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Feeding of larvae of the hybrid surubim *Pseudoplatystoma* sp. under two conditions of food management

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ABSTRACT. We evaluated the growth and diet composition of hybrid surubim larvae (*Pseudoplatystoma corruscans* x *P. reticulatum*) produced in two fish farming by using different systems of feeding with natural plankton: M I, larvae are transferred to fertilized fish pond for being freely fed with natural plankton; M II, larvae are remained inside laboratory in glass fiber boxes and plankton are gathered with a plankton net and offered in a controlled way. It was collected 10 individuals daily during the feeding period with live plankton for 20 days. After the biometry, stomachs were opened and the food items identified and quantified by the volumetric method. The items were represented by algae, protozoa, microcrustacean, insect larvae and surubim fragments (cannibalism). The items with higher volumetric percentage were Chironomidae larvae (29.25%) followed by surubim fragments (19.68%) in M I, and surubim fragments (21.85%) and *Moina micrura* (19.97%) in MII. The items *Chydorus* sp., *Diaphanosoma* sp., sp. *Macrothrix* and Ephemeroptera larvae were found only in fish of M I, while algae *Ulothrix* sp., *Oscillatoria* sp. and the protozoa *Difflugia* sp were only found in stomachs of surubim from M II. Regarding the growth, the surubim had grown faster in M I.

Keywords: larviculture, freshwater fish, diet.

Alimentação de larvas do surubim híbrido *Pseudoplatystoma* sp. sob duas condições de manejo alimentar

RESUMO. Este trabalho avaliou o crescimento e a composição da dieta de larvas do surubim híbrido (*Pseudoplatystoma corruscans* x *P. reticulatum*) produzidas em duas pisciculturas que utilizam sistemas diferentes de alimentação com plâncton natural: M I, as larvas são transferidas para viveiros previamente fertilizados para se alimentarem livremente com plâncton natural e M II, as larvas permanecem no laboratório em caixas de fibra de vidro e o plâncton são coletados com rede e oferecidos de forma controlada. Foram coletados dez exemplares por dia durante 20 dias. Após a biometria e a retirada dos estômagos, os itens alimentares foram identificados e quantificados por meio do método volumétrico. Os itens com maiores percentuais volumétricos foram larvas de Chironomidae (29,25%) seguido de restos de surubim (19,68%) em M I e restos de surubim (21,85%) e *Moina micrura* (19,97%) em M II. Os itens *Chidorus* sp., *Diaphanosoma* sp., *Macrotrix* SP. e larvas de Ephemeroptera foram encontrados apenas nos estômagos dos surubins do M I, enquanto as algas *Ulothrix* sp., *Oscillatoria* sp., assim como o protozoário do gênero *Diflugia*, foram observados apenas nos estômagos dos surubins do M II. Em relação ao crescimento, os surubins do M I apresentaram crescimento mais rápido do que em M II.

Palavras-chave: larvicultura, peixe de água doce, dieta.

Introduction

Fish early life stage, technically named larval stage, is an important phase for determining the survival percentage of fish spawning (FILIPETTO et al., 2005). In this period, the natural food contributes with essential nutrients of high biological values, ensuring its development and survival. In this way, the supply of a high nutritional value food is extremely important for a satisfactory growth (FURUYA et al., 1999).

Studies based on stomach content analysis have based the knowledge of food sources used by fish, and can provide data about habitat, food availability in the environment and even some aspects of behavior (DAJOZ, 1983).

The species of the genus *Pseudoplatystoma* and Order Siluriformes include the largest catfish of the family Pimelodidae. Usually they are found in major South America river basins and regionally known as 'surubins' (ROMAGOSA et al., 2003). Eight species have been described so far: 'pintado' *Pseudoplatystoma corruscans*, 'cachara' *P. fasciatum*, 'carapari' *P. tigrinus*, (from *P. fasciatum* of Amazonas river) *P. punctifer*; (from *P. fasciatum* of Orinoco river basin) *P. orinocoense*; (from *P. fasciatum* of Magdalena river, in Colombia) *P. magdaleniatum*; (from *P. fasciatum* of Paraná and Amazonas rivers) *P. reticulatum* and from Orinoco river *P. metaense* (BUITRAGO-SUÁREZ; BURR, 2007).

All of them have zootechnical and market characteristics fairly attractive, such as mild flavored meat, low fat content, and intramuscular bones absence, which have made surubins extremely appreciated by several consumers worldwide (SMERMAN, 2002).

