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Nictemeral Variations for Pacu Caranha, *Piaractus mesopotamicus* (Holmberg, 1887) Culture in Single - Phase

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ABSTRACT

Studies related to nictemeral variation were executed in a fish growing pond, during all the seasons of the year, collecting data for dissolved oxygen; temperature; pH and electrical conductivity at the feeding channel on pond's surface, bottom and at streamlet bed. The results showed that Autumn was the season which had the lowest values of water temperature, the interval points, during Spring time, had superior average values of temperature when compared to the ones that were observed at external points. The lowest and highest index of pH were during Autumn season. The electrical conductivity didn't show significant differences during Autumn season. The samples obtained from the streamlet had very high significant differences with the samples of fish pond inner part, showing that there was an influence on external environment from the effluent which came from the inner part of the fish pond on limnology variables.

Key words: fish, grow-out, rearing, environment

INTRODUCTION

Fish breeding in closed environments has an expressive relation with water quality where this activity is developed, therefore it reflects on the physico-chemical features of the environment. Fish growing under controlled conditions can be considered as independent systems, where the executed processes in the environment are primarily determined by water quality (Piedrahita, 1991). Water abiotic factors vary daily and with the season of the year, mainly in tropical regions. Authors as Esteves (1998), Tavares and Colus (1995) and Medeiros et al. (2006) showed that the limnological features were highly dynamic, due to the fact that the amplitudes from daily variations were usually more significant than the seasonal variations.

Since 1950, aquaculture has observed an emphatic increase, with an average of 8.7% a year (FAO, 2007). Between 1990 and 2000, the average growth of Brazilian aquaculture and world aquaculture were 23.8 and 10.2% per year, respectively (Kubitza, 2007). The water availability with good quality is important for the success of this practice and to keep an environmental stability.

The high density of fish into ponds produces a great amount of nutrients which can modify or spoil water quality, impairing the ecosystem on its

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several biotic and abiotic aspects (Mires et al., 1990; Phillips et al., 1991; Boyd, 1998). Tavares and Moreno (1994) and Minucci et al. (2005) mentioned that available information was rare for fish growing pond water quality and also that information was less when it was related to the external environment. Thus, information about physico-chemical variables in fish growing would be relevant and the nictemeral study was one of the most important aspects for environment characterization (Teixeira, 1982; Medeiros et al., 2006).

This was aimed to study the hydrological dynamics of a pond for fish growing through nictemeral study of some physical and chemical variables during the four seasons.

MATERIAL AND METHODS

This study was carried out in a farm "Caçador" district of Pirapó in Apucarana (23°; 33'; 26.7"S; 051°; 33'; 41.7"W) north of Paraná, Brazil. The region's climate is cfa and cfb (Köppen cited by IAPAR, 1994) (Cfa - humid subtropical. Very hot summers, very mild winters. Rainfall throughout the year. Cfb - warm temperate climate with warm to hot summers, mild winters. Rain in summer, rain or snow in winter). The soil generates from basaltic rock, mixed with structured red soil, red Latosoil and Litosoil (EMBRAPA, 1984).

A pond for fish growing was dug into the ground with four years of digging and a 2,250 m^2 water mirror, with an averaged depth of 0.91m, an individual system of supplying through derivation channel with open sky and a draining by a "monk" model of floodgate (*valois system*) (Barker, 1970). Fish growing pond quota was determined by altimeter was of 638 meters altitude, above sea level. The averaged time for water permanence was estimated in 20 days changing daily 5% from the water volume, calculated from the volume data, growing pond area and discharge out flow. Provisioning water came from "Graúna" streamle (Christofoletti, 1988), and Pirapó river affluent and the stored volume was estimated as 2,058 m^3. Then this water was returned to the river just after its passage through the pond. At the pond, pacu fingerlings (*Piaractus mesopotamicus,* Holmberg, 1987), native species from Paraná basin (Bernardino and Lima, 1991) in a 1.42 fish/m^2 density, initial average weight of 0.455 g and a 28.6 mm total average length were stocked.

