GROWTH AND SURVIVAL OF LARVAE OF THE AMAZON SPECIES "MATRINXÃ", *Brycon cephalus* (PISCES, CHARACIDAE), IN LARVICULTURE PONDS

SENHORINI, J.A.[2,3], MANTELATTO, F.L.M.[1,3] & CASANOVA, S.M.C.[1]

[1] Department of Biology, Faculty of Philosophy, Sciences and Letters of Ribeirão Preto, University of São Paulo (USP)
[2] Center of Research and Training in Aquaculture, CEPTA/IBAMA/SP/Brazil
[3] Nucleus of Studies on Biology, Ecology and Crustacean Culture (NEBECC)

ABSTRACT

The aims of the study was to determine the growth and survival of larvae of "Matrinxã", *Brycon cephalus,* maintained in two fiberglass incubators each containing 60,000 larvae/60 litres and fed zooplankton and "Pacu" (*Piaractus mesopotamicus*) fish larvae. The water quality and the amount of zooplankton available in the tanks were analyzed. The experiment was carried out in 64 and 160 m^2 tanks. Two treatments (T1 and T2) with two replications each were performed: T1 consisted of tanks with larvae fed zooplankton, and T2 of tanks with larvae fed "Pacu" larvae. At the end of the experiment (24 days), mean weight and length of the fingerling lots were 1.3 g and 4.3 cm for T1 and 2.3 g and 5.4 cm for T2. Mean survival was significantly higher for T2 (47.8 %) than for T1 (17.9 %). The abundance of zooplankton was similar for the two treatments, with Cladocera peaks at the beginning (6 days) and at the end of rearing. Rotifers presented a growing increase in population, with a larger number of individuals/litre at the end of rearing. Copepods reached a maximum peak at 18 days of rearing. Temperature, pH and ammonia concentration in the water of the tanks were within limits considered to be satisfactory for pisciculture. Alkalinity and hardness presented decreasing values, and dissolved oxygen concentrations in water were below recommended levels for fish rearing, with T1 being significantly higher than T2, a fact that probably influenced the final growth and survival values. The species *B. cephalus* is highly promising for pisciculture, but further studies are needed to elucidate other important aspects such as larval feeding requirements both in incubators and in rearing tanks in order to obtain a better growth curve for the definition of a reference diet. In this respect, the present study revealed that complete rearing in incubators provides better chances of larval survival when the larvae are transferred to the tanks.

Keywords: growth, larvae, cultive, Characidae, fishes.

RESUMO

Crescimento e sobrevivência de larvas de matrinxã, *Brycon cephalus* (PISCES, CHARACIDAE) em viveiros de larvicultura

O objetivo do presente trabalho foi determinar o crescimento e a sobrevivência de larvas de Matrinxã, *Brycon cephalus*, provenientes de larvas mantidas em incubadoras, alimentadas com zooplâncton e larvas de Pacu, *Piaractus mesopotamicus*; analisou-se a qualidade da água e quantidade de zooplâncton disponível nos tanques de criação. O experimento foi realizado em tanques de 64 m^2 e 160 m^2, no Centro de Pesquisa e Treinamento em Aqüicultura - CEPTA/IBAMA. Constituiu-se de dois tratamentos (T1 e T2), com duas repetições cada, sendo T1, tanques com larvas provenientes de incubadoras, alimentadas com plâncton; T2, tanques com larvas provenientes de incubadoras, alimentadas com larvas de Pacu. Ao final do experimento (24 dias), os valores médios de peso e comprimento dos lotes de alevinos foram respectivamente: T1: 1,3 g e 4,3 cm e T2: 2,3 g e 5,4 cm. A média de sobrevivência para o tratamento T2, 47,8 foi significativamente maior que o tratamento T1, 17,9%. A abundância do zooplâncton apresentou-se semelhante nos dois tratamentos, com pico de cladóceros no início (6 dias) e no final da criação. Os rotíferos apresentaram um crescente aumento da população, com maior quantidade de indivíduos / litro ao final da criação. Os copépodes atingiram o pico máximo após 18 dias de criação. A temperatura (°C) , pH e concentração de amônia (mg/l) da água dos tanques ficaram dentro dos limites considerados satisfatórios para a piscicultura . A alcalinidade (mg/l) e a dureza (mg/l), apresentaram valores decrescentes enquanto as concentrações do oxigênio dissolvido (mg/l) estiveram abaixo do recomendado para a criação de peixes, sendo no tratamento T1 significativamente maior que no tratamento T2, provavelmente influencinado nos valores finais de crescimento e sobrevivência. A espécie *Brycon cephalus* é altamente promissora para piscicultura, contudo, torna-se necessário um maior número de estudos para a determinação de outros aspectos importantes, como as exigências alimentares das larvas, tanto em incubadora quanto em viveiros, visando alcançar uma melhor curva de crescimento e definir uma dieta referência. Uma criação completa nas incubadoras proporcionará maiores chances de sobrevivência das larvas quando estas forem transferidas para os viveiros de criação.

