Project ID 363

Competitive Research Grant

Sub-Project Completion Report

on

Present Status, Challenges and Scope of Ornamental Fish Trade in Bangladesh and Development of Breeding Techniques of Some Commercially Important Species

Project Duration

July 2017 to September 2018

Prof. Dr. Md. Sadiqul Islam
Department of Fisheries Biology & Genetics
Bangladesh Agricultural University, Mymensingh-2202

Submitted to

Project Implementation Unit-BARC, NATP 2
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215

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Project Implementation Unit
National Agricultural Technology Program-Phase II Project (NATP-2)
Bangladesh Agricultural Research Council (BARC)
New Airport Road, Farmgate, Dhaka – 1215
Bangladesh

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National Agricultural Technology Program-Phase II Project (NATP-2)
Bangladesh Agricultural Research Council (BARC)
New Airport Road, Farmgate, Dhaka – 1215
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Acronyms

Abbreviation	Elaboration
%	Percentage
°C	Degree centigrade
ANOVA	Analysis of Variance
BDT	Bangladeshi Taka
cm	Centimeter
etc.	et cetera
et al.	And others
Fig.	Figure
gm	gram
GMO	genetically modified organism
h	Hour
mg	milligram
SD	Standard deviation
SPSS	The statistical package for the social sciences
SWOT	Strength weakness opportunities threats
USD	US dollar

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Executive Summary

Trading of ornamental fish is expanding rapidly both in domestic and international market. A study was carried out to know the present status of ornamental fish trading and production (induced breeding) strategies in Bangladesh. Data were collected from ornamental fish market of Dhaka, Mymensingh, Sylhet, Chittagong and Rajshahi regions by interviewing wholesaler, retailer, importer and aquarium keeper using a pretested questionnaire. A total of 78 ornamental fish species including fifteen indigenous species were available in the market where the most favorite species were identified as Gold fish, Comet fish, Koi carp, Angel fish, Platy, Guppy, Fighter fish, Parrot fish, Kissing gourami, Zebrafish etc. Around 80% fish in the market were collected from local sources such as Kamrangir Char, Feni, Jessore, Chittagong and Bogra while about 20% were imported from Thailand, India, Malaysia, Singapore and Australia. No quarantine system was followed during importing the ornamental fish in Bangladesh. The price of a pair of ornamental fish at different markets ranged within BDT 60-100,000 depending on species and sizes. Red parrot, Black ghost, Discus fish, Knife fish and Golden arowana were found to be more expensive. Four different marketing channels were identified in ornamental fish trading. Generally, the trading started with the importers and local hatchery owners, passed through some intermediaries and ended with the aquarium keepers. Studies were also carried out to develop production model for both Zebrafish (*Danio rerio*) and Gold fish (*Carassius auratus*) and in the wet lab. of the Faculty of Fisheries, Bangladesh Agricultural University. A number of breeding strategies at different sex ratios (male:female) such as single-pair mating, group crosses, as well as using various substrates (i.e., water hyacinth, jute rope, polythene, net piece and no substrate) were employed in the laboratory to propagate. The highest mean number of eggs (821±67.11) was observed at T_3 (1male:3female) and the lowest (162±31.81) at T_1 (1male:1female) with significant ($p<0.05$) difference among treatment groups with varied sex ratios such as T_1 (1male:1female), T_2 (1male:2female), T_3 (1male:3female), T_4 (2male:1female) and T_5 (3male:1female) for spawning of Zebra fish (*D. rerio*) in aquarium. Female biased sex ratio was observed in this species, where egg production increased significantly compared to the equal sex ratio. The study further revealed that water temperature 27-29 °C enhances spawning of Zebra fish. Spontaneous ovulation in Goldfish was found synchronized with photoperiod and influenced by water temperature and substrates. Goldfish kept in water without substrate (T_5) did not ovulate. Use of substrate served as an effective spawning tool as well as an essential cue for the ovulation of Goldfish. The mean numbers of eggs were observed as 148.66±18.03, 231.66±17.55, 356.66±40.41, 146.33±22.72 and 0±0 in treatments with different substrates such as T_2 (jute rope), T_3 (polythene), T_4 (net) and T_5 (control) respectively, where T_3 (polythene) was significantly ($p<0.05$) higher than other treatments. Total egg production increased in lower temperature and gradually decreased with the increase in temperature. The mean number of eggs at 22-23°C was significantly ($p<0.05$) higher than other temperatures. Thus, information obtained from the survey and various spawning trials revealed a tremendous opportunity for ornamental fish business for the unemployed younger generation of the country.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. **Title of the CRG sub-project:**
   Present Status, Challenges and Scope of Ornamental Fish Trade in Bangladesh and Development of Breeding Techniques of Some Commercially Important Species

2. **Implementing organization:**
   Department of Fisheries Biology & Genetics
   Bangladesh Agricultural University, Mymensingh-2202

3. **Name and full address with phone, cell and E-mail of PI/Co-PI (s):**

PI
Prof. Dr. Md. Sadiqul Islam
Department of Fisheries Biology & Genetics
Bangladesh Agricultural University, Mymensingh-2202
E-mail: sadiqul1973@yahoo.com
Tel: 091-67401-6 (ext. 6910), fax: 091-61510
Mobile: 01726-559543

Co-PI
Prof. Dr. Md. Shahjahan
Department of Fisheries Management
Bangladesh Agricultural University, Mymensingh-2202
Mobile: 01718590903, E-mail: mdshahjahan@bau.edu.bd

4. **Sub-project budget (Tk):**
   a. Total: **45,00,000.00 (Taka Forty Five Lakh Only)**
   b. Revised (if any):

5. **Duration of the sub-project:**
   a. Start date (based on LoA signed): **July 2017**
   b. End date: **30 September 2018**

6. **Justification of undertaking the sub-project:**

The ornamental fish sector is a widespread and global component of international trade, fisheries, aquaculture and development. The demand for aquarium or ornamental fish is increasing in our country day by day. Most of the ornamental fish lovers usually keep them in their houses and offices in order to bring a different look of the place where they stay. The scope of this sector is vast in our country, but we cannot go ahead due to lack of sufficient knowledge on breeding & culture technique techniques of ornamental fish and assistance from government agencies in context to technical, legal and infrastructural issues. Ornamental fish trading should be given special priority because this sector has a tremendous opportunity for earning huge foreign exchange every year by exporting ornamental fish.

In the event of economic growth all over the world, stress has become evident among all people. In order to get relived from stress, everyone tends to nourish a hobby as part and parcel of their way of

life. There are different growing businesses related to hobby in maintaining aquarium in the institutional offices and also at the household (FAO, 2011). The supply of ornamental fish is providing way for eco- friendly breeding and rearing activities. It is evident that the hobby of aquarium is relatively more dominating in developed countries. However, this has been adopted in developing countries as well (Mostafizur *et al*., 2009). In this context, it is imperative to see a problem in setting up business support as well as develop the market with suitable marketing strategies (Cheong, 1996

Therefore, the proposed research focused on breeding & rearing of aquarium fish as well as developing an ornamental fish business channel for the country as a means of poverty reduction and livelihood. However, it will also intend to specify marketing strategies for ornamental fish aquarium business service in an introductory phase. It is aimed at specifying strategies to increase sales that satisfy the aquarium users based on consumer preference.