The samples were collected in each season at the following points: point 1 – placed at the open channel distribution, near the entrance; point 2 - inside the pond just on the opposite side of the out flow point almost 10 cm from the water line; point 3 – placed at floodgate exit, where the water was collected on its deepest part at a depth of 1.33 m, and point 4 - at streamlet bed, 2.0 m ahead from the flowing tube. The studied variables were water temperature (°C), pH, electrical conductivity (µ S/cm) and dissolved oxygen (mg/L) using F-1003 Digital Laboratory of portable measurement, Bernauer®. The saturation of oxygen was also determined (Golterman et al., 1978).

To identify if there were differences of averages among the collection and points, considering the temperature, dissolved oxygen, pH and electrical conductivity as dependents variables, analysis of variance ($P<0.05$) was done using statistics program SAS, concerning two factors: the term factor with four levels (Summer, Fall, Winter and Spring), and the factor: Collect point with four levels - point 1, point 2, point 3 and point 4). To verify which averages were significantly different, the Tukey test was used. For this analysis, a significance level of 5% ($\alpha = 0.05$) was considered. The basic statistics were obtained using the Microsoft Excel and Instat programs.

As a profitable measure, the growth phases of rearing pond was treated with 700 kg (3,111 kg/ha) of virgin lime, fifteen days before the livestocking. From February 3 to June 4, 1998, the pond was fertilized with 50.5 kg of simple superphosphate (224 kg/ha); 50 kg of oxide of calcium (222 kg/ha) and 12.3 nitrocalcium kg (54 kg/ha). During this period, the fishes were fed with 77.2 kg of ration, from Kowalski, with 38% of gross protein. On June 4, total fish biomass was estimated in 78 kg. From June, 5 to September 19, 1998, more than 25.5 kg of simple superphosphate (110 kg/ha) and 200 kg of grounded manure from laying hens (888 kg/ha) were put into the pond. The foodstuff plus the water added 106 kg and total medium weight of fish was calculated as 96.5 kg.

The period from September 20 to November 18, 1998, 200 kg (888 kg/ha) of dolomitic limestone and 197 kg of ration were used. The total medium weight of fish, at this last date, was calculated as

173 kg. From November 19, 1998 to January 3, 1999, the fishes were fed with 320 kg of ration and total fish biomass was calculated as 231 kg**.**

The ration was given daily, initially at a single point, using ground food from February 3 to May 4. After this, an extruded ration was used, and put into the whole enclosure of the pond.

The samplings for nictemeral cycle evaluation were accomplished during June 3 and 4, 1998 (Autumn), September 18 and 19, 1998 (Winter) and November 17 and 18, 1998 (Spring), January 4 and 5, 1999 (Summer), in intervals of four hours at 08:00, 12:00, 16:00, 20:00, 04:00h.

RESULTS AND DISCUSSION

Considering temperature (Fig. 1), data which were obtained on different terms showed very diversified results, although representative of seasonal variation. The least temperature in Autumn almost did not change, reaching 15 ºC and 16 ºC at the four points. The highest temperature reached from 24.5 ºC (at 16:00h) at point 1 in Spring time to 27.4 ºC at point 2 (at the same time) in Summer time. The highest average temperature occurred in the Summer (24.9 ºC) at point 2. This point was situated at the surface and on the superficial water mass, establishing a thermal gradient between the surface and the bottom (Henry, 1981).

For the variable temperature, the general data analysis by Tukey test, suggested the formation of two groups from different points, which were internal points (2, 3) and external points (1, 4). In relation to the periods, three groups were detached: Summer/Spring, Winter and Autumn. Spring time, had higher average values of temperature when compared to the ones that were observed at external points.

In general, in all the seasons and points, the highest values of temperature were observed between 12:00 and 16:00h.