Although there has been a high demand of surubins in the last years, hatchlings supply has not followed market demand since there is a need of importing some species from neighbor countries extractive fishing, mainly from Argentina. The lack of knowledge about food requirements during larval stage and influence of food type on the growth are some of the factors that have concerned the fish farmers, since at the post-larval stage, these species are highly dependent on natural live food, produced through fertilization of fish ponds for this purpose (KUBITZA et al., 2007; URBINATI et al., 2010).

In the state of Mato Grosso do Sul, the production technology of larvae of *Pseudoplatystoma* is pioneer, especially of *P. corruscans*, *P. reticulatum* and the hybrid of these two species (SOARES et al., 2002). On the other hand, although the state of Mato Grosso do Sul is the highest supplier of fingerlings of this genus in the country, little is known about the development of these species since most part of production technology was made by the private sector.

In the State of Mato Grosso do Sul, Brazil, over 90% of surubins produced in larviculture are stemmed from a crossbreeding of 'cacharra' female with 'pintado' male (*P. reticulatun* x *P. corruscans*). This preference, according to the fish farmers, is because hybrid hatchling is plianter as they learn to be fed with fish food easier than usual besides presenting a higher growing rate.

In the State of Mato Grosso do Sul there is not any study of hatchling production which proves this advantage and this confirmation is based on the scarce Brazilian literature about this theme. Besides the management advantages, according to Campos (2010), the consumer market does not distinguish hybrid species from pure ones relating to fish meat quality and price.

Once the lifetime of most fish species is highly variable, the age and size structures of a population have key influence on its dynamics (DE ANGELIS et al., 1993). According to Zhang et al. (2009), the heterogeneity in growth is a common issue for larviculture, especially for carnivorous species. Changes in population size distribution are result from an interaction among four main factors related to individual characteristics in the population composition: (1) initial size, (2) distribution of growth rates due to individual differences, (3) individual influence of time and size on the growth rate and (4) death rate that can affect the size classes differently. In this way, the size structure can be particularly important in population with flexible growth, whose feeding and vulnerability to predation depend on the body length (WOOTTON, 1998).

In many fish species, the growth rate varies sharply according to environmental conditions, and in tropical regions, the food resources are decisive for a satisfactory growth (BOUJARD et al., 1991; NIKOLSKY, 1969).

Studies on natural feeding are important for understanding the biology of fish species (WOOTTON, 1998). Although at the moment, the feed industries have developed specific microdiets for this stage, carnivorous fish, unlike most species with other feeding habitats, have higher growth rates in nature than in hatcheries, when artificially fed. These factors contribute to most surubim fingerlings producers, in the of State Mato Grosso do Sul, choose to use natural life food during larviculture.

In the early productive process, first alive food larvae offered inside the hatchery, soon after opening their mouth, are *Artemia salina* nauplii, been given continuously (day and night) for 7 to 10 days, depending on the temperature until their pigmentation is developed. After this period, two production systems can be employed: 1) mix system (lab-fish pond-lab), on which larvae are transferred from hatchery to fertilized fish pond at a density of 100 to 150 larvae m^{-2} to be fed of natural plankton where they are kept for around 15 days, till reaching 4,0 to 5,0 cm long, depending on the environment condition and food availability; 2) indoor system, where all alive feeding stages are done inside where fish is moved from hatchers to round or rectangular-like fiber glass boxes in a closed circuit at density of 5,000 larvae m^{-2} with light protection and fed with natural plankton gathered with plankton net in external fish ponds previously fertilized.

Based on this information, this study aimed to evaluate the diet composition related to larvae growth of hybrid surubim *Pseudoplatystoma corruscans* vs *P. reticulatum* produced in two fish farmings that employ different techniques of feeding management during the larvae feeding stage by using natural plankton.

Material and methods

Samplings were undertaken in the period of natural reproduction occurring from September 2008 to February 2009 in two commercial fish farmings: one located in Dourados city (M I) and another near Terenos city (Mato Grosso do Sul State, Brazil) (M II).

M I- after the tenth day of exogenous feeding using *Artemia salina* as exclusive food, the larvae are transferred from inner area (laboratory) to external excavated fish ponds, previously fertilized for being feeding with natural plankton.

M II- after the tenth day of life, feeding management is similar to MI. After this, the live plankton, produced in external fish ponds, is collected using plankton net (68 μm) and supplied to fish each hour in laboratory.