Palavra-chave: crescimento, larva, cultivo, Characidae, peixes

INTRODUCTION

Brycon cephalus, Gunther 1869, popularly known in Brazil as "Matrinxã", is a particularly important aquaculture species. Because of the excellent quality of its meat it has a high value and has been tested in several aquaculture studies (Castagnolli, 1992).

"Matrinxã" are omnivorous fish which feed in nature on seeds and fruits, invertebrates and small fish (Goulding, 1980). Their growth and weight gain are rapid (Werder and Saint Paul, 1978; Saint Paul *et al.*, 1981; Eyzaguirre and Cordova, 1993) and they represent a potential species for the development of pisciculture in several regions of Brazil.

Larviculture of species with potential for aquaculture is of importance for the development of fish culture (Fontes *et al.*, 1990).

According to Basile-Martins (1978), in general larviculture frequently fails, with feeding being the major factor in the determination of survival. The low survival of some species, especially during the larval rearing phase, is intimately related to the limited knowledge about larval biology in the rearing environment, especially in terms of developmental and feeding aspects.

According to some investigators (Woynarovich and Sato, 1989; Bernardino *et al.*, 1993), "Matrinxã" present a phase of cannibalism in their early development, this being the main difficulty met in their management during larviculture.

In this respect, the lack of natural food available both in terms of quantity and quality, together with the absence of artificial feeding to replace part of this natural diet, impairs the final production of larvae (Lopes *et al.*, 1994).

At about 30-32 hours after larval hatching, despite still having 50 % of its vitellin sac available, showing vertical swimming and a swimming bladder still uninflated, *B. cephalus* presents a high degree of cannibalism and aggressiveness, seizing with its mouth anything that moves in front of it (personal observation).

One way to minimize this cannibalism is to introduce food (zooplankton or larvae of other fish) in the incubator containing "Matrinxã" larvae (Woynarovich and Sato, 1989; Lopes *et al.*, 1994), thus permitting a longer residence of the larvae in the incubators until they consume most of the vitellus, inflate the bladder with gas and start to swim horizontally, thus being ready for transfer to the rearing tanks.

In laboratory conditions Lopes et al. (1994) tested several types of food in aquaria in an attempt to reduce the cannibalism of "Matrinxã" during the rearing phase. According to this investigator, during this phase which lasts approximately 60 to 70 hours after hatching, larvae are characterized by presenting a considerably consumed vitellin sac (more than 70 %) and horizontal swimming. At this stage they are fit for rearing in larviculture tanks. In the study by these investigators, the best results were obtained with the use of zooplankton and of larvae of other fish together with "Matrinxã" larvae in the incubator.

The objective of the present study was to determine the growth and survival of "Matrinxã" larvae maintained in an tanks, testing the larvae survival that was fed with zooplankton and "Pacu" (*Piaractus mesopotamicus* Holmberg, 1887) larvae (Pisces, Characidae), during the first life hours, when beginning cannibalism. Thus, we monitored the water quality and the quantity of zooplankton available (rotifers, cladocerans, copepods) in the rearing tanks.