7. Sub-project goal:

To develop ornamental fish farming as a means of poverty reduction

8. Sub-project objective (s):

a) Survey on present knowledge of ornamental fish trade in Bangladesh,
b) Development of breeding (induced/natural) techniques of some commercially important ornamental fishes, and
c) Develop a design for promoting ornamental fish business.

9. Implementing location (s):
Department of Fisheries Biology & Genetics
Bangladesh Agricultural University, Mymensingh-2202

10. Methodology:
10.1 Present status of ornamental fish business in Bangladesh
Experimental design:
The present study was carried out as following steps (Fig. 1)

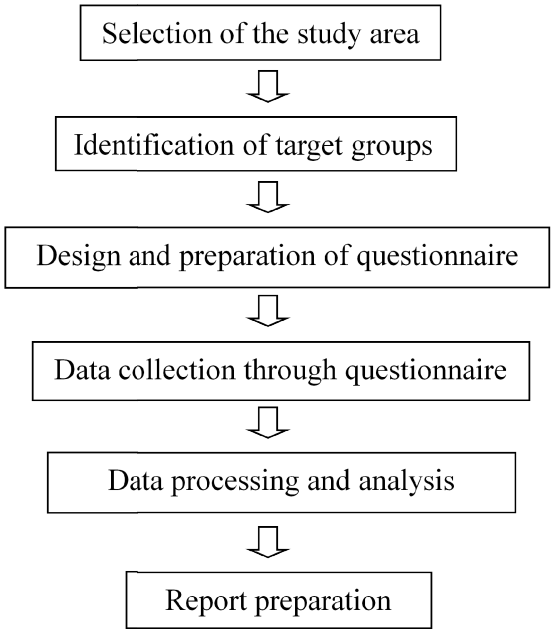


Fig. 1: Schematic diagram of methodology followed in the Expt. 1

Selection of the study area

Study areas were selected on the basis of availability of aquarium business covering the major cities of the country. In this context, ornamental fish markets of Dhaka, Mymensingh, Sylhet, Chittagong, and Rajshahi divisions were selected for collecting data. The survey was carried out for a period of 4 months from August to November, 2017.

Collection of data

Physical visit was performed in different aquarium shops of different cities and towns of Bangladesh for the collection of data. In Dhaka, the investigation was conducted at the Katabon ornamental fish market. Katabon is the only whole sale ornamental fish market of the country and is considered as the center of ornamental fish trading in Bangladesh. This market controls the price and supply of ornamental fish throughout the country. Different stakeholders including importer, wholesaler and retailer, breeder and buyer could easily be met in this market. Data for the present study was collected using a pretested questionnaire (Appendix - 1) by interviewing 39 respondents including 23 wholesalers and retailer, 4 importers and 19 aquarium keepers. Before visiting, the questionnaire was prepared and all primary data were documented on it while interviewing each aquarium shop owner. The questionnaire was pre-tested twice in the study area and finalized as per testing feedback. The questionnaire focused on general information about respondents, trade and marketing issues, aquarium setting, feeding strategies and finally disease and health management issues. All relevant secondary data also collected from the various sources. During collecting data rapport building with the respondents was taken in consideration. Before taking interview the respondents were given brief and clear conception about the study and its objectives. The researchers assured them not to misuse the data and convinced them to give the interview. Then the questions were asked in a simple manner with explanations and the replies were recorded on the questionnaire sheet. Whenever, any respondents faced difficulty in understanding any question, the researchers took outmost care to explain the question clearly. In some cases data were collected through long discussion. The collected data were coded, summarized and processed for analysis using Microsoft Excel. Interpretation and discussion of the findings are presented in simple terms, such as sum, average and percentage.

10.2 Development of breeding technique for Zebra fish (*Danio rerio)*

Experimental sites

The experiment was carried out in the wet laboratory of the Faculty of Fisheries, BAU, Mymensingh, Bangladesh from August to December 2017.

Preparation of aquarium

A total of ten glass aquaria (26x16x26cm^3) were used for this experiment. Each of the aquaria had 15 liter water holding capacities.

Collection of fish species

Adult Zebra fish (*D. rerio)* which is locally called 'Fuldarkina' or 'Onju' were collected from the field complex pond of the Faculty of Fisheries (Fig. 2)**.**

Male fish **Female fish**

Fig. 2: Male and female Zebra fish

Rearing of fish for the breeding

Ten glass aquaria of 15 liter water holding capacity were collected from the Faculty of Fisheries for using in this experiment. A total of 32 male and female fish were kept in different sex ratio in ten aquaria (Fig. 4). Petridish with two layers of marbles and artificial trees were placed in each aquarium as substrate for fish breeding. Aerators with air stone were also placed in each aquarium for aeration. Water exchange and aquarium cleaning was done as required. Zebra fish likes clean water. For this reason any uneaten food, dead eggs and fry, and detritus were removed from the bottom of the aquarium on a daily basis.

Feed and feeding

Zebra fish laid eggs every day. They eat most of their own eggs as a way of recycling the protein that is lost from producing the eggs. That is why they need high protein rich food. Fish were fed twice a day with a commercial floating feed (Mega Fish Feed ltd.) and often with zooplankton (enriched with *Cyclops, Daphnia, Cladocerans,* etc.)

Collection and counting of eggs

Egg collection is very important for any breeding study. In the present study eggs were collected daily at 8 AM from the aquaria. Eggs were deposited in between the gaps of marble in the petridish. To collect the eggs petridish were taken out of the aquaria; the eggs were separated from the marble and transferred into a hatching tray. Then the eggs were checked with the help of a microscope equipped with a camera (OPTICA B350, Italy). Finally the fertilized eggs were counted. The egg collection method is shown in the flow diagram (Fig. 3):

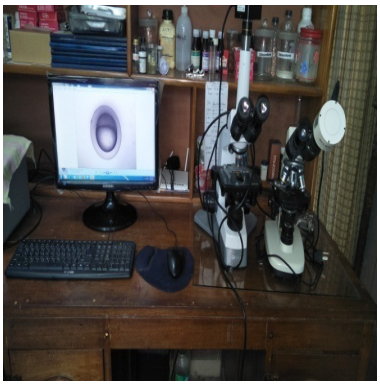
Male and Female fish in glass tank

Set up of aquarium

Providing plastic tray with marbles and artificial trees

Collection of eggs

Eggs counting



Observation of fertilized eggs

Fig. 3: Egg collection and counting from the aquaria

Experimental design:

i) **Factors affecting spawning**

A number of factors that affect egg production and spawning including the age and size of fish, interval at which fish are used for egg production, temperature, photoperiod, life cycle, diet, and fish health status. In this experiment the effect of temperature and sex ratio were studied.

ii) **Breeding and larval care**

The set up was involving 10 aquaria each of 15litre capacity and a maintenance tank to maintain an optimum water level. In this set up 5 different sex ratios were studied.

