Stingelin, 1904		x	x	x	x	x	x	x		x	x	x	83	Very Frequent
<i>Bosmina longirostris</i> Müller, 1785	x	x	x	x	x	x	x		x	x	x		83	Very Frequent
<i>Bosmina</i> sp.						x	x						17	Infrequent
Genera: <i>Bosminopsis</i> Richard, 1895														
<i>Bosminopsis deitersi</i> Richard, 1895	x	x	x	x	x	x	x	x	x	x	x	x	100	Very Frequent
Family: Chydoridae														
Genera: <i>Alonella</i> Fryer 1968														
<i>Alonella dadayi</i> Birge, 1910	x			x				x	x		x		42	Frequent
Family: Sididae														
Genera: <i>Diaphanosoma</i>														
<i>Diaphanosoma birgei</i> Korinek, 1981														
Family: Daphniidae														
Genera: <i>Ceriodaphnia</i>														
<i>Ceriodaphnia cornuata</i> Sars, 1885		x	x		x	x			x	x	x	x	67	Frequent
Family: Macrothricidae														
Genera: <i>Macrothrix</i> Baird, 1843														
<i>Macrothrix</i> sp1				x									8	Sporadic
Family: Moinidae														
Genera: <i>Moina</i>														
<i>Moina minuta</i> Hansen, 1899	x	x	x		x	x	x		x	x		x	75	Very Frequent
Class: Malillopoda														
Nauplio de Copepoda	x	x	x	x	x	x	x	x	x	x	x	x	100	Very Frequent
Order: Cyclopoida														
Copepodito de Cyclopoida	x	x	x	x	x	x	x	x	x	x	x	x	100	Very Frequent

Table 7. Classification and frequency of occurrence of zooplankton organisms in the Murucupi River in 2012.

Taxa	February			May			August			November			FR (%)	Classification
	M1	M2	M3	M1	M2	M3	M1	M2	M3	M1	M2	M3		
Cyclopoida sp1	x	x	x	x	x	x	x	x	x	x	x	x	100	Very Frequent
Cyclopoida sp2	x		x	x			x		x		x	x	58	Frequent
Cyclopoida sp3	x	x						x					25	Infrequent
Cyclopoida sp4									x				8	Sporadic
Cyclopoida sp5									x	x			17	Infrequent
Order: Calanoida														
Calanoida sp1	x						x						17	Infrequent
Copepodito de Calanoida			x			x	x			x	x	x	50	Frequent
Order: Hapartcoida														
Copepodito de Hapartcoida					x				x				17	Infrequent
Hapartcoida sp1				x									8	Sporadic
Hapartcoida sp2	x			x	x	x		x	x			x	58	Frequent
Class: Malacostraca														
Order: Isopoda														
Isopoda														
Phylum: Mollusca														
Class: Gastropoda														
Larva de Gastropoda	x		x	x			x	x		x	x		58	Frequent
Class: Bivalvia														
Larva de Bivalve	x					x			x	x	x	x	50	Frequent
Phylum: Annelida														
Class: Polychaeta														
Poliqueta		x			x					x	x		33	Frequent