MATERIAL AND METHODS

Four cement tanks with a mud bottom, two measuring 64 m^2 and two 160 m^2 each in water surface, with a mean depth of 1.60 m were used. The tanks were invariable supplied with natural water through an open cement canal.

The tanks were exposed to the sun for a period of 5 days, after which they were treated with lime ($CaCO_3$) at a application rate of 30 g/m^2, and filled with water to depth of 1.6 m. One day after lime treatment, the tanks were fertilized only once with fresh cattle manure at a rate of 500 g/m^2.

The "Matrinxã" larvae used in the present study were produced follow the induced spawning method of Bernardino et al. (1993). After hatching, the larvae were placed in two fiberglass Woynarovich incubators each with 200 litres capacity and containing 60,000 larvae/60 litres. After 32 hours of rearing and the beginning of cannibalism, zooplankton (70 % of cladocerans: *Moina micura*, *Diaphanosoma birgi* and *Scapholeberis* sp. and 30 % or copepods: *Argyrodiaptomus furcatus*) was added *ad libitum* to incubator 1, and five live "Pacu" (*P. mesopotamicus*) larvae (with 5 days of life; 5.0 mm of length and 8,0 mg of weight) per "Matrinxã" larvae were added to incubator 2.

At 60 hours of age (28 hours after the introduction of food), the larvae, which were swimming horizontally, were transferred to the tanks. Treatment T1 consisted of one 64 m^2 tank and one 160 m^2 tank containing larvae from the incubators receiving zooplankton, and treatment T2 consisted of one 64 m^2 tank and one 160 m^2 tanks containing larvae from the incubators that received "Pacu" larvae. In each tanks was added 31 "Matrinxã" larvae per m^2 of surface area.

From the second day of rearing in the tanks to the 24th day (end of the experiment) the larvae received artificial food supplied in two daily meals: during the morning (9 a.m.) and in the afternoon (4 p.m.). This food in the form of dry flock containing approximately 30.9 % crude protein (CP) (Table 1) consisting of fish meal, corn meal, Maxtem E (soybean protein), powdered milk and mineral/vitamin Premix: vitamin complex prepared according to Cantelmo & Senhorini (1989) including vitamins A, D3, E, B12, tiamine, riboflavin, pantotenic acid, niacin, pyridoxine, folic acid, biotin. The artificial food was throwed in the entire surface of the tanks in sufficient amounts (5

% of larvae biomass) in an attempt to leave it always available to the larvae.

Although a supplemental dry ration was fed to the larvae the differences in its utilization by larvae from the two treatments have been investigated in another study about diet larvae in preparation.

At 6 a.m., data concerning temperature, dissolved oxygen level, pH, hardness, alkalinity and ammonia concentration were measured.

Zooplankton samples at a depth of 0.5 m from all tanks were collected on the same days and at the same times as for the determination of the physicochemical variables. The material was collected with a 2.2 litres Van Dorn bottle and estimated the abundance.

After 24 days of larval rearing, the study was concluded and 40 fingerlings were collected from each tanks of each treatment for weight determination, measurement and calculation of specific growth rate (G) (Ricker, 1979), where $G = (\ln W_2 - \ln W_1) / (T2 - T1)$. The fish from each tanks were then counted to estimate final survival rate.

The treatments were compared by the nonparametric Mann-Whitney U test (Siegel, 1956) for each variable. The level of significance was set at 5 %.

RESULTS

Fish survival and growth

The larvae used at the start of the rearing tanks phase weighed on average 0.0002 g and 0.0011 g and were 0.58 and 0.60 cm long for T1 and T2, respectively. The coefficient of variation of weight range was 45.8 and 34.5 (%) and the CV length range was 7.8 and 5.4 (%) (Table 2).

After 24 days of rearing, the final mean weight and length were 2.3 g and 5.1 cm (CV = 46.7 and 15.0 %) for T2 fingerlings and 1.3 g and 4.3 cm (CV = 55.9 and 14.7 %) for T1 fingerlings.