The fish were exposed to five treatments for a period of three months (Fig. 4):

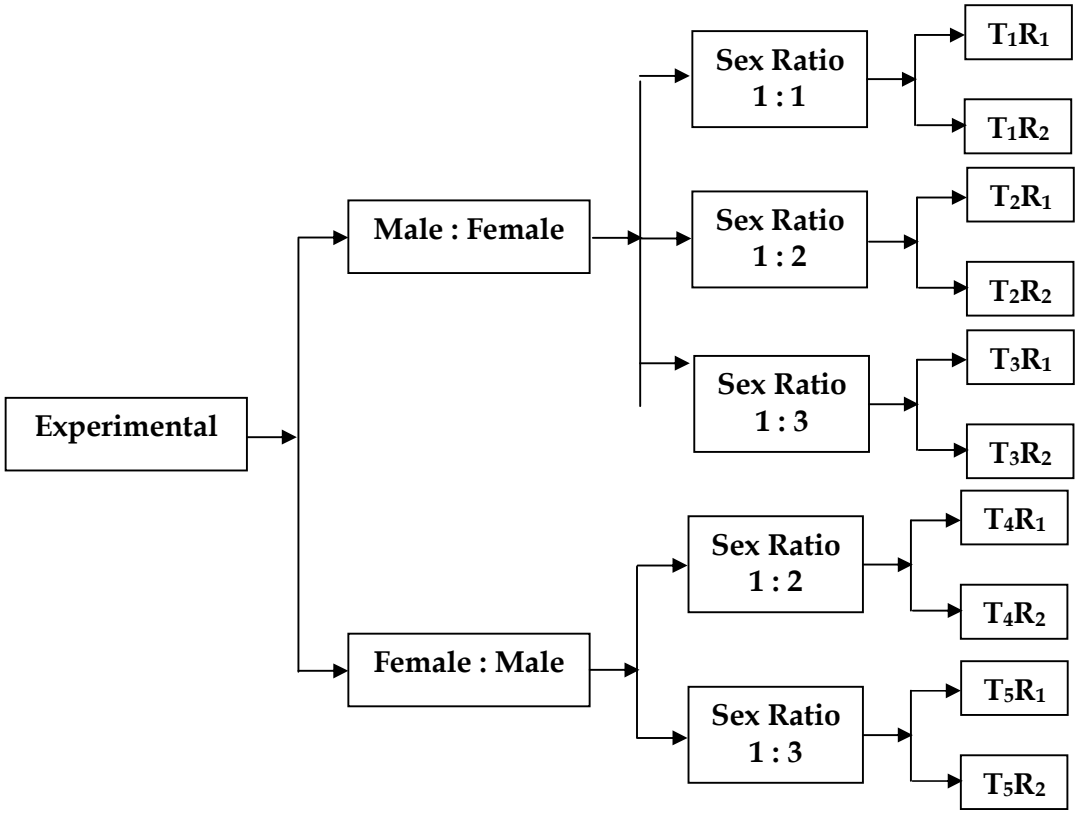


Fig 4. Experimental design

10.3 Breeding of Goldfish (*Carassius auratus)* in Tank

Study area

The experiment was conducted in the wet laboratory of the Fisheries Biology and Genetics department, Bangladesh Agricultural University, Bangladesh. All preparations needed for the substrate preference natural breeding of Goldfish are done in the same wet laboratory. Aquarium set up, water supply facilities, working space etc. were assured before the breeding program. The study period was from November 2017 to April 2018.

The experimental fish

The Goldfish (*Carassius auratus*) is a freshwater fish in the family Cyprinidae of order Cypriniformes. It is one of the most common aquarium fish for their excellent color and behavior (Fig. 5).

Fig. 5: Goldfish (*Carassius auratus*)

Brood fish selection, collection and conditioning

Mature healthy gold fish brood (22-60g), were selected by sexual dimorphism for breeding experiments. The brood fish were selected on the basis of size and color pattern. Female is usually easier to spot, as the belly of a mature female is generally plump, whereas male remains streamlined and more torpedo shaped. When males are ready for spawning, they develop breeding tubercles on the head and pectoral fins, principally along the bones of the fin rays. These are used during breeding, when the male nudges the female with its head and fins to induce her to spawn. Twenty four pairs (24 male and 24 female) brood fishes were collected from the aquarium fish market, Katabon, Dhaka. The brood fish were carried to the laboratory and reared in pond in the Fisheries Faculty complex of Bangladesh Agricultural University, Mymensingh. Floating feed was supplied to the brood fish during the period of conditioning (Fig. 6).

Fig. 6: Brood fish collection and conditioning process

Selection of brood fish

The success of breeding depends on proper brood selection. The mature broods both male and female Goldfish were distinguished by their physical appearance, abdominal condition, genital organs color and flow of sperm or eggs upon gentle pressure on the lower abdomen (Fig. 7). The female could be easily recognized by their swollen abdomen. On the other hand, the mature males were identified by their flat abdomens and slender body (Table 1).

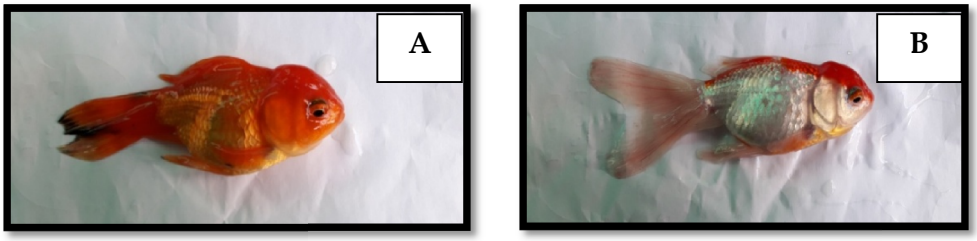


Fig. 7: Mature male (♂) (A) and female (♀) (B) of *C. auratus*

Table 1 Characteristics of mature *C. auratus*

Characteristics	Male	Female
Size	Slender than female	Comparatively large in size
Abdomen	Abdomen normal; not bulky like female	Swollen abdomen
Pectoral fin	Pectoral fin rough	Pectoral fin smooth
Pressure	Milt available following a gentle pressure on the abdominal region from anterior to posterior portion.	Few numbers of eggs from the ovary come out on the gentle pressure seemed to be the criteria for female.
Tubercle	Male develops tubercles on the operculum.	Female never develops tubercles

Selection of substrates for spawning

Four types of substrates were used in the experiment. These were water hyacinth, jute rope, polythene and net (Fig. 8). Goldfish released eggs near these floating substrates. As the eggs were sticky and adhesive, they were found attached on the substrates. Substrate worked as a stimulus for spontaneous ovulation. Substrates were checked twice a day. After laying eggs, the brood fish were immediately removed from the tank.

