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Lists of Species

Micro-phytoplankton richness in Contas River, state of Bahia, northeastern Brazil

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Abstract: Phytoplankton composition in lotic environments has received less attention than that of lentic environments. The aim of the present study was to describe the micro-phytoplankton of the Contas River, which is one of the five most important water bodies in the state of Bahia, Brazil. Collections were carried out at 28 sampling sites at three-month intervals over a three-year period between December 2007 and September 2010. The micro-phytoplankton community was represented by 198 taxa distributed among Bacillariophyceae, Coscinodiscophyceae, Cyanophyceae, Fragilariophyceae, Chlorophyceae, Euglenophyceae, Dinophyceae, Cryptophyceae, Chrysophyceae and Xantophyceae. *Geitlerinema amphibium* (C. Agardh) Anagnostidis, *Planktothrix agardhii* (Gom.) Anagnostidis and Komárek, *Pleurosira laevis* (Ehrenberg) Compère and *Ulnaria ulna* (Nitzsch) P. Compère occurred in all samples. The majority of species (n = 111; 56.06% of the taxa) were classified as rare in the Contas River, as these organisms were only recorded during one or two months.

Introduction

Rivers are complex ecosystems with characteristics that pose particular challenges to organisms, as the habitats are subject to constant change due to high current flow (Rodrigues *et al*. 2007). Phytoplankton in lotic environments has received less attention than that of lentic environments, especially in Brazil (Silva *et al*. 2001; Soares *et al*. 2007). According to Rodrigues *et al*. (2007), knowledge on the biodiversity of phytoplankton in rivers is of extreme importance for the monitoring of water quality, as these systems are increasingly affected by anthropogenic impacts, the most frequent alterations of which are changes in the shape of river channels and water flow due to the construction of dams and multiple-use reservoirs (Maddock 1999).

The study of phytoplankton composition provides information for the characterization of aquatic ecosystems (Pompêo *et al.* 1998). Phytoplankton is mostly made up of autotrophic, solitary or colonial organisms, such as cyanobacteria and a large number of eukaryotic algae. These organisms constitute the first and quantitatively most important link in the food chain, representing the main source of oxygen and energy for other trophic levels of the aquatic environment.

In order to contribute toward a better understanding of the phytoplankton structure in lotic environments, especially rivers with dams, the aim of the present study was to describe the micro-phytoplankton of the Contas River, which is one of the five most important water bodies in the state of Bahia, Brazil.

Materials and Methods

Study area

The Contas River in the state of Bahia, Brazil, has a hydrographic basin with an area of 53,000 km^2 and is just over 500 km in length. The spring of this river is located on the eastern slope of the Serra das Almas in the mountainous geological formation known as the Chapada Diamantina and the river empties into the Atlantic Ocean in the city of Itacaré (CHESF 2011) (Figure 1). The predominant climate is warm, with a mean annual temperature above 18° (SEI 1998). The rainy season is in the summer (November to January) and the dry season is in winter (June to August).

Sampling and data analysis

Collections were carried out at 28 sampling sites at three-month intervals over a three-year period from December 2007 to September 2010. Integrated samples were obtained with plankton nets (mesh: 25 µm) throughout the euphotic zone, which was determined by a digital quantameter (Licor-250). The volumes filtered were calculated by the equation V = A × D, where A is the area (m^2) of the mouth of the net and D is the depth (m) of the drag. The material was preserved in acetic Lugol solution (4%) and subsequently analyzed under an optical microscope and photodocumented with the aid of a microscope (Zeiss/Axioskop) equipped with a photography camera (Samsung SCC833, Japan). Image processing was performed with the Imagelab program (Softium, Brazil). After the taxonomic analysis and photomicrographs, samples were deposited in the Herbarium Professor Vasconcelos Sobrinho, Federal Rural University of Pernambuco (PEURF 50995 to 51326).