Fingerlings production was 3319 and mean survival rate 47.8 % for T2, and 1243 and 17.9 % for T1, respectively (Table 2).

The final specific growth rate (G) was 37.9 % for T1 and 33.6 % for T2.

Plankton composition and water quality

The abundance of zooplankton was similar in the two treatments, with peaks of cladocerans at the beginning (6 days) and at the end of rearing. Rotifers presented a growing increase in population, with a peak at the 21^{th} day of the study. Copepods presented a peak at 18 days of rearing in both treatments (Fig. 1).

Water temperature ranged from 24.5 to 28 ^{O}C (Fig. 2) in both treatments.

Surface dissolved oxygen ranged from 0.9 to 3.0 mg/l (T1) and from 0.7 to 1.6 mg/l (T2). On the bottom, the range was 0.7 to 2.8 mg/l (T1) and 0.6 to 1.4 mg/l (T2), with T1 being significantly higher than T2 ($p<0.05$) (Fig. 3 a,b).

Figure 4 shows the variation of mean ammonia concentration during the experimental period, with small oscillations in the concentration of these ions within treatments.

The two treatments initially presented neutral pH, which tended to be slightly acid at the end of rearing (Fig. 5), with values ranging from 7.2 at the beginning of the study to 6.6 at the end.

Total water alkalinity (mg/l) presented decreasing values and was higher in T2 (Fig. 6), and the same occurred with hardness (mg/l) (Fig. 7).

DISCUSSION

Appropriate feeding is an important factor to consider since it affects the survival of fish larvae during their initial stage.

The concept of a "critical period" during the larval development of fish, related to increased mortality during the transition from endogenous to exogenous food, can be controlled by supplying an adequate first diet (Qin & Culver, 1992) and can result in higher survival and growth in rearing units.

During this study we observed that "Matrinxã" larvae, the "critical period" starts when the larvae are in the incubator, with little consumption of vitellus (approximately 1/4), non-inflated swimming bladder, vertical swimming, and age of 32 to 36 hours. During this phase we registered a high rate of cannibalism.

The present study demonstrated the effect of initial larval feeding on final fingerlings survival and growth in T2 tanks which were stocked with "Matrinxã" larvae that had received "Pacu" larvae as food in the incubator. However, even in T1, in which mean survival rate was 17.9 %, the rate was higher than that obtained by Bernardino et al. (1993) (5.2 %) in a study in which larvae were placed in the tanks at 36 hours of age and did not receive food in the incubator. Woynarovich and Sato (1989) reported a high survival rate (80 %) for incubated *Brycon lundii* Reinhardt, 1874 larvae when larvae of other fish were added as food.

This higher final survival rate of "Matrinxã" fingerlings in tanks after receiving food in the incubator may be related to the easy because of food available and consequent capture (copepods, cladocerans and rotiferans) and flight from predators (aquatic insects) by the larvae, which are more agile.

The successful rearing of fish larvae is related to the abundance of zooplankton preferred by the larvae and to the management of water quality in the tanks (Geiger and Turner, 1989). Zooplankton was available to "Matrinxã" larvae in all four tanks and in both treatments, with a constant production throughout the rearing period, especially of cladocerans for which "Matrinxã" larvae present higher preference during this developmental phase (Senhorini, 1995).

Biotic factors are considered to be the major causes of mortality of tropical species of Characidae Family (*Brycon* sp, *Piaractus* sp and *Colossoma* sp), abiotic factors are rarely taken into account (Smith and Piper, 1975; Koenst and Smith, 1976).

Temperature has a considerable effect on the metabolism of fish, especially breathing, growth and reproduction (Boyd, 1981). According to Vinatea (1982), tropical species mentioned above have the ability to tolerate water with temperatures ranging from 15 to 30 ^{o}C. Saint-Paul (1986) pointed out that fish of the Characidae family requires waters with temperatures above 20 ^{o}C. The values obtained in the present study, 25 to 28 ^{o}C, were within the above limits.