Water hyacinth

Water hyacinth was a free-floating perennial aquatic plant (or hydrophytes) native to tropical and sub-tropical region. They had long, spongy and bulbous stalks. The feathery, freely hanging roots were purple-black. Goldfish, Zebra fish, koi carp and catla fishes were laying their eggs on the roots of water hyacinth. Water hyacinths were collected from the faculty pond and placed in the breeding drum.

Jute rope

Jute fibers were composed primarily of the plant materials cellulose and lignin. Jute fiber was used to produce jute rope. A large size rope was cut into small pieces. Then these were tightened with a rope as a bundle. Upper part of the bundle was fixed with the pieces of cork sheet so that the bundle could float on water then stocked in the breeding drum.

Polyethylene

Polyethylene or polythene was the most common plastic. It's primary use was in packaging (plastic bags, plastic films, geo-membranes, containers including bottles, etc.). Transparent plastic bags were bought from market for making substrate. A large plastic bag was cut into small pieces. Then these were tightened with a rope as a bundle. Upper part of the bundle was fixed with the pieces of cork sheet so that the bundle could float on water then placed in the breeding drum.

Net

Nylon was used as raw material for net. A large size net was cut into small pieces. Then these were tightened with a rope as a bundle. Upper part of the bundle was fixed with the pieces of cork sheet so that the bundle could float on water then placed in the breeding drum.

Fig. 8: Photographs showing water hyacinth (A), jute rope (B), polythene (C) and net (D)

Preparation of breeding tank

Plastic drums (2×1.5×1.8 ft^3) were used as breeding tank for fish. Plastic drums were cut at the middle to make two tanks from each. The water holding capacity of each tank was 80 L. On each plastic tank, an aerator was placed to supply oxygen. The process of tank preparation for the experiment is given below in (Fig. 9).

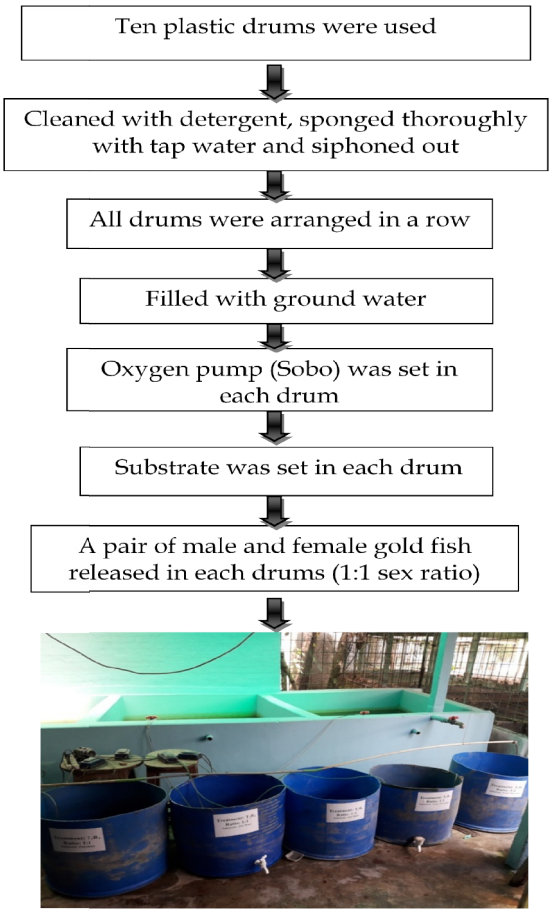


Fig 9. Photograph showing the arrangement of plastic tanks for the spawning of Goldfish

Foods and feeding

Goldfish is a very opportunistic omnivorous feeder, and consume just about anything that may fit into their mouths. Newly hatched fries remained near the bottom of the water column before they were free swimming. During this time they were absorbing the remainder of their yolk-sac. Fish were fed twice a day with a commercial floating feed (Nova, Osaka, turtle) and fry were fed powder feed (Perfect Companion Group Co., Ltd) twice a day (Fig. 10). Proximate composition of floating feed were composed of 20% protein, 3% fat, 7% fiber, 10% moisture and 0.7% calcium. The artificial powder feed were spread homogenously in the surface of the plastic drum.

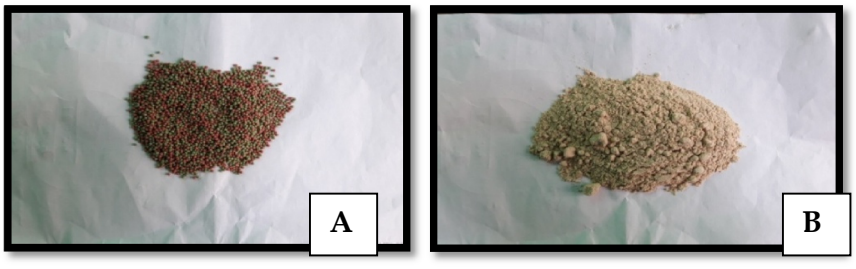


Fig 10. Photographs showing the commercial floating feed (A) and powder feed (B)

Experimental design

To assay the spawning of Goldfish mature broods (1:1) were stocked in five different experimental conditions. These five conditions were treated as treatments. Fish with substrates like water hyacinth, jute rope, polythene, net and without substrate (control) were considered as T_1, T_2, T_3, T_4, and T_5, respectively. Each treatment had two replications (Fig. 11).

