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Changes in the structure of the phytoplankton community in a Nile tilapia fishpond

Mudanças na estrutura da comunidade fitoplanctônica em viveiro de tilápia-do-Nilo

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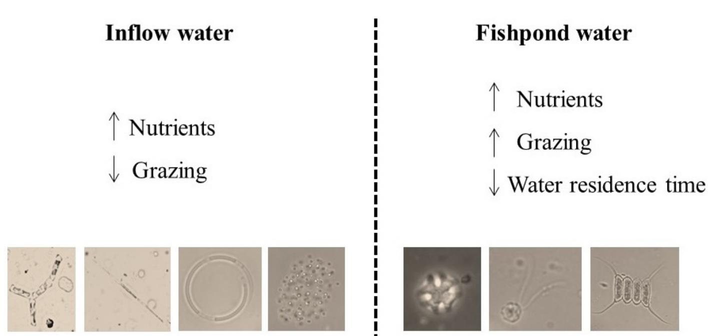
Abstract: Aim: Our objectives were to recognize species that can serve as biological descriptors and evaluate the changes in the phytoplankton community throughout the grow-out period of the Nile tilapia (*Oreochromis niloticus* Linnaeus 1758) related to management practices and to limnological variables. **Methods:** Samples from the inflow water and the fishpond were collected for the analysis of limnological variables and the structure of the phytoplankton community. **Results:** In the fishpond, we registered a 1.5 times increase in nitrogen and total suspended solids and a 2 times increase in phosphorous compared to the inflow water. During the grow-out period (113 days), 134 taxa belonging to 10 taxonomic classes were registered. Chlorophyceae (60 taxa) and Cyanobacteria (26 taxa) showed the greatest diversity and abundance of species. The largest biovolumes were recorded in the fishpond. Nanoplanktonic species were the most abundant and represented 35% of the descriptor species in the phytoplankton community of the fishpond. **Conclusions:** The instability of the system associated with the control of the hydraulic retention time as a consequence of management practices, favored the presence of species with small cellular dimensions. The decrease in air and water temperature registered at the end of the grow-out period probably favored the increase and persistence of diatoms.

Keywords: descriptor species; ecology of fishponds; microalgae; nutrient cycle.



Graphical abstract. Spatial variation of the main phytoplanktonic taxa in the fishpond.

Resumo: Objetivo: O presente artigo visa avaliar quais as espécies podem ser descritores biológicos e avaliar as mudanças na comunidade fitoplanctônica durante a etapa final de crescimento de tilápia-do-Nilo (*Oreochromis niloticus* Linnaeus 1758), relacionando com o manejo de produção e com as variáveis limnológicas. **Métodos:** Amostras da água de abastecimento e do centro do viveiro foram utilizadas para as análises limnológicas e para avaliar estrutura da comunidade fitoplanctônica. **Resultados:** No viveiro de piscicultura, registramos aumento de 1.5 vezes nas concentrações de nitrogênio e sólidos totais suspensos e na ordem de 2 vezes incremento de fósforo comparado com a água de abastecimento. Durante o ciclo de produção (113 dias), foram registrados 134 táxons distribuídos em 10 classes taxonômicas. Chlorophyceae (60 táxons) e Cyanobacteria (26 táxons) foram as classes com maior riqueza e abundância de espécies. Os maiores biovolumes foram registradas no centro do viveiro. Espécies nanoplanctônicas foram as mais abundantes e representaram 35% das espécies descritoras da comunidade fitoplanctônica do centro do viveiro. **Conclusões:** A instabilidade do sistema, quanto ao controle do tempo de retenção hidráulica como consequência do método de criação utilizado, favoreceu a presença de espécies com pequenas dimensões celulares. Os decréscimos de temperatura do ar e da água registrados na etapa final de crescimento possivelmente favoreceram o aumento e manutenção das diatomáceas.

Palavras-chave: espécies descritoras; ecologia de viveiros de piscicultura; micro algas; ciclagem de nutrientes.

1. Introduction

Fish farming is an economic sector in global expansion due to the capacity of producing healthy and nutritionally rich food that represents a primary protein source in many countries. Like any other activity related to agricultural production, however, if not well managed it may lead to environmental and financial damages (Gorlach-Lira et al., 2013; FAO, 2016).

