Breeding of Ornamental Fish (*Pterophyllum scalare*) in Home Environment and its Commercialisation

M.Sc. Thesis Submitted to Midnapore City College

for the Partial Fulfilment of the Degree of

Master of Science Fisheries Science

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2023

1. Introduction:

Introduction Since its inception in 1911, angelfish have occupied a special place in the fishing industry. In addition to that, angelfish have been referred to as the “kings of aquariums”, as they are tremendously eye-catching animal with especial varied finnage along with colour arrangements. They belong to the family of Cichlidae.

The genus, *Pterophylhun* comprises of three species. The distance between the caudal fin's tip and the dorsal fin's tip of *Pterophylhun altum* is 13” and it is local to the Orinoco River basin, South America (Pellegrin 1903). The remaining two species, *P. dumerilii* (Castelnau 1855) and *P. scalare* (Liechtenstein 1823) were discovered in the Guinean coastal rivers and throughout the Amazon basin. These two species, *P. dumerilii* and *P. altum* are aquarists’ rarities. Yet *P. altum* is just charming as *P. scalare*, both are rarely exported. Requirements of water parameters may partly explain the little availableness of the two species compared with the broadly available congener Pterophyllum scalare.

Pterophyllum scalare is famous and available Cichlidae family member. Both the silver along with a wide variety of artificially chosen colour and variety of finnage are commercially produced. These Cichlids build a splendid solo exhibit, however, there is no cause to remove other fish from their environment. None of the Pterophyllum species are appropriate for a group with persistent fin-nippers or hostile tank mates.

The most beautiful species to see spawn are angelfish, and with a little practise, a producer will find it to be a relatively straightforward operation. As a result, this project study will discuss the biological prerequisites and spawning procedures for Pterophyllum scalare.

The surroundings of India offer enormous potential for capturing both freshwater and marine ornamental fish resources, but these breeding units are unable to produce varieties that are in demand on the global market due to a lack of adequate infrastructure and essential inputs like suitable feed and quality brood stock. The suitable climatic conditions, availability of labour force needed for collecting, ease of breeding and rearing, and high market demand are the variables that play a significant role in luring individuals from many industries to choose to cultivate and propagate this species, which is the freshwater angel fish. In West Bengal, a continual migration from rural to urban areas in search of employment and income led to urban overpopulation and a corresponding decline in the labour force in rural areas. In such a situation, ornamental fish culture and breeding could be an additional source of revenue for the rural populace. An appealing option to preventing such migration is the breeding and culture of ornamental fish, which is an extremely profitable endeavour.

2. Literature Review:

One of the most well-liked aquarium fish in the world today is *Pterophyllum scalare*. In 1909, Hamburg, Germany received its first import of angelfish. They hold a unique position in the world of fish keeping thanks to its 1911 introduction to the USA. According to Lim and Wong (1997), the trade in freshwater ornamental fish is a multimillion dollar business. They have been refered to as “kings of aquarium”. Central Amazon is where they naturally occur.

Angelfish (P. scalare) was discovered in a tributary of the Amazonas River (Tapajoz River) in northern Brazil (Soriano-Salazar and Hernández-Ocampo, 2002). Angelfish are omnivorous in nature, consuming plankton, insect and crustacean larvae, plants, and worms (Soriano-Salazar and Hernández-Ocampo, 2002).

According to Bishnoi (2013), water factors play a significant influence in angel fish breeding in aquarium conditions. The optimal breeding water temperature was between 24oC and 28oC, while the pH range for fresh water fish is between 6.8 and 7.1. Cooper (2004) reported that, the angel favoured pH values of 6.8 to 7.1 during breeding.

However, the quality and quantity of nutrition are critical determinants influencing fish growth and reproduction (Degani and Yehuda, 1996; James and Sampath, 2002; Bishnoi, 2013). Because aquarium fishes have a short reproductive cycle, continuous oogenesis in adult females is possible, so having the correct type of feed available is critical.

Nandeesh et al. (1994) observed that diversified feeding routine were preferable to the high protein of a single diet for angel fish reproduction because nitrogen retention was high in fish fed with mixed schedules.

A huge, energetic fish cannot breed in such a limited area. (Mercy, 2009). The larger fish (length and weight) has significantly greater fertility than the smaller size. A typical male-to-female ratio of one (1:1) was maintained (Solomon et al., 2011).

Chatterjee et al. (2013) discovered that the synthetic hormone Ovaprim (sGnRH+ Domperidone) is effective for angelfish induced spawning (0.35ml/kg body weight). A single dosage of Ovaprim produced approximately 665.66 eggs (n=3), and the fertilisation rate was higher (95%). Nayak et al. (2001) made the same observation, as the ovaprim boosted the hatching percentage.

Cacho (2007) demonstrated that, angel fish pair adopted serial monogamy under both artificial and semi-natural circumstances. The fish mated and stayed with their spouses for one to three breeding cycles in semi-natural settings. The pair bond was broken after the 3rd cycle, and both fish sought new mating partners. Under semi-natural circumstances, the presence of offspring and the urge to protect them may have encouraged the pair bond to last until the third cycle. Abandoning females must be seen as a male tactic to maximise reproductive success through increased mating. Females accept new courtship and mating once the young have achieved indepen dence. A male, on the another hand, was never spotted mating.

Under experimental circumstances, the couples did not keep the pair bond past the second breeding cycle, instead acquiring new partners. In serial monogamy, as described by Gould and Gould (1989), after investing in the offspring, the partners seek new mating opportunities. The total outcome of this study are in accordance with this description.

Ghosh et al, (2000), and Bishnoi, (2013), revealed that maintaining the temperature, the ornamental fish could be bred and reared in the local area as an indoor aqua business. Less space requirement and less investment with high-cost benefit ratio are the main advantages. It might be seen as a small-scale bio business, particularly for women, as a means of supplementing their income. In rural places, small towns and rural areas, a small open space of the houses may be converted into a small ornamental indoor fish culture unit and can generate additional income source from this trade especially by women.

Angelfish is the most significant species of ornamental cichlid, however the primary barriers to optimal commercial production is a lack of understanding about adequate diet for the various life steps (Luna-Figueroa et al., 2000). The most valuable live larval diet used in captivity for raising the ornamental fish is macro-zooplankton like Moina, Daphnia, Artemia nauplii, (Lim and Wong, 1997). Despite the fact that artificial foods are known to be accepted by angel fish (Luna-Figueroa et al., 2000), *P. scalare w*hen such diets are used as the exclusive feed, mainly during the fry and juvenile phases, scalare are frequently attained (Luna-Figueroa, 1999). Fish nutritional requirements vary depending on factors like the diet-fish interaction. But as a common practice for culturing angel fish, on-growing diets are also used to promote its reproduction (Pérez et al., 2002; Luna- Figueroa, 2003).