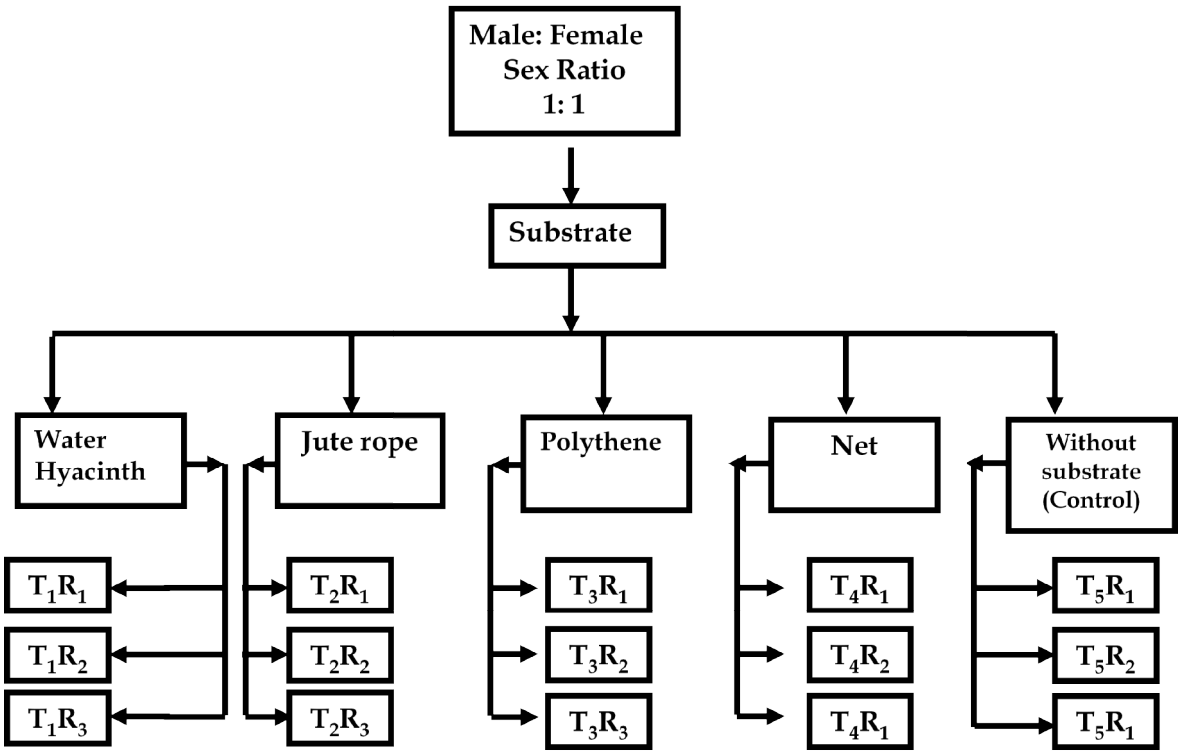


Fig 11. Flowchart of experimental design

Observation of spawning behavior

The male and female Goldfish were kept together in spawning drum. At that time female laid large number of eggs which were attached with substrates. Male released sperms to fertilize the eggs. The substrate of each treatment was checked daily and removed the breeders immediately after spawning. Then eggs were left to hatch in the breeding drum. In this experiment natural methods were adopted for successful spawning. Male and female fish were kept in the same spawning tank and fishes were allowed to release eggs and sperm to fertilize naturally in the plastic drums.

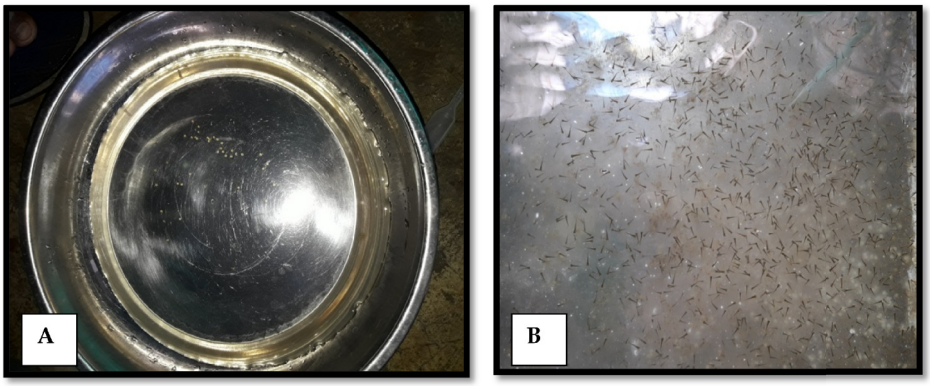


Fig 12. Photographs of fertilized eggs (A) and hatchlings (B)

Determination of fertilization rate

After a certain period of time (1 or 2 hour later), the eggs were examined to examin the fertilization rate. For this purpose water samples from bottom of the plastic drum were taken in a small steel plate and counted the number of eggs. Then the eggs were observed under microscope to separate fertilized and unfertilized eggs. The fertilized eggs were easily separated from the unfertilized eggs by the presence of transparent shell with grey or black spot within the egg shell, where the unfertilized eggs were opaque. The fertilization rate was determined by the following formula:

$$\text{Fertilization rate (\%)} = \frac{\text{Number of fertilized eggs}}{\text{Total no.of egg}} \times 100$$

Collection of fertilized eggs and incubation

Fertilized eggs were transferred into the hatching jar where a continuous flow of water was maintained. The hatchlings come out from eggs after 48 hrs of fertilization which was kept in the hatching jar for three days without feeding. Yolk sac absorption occurred in this time. After three days, the hatchlings were transferred to circular tank and maintained a gentle circulation of water for proper larval development. At that time air temperature was recorded at about 26-28ºC and water temperature was at about 20-23ºC. Then hatchlings were fed twice a day with a commercial powder feed (Nova, Osaka, turtle).

Determination of hatching rate

To determine hatching rate the hatchlings were collected from the hatching jar and the total number of fertilized eggs in the samples and number of hatchling were counted by visual observations. The hatching rate was determined by the following formula:

$$\text{Hatching rate (\%)} = \frac{\text{No.of Hatchings}}{\text{Total no.of fertilized eggs}} \times 100$$

Measurement of water quality parameter

Water quality parameters such as temperature, dissolved oxygen (DO), and pH were recorded twice a daily during morning and evening. For consistence, mean average data (Mean ± SD) were presented. Temperature and DO of each tank were recorded by a mercury thermometer and DO meter (Lutron DO-5510), respectively, whereas the pH was recorded with the help of pH meter (Hanna ISO 9001).

Statistical analysis

The results were analyzed by one-way analysis of variance (ANOVA) followed by Tukey's test. Statistical significance was set at $p<0.05$. All the analysis were performed using MS excel and the SPSS 20.0 version software.

11. Results and Discussion:

11.1 Present status of ornamental fish business in Bangladesh

Reasons for choosing ornamental fish business

In a gross view two most important reasons for choosing ornamental fish business as mentioned by the interviewed traders included personal hobby and interest (50%), and family business and having previous experience of working (33%). Other reasons were influenced by friends and for having esthetic view (17%) (Fig. 13).

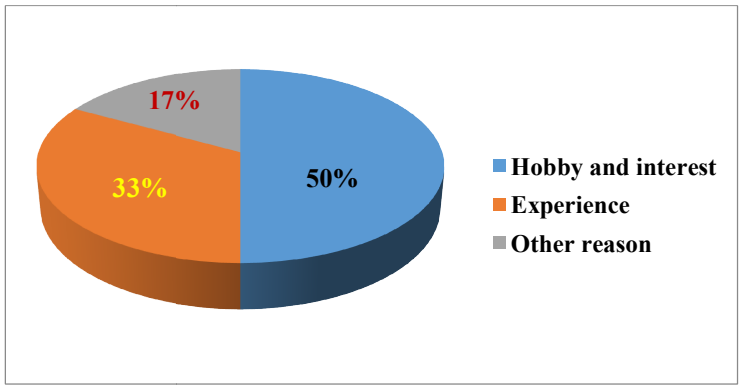


Fig. 13: Reasons for choosing ornamental fish business

Pet shop (fish and aquatic animals) in different regions

The aquarium shops in Bangladesh largely serve the local consumer market and are sited mostly in the cities where the population is high (Fig. 14). Dhaka works as the center point of the business, so the number of the shops in Dhaka in much more higher than any other place in Bangladesh. Another divisional city Chattrogram has the 2nd largest pet fish and aquatic animal shop.