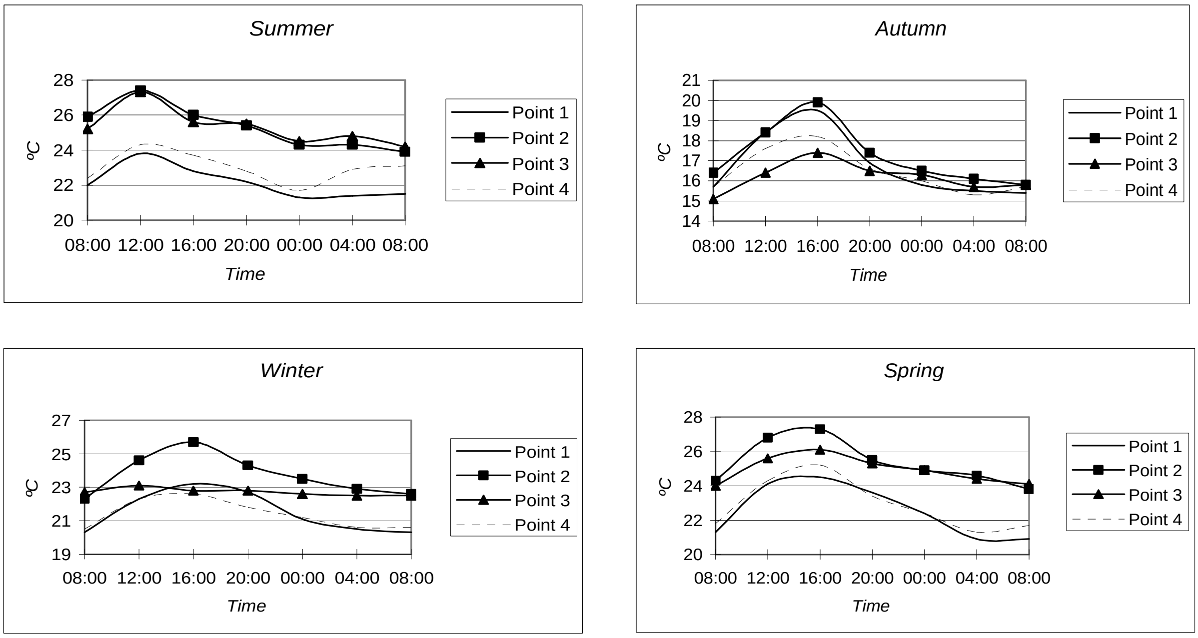

Figure 1 - Nictemeral variation of temperature in different points.

Large part of the most common noxious effects, resultant from pollution, is related direct or indirectly to the oxygen supply for fish breathing (Branco,1972; Salvador et al., 2003). Henry (1981) and Carvalho et al. (2007) suggested that the low levels of dissolved oxygen occurred during the Summer. This was confirmed as the point 2 recorded the least value (2.3 mg/L) and saturation of 29% at night.

The highest averages of dissolved oxygen concentrations were recorded in the Autumn (9.3 mg/L), at point 1; 13.5 mg/L at point 2 (Fig. 2), probably influenced by the temperature, since during this season, one of the least values of water temperature (16.6 ºC) was observed. Dissolved oxygen concentrations which occurred at internal points could also be attributed to an inverse relation between water temperature and dissolved oxygen content (Neill and Bryan, 1991; Piedras et al., 2006). During the nictemeral cycle from Autumn, after a dragging action inside the growing phases of rearing, the dissolved oxygen was of 4.8 mg/L (54% of saturation) at 16:00h at point 3.

The least saturations of oxygen, which were obtained at the external points, varied 66% during the Summer (point 1) and in 84% (point 4) during Spring time. During the hottest months, the low values were due to, probably, the highest temperatures, while in the Winter, the most probable cause was the occurrence of the driest period, contributing with the least amount of rain water into the pond.

The data for dissolved oxygen variable by Tukey test suggested the formation of two groups from distinct points, internal points (2, 3) and external points (1, 4). For all the studied terms, the formation of two distinct groups of collecting points was seen, that were the group number one, constituted by internal points (2, 3) and the second one with the external ones (1, 4). In all the seasons, the external points showed stable values of dissolved oxygen, without great amplitude of variation. The amplitude between the maximum and minimums ranges of dissolved oxygen was 10.15 mg/L (109% of concentration), which occurred during Autumn and Summer periods.

