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Life cycle and spawning frequency in angel fish (*Pterophyllum scalare* Lichtenstein, 1823) in captivity

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ABSTRACT

This study, to report the life cycle and spawning frequency of angel fish (*Pterophyllum scalare*) in captivity. Life cycle was determined for six months considering: time during embryonic development, fry, breeding, juvenile and adult; and frequency of spawning for four months, in four varieties: marble, koi, smokey-chocolate and striped. Organisms were maintained in 40 L aquariums, with biological filter, temperature of 27 °C, pH 7.5, dissolved oxygen between 3-5 mg L^{-1}, photoperiod of 12L/12D. Fishes were fed with TetraColor® 47.5% of protein. Results regarding to average time of embryonic development were of 3.8±0.4 days, fry stage 8.1±0.8 days, juvenile 26.9±1.0 days and for adults was considered from presence of sexual dimorphism that was manifested after five months. Courtship and reproduction were detected after six months. On the other hand, each *P. scalare* variety had nine spawns in fourth months and time between spawns was of 14.6±0.8 days with an average of 503.1±16.4 eggs, there were not significant differences (P>0.05) between four varieties. Reproductive comparison of *P. scalare* allows determine its feasibility in captivity and guarantee commercialization of attractive fish in aquarium industry, a sustainable activity in many states of Mexican Republic.

Key words: Stages of life development, spawning, eggs, reproduction.

RESUMEN

En este estudio reporta el ciclo de vida y frecuencia del desove en el pez ángel, (*Pterophyllum scalare*) en cautiverio. El ciclo de vida se determinó durante seis meses considerando la duración del desarrollo embrionario, alevín, cría, juvenil y adulto y la frecuencia del desove durante cuatro meses, en cuatro variedades: mármol, koi, humo-chocolate, rayada. Los organismos se mantuvieron en acuarios de 40 L, con filtro biológico, temperatura 27 °C, pH 7.5, oxígeno disuelto entre 3-5 mg L^{-1}, fotoperiodo de 12L/12O. Los peces fueron alimentados con TetraColor® al 47.5 % de proteína. Los resultados, en cuanto al tiempo promedio del desarrollo embrionario fue de 3.8±0.4 días, etapa de alevín de 8.1±0.8 días, juvenil a los 26.9±1.0 días y la etapa adulta fue considerada desde la presencia del dimorfismo sexual, la cual se manifestó a partir de los cinco meses. El cortejo y reproducción se detectó a los seis meses. Por otra parte, cada variedad del *P. scalare* tuvo nueve desoves en cuatro meses y el tiempo entre los desoves fue de 14.6±0.8 días con un promedio de 503.1±16.4 huevos, no se detectaron diferencias significativas entre las cuatro variedades (P>0.05). La comparación reproductiva de *P. scalare* permite determinar su factibilidad en cautiverio y garantiza la comercialización de peces atractivos en la acuariofilia, actividad sustentable en muchos estados de la República Mexicana.

Palabras clave: Etapas del desarrollo de vida, desoves, huevos, reproducción.

INTRODUCTION

Aquaculture is the sector dedicated to production of aquatic organisms, many of which are destined for human consumption and others to ornamental activity.

In Mexico, ornamental fish industry is an alternative of cost-effective production with prospects of social and economic growth, in which more than 160 species with their respective varieties

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are cultivated, in 23 states of Mexico. Among the species with more demand and production are guppy (*Poecilia reticulata*), goldfish (*Carassius auratus*), angelfish (*Pterophyllum scalare*), platy (*Xiphophorus maculatus*), zebrafish (*Danio rerio*), tetra (*Hemiframmus caudovittatus*), betta (*Betta splendens*), gurami (*Trichogaster* sp), (SAGARPA 2015).

Within ornamental species, angelfish is one of most demanded and popular species in market due to its beauty, colors, varieties and diverse forms of fins that can be shorts, delta dorsal, veil and bifurcated veil (Landines et al. 2007), making it one of the most attractive and appreciated fish by public, which increments its commercial price (Ortega et al. 2009; Kasiri et al. 2011).

P. scalare is a tropical cichlid from Amazonas, which due to complexity of its reproduction in captivity was difficult to tame. Breeders William Paulin and Franklin Barrett achieved reproduction in captivity in 1921 in Pennsylvania, Unites States of America and from then it is empirically reproducing in captivity, because there are still unknown basic aspects of their biology (Bakalárska 2011).

Therefore, aim of this investigation is to determine life cycle of *P. scalare* in captivity and spawning between varieties, information that will allow producers and investigators to optimize its reproduction for commercialization and investigation.