The classification system proposed by Van den Hoek *et al*. (1997) was used for the classes Cryptophyceae, Dinophyceae, Chrysophyceae, Euglenophyceae and Chlorophyceae. The system proposed by Round *et al*. (1990) was used for Coscinodiscophyceae, Fragilariophyceae and Bacillariophyceae and the system

proposed by Komárek and Anagnostidis (2000; 2005) was used for Cyanophyceae.

The frequency of occurrence of the taxa was calculated based on the method described by Matteucci and Colma (1982), considering the number of samples in which a given taxon occurred in relation to the total number of samples collected. For this, the following categories were used: very frequent (VF) - > 70%; frequent (F) - ≤ 70% |-- >40%; infrequent (I) - ≤ 40% |-- > 10%; sporadic or rare (S) - <10%.

Results and Discussion

The micro-phytoplankton of the Contas River was represented by 198 taxa: 34 Cyanophyceae, 15 Coscinodiscophyceae, 7 Fragilariophyceae, 37 Bacillariophyceae, 80 Chlorophyceae, 14 Euglenophyceae, 3 Dinophyceae, 4 Cryptophyceae, 3 Chrysophyceae and 1 Xantophyceae (Table 1). This high degree of diversity was likely due to the high degree of habitat heterogeneity in the ecosystem studied, with some regions exhibiting characteristics of lentic environments and other stretches exhibiting characteristics of lotic environments, which is common in dammed rivers. Fuentes *et al*. (2010) also reported the presence of aquatic macrophytes in some stretches as one of the factors that contribute toward the increase in diversity in the Contas River. These macrophytes provide substrate for epiphytic algae, which can move to the pelagic region of the river due to perturbation in the hydrological levels.

A large number of the taxa have also been recorded in other rivers in Brazil. In the rivers of the Upper Paraná River floodplain, Rodrigues *et al*. (2009) identified 177 taxa in the Paraná River, 288 in the Baía River and 277 in the Ivinhema River. Ferrareze and Nogueira (2006) found a total of 205 taxa in the Paranapanema River in the state of São Paulo. In these studies, the classes Bacillariophyceae and Chlorophyceae were also predominant, demonstrating the importance of these groups in aquatic ecosystems in Brazil.

In the Boa Esperança reservoir situated between Maranhão and Piauí, Pompêo *et al.* (1998) interpreted the presence of Bacillariophyceae as being a function of the habitat. In this study, diatoms dominated sites with lotic characteristics. Chlorophytes commonly exhibit a high degree of richness in aquatic systems in Brazil, especially Zygnematales (desmids) in south and southeast (Padisák *et al*. 2000; Bittencourt-Oliveira and Moura 2001; Soares *et al.* 2007). In northeastern Brazil, Chlorococcales generally stand out in terms of floristic representativity, as reported by Bouvy *et al*. (1999; 2000) in the state of Pernambuco as well as by Barbosa and Mendes (2005) in the state of Paraíba. This order also stood out in the Contas River.

Regarding frequency of occurrence, only the species *Geitlerinema amphibium* (C. Agardh) Anagn., *Planktothrix agardhii* (Gom.) Anagn. and Komárek, *Pleurosira laevis* (Ehrenberg) Compère and *Ulnaria ulna* (Nitzsch) P. Compère occurred at all sampling sites. Another 16 species were also considered very frequent: the cyanobacteria *Cylindrospermopsis raciborskii* (Woloszynska) Seenaya and Subba Raju and *Oscillatoria* sp.; the diatoms *Aulacoseira granulata* (Ehrenberg) Simonsen, *Cyclotella meneghiniana* Kützing, *Fragilaria crotonensis* Kitton, *Melosira varians* C. Agardh and *Pinnularia* sp.; the chlorophytes *Coelastrum reticulatum* (P.A. Dangeard) Senn, *Closterium* sp., *Radiococcus planktonicus* J.W.G. Lund, *Sphaerocystis schroeteri* Chodat, *Planktosphaeria gelatinosa* G.M. Smith, *Scenedesmus quadricauda* (Turp.) Bréb. ex Ralfs and *Spirogyra* sp.; the cryptophyte *Cryptomonas ovate* Ehrenberg; and the euglenophyte *Trachelomonas volvocina* Ehrenberg. The majority of species (n = 111; 56.06% of the taxa) were classified as rare in the Contas River, as these organisms were only recorded during one or two months.