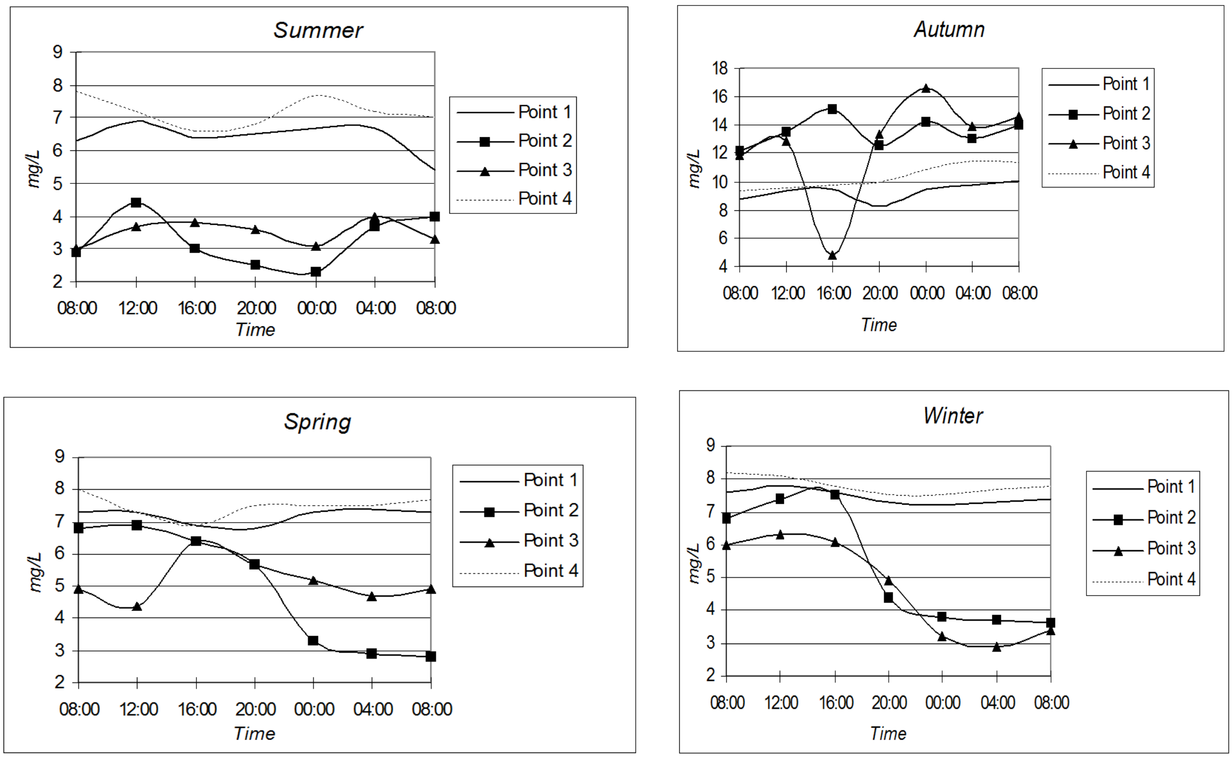

Figure 2 - Nictemeral variation of dissolved oxygen in different points

Considering the pH, the least answers were in the Winter, varying from 5.13 to 5.79, meanwhile the greatest recorded averaged value was 7.34, during Springtime. The highest value of pH was 7.9 and was recorded in the Spring at point 4, at 8:00 o'clock PM (Fig. 3).