In both fish farming, the fertilization is conducted with prior disinfection with hydrated lime and drying in the sun for three days. The fish pond is fertilized with 10 kg rice bran and 3 kg urea per 1,000 m^2, when the water level reaches 40-50 cm depth. After initial fertilization, it is performed a daily fertilization with 5 kg rice bran per 1,000 m^2.

We collected from each fish farming 10 individuals per day for 20 days, period when the species were fed exclusively on live plankton in both fish farming. For capturing them it was used a rectangular net (1 x 0.8 m; 0.2 mm mesh size). Individuals of the same batch of each fish farming were captured by early morning and anesthetized with eugenol at a ratio of 10 mg L^{-1} and then taken to 500 mL-flasks with formalin solution (4%), an identification number, location, collection date, and type of management, for further biometry and analysis of stomach content.

Samples were taken to the laboratory of aquatic biology of the Faculty of Biological and Environmental Sciences from Federal University of Grande Dourados (UFGD) in the State of Mato Grosso do Sul, Brazil. Each individual was put under stereoscopic microscope where it was measured the standard length (cm) and total length (cm) by using a caliper. Then they were individually weighed (g) for growth analysis.

From the total of 400 fish captured, 183 stomach of the hybrid surubim from the M I, and 169 from the M II have had content to be analyzed. By using stereoscopic and light microscopes the identification of the food items were done and then preserved in alcohol solution (70%). Given the absence of other fish species during the assessment in M I and M II management, where the larvae were collected, the item 'fish fragments' consisted of exclusively smaller individuals consumed by cannibalism.

For diet quantitative analysis volumetric method was used, in which the volume of each food item was calculated related to the total volume of stomach content (HYSLOP, 1980). These measurements were obtained using a millimeter plate, where the volume of each taxonomic category was calculated in mm^3 and then transformed into 'ml' (HELLWELL; ABEL, 1971). In order to obtain a representation of variation in the set of food items consumed, and evaluate the diet composition in relation to the two types of management, the samples were ordinated by means of a non-metric multidimensional scaling (NMDS), using the R software (R DEVELOPMENT CORE TEAM, 2010) for statistical analyses, and for ordination (NMDS), the vegan package (OKSANEN et al., 2010).

Results and discussion

The initial weight of larvae was 0.01576 ± 0.005635 g in M I and 0.00958 ± 0.001802 g in M II. From the 22 total items found in the stomach content of the hybrid surubim, 19 were in M I, and 18 in M II (Table 1).

Table 1. Volumetric percentage of the main taxa found in the stomach content of hybrid surubim in different kinds of management (M I and M II).

Food items	Pond (M I)	Hatchery (M II)
Cladocera		
Unidentified cladocerans	13.97	5.69
Bosmina sp.	0.56	0.55
Ceriodaphnia sp.	0.33	0.74
Chydorus sp.	0.37	--
Daphnia sp.	4.55	0.32
Diaphanosoma sp.	4.23	--
Macrothrix sp.	0.44	--
Moinodaphnia sp.	1.71	2.37
Moina sp.	5.26	4.41
Moina minuta	0.68	13.10
Moina micrura	0.26	19.97
Copepoda		
Unidentified copepods	5.81	7.00
Cyclopoida	2.37	3.41
Calanoida	1.77	14.73
Insecta		
Chironomidae larvae	29.25	0.06
Ephemeroptera larvae	0.34	--
Unidentified algae	1.12	0.04
Ulothrix sp.	--	0.29
Oscillatoria sp.	--	0.39
Protozoa		
Difflugia sp.	--	0.74
Digested material	7.31	4.93
Surubim fragments	19.68	21.85

Food items have been represented by algae, protozoan, microcrustacean, insect larvae, and surubim fragments (cannibalism). The items with the highest volumetric percentages were Chironomidae larvae (29.25%), followed by surubim fragments (19.68%) in M I, and *Moina micrura* (19.97%) and surubim fragments (21.85%) in M II.

The items *Chydorus* sp, *Diaphanosoma* sp, *Macrothrix* sp and Ephemeroptera larvae have been found only in the stomachs of the hybrid surubim from M I, while the algae *Ulothrix* sp., *Oscillatoria* sp. and the protozoan *Difflugia* were found only in the stomachs of the fish from M II.