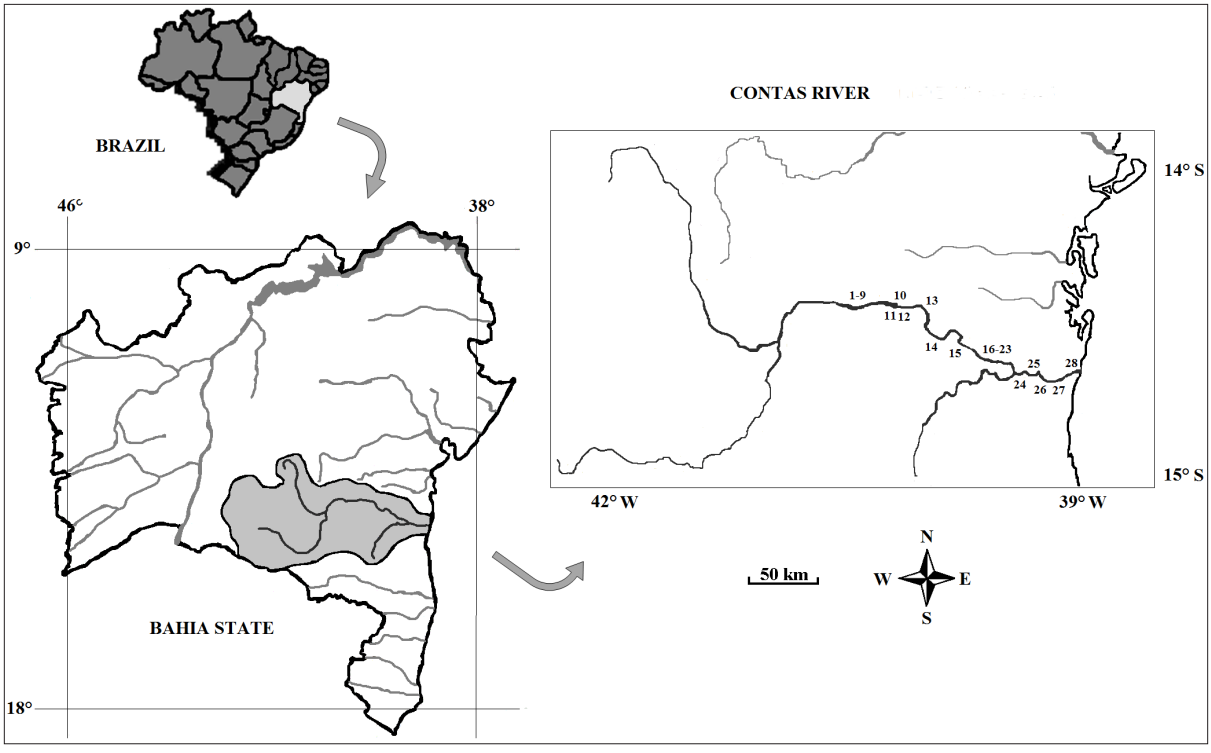

Figure 1. Location of Contas River and the sampling sites in the state of Bahia.

Table 1. Taxa identified in Contas River, Bahia, Brazil, between December 2007 and September 2010; FO = frequency of occurrence; VF = very frequent; F = frequent; I = infrequent; S = sporadic or rare.