As a report, the undifferentiated use of diet for the various living stages of Angel fish is generally associated with distinct biological responses, as highlighted in a few nutritional reviews. The accessibility of sufficient live-food organisms for the feeding of fish larvae, fry, and fingerlings is critical to the effectiveness of hatchery production of fish fingerlings for stocking in the grow-out production method. On the other hand, the industrialization of freshwater ornamental fish cultivation has been slowed down by the lack of suitable live feeds for feeding the fish at different stages of production (Luna-Figueroa et al., 2000; Soriano Salazar and Hernández-Ocampo, 2002; Luna-Figueroa, 2003).

3. Aims and Objectives:

1. To study the breeding behaviour and reproducing biology of *Pterophyllum scalare* in home environment: The aim is to gain knowledge of the natural breeding behaviours of angelfish and how they can be replicated in home aquarium setting. This involves studying their courtship rituals, breeding triggers, and optimal environmental conditions for successful reproduction.
2. To evaluate the feasibility and effectiveness of breeding *Pterophyllum scalare* in home environment: The objective is to evaluate the practicality and success rate of breeding angel fish in controlled home environment. This includes examining factors like water quality management, tank setup, feeding protocols, and appropriate genetic pairings to maximize breeding success.
3. To explore the potential commercialization opportunities for home-bred *Pterophyllum scalare*: The aim is to look over the market demand, pricing, and potential profitability of home-bred angelfish. This involves analysing the preferences of aquarium hobbyists, identifying niche markets for unique angelfish varieties, and assessing the economic viability of commercializing home-bred specimens.
4. To examine the impact of home-bred *Pterophyllum scalare* on conservation efforts and sustainability: The objective is to assess the contribution of home breeding programs to the conservation of angelfish species. This includes assessing the genetic diversity of home-bred populations, comparing them to wild-caught specimens, and evaluating the potential for reducing pressure on wild populations through the accessibility of captive-bred angelfish.
5. To develop guidelines and best practices for the responsible breeding and commercialization of *P. scalare* in home environment: The aim is to establish a set of guidelines and recommendations for breeders to ensure the welfare and well-being of angelfish during breeding and commercialization. This includes addressing issues such as genetic health, appropriate sales channels, customer education, and promoting responsible fishkeeping practices.
6. To provide practical recommendations for hobbyists interested in breeding *Pterophyllum scalare* at home: The objective is to offer practical advice and step-by-step procedures for hobbyists who hope to embark on breeding angel fish in home environment. This includes providing information on tank setup, water parameters,

nutrition, breeding pair selection, and fry care to maximize their chances of successful breeding.

7. By addressing these aims and objectives, the thesis aims to contribute to the knowledge base of breeding *Pterophyllum scalare* in home environment, explore the commercialization potential, and promote responsible practices that support both the hobbyist community and the conservation of angelfish species.

4. Materials and Methods:

4.1. Materials used in the experiments and its specification

Number of Tanks	Size of tanks (inches)	Purpose
1	2 litre capacity plastic bottle	*Artemia* hatching jar.
1	24 ×12×12	*Tubifex* culture tank
2	24×12×12	Hospital Tank
6	24×12×12	Rearing of Broodfish
6	24×12×12	Breeding Tank
6	24×12×12	Larval rearing tank

4.1.1. Instruments:

Instruments	Specific range
Camera (Tascan ™ imaging microscope camera with imaging software)	2 megapixels.
Electronic balance	0.02 g– 600g
Glass thermometer	20-34°C
Immersion Thermostat	20 – 34°C
Microscope (Magnus, MS-24)	10x/0.25,40x/0.65,100x/1.25
PH pen / PH Paper	0-10

4.1.2. Disinfectants:

Disinfectants	Doses	Purpose
$KMnO_4$	2 mg/liter	Prevent the growth of fungi.
Methylene blue	1g/liter	Prevent the growth of fungi.

4.1.3. Others materials:

Name of materials	Rate/Description/Purpose
Aerator	Used for aeration of the aquarium tank
LED Bulb (220 v.)	For illumination of tanks
Plankton net (250 µm)	For plankton collection
Power filter	Used for filtering and aeration of water
Scale	Used for measurement of the specimen
Siphoning pipe	Cleaning of aquarium tank water
Slides, absorbent	For microscopic observation
Tank	For culture of zooplankton
UG filter	Used for filtering of Culture water

4.2. Methods:

4.2.1. Study Location and Collection of the Samples

The current study will be conducted at department of Fishery Midnapore City College, West Midnapore. Initially, Angel fishes were transported from Kolkata. About 20-30 fishes were filled in polythene bag and placed in cartoons and transported to Midnapore by train. The observations were created in the Aquaculture Laboratory of the Department of Fisheries Science, Midnapore City College from, August 2022 to May 2023.

4.2.2. Acquisition and Maintenance of Broodfish

Fish maintenance and acquisition, the study used 28-month-old males and 20 females of the basin of Amazon angel fish, P. scalare species, obtained from an ornamental fish establishment in the laboratory. The fishes were collected from the pet market, Galif Street, Kolkata and transported in oxygenated pack to the laboratory. The breeding pair of single male and single female fish were stocked in 6 separate glass aquariums of size 24x12x12 square inch each in the laboratory. They were kept at a temperature of roughly 27 °C, with a pH between 6.8 and 7.0 and dissolved oxygen levels between 7.7 and 8.0 mg-L-1. Physical-chemical parameters such as pH and temperature acquisition were checked daily. The airing of tanks was done through a system of plastic hoses and an aquarium aerator pump. The fishes were examined weekly to verify and prevent diseases. According to the body weight, the diet was 5% and comprised of Artemia salina Linnaeus, 1758, and cichlid ration, fed daily and with continual aeration. Precautions were taken to minimize disturbance to the fish and the natural photoperiod of 6 to 18 hours was maintained in laboratory.

After two weeks of acclimatization and maintenance period, the fish, which weighed between 9 and 30 g for the males and between 8 and 15.7 g for the females and total lengths ranging 85-145 millimetre for the males and from 80 to 128 millimetre for the females, were selected for observation. Biometry was performed to record weight, height and total length of the species used. According to prior research (Cacho et al., 1999; Chellapp), the fish were classified as small if their total length was less than 95 mm, intermediate if their total length was between 95 and 120 mm, and large if their total length was greater than 120 mm.