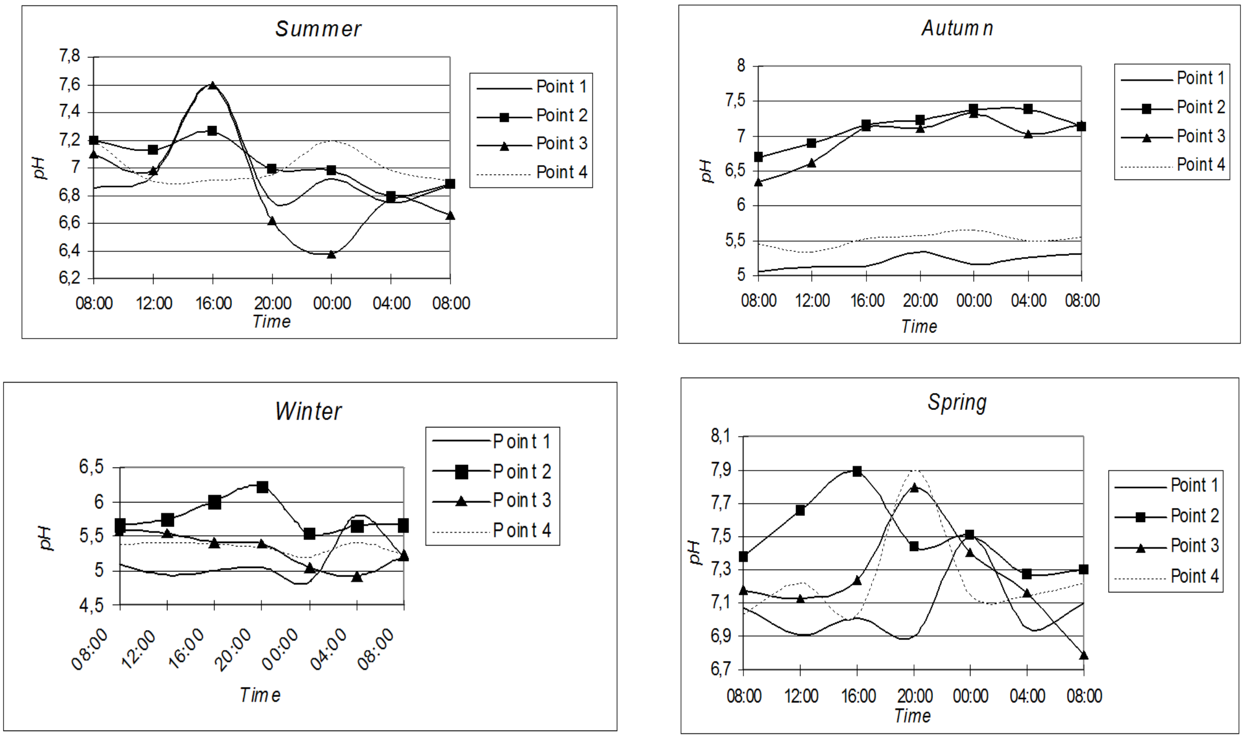

Figure 3 - Nictemeral variation of pH in different points.

The acceptable limits of the pH for the fishes in the pond, and the ones considered more auspicious for the majority of the aquatic species were placed between 6.1 and 9.2 (Dajoz, 1983) and when it was below 6.7, a reduction would take place in the production (Fijan, 1984).

During this study, it was observed that in the Summer and Winter, the pH showed minimum values in the dawn and in the early morning. The least value of the pH occurred at point 1 at 08:00h from an Autumn morning, probably, as a consequence of a high concentration of carbon dioxide dissolved in the water (Gomez and Escobar, 1994; Tavares et al., 1994; Ramirez and Bicudo, 2003; Carvalho et al., 2007). For pH, the general analysis of data by Tukey test suggested the formation of four groups with distinct points point 1, point 2, point 3 and point 4.

Analysing the period separately, the Tukey test presented the following results: the Winter was characterized by the formation of two different groups, group 1 formed by the point 2 (surface), and the second group formed by the points 1 (entrance), 3 (bottom) and 4 (streamlet). For Autumn season, a formation of two groups of collection points was observed, a group formed by the internal points (2 and 3), and a second one formed by the external points (1 and 4).

For Spring time, the Tukey test suggested the formation of three distinct groups: the first one formed by points 2 (surface), 3 (bottom), and 4 (streamlet), the second one formed by points 1 (entrance), 3 (bottom) and 4 (streamlet); and finally the third group which was formed by points 3 (bottom) and 4 (streamlet). At Summertime just one group was formed with the points 1, 2, 3 and 4, so, there was no significant difference among the averages of collection points, for pH variables.

A minimum pH under recommended levels for fish culture on nictemeral of Winter, was observed at all the points. The lowest indexes of pH were 5.05 at point 1, which occurred during Autumn season, while points 2, 3 and 4 were 5.66; 5.23 and 5.23, respectively, and occurred during the Winter.

The water conductivity is a way to evaluate the available amount of nutrients that were into the aquatic environment (Tavares and Gaglianone, 1993; Viana, 2006). During this nictemeral study, the electrical conductivity varied from a minimum of 55.3 µS/cm at point 4 at midnight during the Summer to a maximum of 127 µS/cm at point 3 at 4:00h in the Winter (Fig. 4). The internal points always showed higher conductivity than the points placed on the external side of the pond, as a result of the apply of manure, feedings and because of the presence of the fishes with their metabolites that left the water richer.

The least conductivity for aquatic organisms maintenance was 30 µS/cm (Pádua, 1994); therefore, lower than the average value found in this study, that were of 100.07 µS/cm for points 1 and 4, and 107.5 µ.S/cm for points 2 and 3. Takino and Cipólli (1988) studied growing pond with fertilized hens' manure + chemical manure + ration and observed an average conductivity of 60.0µS/cm, and pH of 8.8. The electrical conductivity and pH did not show significant differences among the points during the Autumn season.

