Influence of management on plankton community of fishponds during the dry and rainy seasons

Influência do manejo sobre a comunidade planctônica de viveiros de piscicultura durante os períodos seco e chuvoso

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Abstract: Aim: The present investigation aims at evaluating attention to the occurrence and abundance of planktonic communities in fishponds and their relationships to the management employed; **Methods:** Seven fishponds (V_1-V_7) fertilized with different treatments were analyzed by monthly sampling, taken between July and December/07, during both dry and rainy seasons; **Results:** Euglenophyceae and Chlorophyceae were most representative during the studied period. In the fishpond with organic fertilizer Cyanobacteria was more than 65 and 90% of total phytoplankton abundance in September and August, mainly represented by *Microcystis* sp. (14,595 and 22,500 ind.L^{-1}, respectively). An inverse relationship occurred between Copepoda and Cladocera, and Copepoda and Rotifera were present in all fishponds during the both seasons. Diversity (H') and species richness was low and equitability indices generally showed the highest values for zooplankton. The lowest values were observed for phytoplankton during the rainy season; **Conclusions:** The use of organic fertilizer and the random emptying of the fishponds affected directly and species diversity and richness, with dominance of Cyanobacteria emphasizing the need to adopt a management technique to increase fishponds productivity and consequently, fish production.

Keywords: phytoplankton, zooplankton, fishponds, management.

Resumo: Objetivo: O presente estudo objetivou avaliar a ocorrência e abundância da comunidade planctônica em viveiros de piscicultura em função do manejo adotado; **Métodos:** Foram estudados sete viveiros (V_1-V_7) com diferentes tratamentos de fertilização, com amostras realizadas mensalmente de julho a dezembro/07, em duas épocas do ano: seca e chuva; **Resultados:** Em geral, Euglenophyceae e Chlorophyceae foram as mais representativas ao longo do período estudado. No viveiro com fertilizante orgânico, Cyanobacteria representou mais de 65 e 90% do total de organismos fitoplanctônicos ocorrido em setembro e agosto representado principalmente por *Microcystis* sp. (14.595 e 22.500 ind.L^{-1}, respectivamente). Relação inversa foi observada entre Copepoda e Cladocera, porém Copepoda juntamente com Rotifera estiveram presentes em todos os viveiros nas duas estações. A diversidade (H') e riqueza de espécies apresentaram baixos valores e, o índice de equitabilidade, em geral, foi elevado para o zooplâncton. Os valores mais baixos de equitabilidade para o fitoplâncton foram observados durante a estação chuvosa; **Conclusões:** O uso de fertilizante orgânico e o esvaziamento aleatório dos viveiros influenciaram diretamente na diversidade e riqueza de espécies, com dominância de Cyanobacteria, enfatizando a necessidade de adotar uma metodologia de manejo para aumentar a produtividade dos viveiros e consequentemente, a produção de peixes.

Palavras-chave: fitoplâncton, zooplâncton, viveiros, manejo.

Biological Limnology

1. Introduction

Fishponds are environments completely managed and handled by man, with constant addition of fertilizer in order to increase the productivity and profitability of the system. Exploitation of fisheries resources in Brazil has been carried out in the absence of adequate limnological knowledge of fishponds.

Farming activities can cause important impacts on the environments due to the discharge of wastewater into streams and rivers and creeks (Konsowa, 2007). Fertilization is by far the most useful technique that provides the essential nutrients for aquatic biota that serve either directly or indirectly as fish food (Begum et al., 2007).

Fertilization (both inorganic and organic) has great implications for the increase of phytoplankton and zooplankton biomass thus affecting directly the fish biomass (Santeiro et al., 2006; Vega et al., 2007). Both quality and quantity abundance of plankton communities in fishponds are of great importance in managing successful aquaculture operations, and they vary from location and pond to pond within the same location even under similar ecological conditions (Bhuiyan et al., 2008).

Plankton distribution and abundance are affected by season, physical and chemical parameters, water movement, soil, and biological factors (Davies et al., 2009).

Therefore the present investigation aims at analysing attention to the occurrence and abundance of phytoplankton and zooplankton in fishponds and their relationships with the management practices employed.

2. Materials and Methods

2.1. Area and sampling sites

The study was carried out at the "Instituto Federal do Espírito Santo (Ifes) "- Campus Alegre, Alegre, ES, Brazil, situated at 20° 45' S and 41° 27' E at a mean altitude of 108 m. According to the Köppen classification, the region climate is AW, subtropical, relatively dry in the winter (June to September) and rainy in the summer (October to December), with mean yearly temperature 23.4 °C and mean yearly rainfall 1,325.9 mm.