In aquaculture, artificial diets with a high nutrient content are commonly used for cultivated fish species. However, only 25% to 40% of the nitrogen and phosphorus of the diet is converted into fish biomass (Chatvijitkul et al., 2017; David et al., 2017a, b; Osti et al., 2018). The diet portion that is not consumed turns into ammonium, nitrate, phosphates, carbon dioxide and organic suspended solids (Montoya et al., 2000), which can cause the rapid growth of the algal community favoring blooms, especially of cyanobacteria (Paerl & Tucker, 1995; Beyruth et al., 2004; Sant'Anna et al., 2006; Boyd, 2016). As a consequence of blooms, fish mortality and a decrease in fish productive performance and profitability might occur (Mercante et al., 2007; Boyd, 2016). On the other hand, phytoplankton is of fundamental importance for the maintenance of water quality for fish culture, because it interferes directly in the production and dynamics of gases in the fishpond through photosynthesis and respiration processes (Mercante et al., 2011; Brraich & Saini, 2015). It is also a secondary food source for the main fish species produced in Brazil, such as tilapia (Beyruth et al., 2004; Turker et al., 2003a, b; FAO, 2016).

Different conditions and factors, such as the existing inoculum, species growth rate, perennial mechanisms, and the ability of sustaining processes of biomass loss, as well as nutrient availability, water temperature, luminosity, hydraulic flow, sedimentation and herbivory, might be responsible for the increase in algal density (Margalef, 1978; Padisák, 1997; Bouvy et al., 2000; Beisner et al., 2006; Fernandes et al., 2009). This set of conditions will determine which species will occur at a given time and place and should be considered and evaluated for the understanding of changes in the phytoplankton structure in fishponds. However, the dynamics of fishponds is strongly influenced by the management practices (the type of organism produced, production method, quantity and quality of feed used, quality of inflow water, hydraulic retention time, among others) that might favor distinct phytoplanktonic groups. Consequently, the use of phytoplankton descriptor species can help to recognize which ecological groups will be established first and which ones may remain in the environment, due to both the morphological characteristics of the organisms and their biological requirements associated with the dynamics of limnological variables.

The aims of this study were to 1) determine the descriptor species of the phytoplanktonic community in a fishpond of Nile tilapia (*Oreochromis niloticus*); and 2) to evaluate the temporal changes in the structure of the phytoplankton community associated with management practices and limnological variables during the grow-out period of Nile tilapia, through the analysis of descriptor species. We expect that the inoculum of varied phytoplanktonic groups in the inflow water together with high nutrient concentrations and high temperature will induce the replacement by mainly filamentous and colonial cyanobacteria in the fishpond.

2. Material and Methods

This study was performed in excavated fishponds of a Nile tilapia production system, located in the Crustacean Sector of the Aquaculture Center of São Paulo State University - CAUNESP, Jaboticabal, SP, Brazil (21° 15' 22" S and 48° 18' 48" W) (Figure 1). The climate according to the Köppen classification is AW tropical rainy with dry winter and mean temperatures in the coldest month of 18°C. Rainfall during the experimental period ranged from 183 mm in March to 7.8 mm in June 2010. The monthly average air temperature was higher in the first half of the grow-out period (24.6 ± 5.7 °C in March and 22.2 ± 6.1 °C in April) than at the end (19.5 ± 6.5 °C in May and 18.5 ± 7.7 °C in June) (CIIAGRO, 2012).

The fishpond had a surface area of 0.02 ha, a volume of 220 m^3 and a residence time of 4 days. The male monosex Nile tilapias (*Oreochromis niloticus* Linnaeus 1758) were in the grow-out stage, with an individual weight of 17.5 g. The adopted production system was semi-intensive, stocked at 3 fishes/m^2. Twice a day, tilapias were fed with a commercially formulated extruded diet, containing 28% of crude protein. The daily ration of feed ranged from 2.5 to 5% of fish weight, considering the population developmental stage (size/age) and the estimate of the biomass produced. To estimate the total biomass, fishes were measured periodically, considering the analysis of a batch containing 10% of the fishpond total population. At the end of the grow-out period (113 days), the final mean fish weight was 176.9 g, the production was 5.3 kg ha^{-1}, and the total amount of feed was 5.987 kg ha^{-1}.

For the analysis of limnological variables and phytoplankton, water samples from the inflow water and the fishpond were collected fortnightly for 113 days, from March 3 to June 24, 2010