The values of the electrical conductivity that showed a homogeneity was the Autumn, with the smallest variables, suggesting stability on present ions amounts, probably, because of the changes that also occurred in the other parameters. Arrignon (1979) and Farias (2006) related that, the electrical conductivity was influenced by the temperature and also by pH and these variables almost kept stability on their values, besides the dissolved oxygen maintained a parity among the similar points (1 and 4), (2 and 3). Egborge (1979) states that significant changes at conductivity values, as an index of changeable number of present ions, which was not expected in a short period interval.

The general analysis of data, using Tukey test, suggested the formation of two distinct groups of points. First group, points 2 (surface) and 3 (bottom); second group, points 1 (entrance) and 4 (streamlet).

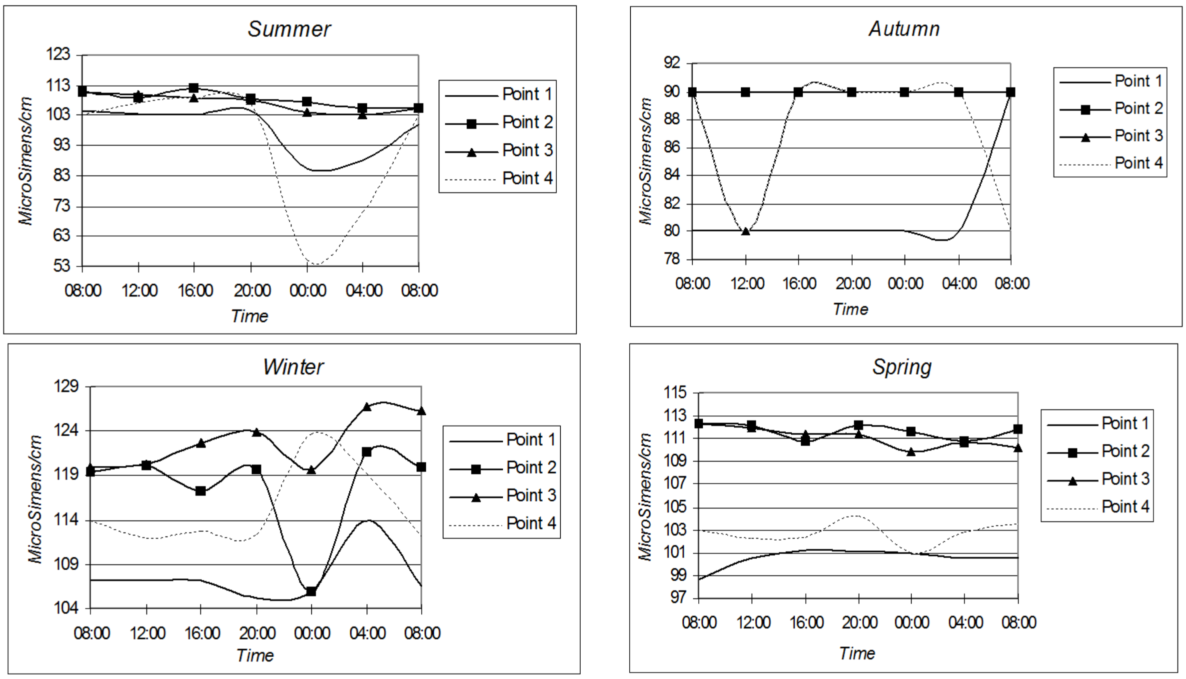

Figure 4 - Nictemeral variation of electrical conductivity in different points.

Observing the period one by one separately, Tukey test showed that in the Winter the formation of three distinct points of collection, group one formed by points 2 (surface) and 3 (bottom), group two composed by points 2 (surface) and 4 (streamlet), and the third one formed by point 1 (entrance). In October, the formation of two collection points groups was observed, group one: formed by the points 2 (surface), 3 (bottom) and 4 (streamlet) and group two: formed by the point 1 (entrance).

During Springtime, Tukey test suggested the formation of three distinct groups. The first group, composed by the points 2 (surface) and 3 (bottom); the second one, composed by the point 4 (streamlet) and the third one formed by the point 1 (entrance). In relation to the Summer term, only one group for all the points (1, 2, 3, 4) was formed, that means, there was no significant differences at the level of 5%, among the average conductivities.