Oxygen is also an important parameter for fish survival. Boyd (1981) reported that fish survive a dissolved oxygen range of 1.0 to 5.0 mg/l. At levels below 4.0 mg/l for prolonged periods of time, growth becomes slower.

In the present study, dissolved oxygen was never above 4.0 mg/l in any of the samples taken. This low level may have been due to the presence of excessive organic matter. In the rearing environment for "Matrinxã", the lowest dissolved oxygen levels were 0.7 (surface) and 0.6 mg/l (bottom) in agreement with data reported by Soares (1989). According to this same investigator, fingerlings and adult "Matrinxã" can survive in waters with very low oxygen levels (<

1.3 mg/l) and more acid pH than tolerated by other temperate zone species.

The biological conditions for fish culture are much better in waters with neutral or alkaline acid pH (7.0 to 8.0) (Boyd, 1981). In the present study there were no sudden variations in pH, which was always between 7.3 and 6.6. This equilibrium may have been related to the cattle manure added to the tanks.

Alkalinity and hardness presented the same variation in magnitude, ranging from 15 to 46 mg/l and from 15 to 36 mg/l, in T2 and T1, respectively. According to Colares de Melo (1990), the waters that present this characteristic are usually considered to be the most productive because of the ionic equilibrium and this level are satisfactory to zooplankton reproduction and development.

Alkalinity and hardness indices did not affect tanks productivity since at the beginning of larviculture, when the larvae require ideal conditions in terms of water quality, these indices were satisfactory, i.e., above 20 mg/l (Boyd, 1981).

The toxicity of un-ionized ammonia (NH_3) for various fish species usually ranges from 0.5 to 3.0 mg/l (Robinette, 1976; Buckley, 1978; Thruston et al., 1981; Alabaster and Lloyd, 1982). In the present study, no sampling showed ammonia levels above 0.29 mg/l. We may also infer that, with pH varying from neutral to acid, the percentage of toxic ammonia was quite low.

The species *B. cephalus* is highly promising for fish culture, showing good adaptation to the intensive rearing system. However, more studies are needed to determine the feeding requirements of the larvae both in the incubator and in tanks, in order to obtain a better growth curve and to define a reference diet. We believe that the full rearing in incubators provides greater chances for larval survival when the larvae are transferred to the rearing tanks.

ACKNOWLEDGEMENTS

We are grateful to biologist Marcos Augusto Valente for help with the collection and analysis of zooplankton.

REFERENCES

ALABASTER, J.S., LLOYD, R. *Water quality criteria for freshwater fish.* 2nd ed. London: Butterworth Scientific, 1982. 361p.

BASILE-MARTINS, M.A. *Comportamento e alimentação de Pimelodus maculatus* LACEPEDE, 1803 (Osteichthyes, Siluriformes, Pimelodidae). São Paulo, 1978. 143 p. Dissertação (Mestrado) – Instituto de Biociências da USP.

BERNARDINO, G., SENHORINI, J.A., FONTES, N.A., BOCK, C.L., MENDONÇA, J.O.J. Propagação artificial do Matrinxã, *Brycon cephalus* (Gunther, 1869), (Teleostei, Characidae). B. Téc. CEPTA, v.6, n.2, p. 1-9, 1993.

BOYD, C.E. *Water quality in warm water fish culture.* Auburn University, 1981. 359 p.

BUCKLEY, J.A. Acuted toxicity of un-ionized ammonia to fingerling coho salmon. *Prog. Fish Cult.*, v. 40, p. 30-32, 1978.

CASTAGNOLLI, N. *Criação de peixes de água doce.* Jaboticabal, FUNEP, 1992, 189 p.

CANTELMO, O.A. SENHORINI, J.A. Alimentação artificial de larvas e alevinos de peixes. *Red. Acuicult. Bol.*, v.3, n.3, p 3-6, 1989.

COLARES DE MELO, J.S. *Alimentação natural em viveiros.* Pirassununga: CEPTA, 1990. 10 p.