The Ifes - Campus Alegre fish farm, totaling 4 ha of flooded land, comprises thirty-seven earthen ponds with independent water supply. The choice and of the seven fish ponds (V_1-V_7) to be sampled was based on morphometry, location and usage availability. Areas of the fishponds varied between

710 (V_2) and 6,550 m² (V_7), and mean depth was 1.50 m. Fishponds' water supply comes from the waterfall Braúnas, 4 km from the fishponds area, and is channeled to the ponds by underground tubes. Continuous water flow provided a 5% daily rate of rearing volume. The fishponds were populated with matrinxã (*Brycon cephalus*) in V_1; catfish (*Ictalurus punctatus*) in V_2; catfish (*Ictalurus punctatus*) and grass carp (*Ctenopharyngodon idella*) in V_3; fries of silver carp (*Hypophthalmichthys molitrix*) and pacu (*Piaractus mesopotamicus*) in V_4; pacu fries (*Piaractus mesopotamicus*), grass carp (*Ctenopharyngodon idella*) and silver carp (*Hypophthalmichthys molitrix*) in V_5; pacu fries (*Piaractus mesopotamicus*), grass carp (*Ctenopharyngodon idella*), silver carp (*Hypophthalmichthys molitrix*), big-head carp (*Aristichthys nobilis*) and catfish (*Ictalurus punctatus*) in V_6; pacu fries (*Piaractus mesopotamicus*), grass carp (*Ctenopharyngodon idella*), and big-head carp (*Aristichthys nobilis*) in V_7, at a density of approximately 0.34 fish per m² (Figure 1).

Management the ponds occurred randomly since they were fertilized according to material availability. The following management has been adopted throughout the study:

- V_1 to V_3 = diet with ration at 32% crude protein;
- V_4 and V_5 = lime spreading; fortnightly fertilization with urea between March and July; rations with 32% crude protein also provided;
- V_6 = lime spreading; fertilization with pig dung and urea; and
- V_7 = lime spreading; fertilization with chicken dung and rations at 32% crude protein. Livestock inner parts were provided at irregular intervals throughout the study period. Sampling for abiotic and biotic variables was conducted once a month, from July to December/07. During this period, both dry and rainy seasons were experienced.
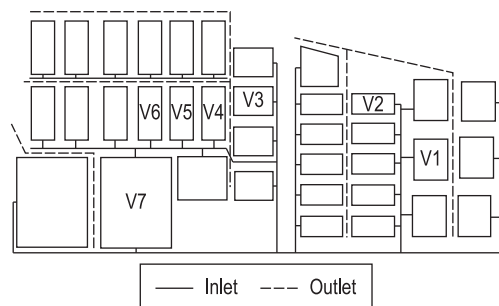

Figure 1. Cross-section of fish ponds of "Instituto Federal do Espirito Santo - Campus Alegre", showing the sampled ponds (V_1-V_7) in the station.

2.2. Plankton

Sampling for plankton was done using a Van Dorn bottle filtering a volume of 5 L for phytoplankton and 12 L to zooplankton. The plankton samples was filtered with 25 μm and 68 μm mesh nets, and preserved in Lugol iodine solution and formalin (4%), respectively for phytoplankton and zooplankton. The concentrated preserved plankton samples were analyzed using a Sedgewick-Rafter counting cell with a compound binocular microscope (Option, TIM-107) at 200× magnification. In addition Cladocera and Copepoda, were counted in a reticulated chamber using a TIM 2B stereoscopic microscope. Numerical densities data were expressed in individuals.L^{-1} (ind.L^{-1}) and percentage abundance (%). Approximately 400 specimens of the most abundant species were counted for a 10% more a less precision, and a 95% confidence interval (Bicudo, CEM. and Bicudo, DC., 2004). The diversity index (H'), equitability and richness (total number of species) were used to analyze the diversity of phytoplankton and zooplankton between seasons and among ponds (Shannon and Weaver, 1963; Odum and Barrett, 2007). The ecological index values were obtained by estimating the mean values obtained for each season (dry and rainy) at each analyzed pond (V1 to V7). Occurrence frequency of different taxa was calculated according to the following classification: constant (50% or over); common (between 10 and 50%); rare (between 1 and 10%) (Sampaio et al., 2002). The criteria of Lobo and Leighton (1986) were also applied to describe species dominance and abundance. Species were considered abundant when the number of specimens was higher than mean density of all species; and dominant when the density was higher than 50% of the total number of specimens.

2.3. Limnological variables

Water samples were collected at a depth of 0.10 m. The transparency was measured by Secchi disk, pH was measured by model Q-400A Quimis pH meter. Chlorophyll-*a* was evaluated according to Nusch (1980) and nutrients according to Koroleff (1976) and Golterman et al. (1978).

2.4. Statistical analysis

The Kruskal-Wallis test (Siegel, 1975) was applied, to the physical and chemical variables and plankton population, to compare sites and seasons, and interactions between them. The significance level was taken as $p = 0.05$.

3. Results

During the period under analysis, the zooplanktonic community was represented by 10 taxa: 5 Rotifera, 3 Cladocera and 2 Copepoda (Table 1). Although Copepoda species were found in all fishponds, only *Argyrodiaptomus* sp. was dominant in V_2; as a rule, *Copepoda nauplii* were abundant and/or dominant. *Argyrodiaptomus* sp. and *Mesocyclops* sp. were present in both seasons and Copepoda nauplii were abundant during the dry season and dominant in the rainy one. *Conochilus* sp., was the only dominant representative of the group Rotifera in V_2 during the rainy season and V_5 during the dry season. An inverse relationship between *Moina* sp. and *Conochilus* sp. occurred, whereupon, when one was dominant in a particular pond, the other was absent. Of the Cladocera, only *Moina* sp. was dominant in V_7

Table 1. Composition (+, -), frequency (%) of occurrence (F) and abundance (A-d) of zooplankton taxa during the dry (D) and rainy (R) seasons in fishponds (V_1-V_7), where: + = present; – = absent; C = constant; c = common; r = rare; A = abundant; d = dominant.