Breeding in Angel (*Pterophyllum scalare*)

The fish were monitored using the animal focal and sequencing methods in experimental and semi-natural circumstances (Sabino, 1999).

Testing under semi-natural circumstances

Breeding was observed in the laboratory under seminatural circumstances, similar to those encountered in nature. In their own habitat, these fish live along river margins in clear water with dense aquatic vegetation, and are usually found among the roots of these plants. The fishes were placed in a glass aquarium with a bottom of crushed river stone and sand, ornamented with an Amazonian aquatic plant, the Amazon Sword Plant (Echinodorous amazonensis), in the laboratory.

In this experiment, 12 angel fish specimens, total six males and six females, each about 10 months old were used. The fishes were kept in semi-natural circumstances for two weeks, and they underwent daily two-hour observation for 14 days. Breeding of randomly-formed pairs was observed during one breeding cycle (a cycle of approximately 21 days, corresponding to the period between independence and territory occupation of the offspring). After the 1st spawning cycle, the pair were separated in different glass tanks so that by identifying the fish individually, the firmness of the existing pair bond or the formation of new pairs can be observed. The same fish were monitored for five additional breeding cycles. The monitoring of the 6 cycles took place over a nine-month period.

Testing under experimental circumstances

To look into the firmness of the pairs under experimental circumstances, the fishes were put in glass aquariums where tests were performed to recognize the partner and the intruder.

Mate recognition test

The duration of a female's relationship with a male was utilised to identify the partners among 12 males and females. The fish were put into six tanks, and six tests with six observations each were run on them. We employed individuals that had previously paired off during a breeding cycle.

In each aquarium the male that had already mated with the female during the 1st breeding cycle was placed along with a stranger. The males were watched under neutral conditions (a situation in which no territory had been established by both fish). The female was met after 48 hours.

These tests included previous partners with male strangers of the same size (total length between 95 and 120 mm), previous partners with larger male strangers (total length greater than 120 mm), and previous partners with intermediate-sized previous partners (total length between 95 and 120 mm). N = 6 participants worked for each category. All of the fish were under a year old, which is the ideal breeding age

The following behaviour was observed:

1. Threatening (while keeping its head down, the fish's fins grew and its mouth's floor closed, bending its body in the direction of the foe);
2. Attacking (quick movement in the direction of the adversary; biting (the act of squeezing or hurting the adversary with the teeth); retreating (when one fish moved away from the other by about 15 cm);
3. submission (The fish kept its head up, extended its fins, and displayed darker colouring when it did so);
4. escape (when the fish stopped fighting and quickly swam away) and female preference (based on the length of time a female remained immobile around a guy for 10 cm or when she swam alongside him to spawn) (Chellappa et al., 1999b).

The various sets of couple will be allowed to breed in different conditions, with Ovaprim and without Ovaprim. Different dosage of the Ovaprim will be administered to find out the appropriate dosage required for freshwater Angel fish breeding.

4.2.4. Standardization of Ovaprim doses (ml/ kg. of the body weight).

Different dosages of Ovaprim tested:

1) 0.25 ml/Kg body weight.
2) 0.3 ml/Kg body
3) 0.35 ml/Kg body
4) 0.4 ml/Kg. body
5) 0.45 ml/Kg. body weight,
6) 0.55ml/Kg. body weight,
7) 0.5ml/Kg. body weight,

The different doses as mentioned yielded different results and the appropriate dose was determined depend on the three experiments.

1. Fecundity at different doses.
2. Response time (hrs) with doses.
3. Different dosages of Fertilization rate (%).

4.2.5. Intrusion test

This test was used to evaluate the pair's reproductive stability and their responsiveness to intruders during the time between breeding cycles. Twelve intruders (six males and six females) and six couples of angelfish with a pre-existing relationship were employed.

Observations were executed in 6 glass aquariums, each containing 1 couple. To test the firmness of the bond, a male invader was introduced and the reaction of each couple was observed. Subsequently, the male invader was removed and substituted by a female intruder, with the reaction of the couple once again observed. The intrusions were repeated three times to look into the behaviour shown by the residents in both situations (couple with male intruder and couple with female intruder). Later, each couple was separated and a male invader was met with the female inhabitant, chased by a female intruder with the male resident for observe the behaviour shown by the resident animals. The introductions were repeated three times to look into the behaviour of the residents in both situations (separated male with female intruder and separated female with male intruder). The behaviour observed was: threatening, attacking, biting, distancing, submission, escape and female liking (of the female inhabitant with the male inhabitant and with the male intruder; of the male inhabitant with the female inhabitant and with the female intruder), all previously described.

4.2.6. Egg Removal Method

Once brood fish start to exhibit courtship behaviour (either the male or the female begins cleaning state), they are transferred to a 60-litre spawning glass tank. The spawning aquarium is aerated and has two sponge filters. This interruption will affect the pair for two or three days, after which they will resume the process for breeding.

After fertilization, the slate with attached eggs are lay down in a 12-20 litre aquarium containing enough methylene blue to give a dark blue colour. An air-stone should be placed underneath the slate to provide circulation. After hatching, one-half of the tank, water should be replaced every day so by the time the fry is free-swimming the water is only slightly blue.

Dead eggs should be take out each day to prevent the spread of fungus to live eggs. When the fry are able to swim freely, they should be moved into a 60-liter aquarium with aeration, 300 fry per aquarium. The tank should have approximately 15-20 cm of water depth and be filtered with a sponge filter. The fry may be fed more easily due of the shallow water depth. When the fry is approximately 15 mm in diameter, the fry should be transferred to a 120 to 200 litre aquarium with aeration and filtration. Fry should grow to a merchantable size in six to eight weeks.

As long as every effort is made to keep metabolite concentrations as low as possible, raising angelfish fry is not difficult. If their finnage is to develop to its fullest degree, they must not be crowded during their first months of life. This is particularly true of the so-called veil strain. With heavy feeding and periodic partial water changes, the young grow quickly. In unusual cases, females start reproducing by the 8th month after spawning.. In most instances, sexual maturity is attained ten months to a year post-spawning.

4.2.7. Water Quality:

Throughout the study, experiment was maintained under the following water parameters:

Physico-chemical parameters of bore-well water.

Parameters	Bore-well water
Temperature (°C)	26-29
PH	7.0-7.8
DO. (ppm.)	6.6-8.5
Alkalinity (mg/l)	560 (n = 6)
Hardness (mg/ l)	762.6(n = 6)
Salinity (ppt.)	4.0-5.0

4.2.8. Statistical analysis

The statistical tests were performed with SPSS, 21 Software, using analysis of variance (ANOVA). Tukey's test and Student's t-test were used to identify differences between the treatments used.