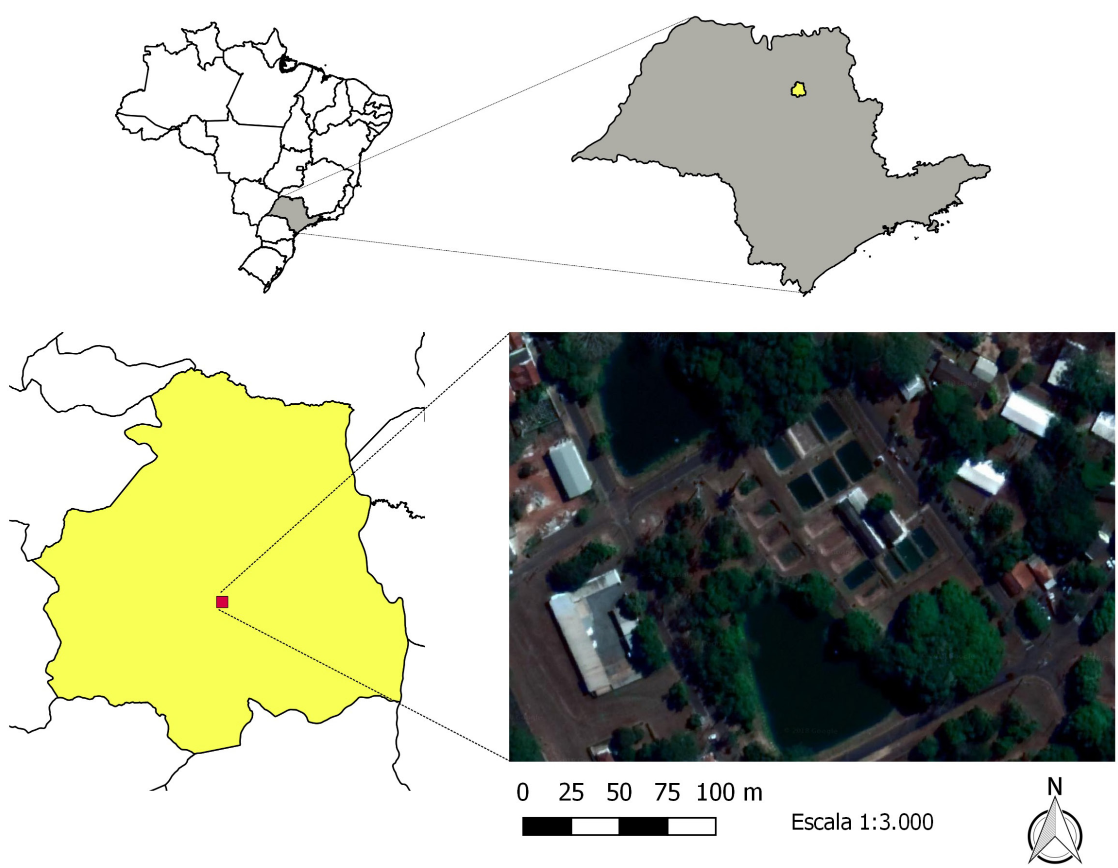


Figure 1. Location of the Crustacean Sector of the Aquaculture Center of São Paulo State University in São Paulo state (Brazil). Image from Google Earth (access in 14-jun-2018).

(n = 9), using sterile bottles. The water temperature, dissolved oxygen, electrical conductivity, pH, and turbidity were measured *in situ* using portable sensors (Horiba U10). Total suspended solids (TSS) were determined according to APHA (2005), total Kjeldahl nitrogen (TKN), dissolved Kjeldahl nitrogen (DKN), nitrite-N and nitrate-N concentrations according to Mackereth et al. (1978) and ammoniacal-N according to Koroleff (1976). Total inorganic nitrogen concentration (TIN) was calculated as the sum of concentration values for nitrite-N, nitrate-N, and ammoniacal-N. Total phosphorus (TP), dissolved phosphorus (DP) and orthophosphate-P (P-ORT) concentrations were determined according to Golterman et al. (1978).

Samples for qualitative analyses of the phytoplankton community were collected using a 20 µm mesh plankton net (n = 9) and preserved in 4% formaldehyde solution. Taxa were identified under the light microscope (Zeiss Axioplan 2), with the aid of specialized literature for each algal group and following the class level classification of van-den-Hoek et al. (1995) and Bicudo & Menezes (2017). For quantitative analyses, samples were fixed in a 1% Lugol's solution. Counting (ind mL^{-1}) was performed in random fields (Utermöhl, 1958) under an inverted microscope (Zeiss Axiovert 25) at 630 × magnification. Sedimentation time was 3 h cm^{-1} (Lund et al., 1958). Counting limit was defined by the species rarefying curve until reaching 100 individuals (cells, colonies, coenobium, and filaments) of the most common species (Bicudo, 1990).

The biovolume was estimated by multiplying the mean cell volume of each taxon (n = 20) by the cell population density. Cell volume was calculated based on geometric models (Hillebrand et al., 1999). To determine the descriptor species of the phytoplanktonic community, species with a relative biovolume > 1% that totaled 80% of the phytoplankton biovolume and those with a total biovolume > 50% as dominant species. Abundant species had a higher occurrence than the mean total number of individuals of the sample (Lobo & Leighton, 1986).