TAXA	F.O
Class Cyanophyceae	
Order Chroococcales	
Family Chroococaceae	
Aphanocapsa elachista W. West and G.S. West	I
Aphanocapsa sp.	I
Aphanothece sp.	S
Chroococcus minutus (Kützing) Nägeli	I
Chroococcus turgidus (Kützing) Nägeli	S
Chroococcus sp.	S
Merismopedia glauca (Ehrenberg) Kützing	S
Merismopedia tenuissima Lemmermann	S
Microcystis aeruginosa (Kützing) Kützing	I
Microcystis panniformis J.Komárek, J.Komárková-Legnerová, C.L.Sant'anna, M.T.P.Azevedo and P.A.C.Senna	S
Microcystis wesenbergii (Komárek) Komárek	I
Microcystis sp.	I
Order Nostocales	
Family Nostocaceae	
Anabaena circinalis Rabenhorst	I
Anabaena constricta (Szafer) Geitler	F
Anabaena sp.	F
Aphanizomenon sp.	S
Cylindrospermopsis raciborskii (Woloszynska) Seenaya and Subba Raju	VF
Raphidiopsis mediterranea Skuja	I
Order Oscillatoriales	
Family Oscillatoriaceae	
Lyngbya majuscula (Dillwyn) Harvey	S
Lyngbya sp.	F
Oscillatoria limnetica Lemmermann	S
Oscillatoria princeps Vaucher ex Gomont	I
Oscillatoria sancta Kützing ex Gomont	S
Oscillatoria sp.	VF
Family Phormidiaceae	
Phormidium sp.	S
Planktothrix agardhii (Gom.) Anagn. and Komárek	VF
Family Pseudanabaenaceae	
Geitlerinema amphibium (C. Agardh) Anagn.	VF
Geitlerinema splendidum (Greville) Anagnostidis	F
Geitlerinema sp.	S
Pseudanabaena catenata Lauterborn	I
Pseudanabaena galeata Böcher	S
Pseudanabaena limnetica (Lemm.) Komárek	F
Pseudanabaena sp.	I
Spirulina sp.	S
Class Coscinodiscophyceae	
Order Coscinodiscales	
Family Coscinodiscaceae	
Coscinodiscus sp.	I
Order Rhizosoleniales	
Family Rhizosoleniaceae	
Urosolenia longiseta (Zacharias) Bukhtiyarova	S
Order Thalassiosirales	
Family Thalassiosiraceae	
Thalalssiosira sp.	S
Family Stephanodiscaceae	
Cyclotella meneghiniana Kützing	VF
Cyclotella stelligera Cleve and Grunow	S
Order Melosirales	
Family Melosiraceae	
Melosira varians C. Agardh	VF
Melosira sp.	I
Order Aulacoseirales	
Family Aulacoseiraceae	
Aulacoseira ambigua (Grunow) Simonsen	I
Aulacoseira granulata (Ehrenberg) Simonsen	VF
Aulacoseira granulata var. *angustissima* (O.F. Müller) Simonsen	I
Order Triceratiales	
Family Triceratiaceae	
Pleurosira laevis (Ehrenberg) Compère	VF
Pleurosira sp.	S
Order Biddulphiales	
Family Biddulphiaceae	
Terpsinoe americana (Bailey) Grunow	S
Terpsinoe musica Ehrenberg	F
Terpsinoe sp.	S
Class Fragilariophyceae	
Order Fragilariales	
Family Fragilariaceae	
Asterionella sp.	I
Fragilaria capucina Desmazières	S
Fragilaria crotonensis Kitton	VF
Fragilaria javanica F. Hustedt	S
Fragilaria sp.	F
Synedra rumpens Kützing	F
Ulnaria ulna (Nitzsch) P. Compère	VF
Class Bacillariophyceae	
Order Eunotiales	
Family Eunotiaceae	
Eunotia flexuosa (Brébisson) Kützing	S
Eunotia sp.	I
Order Rhopalodiales	
Family Rhopalodiaceae	
Epithemia sorex Kützing	I
Epithemia turgida (Ehrenberg) Kützing	S
Epithemia sp.	I
Rhopalodia gibba (Ehrenberg) O.F. Müller	I
Order Naviculales	
Family Diploneidaceae	
Diploneis sp.	I
Family Stauroneidaceae	
Stauroneis phoenicenteron (Nitzsch) Ehrenberg	I
Stauroneis sp.	S
Family Pinnulariaceae	
Pinnularia gibba Ehrenberg	S
Pinnularia maior (Kützing) Cleve	S
Pinnularia sp.	VF
Family Amphipleuraceae	
Amphipleura pellucida (Kützing) Kützing	I
Frustulia rhomboides (Ehrenberg) De Toni	I
Family Naviculaceae	
Navicula disparalis Hustedt	I
Navicula sp.	F
Navicula sp. 2	S
Family Pleurosigmataceae	
Gyrosigma spenceri (W. Smith) Grif. and Henfrey	I
Gyrosigma sp.	F