5. Results:

5.1. Stability of the pairs under semi natural circumstances:

The results obtained under semi-natural circumstances confirm the tendency of the couples to accept new mates. In this circumstances, 50% of the mates did not continue the pair bond after the 1st breeding cycle. The remaining 50% maintained the bond during the second and third breeding cycles. After the 1st breeding cycle, 50% of males abandoned the females with their offspring. After the 3rd cycle, none of the couples maintained the bond. All the males abandoned the females with their offspring and copulated with other females. The females reared the larvae under their protection until they were mature enough to accept new mates. Only two of the six males observed to have mated five times under semi-natural circumstances, one was able to marry four times, another three times, and two mated twice

Two of the observed females mated six times, one mated five times, another mated four times, and two females mated twice. These females likely required more time to get ready for a new egg-laying cycle because they had fewer mating. The males that had fewer mattings were those that had less success when competing for females.

5.2. Stability of the pair under experimental circumstances

This test is not conclusive in affirming if the females recognize their mates or not. The criteria used by the females to remain with one of the males was the aggressiveness or submission displayed by the males and not the previous bond. During the test, the previous mates were more hostile than the strangers, only when the latter were smaller. The prevalence of aggressiveness among the former partners was higher in this scenario than among the strangers. Both the former partners and the strangers were equally hostile when they were of the same size. However, when the previous mates were smaller, they were significantly less aggressive than the strangers.

According to the findings, angel fish pairs both in experimental and semi-natural settings adopted serial monogamy. The fish copulated and stayed with their spouses for one to three breeding cycles in semi-natural settings. After the third cycle, the pair bond was no longer preserved, and both fish started looking for other mates. In the experimental setting, the couples lost their pair bond after the second breeding cycle and began meeting new partners. After investing in the offspring, the spouses in serial monogamy, as reported by Cacho et al. (2005), look for fresh mating chances. This description is supported with the study's findings. The presence of the offspring and the subsequent third cycle may have motivated the pair bond to last under semi-natural settings.

Induced Breeding with Ovaprim:

5.2.1. Dose standardization Process:

Relation between Fecundity (No. of eggs) and Doses (ml/kg of body weight) –

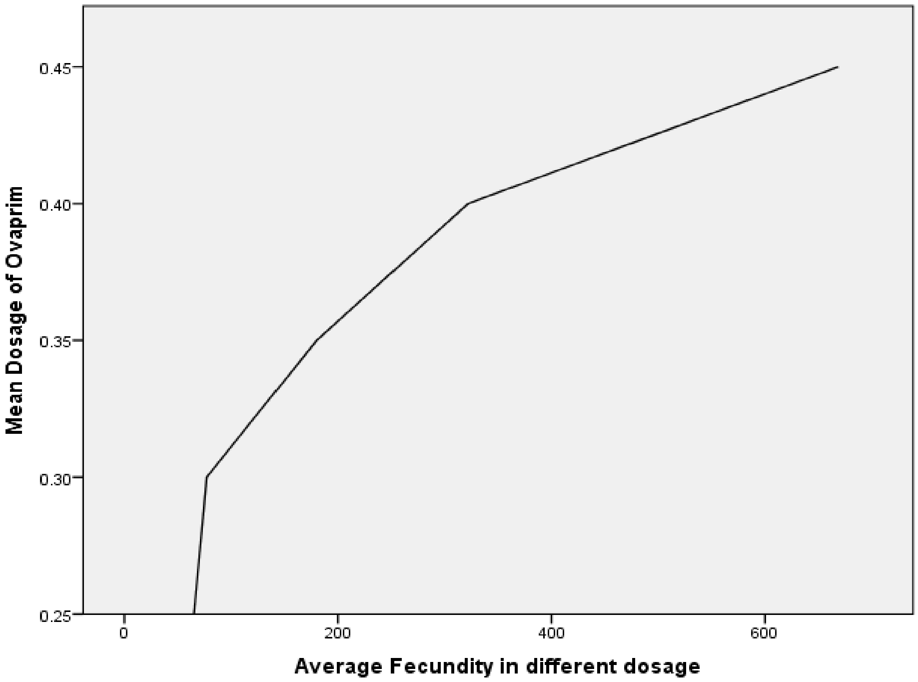
Dosage of Ovaprim	Average Fecundity in different dosage	Response time (hrs.)	Average Fertilised Eggs Procured	Rate of Fertilisation (%)
0.00	50	8.2	20	40.00
0.25	65	3.0	20	30.77
0.30	77	2.5	35	45.45
0.35	180	2.0	92	71.32
0.40	322	1.5	190	74.22
0.45	669	1.4	600	89.69
0.50	321	1.4	225	70.09
0.55	0	0.0	0	0.00

Correlations

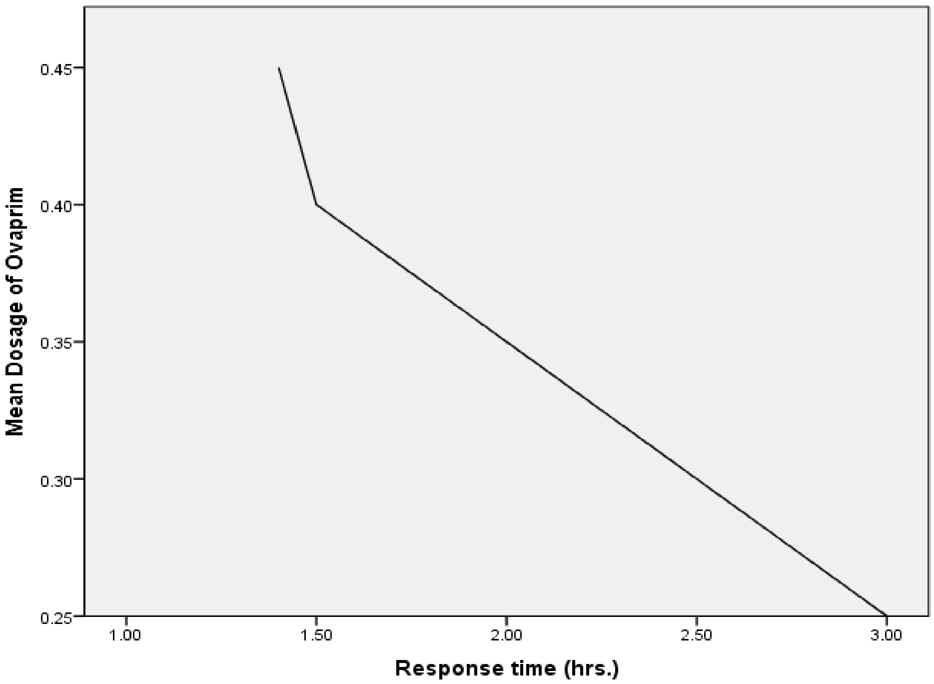
		Dosage of Ovaprim	Average Fecundity in different dosage	Response time (hrs.)	Average Fertilised Eggs Procured	Rate of Fertilisation (%)
Dosage of Ovaprim	Pearson Correlation	1	.921*	-.982**	.866	.977**
	Sig. (2-tailed)		.026	.003	.058	.004
	N	5	5	5	5	5
Average Fecundity in different dosage	Pearson Correlation	.921*	1	-.836	.989**	.864
	Sig. (2-tailed)	.026		.078	.001	.059
	N	5	5	5	5	5
Response time (hrs.)	Pearson Correlation	-.982**	-.836	1	-.759	-.972**
	Sig. (2-tailed)	.003	.078		.137	.006
	N	5	5	5	5	5
Average Fertilised Eggs Procured	Pearson Correlation	.866	.989**	-.759	1	.804
	Sig. (2-tailed)	.058	.001	.137		.101
	N	5	5	5	5	5
Rate of Fertilisation (%)	Pearson Correlation	.977**	.864	-.972**	.804	1
	Sig. (2-tailed)	.004	.059	.006	.101	
	N	5	5	5	5	5