A one-way analysis of variance (ANOVA) was used to evaluate the limnological variables between the inflow water and fishpond, followed by Tukey's test ($p < 0.05$), using Statistica version 7.1 (SN: AX505B150718FA) (StatSoft, 2005). Canonical correspondence analysis (CCA) was performed to evaluate the effect of the limnological variables of the inflow water and the fishpond on the main patterns of the phytoplankton community, during the Nile tilapia grow-out period. The biotic matrix was composed of the phytoplankton descriptor species while the environmental matrix included the limnological variables of the inflow water and the fishpond. The limnological variables that showed the highest Pearson correlation with axes 1 and 2 (r > 0.5) were retained whereas the variables that could cause multicollinearity were excluded (Legendre & Legendre, 2012). Analyses were performed in PC-ORD 6.0 for Windows (McCune & Mefford, 1997), using log-transformed [log (x + 1)] data, except for the pH.

3. Results

As shown in Table 1, the mean values of water temperature, pH, electrical conductivity and dissolved oxygen did not differ between water samples, although the average concentration of dissolved oxygen recorded in the fishpond (7.13 mg L^{-1}) was higher than in the inflow water (6.62 mg L^{-1}). In the fishpond water, the mean values of TSS (18.0 mg L^{-1}), TKN (364.2 µg L^{-1}), DKN (144.2 µg L^{-1}) and TIN (117.3 µg L^{-1}) were 1.5 times higher than in inflow water (TSS 10.7 mg L^{-1}, TKN 219.9 µg L^{-1}, DKN 95.4 µg L^{-1} and TIN 73.8 µg L^{-1}). Mean values of TP (145.1 µg L^{-1}), DP (50.0 µg L^{-1}), P-ORT (14.6 µg L^{-1}) and turbidity (25.4 NTU) recorded in the fishpond were 2 times higher than in inflow water (TP: 70.7 µg L^{-1}, DP: 24.3 µg L^{-1}, P-ORT: 7.13 µg L^{-1} and turbidity: 12.2 NTU).

The highest phytoplankton biovolumes were recorded in the inflow water during the first 28 days of the tilapia culture but thereafter, the highest values were found in the fishpond (Figure 2). Chlorophyceae and Cyanobacteria were abundant in both water samples (Figure 2). Cyanobacteria showed the greatest abundance in the first two samplings, with 49 and 30% of the total phytoplankton biovolume, respectively, while Bacillariophyceae were most abundant in the last two samplings, with 69 and 70% of the total phytoplankton biovolume, respectively (Figure 2A).

In the fishpond, the dominance of the Xanthophyceae *Isthmochloron neustonica*, which contributed to 59% of the total phytoplankton biovolume, was registered after 84 days of culture. No other taxa were dominant during the grow-out period. After this period, there was an increase of Bacillariophyceae, which represented 30 and 52%, respectively, of the total phytoplankton biovolume in the last two samples (Figure 2B).

Table 1. Minimum (min.), mean, and maximum (max.) values of the water temperature (Temp), pH, turbidity (Tur), electrical conductivity (Cond), dissolved oxygen (DO), total suspended solids (TSS), total Kjeldahl nitrogen (TKN), dissolved Kjeldahl nitrogen (DKN), total inorganic nitrogen (TIN), total phosphorus (TP), dissolved phosphorus (DP) and orthophosphate-P (P-ORT), in the inflow water and the fishpond of a Nile tilapia production system during grow-out period (n = 9).

Limnological variables	Inflow water			Fishpond			One-way ANOVA	
	Min.	Mean	Max.	Min.	Mean	Max.	F value	*P* value
Temp (°C)	18.4	23.5	27.6	18.5	23.9	29.3	0.13	0.7198
pH	6.8	7.6	8.5	6.7	7.6	8.5	0.01	0.9507
Tur (NTU)	0.1	**12.2**	44.0	4.0	**25.4**	58.0	15.16	<0.001
Cond (μs cm^{-1})	49.2	75.5	310.0	50.1	73.8	312.6	0.01	0.9451
DO (mg L^{-1})	4.5	6.6	8.7	4.2	7.13	9.8	2.25	0.1401
TSS (mg L^{-1})	7.4	**10.7**	21.6	11.7	**18.0**	24.7	63.28	<0.001
TKN (μg L^{-1})	132.0	**219.9**	308.0	160.0	**364.2**	480.0	71.47	<0.001
DKN (μg L^{-1})	72.0	**95.4**	132.0	72.0	**144.2**	196.0	48.30	<0.001
TIN (μg L^{-1})	53.3	**73.8**	105.5	57.6	**117.3**	167.8	58.54	<0.001
TP (μg L^{-1})	40.7	**70.7**	103.7	112.0	**145.1**	212.4	187.00	<0.001
DP (μg L^{-1})	15.2	**24.3**	37.5	34.7	**50.0**	68.0	147.00	<0.001
P-ORT (μg L^{-1})	5.0	**7.13**	11.0	11.2	**14.6**	21.4	143.60	<0.001

Means in bold indicate differences of statistical significance according to Tukey's test ($p < 0.05$).