Taxa	V_1			V_2			V_3			V_4			V_5			V_6			V_7		
	D	R	F	D	R	F	D	R	F	D	R	F	D	R	F	D	R	F	D	R	F
Rotifera																					
Brachionus sp.	+	+	C	+	+	C	-	A	c	-	+	c	-	-		-	+	C	-	-	
Filinia sp.	+	-	c	-	-		-	+	c	-	-		-	-		+	-	C	-	-	
Lecane sp	-	-		-	-		-	-		-	-		-	-		+	-	C	+	-	c
Polyarthra sp.	+	+	C	-	-		+	+	c	+	+	c	-	-		+	-	C	A	A	C
Conochilus sp.	-	-		+	d	c	-	-		A	-	c	d	+	c	+	-	C	-	-	
Cladocera																					
Ceriodaphnia sp.	-	-		-	-		-	-		-	-		-	-		+	-	C	-	-	
Diaphanosoma sp.	-	A	c	-	+	c	-	+	c	-	-		-	-		-	+	C	-	A	c
Moina sp.	+	+	C	+	-	c	-	+	c	+	-	c	-	+	c	A	-	C	d	-	c
Copepoda																					
Argyrodiaptomus sp.	+	A	c	d	+	C	A	+	c	-	+	c	+	+	c	-	+	C	+	-	c
Mesocyclops sp.	A	A	C	+	-	c	+	+	c	-	A	c	+	+	C	+	-	C	-	A	c
nauplii	A	+	C	+	+	C	A	A	C	d	+	C	A	d	C	A	d	C	A	-	c

during the dry season, and occurred in all fishponds, being present in both seasons in V_1. Among the Rotifera species, *Brachionus* sp. and *Polyarthra* sp. were abundant during the rainy season (V_3) and the latter abundant in both seasons (V_7) (Table 1). *Ceriodaphnia* sp. was the only species found in a single fishpond (V_6) during the dry season associated with high content of nitrate (652 µg.L^{-1}), relatively low phosphorus content (49 µg.L^{-1}) and food consisting mainly of *Ankistrodesmus* sp. and *Scenedesmus* sp. (Tables 1 and 2).

Copepoda was the most abundant group in V_5 to V_7 after the October discharge, and Cladocera was abundant, mainly *Moina* sp. (884 ind.L^{-1}), in V_2

during September. When *Argyrodiaptomus* sp. was more abundant (an herbivorous species), in V_1 in December, and V_4 and V_6 in September, densities of Copepoda and Cladocera were similar. However, when *Mesocyclops* sp. (carnivorous species) was more abundant, Cladocera species were virtually absent in the environment. Copepoda and Rotifera occurred in all fishponds during the two seasons (Figure 2).

The phytoplankton community was represented by 33 taxa with a high number of Chlorophyceae species (9). *Pediastrum duplex*, occurred in both seasons, in all fish ponds, and was dominant or abundant in the environment. Further, *Scenedesmus* sp. also occurred in all fishponds, albeit

Table 2. Composition (+,−), frequency of occurrence (F) and abundance (A-d) of phytoplankton genera and species found during the dry (D) and rainy (R) seasons in the sampled fishponds (V_1-V_7), where: + = present; − = absent; C = constant; c = common; r = rare; A = abundant; d = dominant.

