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Determination of weight and length gain of *Astronotus ocellatus* (Agassiz, 1831) in a Biofloc system with a pigment-rich diet

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Abstract
The aim of this work was to evaluate the effect of carotenoid pigment-rich diet in the growth, in length and weight, of ornamental fish *Astronouts ocellatus*. Plastic beakers of 250 L were conditioned with 125 L of water and 1 org $10L^{-1}$ of juvenile *A. ocellatus*. Two plastic beakers were under commercial diet for trout (El Pedregal®), while the other two were under TetraColor® diet (carotenoid pigment-rich diet) as food source. The organisms fed with TetraColor ® obtained better length and weight gains with 3.96 cm and 16.14 g respectively. Also, the IGR and AGR were higher with values of 0.038 cm day^{-1} and 0.89% for length, and 0.154 g day^{-1} and 3.143% of daily increase in weight. Showing that carotenoid pigment addition is important for the culture of ornamental fish.

Keywords: Carotenoids, biofloc, *Astronotus ocellatus*, pigments, growth rates

Introduction

Ornamental fish industry is a business with broad prospects for development in Mexico, where 711 farms work and produce 66 million of organisms per year with a production value of 120 million of pesos [1]. Ornamental fish market in Mexico has grown 250% during the last ten years [2]. Around 160 species and varieties are cultured for diverse interests, within this species is Oscar fish *Astronotus ocellatus* (Agassiz, 1831). It is a freshwater fish with benthopelagic behavior, with a mean size of 24 cm (maximum 45.7 cm) and a maximum weight of 1.6 kg; usually feeds on smaller fish, crabs, worms and insect larvae. It is mainly located in South America: Peru, Colombia, Brazil, Argentine [3]. It is a popular organism among aquarist, but low produced because of its slow growth [4].

On the other hand, because this specie has a voracious behavior it requires a live supplement as complement to commercial balanced diets. Therefore, new methods of culture haven been proposed in which Biofloc technology (BFT) outstands, to decrease the use of water and space, increasing the culture density [5]. It consist in the development of microbial flocs formed from a relation carbon-nitrogen in the water, with low or non-change of water (0.5 to 1% per day) [6] and high oxygenation [7, 8], in which diets of low raw protein content [9] and external carbon sources like molasses (sugar cane), rice bran, wheat bran [8] and Yucca, Moringa and Macroalgae flours [10] are used. This carbon sources allow the growth of a microbial community, mostly of heterotrophic bacteria that metabolize the carbohydrates and take inorganic nitrogen solving the nutrient saturation problems from its recycling [11, 12].

Considering that in aquarium hobby, coloration is one of the main points for its commercialization and that aquatic species are unable to synthesize carotenoids *de novo*, therefore astaxanthin and other appropriate precursors, as well as pigment producer probiotic strains, must be supplied in the diet or being present in culture system [13]. But also, this have a physiological importance in fish, as antioxidant and hormones precursors that intervene in reproduction processes. As well as, they improve the assimilation of nutrients, accelerate the growth rate and allow that larvae survival increases [14].

Therefore, the aim of this work is to make a culture of *A. ocellatus* in a Biofloc system with an enriched diet with carotenoids pigments.

2. Materials and Methods

The experimental study was done at Life Food Production and Biofloc Laboratory in Universidad Autónoma Metropolitana, Unidad Xochimilco.

Experimental design and culture conditions

For fish culture Rotoplas® plastic beakers (0.80 x 0.70 x 0.70 m) of 250 L were conditioned with 125 L of water and 1 org $10L^{-1}$ of juvenile *A. ocellatus*. In each container it was placed an aeration system with aim of a 25 cm long aerator stone, with enough intensity to move the water column. Also, it was placed a 200W thermostat to maintain the culture temperature at 28±2 °C. Each treatment was made by triplicate (Fig.1).