MATERIAL AND METHODS

Experimental design. The study covered a period of four moths for spawning frequency and six months to determine life cycle. For which, it was obtained a couple of each variety: marble, koi, smokey-chocloate and striped of *P. scalare* of one year old. Organisms were maintained in 40 L aquariums, provided with biological filters, temperature of 27 °C, a pH of 7.5, dissolved oxygen between 3-5 mg L^{-1}, photoperiod of 12L/12D, and were fed three times a day with TetraColor® with 47.5% of protein equivalent to 3% of all biomass from each aquarium.

Spawning assessment. It was based for frequency, from each aquarium, it was introduced a PVC tube of 50 cm length, cut in half, which served as substrate for spawning. Each spawn contained in PVC was deposited in aquariums of 15 L with temperature of 27 °C, a pH of 7.5 and constant aeration to counteract development of pathogens.
From each spawning, it was determined number of eggs by direct observation and seven eggs were measured with a Vernier.

Life cycle. Each *P. scalare* variety was followed up to determine life cycle from each stage in days: embryonic development, fry, breeding, juvenile and adult; for six months, and evaluation of spawning. In breeding stage, organisms were fed *ad libitum* with *Artemia* nauplii three times a day.

Statistical analysis. Results were processed through descriptive analysis expressed as means and standard deviation. To determine significant differences in frequency and number of eggs between four varieties of *P. scalare* it was used a one-way variance analysis (ANOVA). When significant differences ($P<0.05$) was found, a Tukey test was made.

RESULTS

Life cycle of *P. scalare*, as in most bony fish, is characterized by its stages: egg, embryonic development, fry, breeding, juvenile and adult. In case of *P. scalare*, eggs are amber color, adhesive and oval shaped with an average diameter of 1.4±0.3 mm.

Each couple during study had nine spawns with an average range of 14.6±0.8 days (range of 14-16); number of eggs between spawns is shown in Table 1. Variance analysis did not show significant

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differences (P>0.05) in number of eggs by spawn and variety.

characteristic that can be more notorious when female is spawning.

Table 1. Egg number in four *P. scalare* strains.

Variety	Eggs number per spawn									Mean ± E.D.
Marbel	489	544	506	484	491	521	533	508	497	508.1±20.7
Koi	486	497	524	488	506	493	508	497	502	500.1±11.7
Smokey-chocolate	503	482	473	497	513	496	481	503	493	493.4±12.7
Ray	521	514	503	513	482	531	514	526	494	510.9±15.6
Mean ±E.D.	**499.8 ±16.0**	**509.3 ±26.6**	**501.5 ±21.1**	**495.5 ±12.9**	**498.0 ±14.1**	**510.3 ±18.7**	**509.0 ±21.5**	**508.5 ±12.5**	**496.5 ±4.0**	**503.1±16.4**

Striped variety was one that presented highest number of eggs 510.9±15.6 (range of 482-531) and lowest was presented in variety smokey-chocolate with 493.4±12.7 (range of 473-513) (Table 1).

Embryonic development under experimental conditions, had an average duration of 3.8±0.4 days. Fry stage was of 8.1±0.8 days, time in which fry finished developing mouth and digestive tract after absorbing the yolk sac. The hatchlings stage where organisms begin to actively swim and search for food that in this case was *Artemia sp.* nauplii. The juvenile stage, where organisms begin to acquire specie characteristics, was presented at days 26.9±1.0 and adult stage was stablished by presence of sexual dimorphism, which was manifested after five months; courtship and reproduction was detected at six months of age.

Sexual dimorphism in males consist that lower jaw is prominent, protruding and convex forehead, first spines of dorsal fin are stronger, toothed and irregular and presents a short sperm duct finished in tip slightly inclined forward,

The mature female has a bulging belly, slightly concave head, the area where ventral fins are inserted is more rounded, distance between the ventral fins and anal fin is larger, proximal end of anal fin joins ventral zone in a less perpendicular way and one day before spawning female presents genital pore turgid and pink.

Table 2. Number and spawn days in four *P. scalare* strains.

Variety	Number of spawn during period	Mean days between spawn ±E.D.
Marbel	9	15.0 ±0.9
Koi	9	14.6 ±0.7
Smokey-chocolate	9	14.4 ±0.9
Ray	9	14.4 ±0.5
Mean ±E.D.	9	14.6 ±0.8

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DISCUSSION

Even though *P. scalare* is a demanded and popular fish in market, there is few information about its reproductive aspects under captivity. According to characteristic of asynchronous ovaries of this specie, with respect obtained results it considers that *P. scalare* can spawn during entire year, if there are proper light, temperature and food conditions, which constitutes a reproductive advantage compared to other families, which reproduction is seasonal (Landines et al. 2007).