| Taxa	V1			V2			V3			V4			V5			V6			V7		
	D	R	F	D	R	F	D	R	F	D	R	F	D	R	F	D	R	F	D	R	F
Bacillariophyceae																					
Asterionella sp.	+	−	c	−	−		−	−		−	−		−	−		+	−	c	−	−	
Gyrosigma sp.	−	−		+	+	c	−	−		−	−		+	−	c	+	−	c	+	+	C
Navicula sp.	A	+	C	+	A	C	+	−	c	+	+	C	−	−		A	+	C	−	+	C
Surirella sp.	A	−	c	+	+	c	+	−	c	−	−		−	−	C	−	−		−	+	c
Chlorophyceae																					
Ankistrodemus sp.	−	−		+	+	c	−	−		−	−	r	−	−	r	+	−	c	−	−	
Chodatellopsis sp.	−	−		+	+	c	−	−		−	+	c	−	−	c	−	−		−	−	
Desmodesmus armatus (Chord.) Hegewald	A	−	c	−	−		−	−		−	−		−	−		−	−		−	−	
Eutetramorus sp.	+	+	c	A	A	C	+	+	c	−	−		−	−		+	−	c	−	+	c
Pediastrum duplex Meyen	A	A	C	+	A	C	A	A	C	d	+	c	+	+	c	d	+	C	A	+	C
Scenedesmus acuminatus (Largerheim) Chodat	−	+	c	−	+	c	−	+	c	−	+	c	−	−		−	A	c	−	−	
Scenedesmus linearis (Komárek)	A	−	c	−	−		−	+	c	−	−		−	−		−	−		+	+	c
Scenedesmus quadricauda (Turpin) Brébison	−	+	r	−	−		−	−		−	+	c	−	−		−	+	c	−	−	
Scenedesmus sp.	+	−	r	+	+	C	A	+	C	+	+	c	A	−	c	+	−	c	+	+	r
Cyanobacteria																					
Anabaena sp.	−	−		−	A	c	−	−		−	−		−	−		−	−		−	−	
Aphanizomenon sp.	+	+	C	−	+	c	+	+	c	−	−		−	+	c	+	−	c	+	+	c
Lyngbya sp.	−	−		−	+	c	+	−	c	−	+	c	−	−		−	−		−	−	
Merismopedia sp.	−	−		−	+	c	−	−		−	−		−	−		−	−		−	−	
Microcystis sp.	+	+	c	+	−	c	A	+	c	−	+	c	−	−		A	−	c	A	+	C