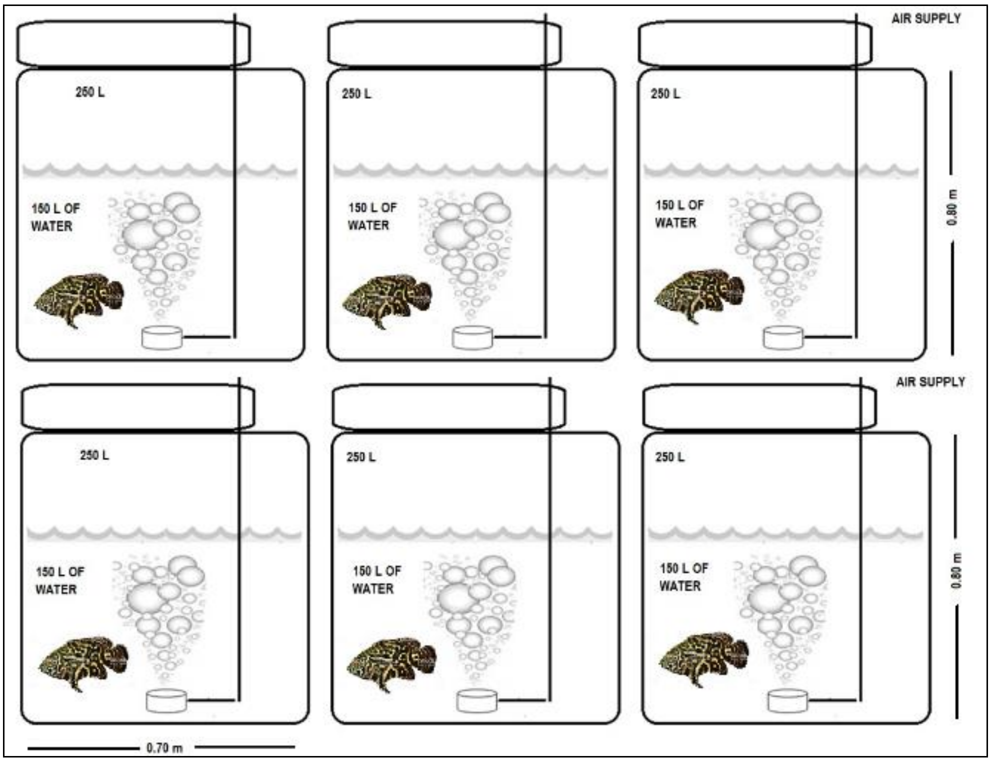

Fig 1: *A. ocellatus* culture with the two experimental diets**.**

2.2 Organism feeding

Three plastic beakers were under diet of commercial food for trout (El Pedregal®) with 40% of protein, while the other three were supplied TetraColor® as food source. Diets were supplied at a relation of the 5% of total biomass of organisms in each container. The food was supplied twice a day (2.5% in the morning and 2.5% in the afternoon) while the carbon source was supplied once per day.

2.3 Biofloc production

For microbial floc production it was added as carbon source *Moringa* sp. flour at a proportion of 0.1% of total biomass in each container.

2.4 Organisms biometry

Every 15 days, all the organisms from each treatment, were weighted with a digital balance Nimbus® with precision of 0.01 g. Also, the organisms were measured the total length, high and width with the aim of a digital Vernier with precision of 0.01mm.

2.5 Data analysis

All the obtained values were introduced to a data base in Excel 2010 to obtain the descriptive analysis. Also, the growth tendency curves were obtained for the considered biometric variables.

The weight and length gains were obtained with the next formulas:

WG= Final weight – Initial weight

LG= Final length – Initial length

The absolute growth rate (AGR) and instantaneous growth rate (IGR) were determined with the next formulas:

$$AGR = \frac{\text{Final weight} - \text{Initial weight}}{\text{Time of experiment}}$$

$$IGR = \frac{(\mathrm{Ln}(\text{Final weight}) - \mathrm{Ln}(\text{Initial weight}))}{\text{Time of experiment}} \times 100$$

It was made a one-way variance analysis (ANDEVA) to determine significant differences between treatments ($p<0.05$), with the aim of statistical program SYSTAT 12.0.