*. Correlation is significant at the 0.05 level (2-tailed).

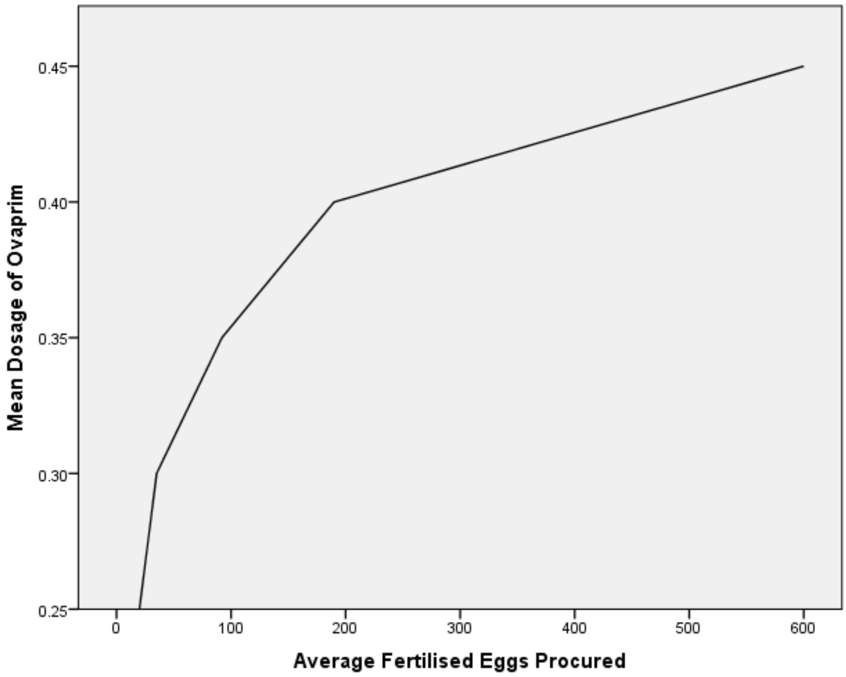
**. Correlation is significant at the 0.01 level (2-tailed).



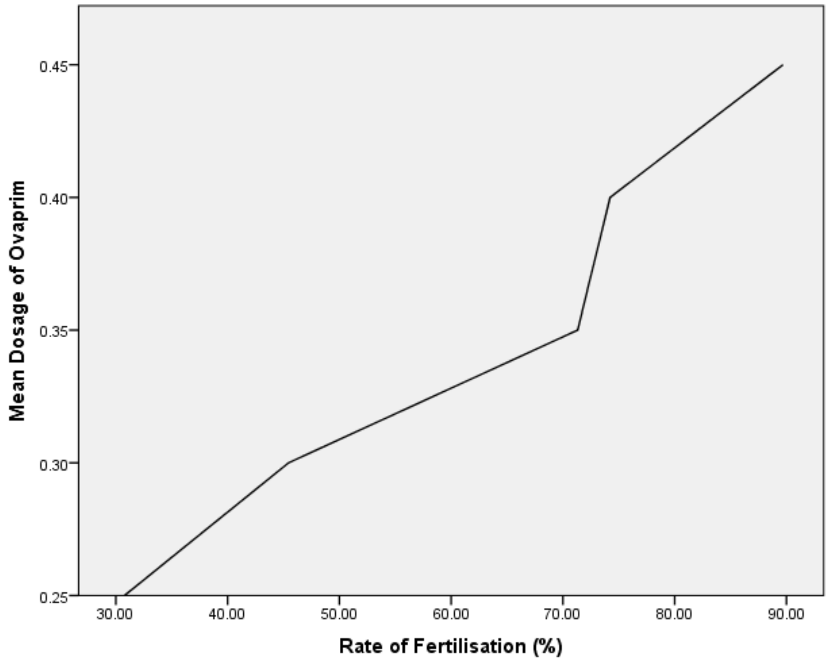
Graph 1: Correlation between Mean Dosage of Ovaprim & Average Fecundity



Graph 2: Correlation between Mean Dosage of Ovaprim and Response time (hrs.)



Graph 3: Correlation between Mean Dosage of Ovaprim and Average Fertilised Eggs Procured



Graph 4: Correlation between Mean Dosage of Ovaprim and Rate of Fertilisation (%)

Relation between average fecundity (Number of eggs) and doses (ml/kg. of the body weight) - Fecundity was seen to vary with different Ovaprim dosages (Table 1). The highest and lowest number of eggs was 669 and 65 obtained at dose 0.25 and 0.45 ml/kg. of the body weight. A positive correlation was seen between average fecundity and dosages of Ovaprim level significance ($r = 0.92$; $p < 0.01$, $n = 5$).

Relation between response time of spawning (hr) and dosages of Ovaprim (ml/kg. of the body weight) - In this study, it was found that reaction time varied with dissimilar Ovaprim dosages (ml/kg. body the weight), as shown in Table 1. The relationship between dosages and the response time (hrs.) of spawning was significantly negative ($r = -0.98$; p0.01; $n = 5$). Response times ranged from 0.45 ml/kg. of the body weight at the minimum to 0.25 ml/kg. of the body weight at the greatest.