Pseudanabaena sp.	−	−		−	−		+	−	c	−	−		−	−		−	−		+	−	c
Euglenophyceae																					
Euglena acus Ehrenberg	A	A	C	+	A	C	+	+	C	−	+	c	−	−		−	+	c	−	−	
Euglena sp.	−	+	c	+	−	c	A	A	c	+	d	C	A	A	c	+	−	c	A	A	C
Phacus longicauda (Ehrenberg) Dujardin	+	A	C	−	+	c	A	−	c	−	+	r	+	−	c	+	−	c	−	−	
Phacus pleuronectes (Muller) Dujardin	−	+	r	−	+	c	−	+	c	−	−		−	−		+	d	c	−	−	
Strombomonas acuminatus (Schmarda) Deflandre	+	+	C	−	+	c	+	+	c	A	+	c	A	+	c	A	+	C	+	+	C
Trachelomonas pulchella Drezepolski	−	−		−	−		−	−		−	−		−	+	c	−	−		−	−	
Trachelomonas sp.	+	+	c	−	−		−	A	c	−	A	c	+	d	c	−	A	c	−	A	c
Eustigmatophyceae																					
Pseudostaurastrum sp.	−	−		+	+	c	−	−		−	−		−	−		−	−		−	−	
Zygnematophyceae																					
Closterium sp.	−	−		+	−	c	−	−		−	−	c	−	−		+	−		−	−	
Cosmarium sp.	−	−		−	−		−	−		−	−		−	−		+	−	c	−	−	
Pleurotaenium sp.	−	−		−	−		−	−		+	−	c	+	−	c	−	−		+	−	c
Spirogyra sp.	−	−		−	−		+	−	c	−	−		−	−		−	−		+	−	c
Staurastrum tetracerum Ralfs	+	+	c	+	+	c	+	−	c	+	+	c	−	−		−	−	c	−	−	
Staurodesmus sp.	−	−		−	−		−	−		−	−		−	−		−	+	c	−	−	
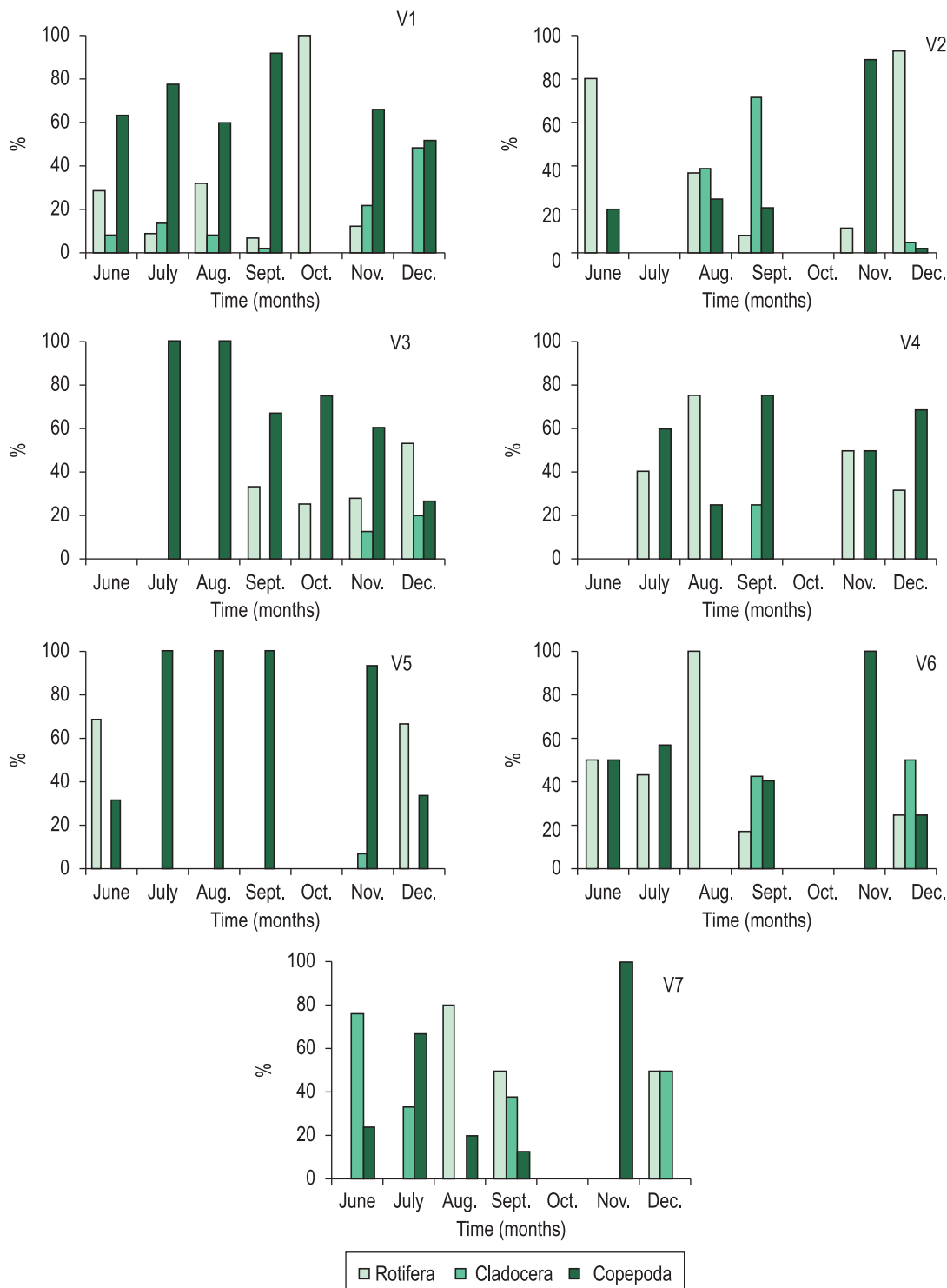
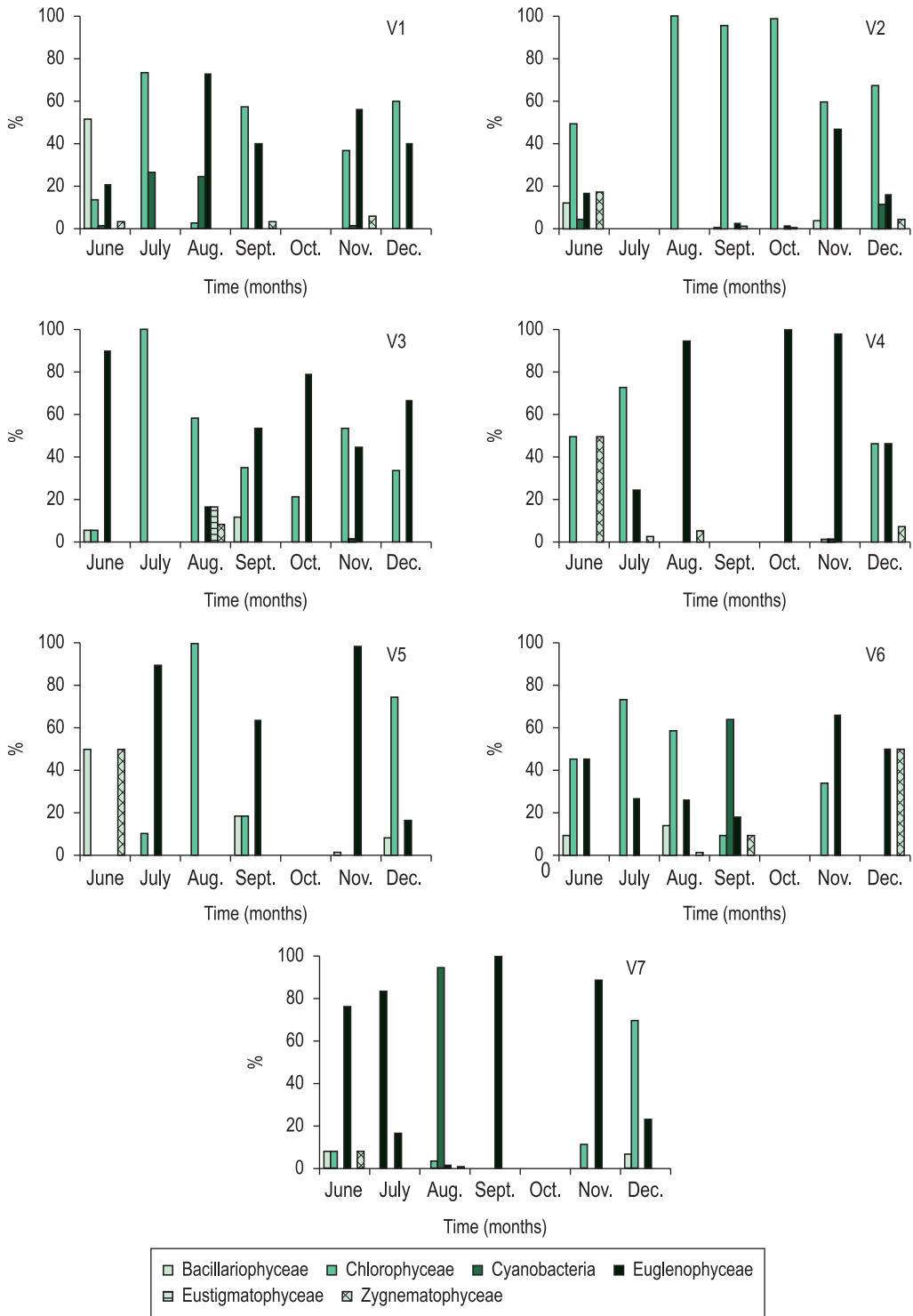**Figure 2.** Relative abundance (%) of zooplankton found in the fishponds (V_1-V_7) during the study period, where: Time (months) = Months.