Table 1. ***Continued.***

TAXA	F.O
Pleurosigma sp.	S
Order Achnanthales	
Family Achnanthaceae	
Achnanthes exigua Grunow	S
Family Cocconeidaceae	
Cocconeis plancetula Ehrenberg	F
Cocconeis sp.	I
Order Cymbellales	
Family Cymbellaceae	
Achnanthes exigua Grunow	S
Encyonema selesiacum (Bleisch) D.G. Mann	I
Placoneis sp.	S
Family Gomphonemataceae	
Gomphonema acuminatum Ehrenberg	S
Gomphonema gracile Ehrenberg	I
Gomphonema parvulum (Kützing) Grunow	F
Gomphonema truncatum Ehrenberg	S
Order Bacillariales	
Family Bacillariaceae	
Nitzschia palea (Kützing) W. Smith	I
Nitzschia sp.	F
Tryblionella coarctata (Grunow) D.G. Mann	S
Tryblionella victoriae Grunow	I
Order Surirellales	
Family Surirellaceae	
Surirella biseriata Brébisson	S
Surirella linearis W. Smith	I
Surirella robusta Ehrenberg	F
Surirella sp.	I
Class Chlorophyceae	
Order Chlorococcales	
Family Radiococcaceae	
Radiococcus planktonicus J.W.G. Lund	VF
Family Hydrodictyaceae	
Pediastrum duplex Meyen	F
Pediastrum simplex Meyen	I
Pediastrum tetras (Ehrenberg) Ralfs	S
Family Oocystaceae	
Eremosphaera eremosphaeria R.L. Smith and Bold	S
Dactylococcus infusionum Nägeli	S
Oocystis elliptica W. West	I
Oocystis lacustris Chodat	S
Oocystis pusilla Hansgirg	F
Oocystis sp.	I
Oonephris obesa (W. West) Fott	S
Planktosphaeria gelatinosa G.M. Smith	VF
Family Golenkiniaceae	
Golenkinia paucispina W. West and G.S. West	I
Golenkinia radiata Chodat	I
Family Micractiniaceae	
Micractinium pusillum Fresenius	S
Micractinium sp.	I
Phytelios viridis Frenzel	I
Family Chlorococcaceae	
Chlorococcum infusionum (Schrank) Meneghini	I
Schroederia robusta Korshikov	S
Schroederia setigera (Schröder) Lemmermann	S
Tetraedron gracile (Reinsch) Hansgirg	I
Tetraedron trigonum (Nägeli) Hansgirg	S
Family Scenedesmaceae	
Crucigenia quadrata Morren	I
Crucigenia tetrapedia (Kirchner) West and West	S
Scenedesmus acuminatus (Lagerheim) Chodat	F
Scenedesmus arcuatus (Lemm.) Lemmermann	S
Scenedesmus bijugus (Turpin) Kützing	VF
Scenedesmus ecornis (Ehrenberg) Chodat	I
Scenedesmus incrassatulus Bohlin	S
Scenedesmus quadricauda (Turp.) Bréb. ex Ralfs	VF
Scenedesmus sp.	S
Sorastrum spinulosum Nägeli	S
Willea irregulares (Wille) Schmidle	S
Family Coelastraceae	
Actinastrum gracillimum Smith	F
Actinastrum hantzschii Lagerheim	I
Actinastrum sp.	I
Coelastrum astroideum De Notaris	S
Coelastrum cambricum W. Archer	S
Coelastrum microporum Nägeli	I
Coelastrum reticulatum (P.A. Dangeard) Senn	VF
Family Botryococcaceae	
Botryococcus braunii Kützing	S
Dictyosphaerium ehrenbergianum Nägeli	S
Dictyosphaerium pulchellum H.C. Wood	VF
Dictyiosphaerium sp.	S
Family Chlorellaceae	
Ankistrodesmus fusiformis Corda ex Korshikov	I
Ankistrodesmus gracilis (Reinsch) Korshikov	I
Ankistrodesmus sp.	S
Chlorella vulgaris Beijerinck	F
Kirchneriella lunaris (Kirchner) K. Möbius	F
Kirchneriella obesa (G.S. West) Schmidle	I
Monoraphidium arcuatum (Korshikov) Hindák	I
Monoraphidium braunii (Nägeli) Kom.-Legn.	S
Monoraphidium contortum (Thuret) Kom.-Legn.	F
Monoraphidium griffithii (Berkeley) Kom.-Legn.	I
Monoraphidium komarkovae Nygaard	S
Monoraphidium sp.	I
Order Tetrasporales	
Family Palmellaceae	
Sphaerocystis schroeteri Chodat	VF
Order Zygnematales	
Family Zignemataceae	
Mougeotia sp.	F
Spirogyra sp.	VF
Family Closteriaceae	
Closterium ehrenbergii Meneghini ex Ralfs	F
Closterium moniliferum Ehrenberg ex Ralfs	S
Closterium sp.	VF
Family Desmidiaceae	
Cosmarium bioculatum Brébisson ex Ralfs	I
Cosmarium margaritatum (P. Lundell) J. Roy and Bisset	I
Cosmarium sp.	F
Desmidium sp.	S
Euastrum sp.	S
Staurastrum gracile Ralfs ex Ralfs	S
Staurastrum leptocladum L.N. Johnson	F
Staurastrum rotula Nordstedt	I