Fig. 14: Distribution of pet shop in different region of Bangladesh

Source of fish

It was found that average 80% of ornamental fishes at Katabon market, Dhaka comes from the local hatchery and only 20% fishes are imported from other countries (e.g., Thailand, India, Malaysia, Singapore and Australia) by the importers. Local sources of ornamental fish are the hatcheries around Kamrangir Char, Feni, Jessore, Chittagong and Bogura.

Available species

A total of 78 ornamental fish species including fifteen indigenous species were found available at different shops of surveyed market which are listed in Table 2. Among 78 fish species a few representatives are shown in Fig. 15.

Table 2. List of common ornamental fish species in Bangladesh (E= exotic, N = native)

Sl No.	Name of the species	Sl No.	Name of the species	Sl No.	Name of the species
01	Gold fish - E	11	Koi carp - E	21	Catfish – E
02	Golden arona - E	12	Angel fish - E	22	Guppy – E/N
03	Silver arona - E	13	Butter - E	23	Neiotetra – E
04	Arapima - E	14	Sword tail - E	24	Rainbow shark – E
05	Clown fish - E	15	Oscar - E	25	Glass fish – E
06	Discuss - E	16	Parrot - E	26	Barb – E
07	Fighter - E	17	Dollar fish - E	27	Gourami (small, giant, blue, pearl, kissing gurami) – E/N
08	Comet - E	18	Moly (Black, white) - E	28	Zebra fish –N
09	Shark (albino, silver, tiger) - E	19	Platy - E	29	Punti – N
10	Silver shark - E	20	Piranha - E	30	Rani - N

Fig. 15: Some ornamental fish species in Bangladesh

Price of the different ornamental fishes

Price of the different ornamental fishes depends mainly on the species, time of production and its demand and supply. Some species are high priced such as Golden arona (1-2 lack/fish), Silver arona (40 thousand Tk/fish) and Arapima (10 thousand/fish) (Fig 16).

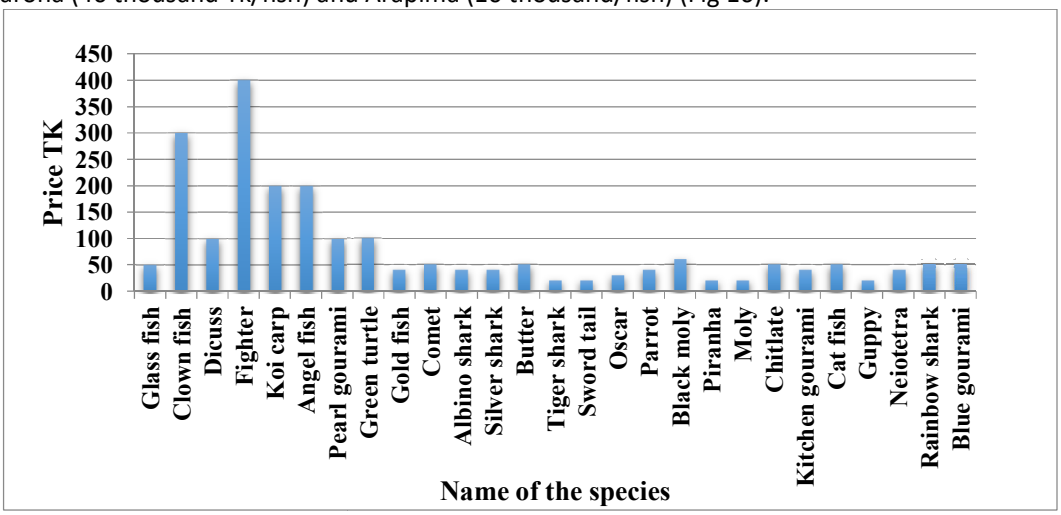


Fig. 16: Average price/piece of ornamental fish species

Demand of species

Demand of ornamental fish is the one of the most striking factors that defines the whole business strategies. Demand of the fish among different class of people totally depends on their choice. In contemporary time, the desire of people toward the beautifying the interior with space limitation is also a factor determining the demand of fancy fishes. Generally small to mid-sized fishes with colorful looks gain the attention. Price factor is also important, the increasing demand of fishes like gold fish, comment, angel, guppy, platy, molly shows that small sized and low priced fishes are more demandable among most of the customers that keeps these pet fishes at home. The most demandable species of ornamental fishes was identified as the gold fish and comet fish which are sold more than 70%. Accordingly, decreasing the demand towards less vibrant color and more priced ones (Fig. 17). In our experiment it was also found that the import and hobbyist trends are increasing in the recent days (Fig. 18).

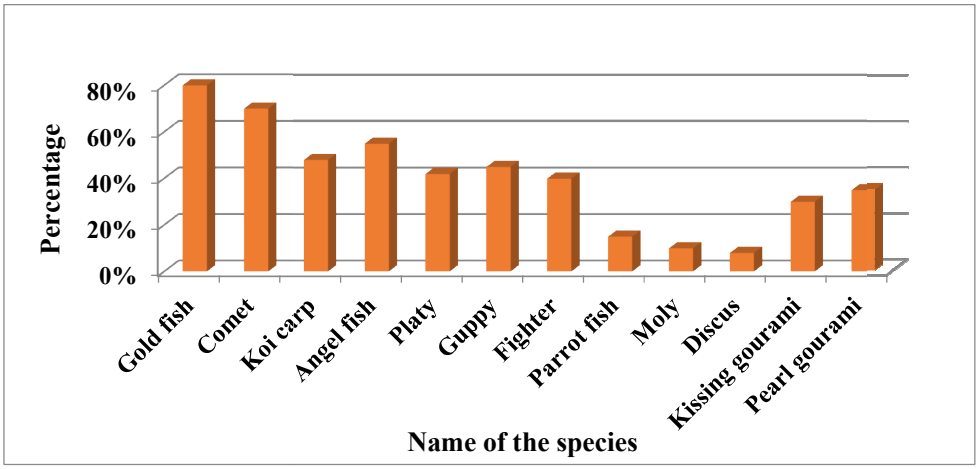
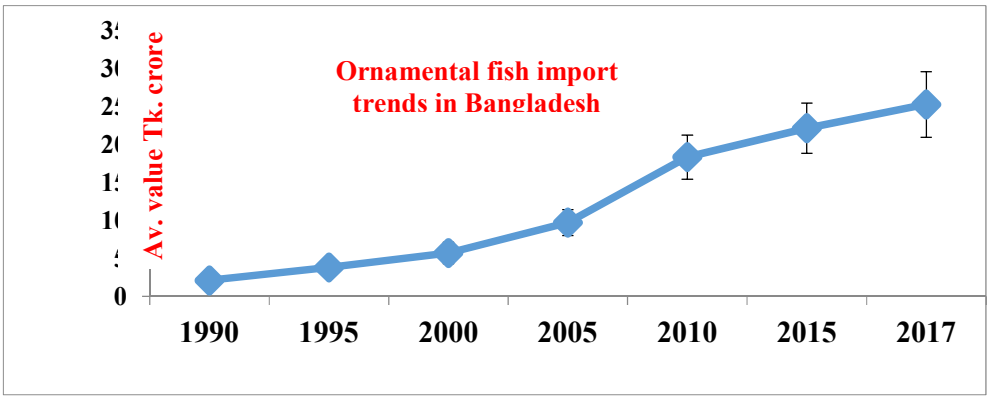