Relation between average fertilised eggs procured and dosages of Ovaprim (ml/kg. of the body weight) - In this study, it was seen average fertilised eggs procured was not significantly varied with individual doses of the Ovaprim (ml/kg. of the body-weight) in Table 1. Though average fertilised eggs procured was maximum @ 0.45 ml/ kg. of the body weight and minimum @ 0.25 ml/ kg. of the body weight.

Relation between rate of fertilisation and dosages of Ovaprim (ml/kg. of the body weight) - It was seen that, rate of fertilisation varied with individual doses of the Ovaprim (Table 1). The highest and lowest rate of fertilisation obtained at dose 0.45 and 0.25 ml/kg. of the body weight. A positive correlation was seen between average fecundity and dosages of Ovaprim level significance ($r = 0.98$; $p < 0.01$, $n = 5$).

Relation between spawning response time with doses of Ovaprim:

Doses of Ovaprim (ml/kg. of the body weight)	Average response time (hr)	Characters
0.55	0	Highly stressed Settled down in the bottom Slow movement of fins. No breeding was found. In few hours males are separated from females. Male cannot fertilize the eggs.
0.50	1.4	Abnormal behaviour was observed Come to the bottom, slow movement of fins, tilting and stressed. Low fertilization rate was very less (%)
0.45	1.4	Abnormal behaviour was found. Come to corner of the aquarium. Dorsal and anal fin closed. Slow movement of female. When female entered to the breeding tank male comes to female, influensing them but no response from female. Lower fertilization rate (%)
0.4	1.5	Moderate fertilization. Large no of eggs are released within few seconds.
0.35	2.0	High fertilization rate (%) High fecundity Complete spawning
0.3	2.5	Fertilization rate reduced
0.25	3.0	Low fertilization rate (%), less fecundity
0.00	8.2	Low fertilization rate (%), less fecundity, long response time

5.2.2. Standard dosages of Ovaprim for angelfish breeding:

The recommended doses of the Ovaprim is @ 0.45 ml/kg. of the body weight compared to other dosage. Without Ovaprim, in case of natural breeding, the reaction time is much longer, 8.2 hrs., and the fecundity and fertilisation rate are also poor.

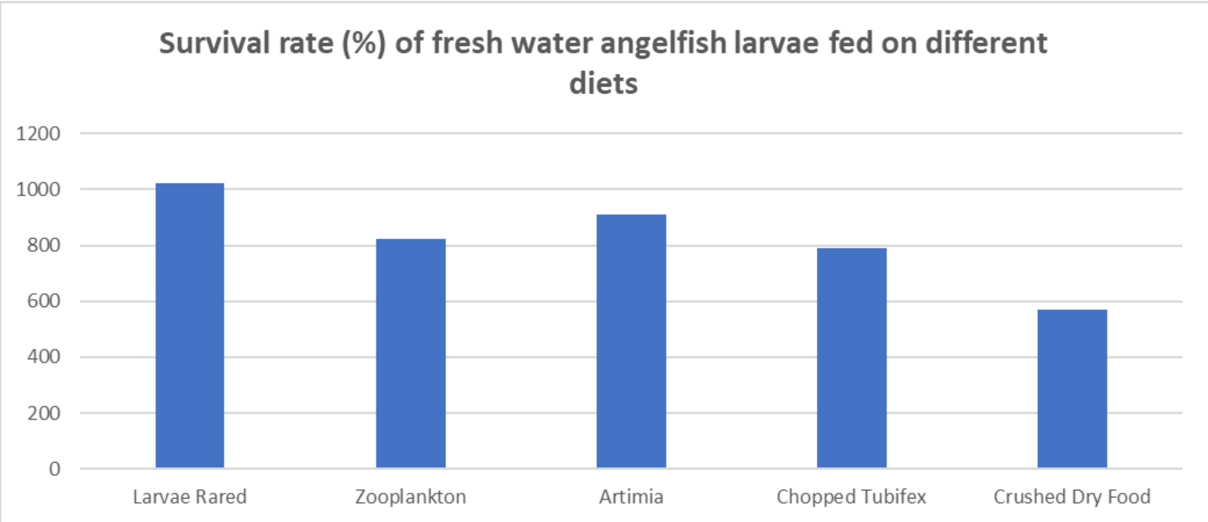
It was seen that, the hatching rate (%) varied from in different dosages of the Ovaprim. During this study, a negatively significant relation between dosage of Ovaprim and reaction time was recorded. Hence, the reaction time is much lower after application of Ovaprim. After different dose (ml/kg. of the body weight) of the Ovaprim injection, spawning behaviour of angelfish was seen in the laboratory condition. At higher doses 0.55 spawning was not done as the fishes become severely stressed. Lower number of eggs were laid in the doses @ 0.5 ml/kg of Ovaprim, compared to 0.45 ml/kg. of the body weight. But it was seen that complete breeding occurred at the doses @ 0.45 ml/kg. of the body weight.

Survival rate (%) of the freshwater angel fish larvae fed on various diets:

Larvae Reared	Zooplankton	*Artemia*	Chopped Tubifex	Crushed Dry Food
1023	825	912	789	568
Percentage of Larvae Survived	80.64	89.15	77.13	55.52

Survival rate (%) of angel fish larvaes fed on various diets like Zooplankton, *Artemia*, chopped tubifex and crushed dry food were tested for 20 days in different tanks. The mean survival rate (%) after 20 days monitoring was 89.15% for *Artemia*, 80.64% for zooplankton, 77.13% for Chopped Tubifex, 55.52% for crushed dry food,

In following graph are shows that the survivable rate (%) is greater in *Artemia* than zooplankton, chopped tubifex and crushed dry food respectively.



Graph 5: Survival rate (%) of fresh water angelfish larvae fed on different diets

PLATE-I

Fig 1: Gallif Street pet market

Fig 2: Gallif Street pet market

Fig 3: Angel Fish pair (male & female)