absent in fishponds V_1, V_5 and V_6 during the rainy season (Table 2).

Euglena sp. and *Strombomonas acuminatus*, among the Euglenophyceae species, occurred in all fishponds, with the former dominant in V_4 during the rainy season. *Phacus pleuronectes* and *Trachelomonas* sp. were also dominant during the

rainy season, respectively in V_6 and V_5. All the Euglenophyceae species were abundant or dominant throughout the study period, with the exception of *Trachelomonas pulchella*, which was only found in V_5 during the rainy season (Table 2; Figure 3).

Zygnematophyceae was represented by six low density taxa with main occurrence in the dry season.

Figure 3. Relative abundance (%) of phytoplankton found in the fishponds (V_1-V_7) during the study period, where: Time (months) = Months.

The exceptions were *Staurastrum tetracerum* which occurred during both seasons and *Staurodesmus* sp. which occurred only in V_6 during the rainy season. Eustigmatophyceae was represented by the single taxon *Pseudostaurastrum* sp. which occurred during both seasons only in V_2, associated with low nitrate and nitrite concentrations (<11 µg.L^{-1}) and high concentrations of orthophosphate and total phosphorus (>31 µg.L^{-1}). Cyanobacteria were represented by 6 species, generally represented abundant, constant or common species in the fishponds. *Merismopedia* sp. occurred only in V_2

during the rainy season. The density of Cyanobacteria was low in V_5 (20 ind.L⁻¹) represented mainly by *Aphanizomenon* sp. (Table 2; Figure 3).

Euglenophyceae was dominant during the rainy season and Chlorophyceae constant during the dry season (Table 2). Inadequate management water discharge and consequent filling up occurred in V_2 in July and in V_5 to V_7 in October, these factors could have caused Euglenophyceae dominance in V_5 to V_7 in November. Cyanobacteria dominance (>90%), chiefly represented by *Microcystis* sp. with 22,500 ind.L⁻¹ (Figure 3), occurred in V_7 during August (dry season).

Diversity (H') of the plankton community was low, tending towards a decrease from V_1 to V_5 in the case of phytoplankton and from V_3 to V_5 in the case of zooplankton during the rainy season. The species richness was low with the highest values (19) being observed in V_2 during the rainy season. The values of species richness were lowest for the zooplankton community. Equitability indices generally showed the highest values for zooplankton. The lowest values were observed in the V_4 (0.30) and V_5 (0.31) for phytoplankton during the rainy season (Figure 4).

The phytoplankton community was not represented in V_1 during October, with only one Rotifera species, *Polyarthra* sp. (16 ind.L⁻¹), being reported *Moina* sp. (17 ind.L⁻¹) and Copepoda nauplii (51 ind.L⁻¹) among the zooplankton, occurred in V_4 during September, in the absence of phytoplankton. When zooplankton did not occur in V_3 during June, Euglenophyceae presented a high percentage (89.4%), consisting of *Euglena* sp. (36,140 ind.L⁻¹), *Strombomonas* sp. (8,340 ind.L⁻¹) and *Euglena acus* (2,780 ind.L⁻¹). The same pattern was reported in V_4 during October when two algae, *Trachelomonas* sp. (705,500 ind.L⁻¹) and *Euglena* sp. (232,400 ind.L⁻¹), occurred, and also, during June, when *Closterium* sp. and *Scenedesmus* sp., both with abundance of 5,355 ind.L⁻¹ were recorded (Figures 1 and 2; Tables 1 and 2).

The phytoplankton and zooplankton communities did not differ between fishponds and seasons (p > 0.05) during the study period.

The pH values varied from 6.4 to 8.3 without differences (p > 0.05) between fish ponds and seasons. Transparency values were significantly different (p < 0.05) among the fishponds reaching the highest value (1.00 m) in V_5 in both seasons. Lowest transparency was observed in the fishponds V_1, V_3, V_4 and V_7 and was more associated with management than with the content of Chlorophyll-*a*
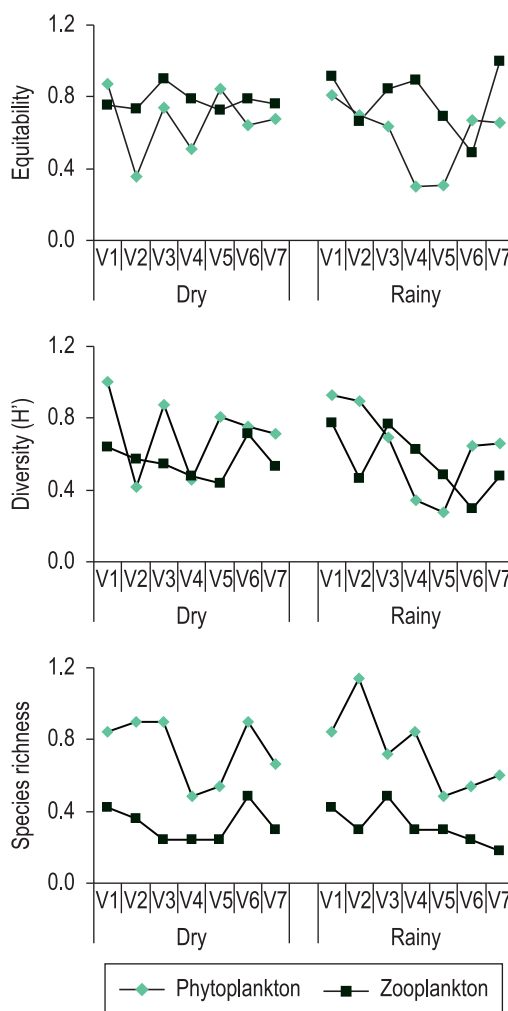