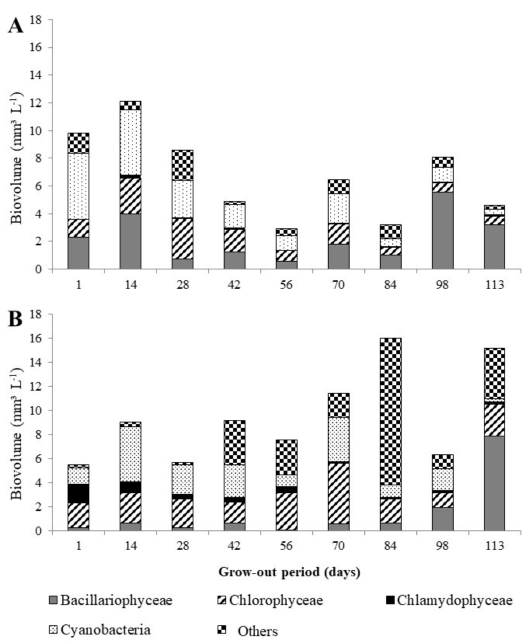


Figure 2. Fortnightly variation in the biovolume ($mm^3 L^{-1}$) of phytoplankton groups, in the inflow water (A) and the fishpond (B) of a Nile tilapia production system during the grow-out period (n = 9). (Others = Chrysophyceae, Cryptophyceae, Euglenophyceae, Dinophyceae, Xanthophyceae and Zygnemaphyceae).

We identified 134 taxa; 29 taxa showed a mean biovolume > 1% of total biovolume and were classified as descriptors species and along with six limnological variables were used in the canonical correspondence analysis (CCA) (Table 2; Figure 3). The first two axes of the CCA explained 34.3% of the total variation (Axis 1: 17.5% and Axis 2: 16.8%). Monte Carlo´s test proved that the eigenvalues for these axes (λ1 = 0.431 and 2 = 0.414 for axis 1 and axis 2, respectively) were statistically significant (p < 0.05). The correlation species-environment was significant ($p < 0.05$) for axis 1 (r = 0.933) and axis 2 (r = 0.950) indicating a strong relationship between the distribution of the phytoplankton taxa and the limnological variables of the inflow and fishpond water. Axis 2 evidenced a temporal variation over the grow-out period.

Intra-set correlation and canonical coefficients indicated that total suspended solids (TSS) (r = -0.8), total Kjeldahl nitrogen (TKN) (r = -0.8), total inorganic nitrogen (TIN) (r = -0.8), total phosphorus (TP) (r = -0.9) and orthophosphate-P (P-ORT) (r = -0.8) contributed to axis 1 and clustered together the samples of fishpond on the negative side. *Chlamydomonas microscopica*, *Coelastrum proboscideum*, *Cryptomonas brasiliensis*, *Cylindrospermopsis raciborskii*, *Isthmochloron neustonica* and *Peridinium* cf. *volzii* showed a strong correlation (r > 0.5) with the highest nutrient concentrations while *Chlorella minutissima*, *Crucigenia fenestrata* and *Synechocystis aquatilis* characterized the inflow water and correlated with the lowest nutrient concentrations (r > 0.5).

In CCA, water temperature (Temp) was the variable that contributed most to axis 2 (r = 0.9) and evidenced the variation of the phytoplankton taxa over the grow-out period. On the positive side, samples of the first 56 days of culture were clustered together, associated mainly with *Planktolyngbya contorta* (r = 0.7) whereas, after this culture period,