In addition to above, authors like Agudelo (2005) reports a mean frequency of spawning of 12.0±2.6 days (interval of 8-20) by providing dry food in flakes, a lower value to ones obtained in this study which frequency was 14.6±0.8 days (14-16 range) by providing commercial food TetraColor®. Nevertheless, there are studies that show that supply of live food influences the frequency of spawning. Luna et al. (2000), report a frequency of 8-12 and of 12-16 by providing water flea (*Daphnia pulex*), 53.6% of protein and commercial food Wardley® 45.0% of protein respectively, values that are within ranges reported by Agudelo (2005) that provided commercial food and inferior to one described in this investigation where it was provided commercial food TetraColor®.

Luna y Gómez (2005) showed the effect of three diets, mosquito larvae (*Culex quinquefasciatus*) 42.6% of protein, water flea (*Daphnia* sp) 50.0% of protein and commercial food special for angel fish 52.0% of protein obtaining as result a frequency of 14.4±0.7, 11.1±0.6 and 7.8±0.4 days and an average of 506.5±30.6, 670.0±28.3 and 385.0±19.5 produced eggs respectively, detecting that diet with commercial it was who presented a faster frequency 7.8±0.4 days. Nevertheless, eggs average was lower 385.0±19.5, having favorable effects with water flea supply (670.0±28.3 eggs). Obtained results by these authors regarding spawning frequencies are within reported by Agudelo (2005) and those obtained investigation.

However, eggs average (503.1±16.4) reported in this study with four varieties only overcome obtained by Luna and Gómez (2005) 385.0±19.5 produced eggs by suppling special food for angel fish and obtained 506.5±30.6 eggs by suppling mosquito larvae.

On other hand, Pérez et al. (2002) by providing a mixed diet of live food with *Artemia* sp and dry food in flakes Sera-Vipan® or Tetra-Min® obtained a frequency of eight days and an average of 540 eggs, coupled with it results of this study indicate a higher frequency of 14.6±0.8 days (range of 14-16) by supplying commercial food TetraColor®, but eggs average in four varieties was lower 503.1±16.4 which demonstrate that mixed diet supply with live and commercial food affects process of oogenesis having as a result, constant spawns and higher number of eggs allowing to accelerate production of this specie under culture conditions.

According to Takahashi et al. (2010) and Luna et al. (2010), previous results could be explained because live food provides higher protein content, and can be available for more time, its distribution in water column is homogeneous, allowing that all individuals to feed, reducing effect of dominant fish during alimentation.

Results of previous studies demonstrate affect that live food has in quantity of oocytes and protein quantity affect in frequency of spawning as well as having positive effects on growth as reported by Soriano and Hernández (2002), Ortega et al. (2009); Jiménez et al. (2012). However, Pérez et al. (2002) mentions that for reproductive purposes it is better to provide a mixed diet of live and commercial food.

Nevertheless, Rurangwa et al. (2004) and Schulz et al. (2010) report that regardless of abundance and quality of food, there are other variables that must be considered and related with variations in frequency and number of oocytes, such as age, reproducers genetic variability, water physicochemical characteristics and photoperiod.

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There is few information about life cycle of *P. scalare* nevertheless, some works like Orkisz et al. (2012) report a duration of four days for stage of embryonic development and three days for fry stage. However, results of present study show a duration of 3.8±0.4 days for embryonic stage development and for stage fry 8.1±0.8 days, the latter being greater than that reported by Orkisz et al. (2012) whose difference is of 5.1 days, but variation must be caused by temperature differences.

In addition to above, the results of this study and those reported by Orkisz et al. (2012) in terms of embryonic development show differences in days while Radael et al. (2013) reported a duration of 42.5 hours post-fertilization at 28 ° C, indicating that as in most species, the duration of this phase is affected by temperature.

Parada et al. (2012) mention a duration of 30 days for fry stage, which is extensive, because it overcomes reported by Orkisz et al. (2012) which indicates a duration of three days and overcomes results in this study which average duration was of 8.1±0.8 days. Considering duration reported by Parada et al. (2012) it can infer that these authors, might consider juvenile stage because difference in days is close to obtained in this study for juvenile stage which was of 26.9±1.0 days.

Breeding stage was considered since yolk sac was fully absorbed and organisms began to consume *Artemia* sp nauplii and according to Orkisz et al. (2012) this stage has a duration between five and seven days.

On the other hand, to juvenile stage, Orkisz et al. (2012) mentions that after 23 days, organisms already have similar adults characteristics, crown and fins begin to develop: dorsal, caudal, anal and ventral. In this investigation, those characteristics were observed at 26.9±1.0 days. Adult stage was considered since organisms initiate courtship and reproduction, according to Agudelo, (2005) *P. scalare* is sexually mature between nine and 12 months old, which differs from what was observed, because sexual maturity became noticeable after six months of age when they began to reproduce. However, this process can vary depending on genetic, water physicochemical conditions, nutritional regime, temperature and photoperiod.

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