Figure 4. Seasonal values of species equitability, diversity (bits.ind⁻¹) and richness of phytoplankton and zooplankton during the study period in the different fishponds (V_1 -V_7).

(6 to 59 µg.L⁻¹). The transparency was higher in V_5 during the dry season (1.00 m) and in V_6 (0.98 m) during the rainy season, coinciding with lowest Chlorophyll-*a* concentration (8.4 and 6.0 µg.L⁻¹, respectively) in the fishponds (Table 3).

Among nitrogen compounds, ammonia values were highest and differed significantly among fishponds and seasons (p < 0.05). In fishponds V_1, V_6 and V_7 during the dry season, nitrate displayed the highest values and differed significantly from the other fishponds (p < 0.05). The total phosphorus and orthophosphate did not differ between fishponds and seasons (p > 0.05) (Table 3).

4. Discussion

The management of fertilization in the fishponds was carried out according to the availability of material to be used for this purpose. This

Table 3. Average, minimum and maximum values of nutrients (µg.L⁻¹), Chlorophyll-*a* (µg.L⁻¹), pH and transparency (m) in the fishponds (V₁-V₇) during the dry (D) and rainy (R) seasons.

Parameters	V₁ D	V₁ R	V₂ D	V₂ R	V₃ D	V₃ R	V₄ D	V₄ R	V₅ D	V₅ R	V₆ D	V₆ R	V₇ D	V₇ R
Ammonia	55	63	136	83	165	129	94	98	125	97	461	92	107	132
	12-81	39-93	9 -347	68-102	6-472	122-136	22-155	71-142	22-366	95-102	57-1,651	59-124	47-151	38-281
Nitrite	4.2	4.5	5	4.4	4.5	4.8	4.7	4.9	8.4	6	16.6	5.6	5.2	4
	3.7-5.1	4-4.9	3.5-6.3	3.8-5.1	3.4-5.4	4.4-5.2	3.5-5.9	4.6-5.2	3.8-20.8	5.1-7.1	3.5-52	3.7-9	5.2-7	4-4
Nitrate	307	59	*5.7	11	26	*0.5	39	30	109	27	*652	—	162	67
	68-883	21-37		1-21	1.4-51		16-63	11-48	8-188	2-53			16-351	21-113
Orthophosphate	28	21	31	67	21	22	29	34	21	32	19	25	22	22
	18-52	13-36	18-54	23-153	10-35	7-43	17-46	21-44	12-31	21-54	18-21	23-27	18-24	20-25
Total Phosphorus	85	85	74	135	76	83	71	95	53	95	49	101	71	62
	47-115	60-109	55-98	60-250	57-93	57-109	52-85	90-104	17-71	76-125	17-71	71-131	55-85	57-68
Chlorophyll-*a*	48.8	16.7	20.5	18.6	58.6	42.8	32.8	31	8.4	40	34.9	6	30	59
	22-62	11-25	14-28	6-25	45-92	6-70	17-53	14-56	3-17	14-67	8-59	6-6	8-59	6-95
Transparency	0.25	0.19	0.55	0.32	0.15	0.21	0.41	0.39	0.95	0.76	0.59	0.98	0.45	0.21
	0.20-0.30	0.18-0.19	0.40-0.62	0.33-0.63	0.12-0.25	0.12-0.25	0.28-0.55	0.13-0.80	0.75-1.00	0.27-1.00	0.38-0.72	0.98-0.98	0.30-0.51	0.13-0.30
pH	7.1	7.7	7.2	7.7	7.2	7.3	7.3	7.3	7.2	7.4	7.5	7.4	7.2	7.3
	6.4-8.3	7.3-8.1	6.9-7.6	7.6-7.9	7.0-7.5	7.0-7.5	6.9-7.4	7.3-7.3	6.5-7.8	7.1-8.0	7.0-7.7	7.3-7.5	6.5-7.5	7.2-7.4

randomness reflected directly on the biotic and abiotic factors of the studied fishponds. In fishponds V_6 and V_7 where organic fertilization was applied (pig and chicken dung), the content of ammonia, nitrite and nitrate were high during the dry season and the total phosphorus and Chlorophyll-*a* were high during the rainy season. Transparency values seemed to have been directly affected by climatic factors, and displayed very low values (0.13 to 0.30 m) during the rainy season, perhaps associated with the presence of allocthonous material in the fish ponds.