3. Results

The organisms under TetraColor® experimental diet reached a total length of 6.519±0.628 cm, with a gain of 3.968 cm, an AGR of 0.038 cm day^{-1} and an IGR of 0.89% of daily increase. On the other hand, the organisms of Control treatment reached a total length of 4.541±0.551 cm, with a gain of 2.039 cm, an AGR of 0.019 cm day^{-1}, and an IGR of 0.56% of daily increase (Table 1).

Table 1: Mean values of total length (TL) of *A. ocellatus* with the two experimental diets

Time of experiment (Days)	Total length (cm) Control	Total length (cm) Tetra Color
0	2.501±0.248	2.551±0.258
15	2.853±0.266	3.106±0.273
30	2.982±0.300	3.299±0.282
45	3.277±0.281	3.777±0.312
60	3.650±0.251	4.260±0.325
75	3.937±0.295	4.876±0.402
90	4.247±0.393	5.686±0.509
105	4.541±0.551	6.519±0.628
Gain	2.039	3.968
AGR	0.019	0.038
IGR	0.56	0.89

The fishes total length curve was a linear growth through the experiment (Fig.2)

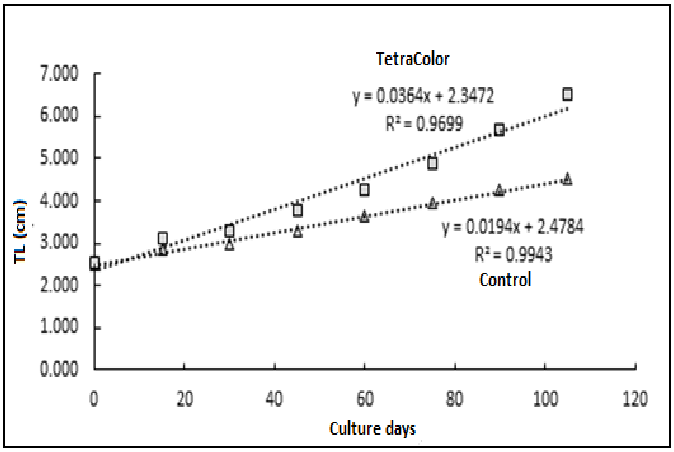

Fig 2: Growth tendency curves of length in the two experimental diets

Regarding to weight gain, the organisms cultured in TetraColor® diet reached 16.764±0.398 g, with a gain of 16.145 g, with an AGR of 0.154 g day^{-1}, and an IGR of 3.143% of daily increase. Unlike the organisms fed with conventional food (Control), which reached final weight of 4.646±0.157 g, gain value was only of 3.98 g, AGR of 0.038 g day^{-1}, and an IGR of 1.862% (Table 2). Both cultures presented exponential growth curves in weight through all the experiment (Fig.3).

Table 2: Mean values of weight of *A. ocellatus* with the two experimental diets

Time of experiment (days)	Weight (g) Control	Weight (g) TetraColor
0	0.658±0.017	0.618±0.022
15	0.943±0.023	1.082±0.027
30	1.205±0.030	1.509±0.036
45	1.561±0.035	2.059±0.047
60	2.292±0.047	3.661±0.085
75	3.130±0.086	6.094±0.146
90	3.669±0.098	8.538±0.209
105	4.646±0.157	16.764±0.398
Gain	3.989	16.145
AGR	0.038	0.154
IGR	1.862	3.143