EYZAGUIRRE, H.F., CORDOVA, R.V. Aspectos básicos de la producción piscicola de caracídeos tropicales. *In:* SIMPÓSIO INTERNACIONAL SOBRE FAUNA SILVESTRE Y PESCA FLUVIAL Y LACUSTRE AMAZÔNICA, 1993, Manaus. p. A1-A11.

FONTES, N.A., SENHORINI, J.A., LUCAS, A.F.B. Efeito de duas densidades de estocagem no desempenho larval do paqui, *Piaractus mesopotamicus* (fêmea) (Holmberg, 1887) x *Colossoma macropomum* (macho) (Cuvier, 1818), em viveiros. *B. Téc. CEPTA*, v. 3, p. 23-32, 1990.

GEIGER, J. G., TURNER, C. J. Fertilização de tanques e manejo de zooplâncton. *In:* HARVEY, CAROLSFELD, J (eds). *Workshop on larval rearing of finfish.* (s.l.): CIDA, ICSV, CASAFA, 1989. p. 93-100.

GOULDING, M.W., 1980. *The fishes and the forest*: exploration in Amazonian natural history. Los Angeles: University of California Press, 1980. 280 p.

KOENST, W.M., SMITH JR, L.L. Thermal requirements of the early life history stages of walleye, *Stizostedion vitreum vitreum*, and sauger, *Stizostedion canadense*. J. Fish. Board. Can., v.23, p. 1130, 1138, 1976.

LOPES, R.N.M., SENHORINI, J.A., SOARES, M.C.F. Crescimento e sobrevivência de larvas de Matrinxã *Brycon cephalus* sob diferentes dietas alimentares. B. Tec. CEPTA, v.7, p. 41-48, 1994.

QIN, J., CULVER, D.A. The survival and growth of larval walleye, *Stizostedion vitreum*, and tropic dynamics in fertilized tanks. *Aquaculture*, v. 108, p. 257-276, 1992.

RICKER, W. E. Growth rates and models. *In*: HOAR, W.S., RANDALL, D.J., BRETT, J.R. (eds), *Fish Physiology*, New York; Academic Press, 1979. V. 3, 300 p.

ROBINETTE, H.R. Effects of selected sublethal levels of ammonia on the growth of channel catfish (*Ictalarus punctatus*). Prog. Fish-Cult., v.38, p.26-29, 1976.

SAINT-PAUL, V., Werder, V., Teixeira, A.S. Use of water by acinth in feeding trials with Matrinxã (*Brycon* sp.). *J. Aquat. Plant. Manage.*, v. 19, p. 18-22, 1986.

SAINT-PAUL, V. Potential for aquaculture of South American freshwater fishes: a review. *Aquaculture*, v.54, p.205-240, 1981.

SENHORINI, J.A. *Desenvolvimento larval do Pacu Priaractus mesopotamicus Holnisley, 1887 (Pisces, Characidae) em viveiros.* Botucatu, 1995. 112 p. Dissertação (Mestrado) – Universidade Estadual Paulista.

SIEGEL, S. *Nonparametric statistics for the behavior sciences*. New York: MacGraw-Hill, 1956. 321 p.

SMITH, C.E., PIPER, R.G. Lesions associated with chronic exposure to ammonia. *In*: RIBELIN, W.E., MIGALSI, G. (eds), *The*

Pathology of fishes. Madison: University of Wisconsin Press, 1975. P. 497-514.

SOARES, M.C.F. *Estudos preliminares do cultivo do Matrinxã (Brycon cephalus - Gunther, 1869) (Teleostei, Characidae), aclimatação, crescimento e reprodução.* Salvador, 1989. 91 p. Dissertação (Mestrado) – Universidade Federal da Bahia.

THRUSTON, R.V., RUSSO, R.C., VINOGRADOV, G.A. Ammonia toxicity to fish: effects of ph on the toxicity of the un-ionized ammonia species. *Environ. Sci. Technol.*, v. 15, n.7, p.837-840, 1981.

VINATEA, J.E. *Acuicultura Continental*: peces, artemias y dafnias, camarones e lagostinos. Lima: Libreria Studium, 1982. P.25-35.