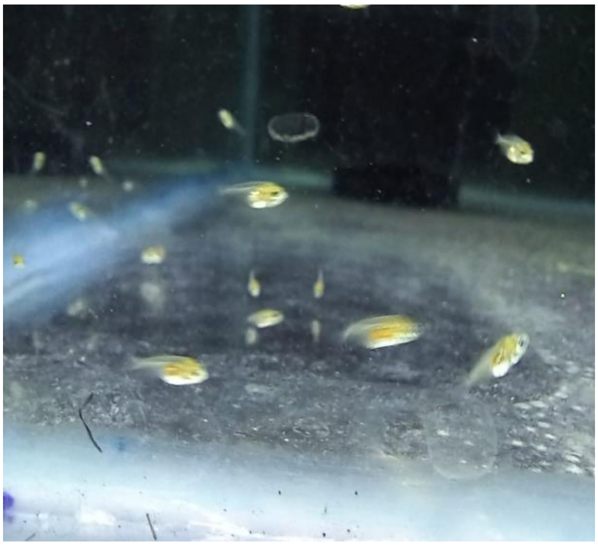


Fig 4: Angel Fish Fry

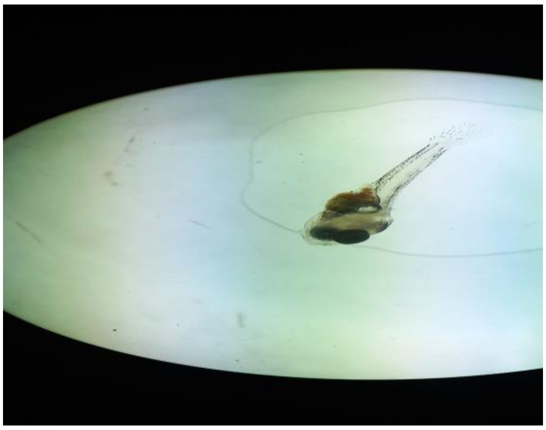


Fig 5: hatchling

Fig 6: Methylene Blue

PLATE-II

Fig 7: Tubifex culture

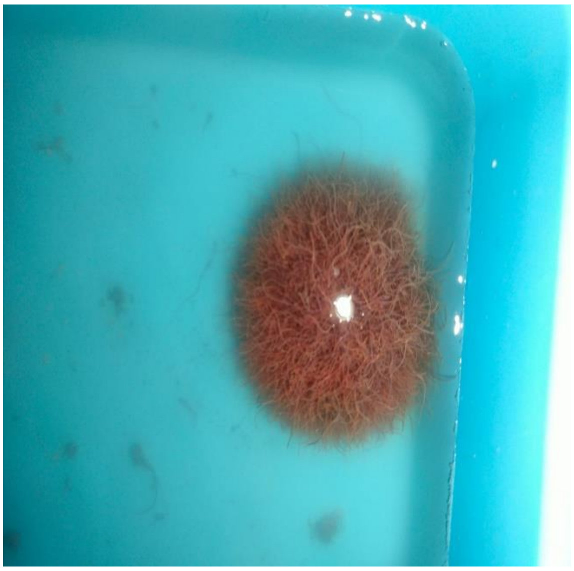


Fig 8: Tubifex worm

Fig 9: Artemia culture

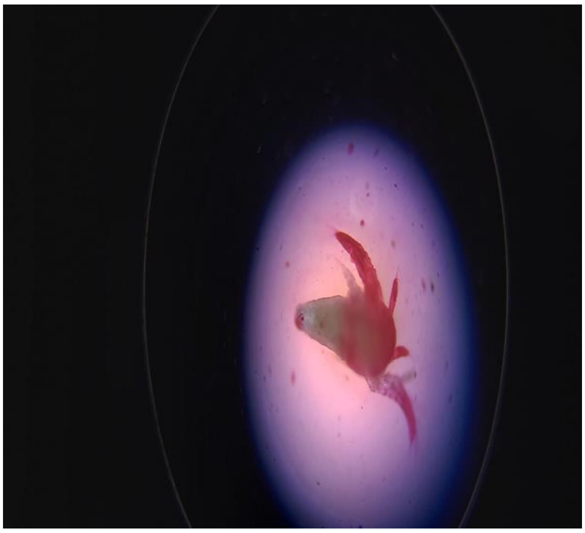


Fig 10: Artemia nauplii

Fig 11: Brine shrimp eggs

Fig 12: Artemia cyst

PLATE-III

Fig 13: Aerator

Fig 14: Sponge Filter

Fig 15: Plastic plants

Fig 16: Thermometer (Alcohol thermometer)

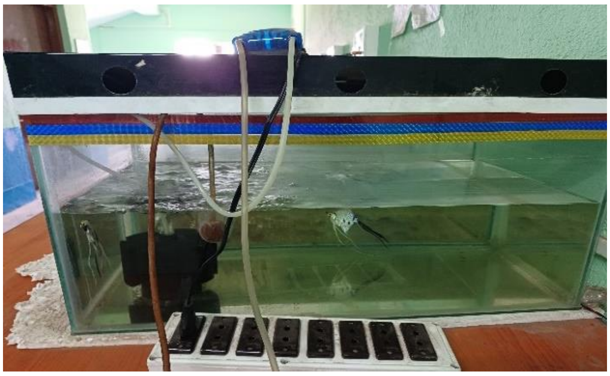


Fig 17: Aquarium

Fig 18: Hormone Injection

Plate-IV

Fig 19: Thermostat

Fig 20: Aquarium light

Fig 21: pH meter (LMPH-10)

Fig 22: Plankton net/ Artemia net

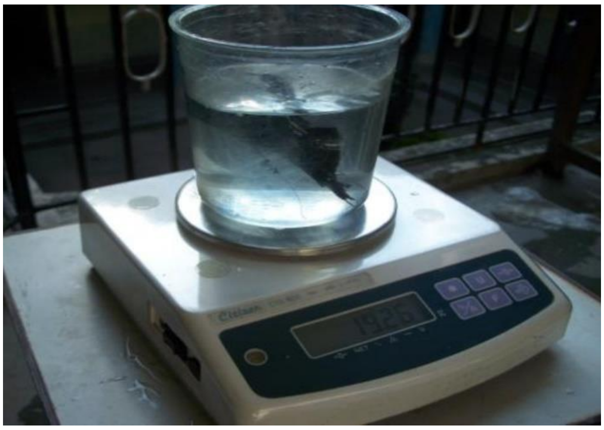


Fig 23: Weighing machine

Fig 24: Microscope (SM 100)

Plate-V

Fig 25: Hormone Injection

Fig 26: Group photo

6. Discussion:

6.1. Ideal Dosage of Ovaprim:

Ovaprim is necessary for angel fish breeding. The present work revealed that dosages of Ovaprim is @ 0.45 ml/kg. of the body weight is optimum for angel fish breeding compared to other dosage in laboratory environment of Midnapore City College. Without ovaprim, in case of natural breeding, the reaction time is much longer, 8.2 hrs., and the fecundity and fertilisation rate are also poor. Das et al., (1994) injected 0.35 ml/kg. of the body weight of a mature female's *Puntius javanicus* and get better spawning within 4-5 hrs. Fish spawned within 6.65 hours (Average spawning time) after the injection. A single dosage of the Ovaprim yielding about 669 eggs (n = 3) and implantation rate was higher (89.69%). So, the ideal doses of the Ovaprim was 0.45 ml/kg. of the body weight for angelfish, as recorded by (0.35 ml/kg. of the body weight) Chatterjee et al., (2013). Ovaprim has been used successfully to induce effective spawning in numerous carp species in India (Nandeesha et al. 1990; Das et al. 1994). According to Nandeesha et al. (1990), (1993), and Alok et al. (1993), utilising ovaprim boosted the fertilisation rate (%) and hatching rate (%). In C. striatus that had received ovaprim injections, the highest level of fertilisation (95–98%) was noted. In mrigal that had been injected with ovaprim, 90% fertilisation was seen by Azad and Shimray in 1991. According to Nayak, P.K., Mishra, T.K., Singh, B.N., Pandey, A.K., and Das (2001), using ovaprim increased the percentage of eggs in *Heteropneustes fossilis* that fertilised and hatched.