Fig. 17: Demand (%) of ornamental fish by the aquarium keeper



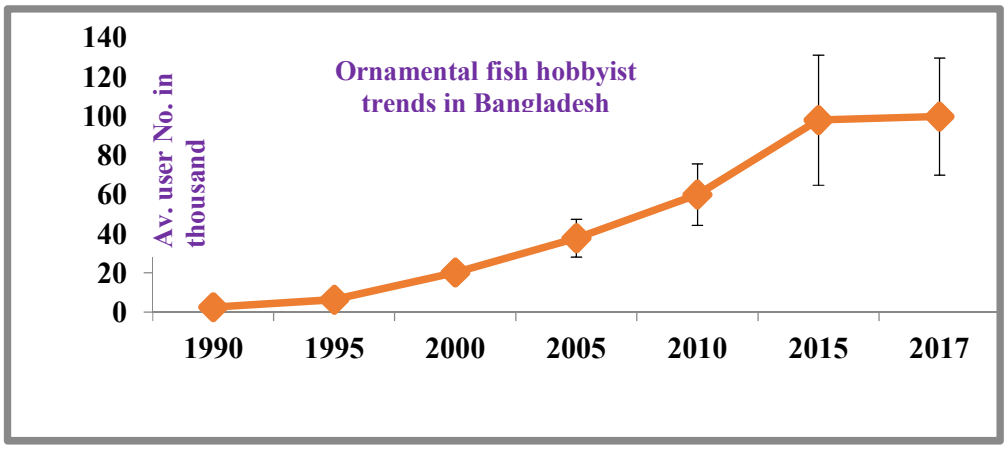


Fig 18: Ornamental fish import and hobbyist trends in Bangladesh

Marketing channel of ornamental fish

Four types of marketing channel were identified in the present study which is described below (Fig. 19):

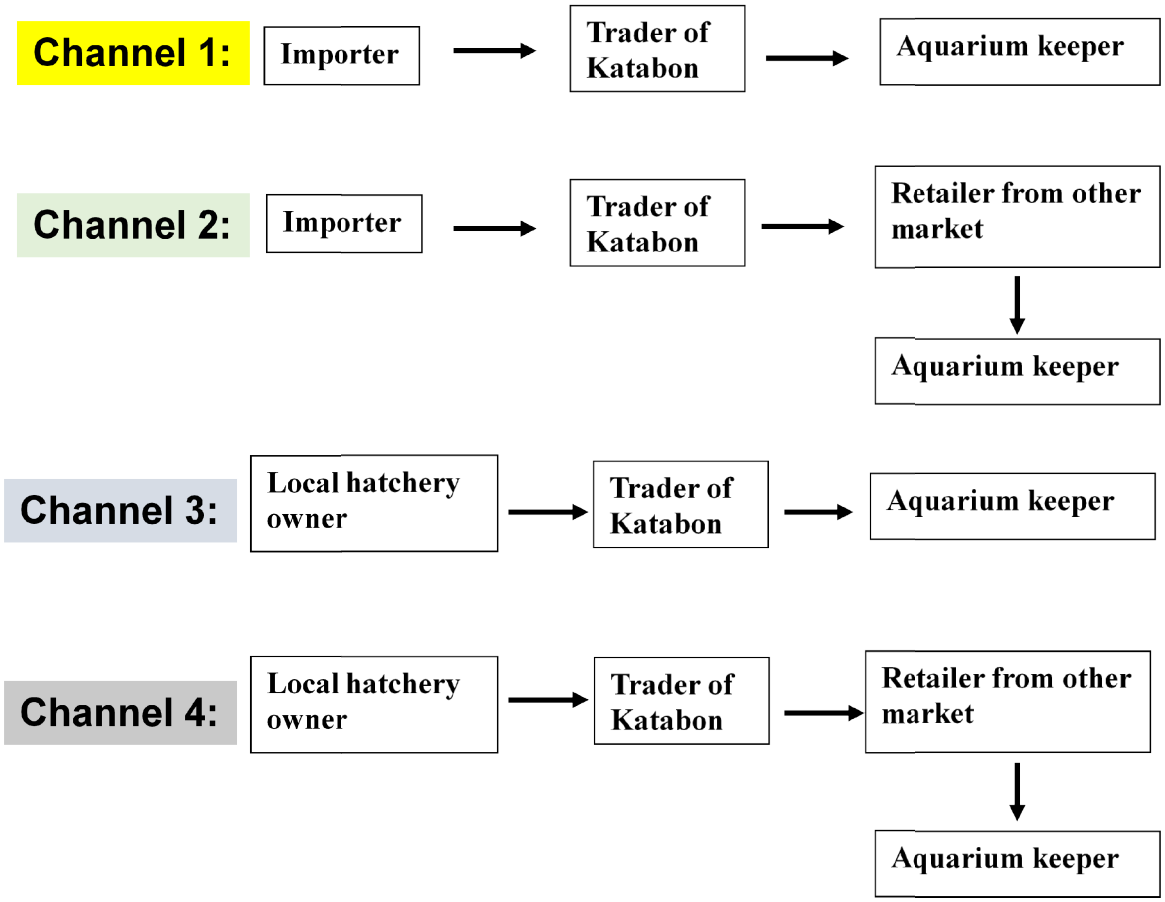


Fig. 19: Different marketing channel of ornamental fish

Ornamental fish marketing channel starts with the importer and local hatchery owners and passes through some intermediaries and ends with the aquarium keepers. Among the fur marketing channels the first two channels showed that the trades of Katabon market collect around 20% of their fish directly from the importer (Fig. 20). They sell these fish to the aquarium keepers directly (Channel 1) or to the retailer (Channel 2) whose ultimate customers are the aquarium keeper (Fig. 19). These imported fish are more costly than local sourced fish. For their perfect shape and prominent color, they have special demand by the aquarium keepers. Imported fish also have demand as brood and local hatchery owners collect them directly from the importer.

Eighty percent of the ornamental fish are supplied by local hatchery owners to the wholesaler of Katabon market (Fig. 20). These fishes are comparatively cheaper and available. Aquarium keepers purchase local bred ornamental fish directly or from retailer of different market. Katabon market traders sell about 43% of their total fish directly to the aquarium keepers and 57% of their total fish directly to the retailer (Fig. 20). Ornamental fish are transported by

retailer and aquarium keeper using poly packs filled by water and oxygen. No middlemen were found in any marketing channel.