WERDER, V., SAINT PAUL, V. Feeding trials herbivorous and omnivorous Amazonian fishes. *Aquaculture,* v.15, p.177, 1978.

WOYNAROVICHE, E., SATO, Y. Special rearing of larvae and post-larvae of matrinxã (*Brycon lundii*) and dourado (*Salminus brasiliensis*). *In*: HARVEY, B, CAROSFELD, J, (eds). *Workshop on larval rearing of finsfish.* (s.l) CIDA, ICSU, CASAFA, 1990.

TABLE I .Composition of the artificial food (ration) use to feed "Matrinxã" (*Brycon cephalus*) larvae during larviculture

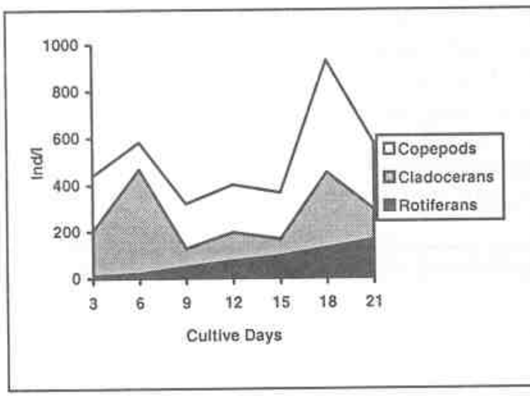
Ingredients	Ration (%)	Crude Protein (%)
Fish meal	40	18,4
Maxtem E	15	7,8
Powdered milk	14	2,0
Corn meal	30	2,7
Mineral premix	0,5	-
Vitamin premix	0,5	-
TOTAL	100	30,9

TABLE II . Weight gain, length, specific growth rate (G) and survival in treatments T1 and T2 for "Matrinxã" (*Brycon cephalus*) larviculture

	T1	T2
Initial mean weight (g)	0.0002	0.0011
Variation in initial mean weight (CV%)	45.8	34.5
Final mean weight (CV%)	1.3b	2.3a
Variation in final mean weight (CV%)	55.9	46.7
Initial mean length (cm)	0.58	0.60
Variation in initial mean length (CV%)	7.8	5.4
Final mean length (cm)	4.3	5.1
Variation in final mean length (CV%)	14.7	15.0
Specific growth rate (G%)	37.9	33.6
Survival (%)	17.9b	47.8a

Different letters indicate significant differences at the 5% level

A.



B.

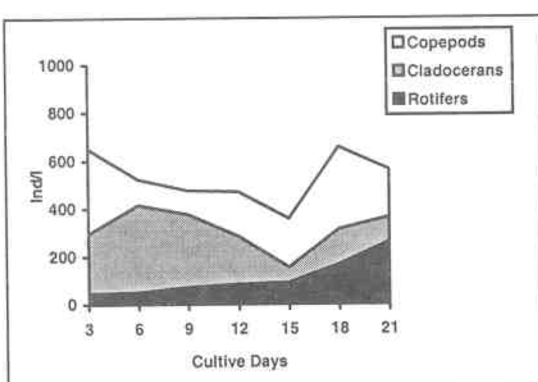


Fig.1. Concentration of the zooplankton population, rotifers, cladocerans and copepods (ind/l) in "Matrinxã" (*Brycon cephalus*) larviculture. A) Treatment T1 and B) Treatment T2

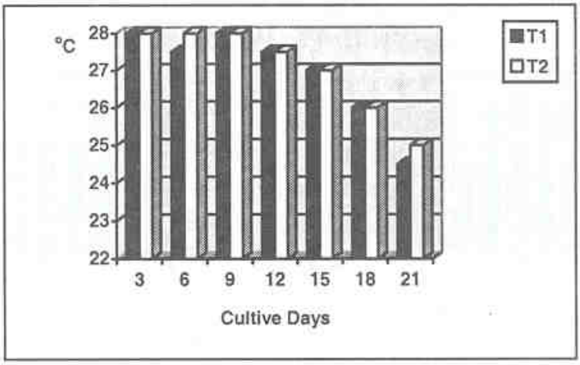


Fig.2. Water temperature (°C) in the tanks for "Matrinxã" (*Brycon cephalus*) larviculture in Treatments T1 and T2