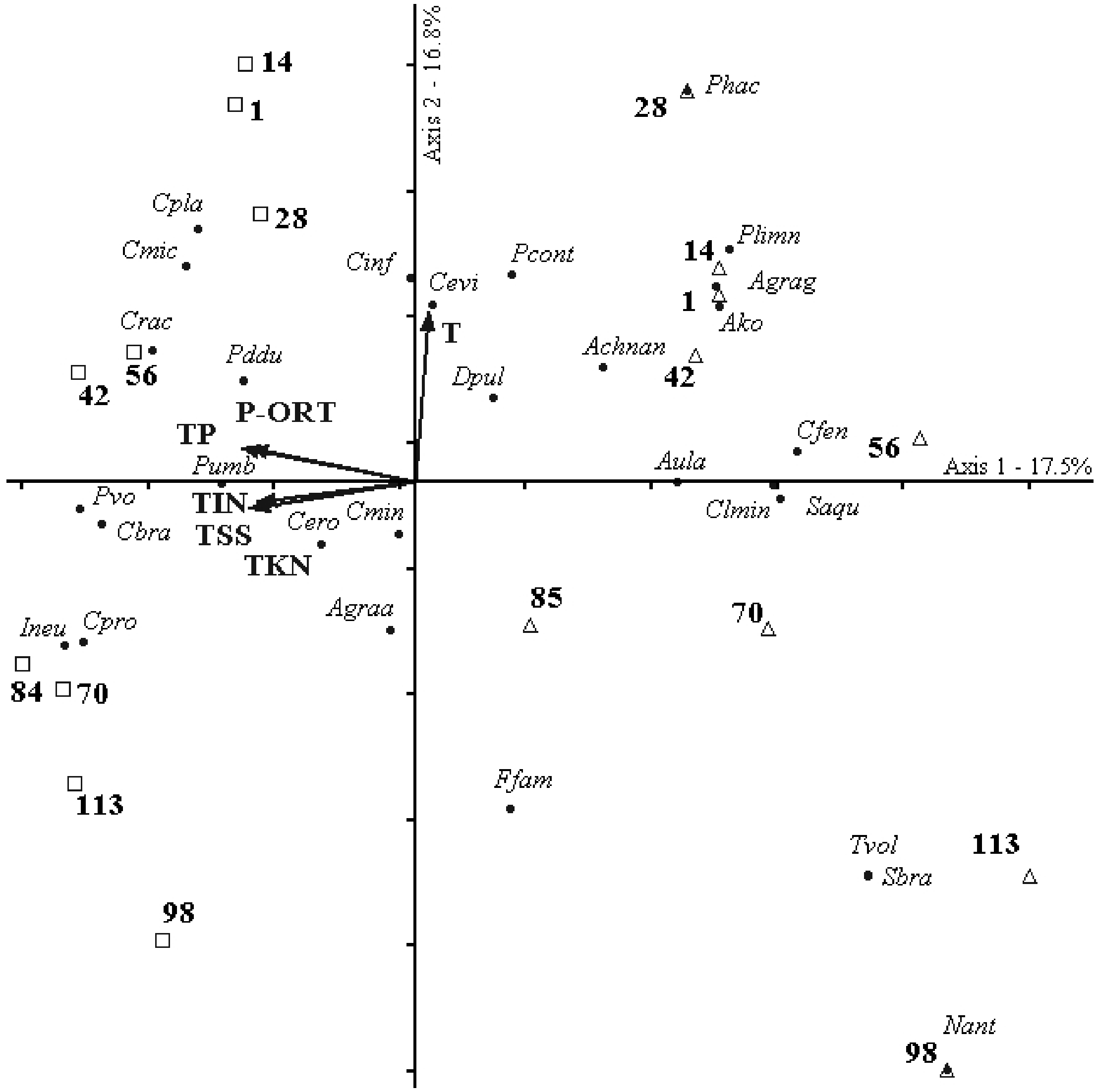


Figure 3. Canonical correspondence analysis (CCA) biplot of the phytoplankton biovolume and six limnological variables, in a production system of Nile tilapia (*O. niloticus*) during the grow-out period. Species correlation with axes 1 and 2 and the respective codes are given in Table 2. Score abbreviations: "sites" (Δ = inflow water and □ = fishpond); "limnological variables" (T – water temperature; TSS - total suspended solids; TKN - total Kjeldahl nitrogen; TIN - total inorganic nitrogen; TP - total phosphorus and P-ORT – orthophosphate-P) (n = 9).

samples were associated with the lowest water temperature and characterized by the diatom *Fragilaria familiaris* (r = -0.7).

4. Discussion

In our study, descriptor species were good indicators of the phytoplankton diversity of the fishpond. We classified 25 of 134 identified taxa as descriptor species, representing 82% of the phytoplankton community. Descriptor species were also an appropriate tool for the study of temporal dynamics of the phytoplankton community during the Nile tilapia grow-out period. Chlorophyceae and Cyanobacteria, which are considered the most representative in fishponds (Boyd, 2016), were also abundant in the fishpond analyzed. Mercante et al. (2011) reported that Chlorophyceae and Cyanobacteria accounted for 60% and 10% respectively of the phytoplankton community of a Nile tilapia fishpond, while Costa et al. (2015) observed that 43% of the phytoplankton community of a tambaqui fishpond (*Colossoma macropomum*) was represented by the Chlorophyceae.