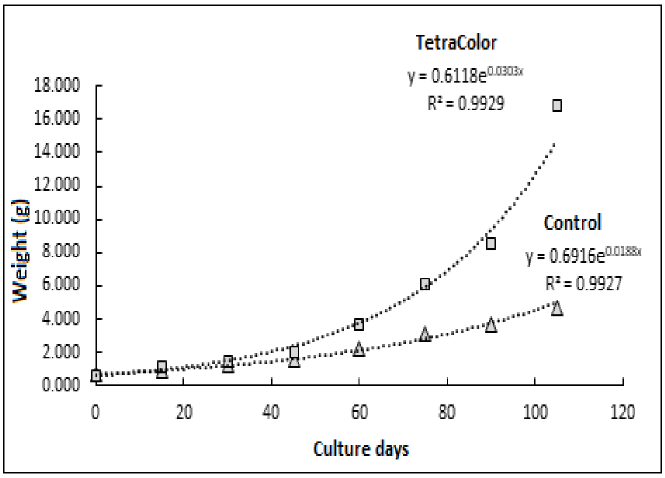

Fig 3: Growth tendency curves of weight in both experimental diets

The one-way variance analysis (ANDEVA) showed significant differences ($P<0.05$) between diets both in size and weight.

4. Discussion

The obtained results show that the carotenoid pigment-rich diet, was more efficient and presented better gains in size and weight, than control diet, even though the protein levels of both diets were between 47-55%. This can be due that carotenoids have proved that can improve some parameters in cultured species, as mentioned below.

The better growth with a carotenoid pigment-rich diet is like the one obtained by Ponce *et al.* [15] with a culture of *Puntius conchonius* where it was used *Rhodococcus* sp. They obtained better gains in weight, length and high than with the diet without pigments. Other study that has proved a positive effect of the pigments in the growth of fish is the one of Pérez-Escalante [16], who worked with anthocyanins extracted from Jamaica (*Hibiscus sabdariffa*) and observed that the growth rate, gained weight and survival, increased as the dose of anthocyanins increased in the diet, showing significant differences regarding control group.

This positive effect of carotenoids also has been proved in salmonids by Torrisen [17] and Christiansen *et al.* [18], meanwhile Pitt [19] points out that astaxanthin can improve fish growth. Also, Liang *et al.* [20] suggested that the increase in concentration of astazine, product of the oxidation of astaxanthin, in diets can lead to increases in weight as they prove it in koi carp. Nevertheless, this positive effect has not been replicated in other species until this work with *A. ocellatus*. Wang *et al.* [21] found out that supplementation of carotenoids does not affect in the growth of the characid *Hyphessobrycon callistus*. Also, Montoya-Martínez *et al.* [22] registered that lycopene does not affect in the growth of *Carassius auratus*, and also with this specie, Xu *et al.* [23] found out that the addition of astaxanthin from the yeast *Xanthophyllomyces dendrorhous* did not affect the weight gain.

Regarding to AGR obtained in the organisms weight, the highest was obtained in the pigment-rich diet with 0.154 g day^{-1}, which means the cultured organisms increased their commercial weight (2.235 g) every 15 days, higher values to the ones obtained by Avilés *et al.* [4], which cultivated *A. ocellatus* with a live food diet enriched with Biofloc bacteria, where its AGR was of 0.089 g day^{-1} which represents that the commercial weight was obtained at 25 days. Also, it was obtained higher values than the ones obtained by Domínguez and Soto [24], when culturing *A. ocellatus* with five diets (live food, commercial, processed, live food + commercial and live food + processed) where the live food was the one that obtained a higher growth rate, the organisms reached the commercial weight in 24 days and in commercial diet in 69 days.

On the other hand, Biofloc technology proves to be an economically profitable technology, because it is easy to operate and has low water in food costs, because throughout the experiment no water change was made. Likewise, it decreases the risk of introducing a pathogen or sickness in the culture, and it increases the survival and growth of organisms, as observed in this work where survival rates for both experiments was above 85%, similar to the obtained by Avilés *et al*. [4] which obtained survival rates above 90% in a culture of *Danio rerio* and *A. ocellatus*, cultured in a Biofloc system.

5. Conclusion

Because of the mentioned above, it can be conclude that the addition of carotenoids pigments in the diet of cultured fish, represents an important aspect for the growth in size and weight, obtaining commercial sizes faster and therefore improve the sale of this ornamental fish. It is recommended to continue with this type of tests to observe the improvement in fish coloration, being this one of the main aspects in the sale of ornamental fish. Also, the use of Biofloc technology is proving to be an economically profitable technology and by their nutritional input for ornamental fish culture, not only of tilapia and shrimp.

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