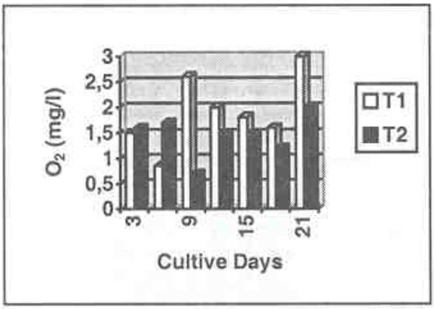


Fig.3(a). Concentration of dissolved oxygen on the surface of the tanks (0.10 m) in Treatments T1 and T2 for "Matrinxã" (*Brycon cephalus*) larviculture.

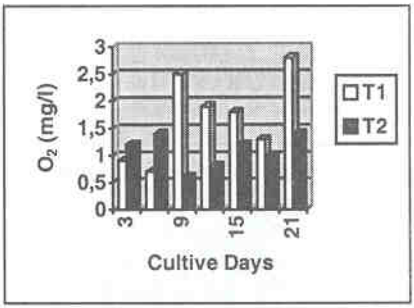


Fig.3(b). Concentration of dissolved oxygen on the bottom of the tanks (1.20 m) in Treatments T1 and T2 for "Matrinxã" (*Brycon cephalus*) larviculture.

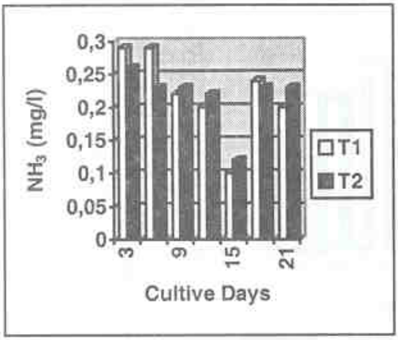


Fig. 4. Mean ammonia (NH_3) concentration in the water of the tanks in Treatments T1 and T2 for "Matrinxã" (*Brycon cephalus*) larviculture.

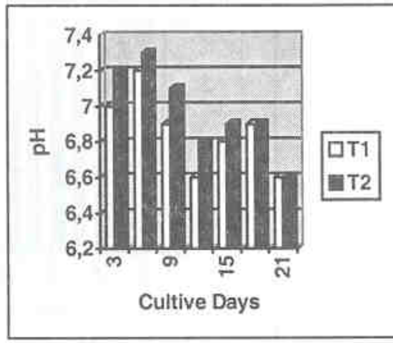


Fig. 5. Mean pH distribution of water pH in the tanks in Treatments T1 and T2 for "Matrinxã" (*Brycon cephalus*) larviculture.

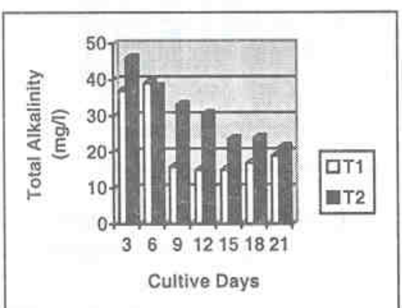


Fig.6. Mean total alkalinity of the water of the tanks in Treatments T1 and T2 for "Matrinxã" (*Brycon cephalus*) larviculture.

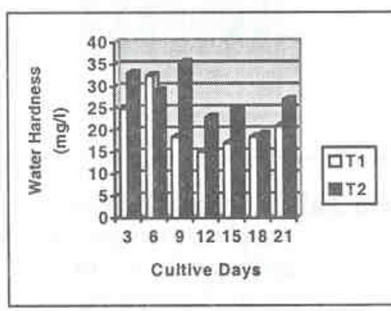


Fig.7. Mean concentration of water hardness in the water of the tanks in Treatments T1 and T2 for "Matrinxã" (*Brycon cephalus*) larviculture.