The overall objective of fertilizer application is to increase the productivity of the fish pond and both organic and inorganic fertilizers can be used. While the inorganic fertilizers mainly increase the quantity of primary producers, organic fertilizers such as dung of cattle, pig and poultry, biomass slurry, compost and other livestock wastes serve as substrates for stimulating abundant growth of zooplankton, insect larvae and other forms of fish food organisms (Begum et al., 2007).

In the studied fish farm, the values determined for species richness and diversity were not high for neither phytoplankton or zooplankton, due to lack of fertilization methodology and the fact that the ponds were randomly emptied during the year.

Euglenophyceae increase coincides with high pH levels, high orthophosphate and total phosphorus concentrations and high levels of organic matter (Taniguchi et al., 2005). Euglenophyceae and Cyanobacteria are better adapted to environments with high levels of nitrogen and organic matter, such as fishponds (Pereira et al., 2001). In this study, in the fishponds fertilized with organic manure, Cyanobacteria was more abundant and represented 60% of the total phytoplankton abundance found in September in V_6 and 91.4% of total found in August in V_7.

Crustacea (Copepoda, Cladocera) and Rotifera can be abundant in manure treated ponds. The zooplankton production in ponds under going manure treatments increased rapidly from around the 3rd week of fertilization and also that water quality determined the species composition in the ponds (Santeiro et al., 2006; Begum et al., 2007).

Inorganic fertilizer can also influence the dynamics of the zooplanktonic community leading to high population abundances of small Cladocera and Cyclopoida (Vega et al., 2007). In the present study, the fishponds V_4 and V_5 that were fertilized with urea demonstrated high abundance of Copepoda, represented mainly by Copepoda nauplii. In fishponds V_1 and V_3 where only ration was added, without fertilizer addition, the Cladocera species were present in almost every month, but were abundant only in fishpond V_1. According to Okojin and Obi (1999), organic fertilizer increases the growth of smaller sized zooplankton (Rotifera) while inorganic fertilizer favors growth of bigger sized zooplankton (Copepoda), the later resulting in more favorable conditions for fish culture. Predominance of juvenile organisms (nauplii) among crustaceans may be associated with the management adopted (fertilization) (Begum et al., 2007).

There was a greater Copepoda constancy during the dry period which was associated with a total lack or low abundance of Cladocera (V_1; V_3-V_5). The use of organic fertilization in V_7 could have decreased species richness and, consequently, favored the occurrence of opportunist species. Several authors have observed that trophic state decisively affects

the distribution of Rotifera species. Some species of this group such as *Keratella quadrata* and *Brachionus angularis* are found more frequently in water with high nutrient levels (Vega et al., 2007).

In fishpond V_6 with organic fertilizer, Rotifera species during the dry season were the most abundant, especially in August when they represented 100% of the zooplanktonic population. At the beginning of the rainy season in October, in V_1, Rotifera also represented 100% of the total zooplanktonic with great relative abundance of *Polyarthra* sp. When the same treatment was applied to fishponds V_1 to V_3 (addition of ration only); V_4 and V_5 (lime and urea), and V_6 and V_7 (organic fertilizer), no seasonal patterns were recorded in species fluctuation in the populations of either phytoplankton or zooplankton. In this case, the random emptying of the fishponds to harvest the fish, as well as the continuous water flow could have directly affected diversity and species richness.

Rotifera abundance may be inversely related to abundances of Protozoa and Copepoda (Kyewalyanga and Mwandya, 2004). Such an inverse relationship (between Rotifera and Copepoda) was also observed in the present study, when Copepoda was more abundant during the dry season.

Due to low water depth the artificial fishponds environment can be greatly affected by local climatic factors. However, in fishpond systems in which proper management fails to occur, especially with regard to stocking density, fertilization, feed (ration), type of breeding species, control of water flow in the fishpond and adequate treatment of inflowing water human activities can be the main factors influencing the abiotic and biotic conditions of these systems.

Basic information regarding phytoplankton and zooplankton, and the relationships of these organisms with management and water quality is a key factor in devising a successful fish farm strategy (Kyewalyanga and Mwandya, 2004). This is because plankton density, composition and succession patterns can greatly affect production of the earlier development stages of fish.

The results of the present study are in agreement with other analyses on the effects of management and environment variables on plankton in ponds with regard to extensive and policulture fish farming. In the present study, inorganic fertilizer addition and use of ration alone promoted better water quality, and the dominance of Chlorophyceae and Euglenophyceae species among the phytoplankton, and Rotifera and Copepoda

especially the calanoid, *Argyrodiaptomus* sp., among the zooplankton compared to the fishponds treated with organic fertilizer. The latter presented elevated relative abundances of Cyanobacteria. In addition, the continuous water flow, a common practice in the Southeast region of the country, associated with the fact that in the studied fish farm the ponds were randomly emptied, seemed to have influenced diversity and species richness. Therefore, it is recommended that the management should be standardized in order to increase system productivity and consequently, fish production.

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