Although samplers had been carried out in two different locations, probably the taxa composition would be different due to environmental conditions and the seasonality of each fish farming, it was observed that the items exclusive at M I are typical of benthic regions. Only the fish of M I, stocked in fertilized hatcheries, could be captured, showing that the larvae at this life stage already feature the benthic habit found in adults (INOUE et al., 2003).

The copepods presented a low percentage in relation to M II, possibly because in M I the larvae had preference for cladocerans. Unlike copepods, cladocerans have contrasting eyes, besides being larger with more movements, which attract more fish attention (FREGADOLLI, 2003).

In M II, the copepods have may been more consumed because the larvae of this kind of management were fed with plankton collected with a net by the farmer being a less effective method in capturing cladocerans, reasoned to their greater ability to escape than the copepods (FREGADOLLI, 2003).

According to Hart and Purser (1996), there are some disadvantages in the supply of plankton collected by nets, among them: the favorite food may not be available at the moment of capture, the capture may not ensure enough amounts of organisms and inappropriate larvae mouth size. Another shortcoming is the possibility of introducing pathogens in the rearing units. Indeed, the diet variations regarding to the food items composition evidenced by the NMDS in those two types of management have been significant (t = 9.79; gl = 28; p < 0.001) (Figure 1).

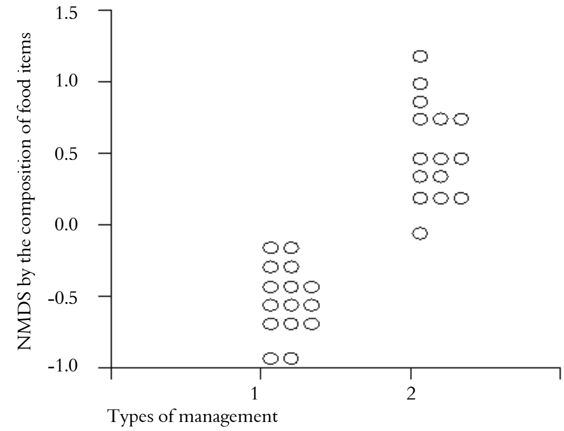

Figure 1. Ordination of the samples by the food items indicating the difference in the composition of items in M I and M II, where each sample is equal to 10 fish ordinated in a similarity relationship between the managements.

The ordination produced variation percentage obtained from NMDS first dimension data has separated clearly the diet of the species between the two managements, indicating little similarity in food composition (r^2 = 0.68) (Figure 2). Regarding the cannibalism, although the hybrid surubim had presented fragments of fish in the stomach in M I, the ordination pointed out that the consumption was more frequent in M II.

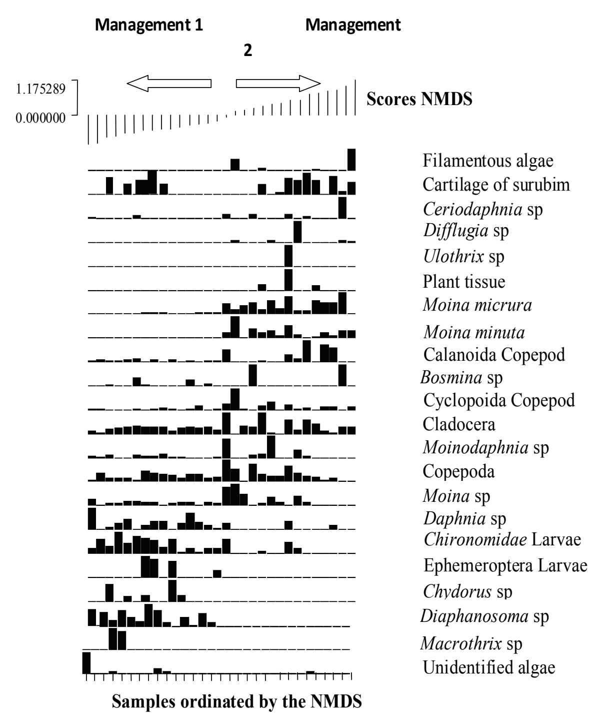

Figure 2. Ordination of the samples by non-metric multidimensional scaling (NMDS) in one dimension (r^2 = 0.68), where each sample is equal to 10 fish of surubim ordinated in a similarity variation.

The growth curve relating to the biomass increase, during the days when the fish were fed by live plankton, has indicated that in the first five days, the surubim growth in the two types of management was similar (Figure 3). However, from the sixth day, the surubim of the M I had grown faster than those in M II. Although differences in the batches may have influenced the results of growing, feed management done in the first ten days of the larvae followed the same protocol in both fish farming. These differences may have been diminished by similarities found in the initial average weight of larvae.