The cell biovolume and diversity of the phytoplankton in the fishpond might be related to a high nutrient availability. Our results indicated a 1.5 times increase in the N and TSS concentrations

Table 2. Pearson´s correlations obtained for the biovolume of the phytoplankton species and axes 1 and 2 of the CCA.

	Codes	Axis 1	Axis 2
Achnanthidium sp.	Achn	0.390	0.388
Aphanocapsa koordersii Ström	Ako	0.423	0.346
Aulacoseira sp.1	Aula	0.329	0.014
A. granulata var. *angustissima* (Müller) Simonsen	Agraa	-0.167	-0.377
A. granulata var. *granulata* (Ehrenberg) Simonsen	Agrag	0.381	0.349
Chlamydomonas microscopica West	Cmic	-0.520	0.490
C. planctogloea Skuja	Cpla	-0.345	0.394
Chlorella minutissima Fott & Nováková	Clmi	0.850	-0.023
Chlorococcum cf. *infusionum* (Schrank) Meneghini	Cinf	-0.078	0.378
Chroococcus minutus (Kützing) Nägeli	Crmi	-0.296	-0.240
Coelastrum proboscideum Bohlin	Cpro	-0.616	-0.285
Coelosphaerium evidenter-marginatum Azevedo & Sant'Anna	Cevi	0.062	0.458
Crucigenia fenestrata (Schmidle) Schmidle	Cfen	0.792	0.108
Cryptomonas brasiliensis Castro, Bicudo & Bicudo	Cbra	-0.765	-0.083
C. erosa Ehrenberg	Cero	-0.447	-0.198
Cylindrospermopsis raciborskii (Woloszynska) Seenayya & Raju	Crac	-0.597	0.313
Dictyosphaerium pulchellum Wood	Dpul	0.143	0.455
Fragilaria familiaris (Kützing) Hustedt	Ffam	0.090	-0.666
Isthmochloron neustonica Zalocar & Pizarro	Ineu	-0.552	-0.248
Navicula cf. *antonii* Lange-Bertalot	Nant	0.346	0.473
Pediastrum duplex var. *duplex* Meyen	Pddu	-0.388	0.227
Peridinium cf. *umbonatum* Stein	Pumb	-0.377	0.014
Peridinium cf. *volzii* Lemmermann	Pvol	-0.568	-0.031
Phacus sp.	Phac	0.162	0.326
Planktolyngbya contorta (Lemmermann) Anagnostidis & Komárek	Pcont	0.149	0.725
P. limnetica (Lemmermann) Komárek, Legn. & Cronberg	Plimn	0.402	0.413
Sphaerocavum brasiliensis Azevedo & Sant'Anna	Sbral	0.419	-0.455
Synechocystis aquatilis Sauvageau	Saqu	0.819	0.017
Trachelomonas volvocinopsis Svirenko	Tvol	0.419	-0.454

and a 2 times increase in P concentrations of the fishpond compared to the inflow water. Previous studies have also documented an increase in nutrients in the fishponds. Henry-Silva & Camargo (2006) reported an increase of 3.4 times for TP and 1.7 times for TKN in the outlet water compared with the inflow water in a tilapia fishpond, while Osti et al. (2018) registered that 15.931 g of N and 4.189 g of TP were exported during the grow-out period of tilapia and estimated that only 26% of the N and 45% of the P of the diet was converted into fish biomass. These authors found that this increase in nutrient concentrations in the fishponds was related to the entry of these compounds derived from the production practices (e.g. via inflow water and leftover fertilizers). In our study, the chemical fertilization with single superphosphate and ammonium, in addition to the diet provided (up to 68.8 kg ha^{-1} day^{-1} recorded at the end of the grow-out period), favored the entry of nutrients. However, the dynamics of the phytoplankton community in the fishpond was not only dependent on these factors. As previously observed by Boyd (2016), the inflow water had a diverse resident community that influenced significantly the dynamics and structure of the phytoplankton in the fishpond. Of the 27 descriptor species recorded in the inflow water, only *Aulacoseira* sp. 1, *Phacus* sp., *Sphaerocavum brasiliensis* and *Trachelomonas volvocinopsis* were not registered in the fishpond. We recorded high phytoplankton biovolumes in the inflow water during the first 28 days of the tilapia grow-out period. These high values might be related to the water source, since the inflow water comes from two dams that are oligo-mesotrophic and hypereutrophic and receives effluents from the sectors of fish and frog farming of CAUNESP (Pistori et al., 2010). Furthermore, this period coincided with harvesting in these sectors, when water is rich in nutrients and organic materials are released into the dam.