Survival Rate of Larvae in Different Diets:

The recent study is also unveiled that *Artemia nauplii* give better result for the survival of fresh water angel fish larvae in home environment. The usage of Artemia nauplii has been shown in a recent study on the culture of fry and adults of the guppy (Poecilia reticulata), which was noticed by Lim et al. in 2002a. The utilisation of Artemia nauplii in the feeding of Brown Discus (Symphysodon aeuifasciata axelrodi) has been shown in another study on freshwater ornamental fish in Singapore (Lim and Wong, 1997). However, it was found in the current study that Artemia has the highest survival rates (89.15%). According to Muguet et al. (2011), low ingestion rates of dry feeds and nutrient leaking from dry feeds are additional variables contributing to the poor growth of fish larvae on dry feeds. Additionally, the physical characteristics of feeds and the nutritional requirements of larvae during each developmental stage (Sarkar et al., 2006).

7. Conclusion:

In conclusion, the breeding of *Pterophyllum scalare*, commonly known as angelfish, in home environment offers a rewarding and potentially profitable opportunity for aquarium enthusiasts. This thesis has explored various aspects of breeding angelfish in the home environment and examined its commercialization potential.

The current study has demonstrated that with proper knowledge, equipment, and dedication, hobbyists can successfully breed *Pterophyllum scalare* in their homes. By carefully managing water quality, temperature, and providing suitable breeding conditions, individuals can encourage angelfish to reproduce and raise their fry. This process not only provides a fulfilling experience for hobbyists but also contributes to the conservation and preservation of this beautiful species.

The commercialization potential of breeding *Pterophyllum scalare* in home environment is significant. The demand for angelfish in the aquarium trade remains high due to their graceful swimming patterns and distinctive appearance. Breeding angelfish at the home allows hobbyists to produce a sustainable supply of healthy and genetically diverse specimens, reducing the reliance on wild-caught individuals and promoting responsible fishkeeping practices.

Furthermore, the commercialization of home-bred angelfish offers several advantages. It ensures a consistent supply of angelfish with desirable feature and characteristics, as breeders can selectively pair individuals to enhance specific features, such as finnage or colour patterns. This ability to produce unique and high-quality angelfish varieties can lead to increased market demand and potentially higher prices for home-bred specimens.

Additionally, breeding *Pterophyllum scalare* at home promotes local entrepreneurship and economic growth. Hobbyists who successfully establish breeding operations can sell their surplus angelfish to local pet stores, fellow hobbyists, or online platforms, generating income and giving to the aquarium trade industry. This not only benefits the breeders themselves but also supports the broader fishkeeping community.

However, it is essential to emphasize responsible spawning practices and adherence to ethical standards in the commercialization of home-bred angelfish. Breeders should prioritize the health and the welfare of the fish, ensuring adequate space, nutrition, and appropriate care for the breeding pairs and their fry. Additionally, breeders should educate buyers about the proper care requirements of angelfish to promote responsible ownership and the long-term well being of the fish.

In conclusion, the breeding of Angel fish in the home environment presents an exciting opportunity for aquarium enthusiasts. Through proper knowledge, dedication, and responsible practices, hobbyists can successfully breed and commercialize angelfish, giving to the conservation of species while potentially generating income and fostering entrepreneurship within the aquarium trade industry. By prioritizing the health and the welfare of the fish, breeders can ensure the long-term sustainability and growth of the home-bred angelfish market.

8. Future Scope:

Prospects of the current work are -

Enhanced Genetic Selection: Future research in this area could focus on genetic selection techniques to further improve the traits and characteristics of home-bred angelfish. By employing advanced breeding methods, such as genetic markers and selective breeding, breeders can produce angelfish with even more diverse and desirable features, catering to specific market demands.

Sustainable Production Systems: As the demand for acceptable and environment friendly practices increases, future studies could explore the growth of innovative and eco-conscious manufacturing systems for breeding Pterophyllum scalare. This may involve investigating alternative feed sources, energy-efficient technologies, and waste management strategies to minimize the ecological footprint of home breeding operations.

Health Management and Disease Prevention: Future research could focus on improving health management and disease prevention strategies in home-bred angelfish. This includes studying common diseases, developing effective vaccination protocols, and implementing biosecurity measures to safeguard the health of the breeding pairs and their offspring, ensuring a robust and disease-free stock for commercialization.

Market Expansion and Niche Markets: Further investigation into niche markets and specialized angelfish varieties can open new commercialization opportunities. Research could identify specific colour patterns, fin shapes, or genetic mutations that appeal to collectors and enthusiasts, allowing breeders to target niche markets and potentially order premium prices for their home-bred specimens.

International Trade and Export: With advancements in transportation and logistics, there is potential for the international trade and export of home-bred *Pterophyllum scalare*. Future studies could explore the regulatory requirements, market dynamics, and economic viability of exporting angelfish to different regions, giving to the global aquarium trade while promoting sustainable and responsible breeding practices.

Consumers Education and Awareness: Promoting consumer education and awareness about the benefits of home-bred angelfish can further enhance the commercialization prospects. Future research could focus on developing educational materials, online platforms, and collaborations with aquarium societies or organizations to educate potential buyers about the advantages of supporting home breeders and responsible fishkeeping practices.

Collaboration and Networking: Encouraging collaboration and networking among breeders, researchers, and the aquarium trade industry can foster knowledge exchange, innovation, and market growth. Future studies could explore the establishment of breeding networks, forums, or industry associations to facilitate information sharing, mentorship, and collaborative initiatives that benefit breeders and the overall angelfish breeding community.

By exploring these prospects, a thesis on breeding *Pterophyllum scalare* in home environment and its commercialization can contribute to the continued advancement of sustainable breeding practices, market expansion, and the overall development of the angelfish breeding industry.

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