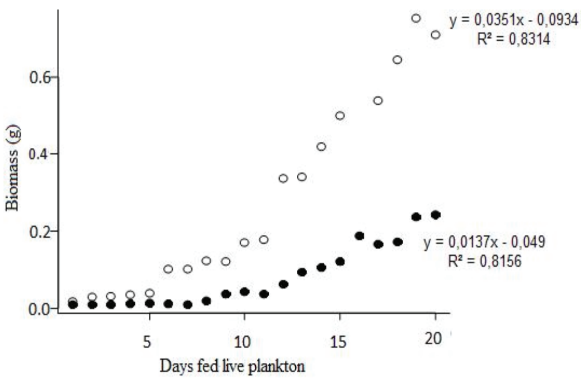

Figure 3. Growth curve of the relationship between biomass and age of the fingerlings (in days), where the empty circles correspond to M I, and those filled, M II.

Fast growth is vital for fish larvae because the predation decrease quickly as larval length increase (PEDERSEN, 1997). The reason for larvae at M I having been grown faster may have been due to the following two factors: i) the lower density of organisms per area, since M I pond had 2,000 m^2, with stocking density of 400,000, and M II pond had 1,000 liters and the density was 50,000 larvae, which strongly decreases the encounter rate between individuals, reducing the confinement stress, and the emergence of agonistic behavior; ii) in M I, the larvae had free access to food and could explore different compartments of the hatchery in the search for organisms-food, as evidenced by the higher diversity of food items found in stomach of the M I larvae.

A successful diet for larvae survival and growth is determined by a balance between the capture effort and the amount of energy and nutrients acquired with its intake. This depends on factors such as nutritional requirements, feeding behavior, environmental factors and characteristics of the prey, as well as, size, shape, concentration, caloric value, and nutrient content (PASCUAL; YÚFERA, 1987).

Cho and Kaushik (1990) state that, great part of the energy requirement in fish is obtained from protein and lipid, and carnivorous fish need a high protein diet due to their great ability to metabolize protein associated with a limited ability to digest and catabolize carbohydrates. In this way, the most remarkable change in the diet was the increase of fish larvae in the diets of the two managements.

In M I, besides the increase of fish in the diet, there was an increase of proteins from insect larvae, especially Chironomidae larva, which was not observed in M II, what explains the high level of cannibalism verified in this management. According to Kubitza et al. (1998), since fish at larval stages have few body reserves of nutrients, any deficiency in nutrition can cause severe problems for growth.

The amount of plankton supplied for feeding in this fish life stage has direct influence on the final length of larvae (YOSHIMATSU; KITAJIMA, 1996). In this way, it is believed that the lower growth of the hybrid surubim at M II took place due to the food conditioning of the larvae. This may have been caused by a high density, which is another important factor to be considered, once it can interfere growth, feed efficiency, and mostly on the survival (IWAMOTO et al., 1986).

According to Inoue et al. (2003, 2009) there is a huge survival rate difference in those two kinds of management, ranging from 15 to 20% in M I and from 50 to 80% in M II, during this production stage. On the other hand, survival in M I ranges from 80 to 90%, which is rather lower in M II, from 30 to 40% in next stage, named feed training.

Studies with native species like Pacu *(Piaractus mesopotamicus)* have shown the benefits of a good nutrition and appropriate food management in the early stages are further than higher survival rate. Moreover, it reflects fish improvement physiological condition as it will influence fish meat quality (ASSIS et al., 2004; LEITÃO et al., 2011). Therefore, although initial stages of development are fast, unfavorable management condition for the species may endanger species development on the following stages, damaging growing and muscle development (LEITÃO et al., 2012; MENOSSI et al., 2012).

These results corroborate the importance of natural food for surubim fingerlings development. Live organisms play a key role on the first feeding of fish larvae, because in addition to their high nutritional value also provides increased consumption, stimulating the secretion of enzymes and consequently improving the growth and survival of animals.

Conclusion

These results have highlighted differences in the food preferences of larvae of the hybrid surubim in the different kinds of management and these differences were reflected significantly on the surubim growth. Although the particular environmental conditions of each fish farming may have influenced the composition of food items, it is believed that the use of other food resources, besides natural plankton and low density of individuals provided by the M I, have made this kind of management the most suitable for the surubim in this study.

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