Management practices during the tilapia grow-out period also seem to have a significant effect on the phytoplankton structure of the fishpond. During the pond arrangements before the fish reception, we provided fertilization and stopped the water renewal with the aim of stimulating algal growth. In the first collection, *Chlamydomonas* spp. presented the highest abundance, which represented 35% of the phytoplankton biovolume in the fishpond. These small algae have a faster growth than larger algae and are considered pioneer organisms in aquatic environments (Reynolds et al., 2002; Kruk & Segura, 2012).

In aquaculture ponds, the flowering of filamentous and colonial microorganisms, especially of cyanobacteria, is common during the production cycle. For example, Kopp et al. (2016) recorded the flowering of *Planktothrix aghardii* in fishponds in the Czech Republic and Beyruth & Tanaka (2000) registered the flowering of *Eudorina elegans, Microcystis flos-aquae, Microcystis aeroginosa* and *Anabaena solitary* in ponds of prawn farming (*Macrobrachium rosenbergii*). Blooms are associated with the entry of inoculum from varied taxonomic groups in the inflow water together with high nutrient concentrations and high temperatures. However, the constant water renewal (residence time: 4 days) seems to have favored small-sized species and/ or with the presence of flagella. On average, 35% of the descriptor species of the phytoplankton community in the fishpond were characterized as nanoplankton (maximum cell size between 2 - 20 µm). These organisms can be found in environments of different trophic levels (Kruk & Segura, 2012) and have peculiar traits, such as fast growth, high productivity, high nutrient stock and rapid light absorption (Reynolds, 1997). In cases of changes in the hydraulic conditions, particularly losses in the outflow, nanoplanktonic species have a competitive advantage over slow-growing species (Brasil & Huszar, 2011), such as the Cyanobacteria *Cylindrospermopsis*, *Dolichospermum, Microcystis,* and *Planktothrix*, which are affected to a greater extent (Reynolds, 1997). Flagellated species like *Chlamydomonas plactogloea, C. microscopica, Cryptomonas brasiliensis, C. erosa* and *Peridinium* cf. *volzii* were also abundant during the production cycle.

Diatoms were abundant in both the inflow water and the fishpond at the end of the grow-out period of the Nile tilapia, associated with low water temperatures. Certain diatom species are good competitors in environments with low solar radiation and low water temperature (Kruk & Segura, 2012). In our study, the highest biovolume of diatoms was registered in the fishpond during the last two samplings and can be attributed to the proximity of the winter period that besides giving the diatoms a competitive advantage over other algal groups, it may have affected the feeding efficiency of the tilapias.

Finally, the Nile tilapia is an omnivorous filter-feeding species in an intermediate trophic position between the primary producers and piscivorous predators (Attayde et al., 2007). Turker et al. (2003a, c) and Attayde et al. (2007) demonstrated that filtration favored the presence of small-sized algae since tilapias promoted a significant reduction in the abundance of large species (i.e., *Microcystis* and *Desmodesmus*) through non-selective foraging (Turker et al., 2003d). Larger organisms such as colonial and filamentous Cyanobacteria were filtered more efficiently than smaller organisms, as demonstrated by the presence of the descriptor species *Chlamydomonas plactogloea*, *C. microscopica*, *Chroococcus minutus* and *Isthmochloron neustonica* in the fishpond. In agreement with our results, Turker et al. (2003a) compared a system with and without tilapias and found 2 to 3 times more cyanobacteria in the system without tilapia.

Eutrophication does not seem to be the only factor that influences the structure of the phytoplankton community in fishponds. Specific local conditions, such as the physical structure of the aquaculture system, the availability and quality of the inflow water, hydraulic drainage processes and herbivory are also of key relevance. Therefore, the management practices involved in the production of tilapias, such as hydraulic retention time (average of four days), fertilization (with single superphosphate and urea), diet supplementation (portions up to 68.8 kg ha^{-1} day^{-1} at the end of grow-out period), and even the trophic interactions and the herbivory by zooplankton and tilapias, seem to have determined the composition of the phytoplankton community and have influenced the group of algae that prevailed in the present study. Therefore, the fishpond for Nile tilapia culture was characterized by a diversified phytoplankton community with a high richness and abundance of Chlorophyceae and Cyanobacteria. The presence of species with small cellular size might be attributed to the system instability. The decrease in the air and water temperatures at the end of the grow-out period favored the presence of diatoms. We concluded that management practices related to the system hydraulic retention time did not contribute to the occurrence of blooms, despite other favorable conditions, such as availability of nutrients, a water temperature around 23°C, and the presence of flowering species and oxygen availability.

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