The electrical conductivity showed a positive correlation with the temperature in the Spring and Summer, while the just the opposite occurred during the Autumn, probably, influencing the growth and the biomass of the present organisms (Koike, 1987; Pessano et al., 2005) Another factor that certainly contributed for this result was the great contribution of input which was placed.

During the seasons, the correlations that occurred between the variable temperature and dissolved oxygen were negative. In the Summer, the greatest correlation was quantified, corroborating the deterministic relation, since dissolved oxygen solubility was strongly influenced by temperature (Esteves, 1998; Arana, 1997; Pinheiro, 1987; Barbosa et al., 2006).

The final biomass was 231.11 kg from *Piaractus mesopotamicus*, and this was related to a productivity of 1,027 kg/ha/year, 34% from the average of *P. mesopotamicus* towards the region where this trial was carried out (EMATER-Paraná, 1998). The final survival was 57%. From 3,206 individuals, with an initial weight of 0.455 g 1,828 remained, with a total weight of 126.43 g.

The presence of the fishes did not contribute to the water quality deterioration, because the biomass during the study period was considered low. Nevertheless, these results did not differ a lot from the ones obtained by Leung et al. (1998), who in raising with high stocking density of *Brycon orbignyanus* could find different answers of temperature, ranging from 22.0 to 26.6 ºC; pH, ranging from 5.5 to 6.5; conductivity from 159 to 327 µS/cm, and dissolved oxygen from 4.1 a 13.5 mg/L.

Delbin and Paterniani (1998), observing the water analyses between the entrance and the exit of fish culture tanks concluded that in 81% of the studied farms, the effluents were thrown directly into the streamlets, without any treatment. Even so, the limnologic analyzed parameters varied or not between the entrance and the exit of the pond water.

Nictemeral evaluations which were carried out during this study, showed different answers at 5% level between the external points (entrance - point 1 and exit - point 4), and also between the internal points (surface - point 2 and the bottom of the hatchery - point 3). Thus it could be concluded that there was an influence on external environment from the effluent which came from the fish growing pond's inner part on limnology variables.

RESUMO

Realizou-se o experimento de engorda de peixes em um viveiro escavado em terra, com espelho d'água de 2.250m^2 e profundidade média de 0,91 m, localizado no município de Apucarana (Lat. S. 23º33'26,7", Long. W. 51º 33' 41,7"), norte do Estado do Paraná, Brasil. Durante o período experimental foram feitos estudos de variações nictemerais, durante as quatro estações climáticas do ano, coletando-se os dados no canal de alimentação (ponto 1), na superfície do viveiro (ponto 2), no fundo do viveiro (ponto 3) e no leito do córrego (ponto 4), com quatro variáveis: Oxigênio dissolvido (mg/L) e (%), temperatura (ºC), pH e condutividade elétrica (µ.S/cm). Coletou-se os dados em intervalos de quatro horas, iniciando-se às 08:00 hs. e concluindo no dia seguinte no mesmo horário. Os resultados obtidos indicaram que o outono foi a estação onde ocorreram os menores valores de temperaturas da água; os pontos internos na primavera apresentaram valores médios de temperatura superiores aos observados nos pontos externos. A amplitude entre as taxas máximas e mínimas de oxigênio dissolvido foi de 10,15 mg/L (concentração de 109%), os quais aconteceram nos períodos entre o outono e verão.

Identificou-se um pH mínimo, abaixo dos níveis recomendados para a criação de peixes no nictimeral de inverno em todos os pontos. Os menores índices do pH foram 5,05 no ponto 1 ocorrido no outono, enquanto que nos pontos 2, 3 e 4 ficaram em 5,66, 5,23 e 5,23 respectivamente, e que ocorreram no inverno. O máximo do pH registrado foi de 7,9 no outono. A condutividade elétrica e o pH não apresentaram diferenças significativas, no outono. As amostras obtidas no leito do córrego (ponto 4) apresentaram alta diferença significativa (P<0.05) comparadas as amostras da parte interna do viveiro de engorda, significando que houve influência sobre o ambiente externo através do efluente proveniente da parte interna do viveiro de engorda sobre as variáveis limnológicas.

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