Table 1. ***Continued.***

TAXA	F.O
Staurastrum tetracerum Ralfs	I
Staurastrum sp.	F
Staurodesmus sp.	I
Family Peniaceae	
Gonatozygon monotaenium De Bary	I
Gonatozygon pilosum Wolle	S
Gonatozygon sp.	S
Order Oedogoniales	
Family Oedogoniaceae	
Oedogonium sp.	I
Order Volvocales	
Family Volvocaceae	
Eudorina sp.	I
Pandorina morum (O.F. Müller) Bory de Saint-Vincent	S
Volvox sp.	I
Class Cryptophyceae	
Order Cryptomonadales	
Family Cryptomonadaceae	VF
Cryptomonas ovata Ehrenberg	F
Cryptomonas subovalis Ehrenberg	I
Cryptomonas sp.	
Order Pyrenomonadales	
Family Pyrenomadaceae	I
Rhodomonas sp.	
Class Dinophyceae	
Order Peridiniales	
Family Ceratiaceae	I
Ceratium hirundinella (O.F.Müller) Dujardin	S
Ceratium sp.	S
Family Peridiniaceae	I
Peridinium cinctum (O.F. Müller) Ehrenberg	I
Peridinium sp.	
Class Chrysophyceae	
Order Monosigales	
Family Synuraceae	
Synura sp.	S
Order Ochromonadales	
Family Dinobryaceae	
Dinobryon sertularia Ehrenberg	S
Dinobryon sp.	S
Class Euglenophyceae	
Order Euglenales	
Family Euglenaceae	
Euglena acus Ehrenberg	I
Euglena oxyuris Schmarda	I
Euglena sp.	F
Lepocinclis sp.	I
Phacus curvicauda Svirenko	S
Phacus longicauda (Ehrenberg) Dujardin	I
Phacus pleuronectes (O.F. Müller) Dujardin	S
Phacus sp.	I
Trachelomonas acanthophora Stokes	S
Trachelomonas armata (Ehrenberg) F. Stein	S
Trachelomonas obesa Ehrenberg	I
Trachelomonas oblonga Ehrenberg	I
Trachelomonas volvocina Ehrenberg	VF
Trachelomonas sp.	F
Class Xantophyceae	
Order Mischococcales	
Family Centritactaceae	
Centritractus belenophorus Lemmermann	I

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