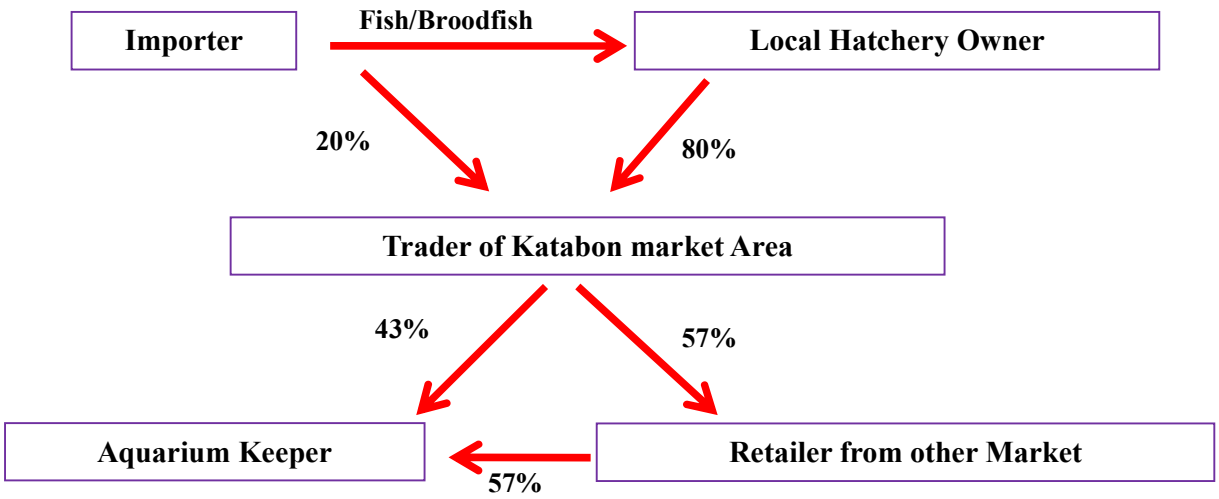


Fig 20: Sharing (%) of market of ornamental fish in Bangladesh

Ornamental fish trade in the world

Ornamental fish business in the world gained much attention in recent times. Although there is a vast resource of Bangladesh to earn foreign currency but we are still importing ornamental fishes and spending 0.29 million USD in 2015 (Table 3). Whereas neighboring country like-India, Singapore, Indonesia, etc. are earning a huge remittance from the ornamental fish. Only four importers were found to import ornamental fish from different countries especially from Thailand, Malaysia, India, Singapore etc. They also import fish feed, medicine, aerator and other accessories required for ornamental fish keeping. The importer pays the Govt. tax up to 15% of their importing cost and 15% vat on their profit annually. They also had their own license for importing fish.

Table 3. Ornamental fish trade in the world

Country	Year	Import (Million USD)	Export (Million, USD)
USA	2015	49.67	-
UK		24.31	-
Germany		18.62	-
Japan		15.71	31.08
India		0.34	1.02
Singapore		14.33	45.44
Spain		-	36.07
Czech Republic		-	20.43
Indonesia		-	19.67
Bangladesh*		0.**29***	-

*Source: On-site fish farm/pet shop survey

Investment of the traders

Traders were found to invest an average of BDT 4.5 lack in the starting of their business. The investment amount raged from BDT 1 lack to 12 lacks.

Costs

The total cost of the traders includes variable cost and fixed cost. The fixed cost of the traders was the rent of shop per month. Variable cost includes the cost of fish, electricity bill, salary of worker, total cost of other equipment, medicine and artificial feed etc.

Profits

Total profit from ornamental fish was calculated by subtracting total cost from total sell and was 30% of total expenditure for an individual trader.

Aquarium fish feed

Aquarium fish feed was specially formulated with the completed nutritional value to give fish healthy growth. Super nova, Osaka, optimum etc. were used for all aquarium fish species such as gold fish, fancy carp and guppy (Table 4).

Table 4: Different types of feed of ornamental fish with their sources and price

Sl No.	Name of the feed	Company/Brand	Source		Price (Tk/100gm)
			Local	Imported (country)	
1	Nova	Perfect Companion Group Co., Ltd.	-	Thailand	38-60
2	Osaka	Perfect Companion Group Co., Ltd.	-	Thailand	43-65
3	Optimum	Perfect Companion Group Co., Ltd.	-	Malaysia	45-70
4	Turtle	Perfect Companion Group Co., Ltd.	-	Singapore	80

Accessories related to ornamental fish

Most of the shop keeper made aquarium by the use of glass, wood, glue and other accessories. The prices of different accessories are given below (Fig. 21):

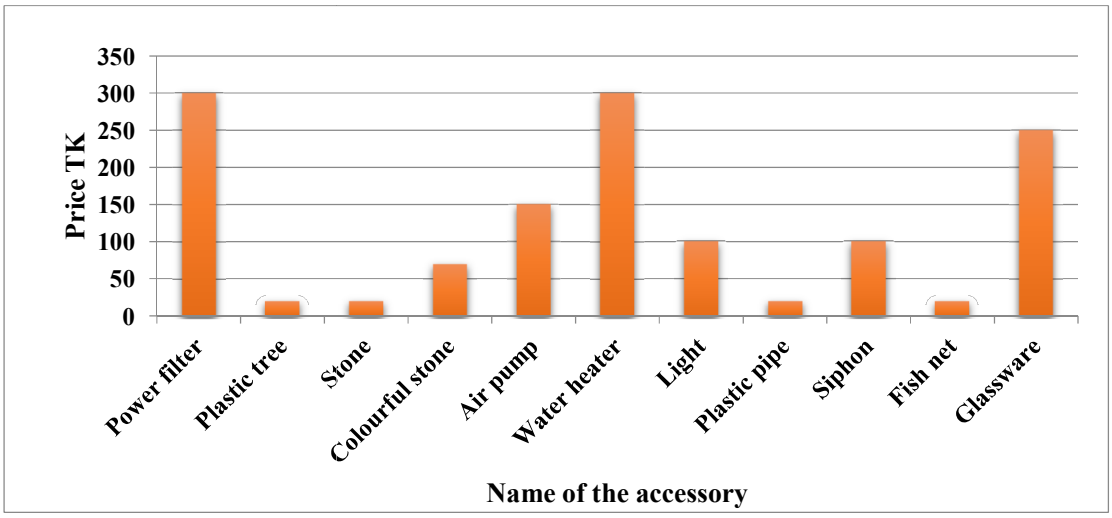


Fig. 21: Average selling price of accessories related to ornamental fish business

Disease and health care of ornamental fish

In the present study ornamental fish were found to suffer from various disease and health problems as mentioned by the respondents which included white spot, ulcer, tail and fin rot, dropsy, and mouth fungus etc. Some medicines were used to protect fish from diseases are given below (Table 5):

Table 5: Ornamental fish disease and their treatments

S/L No.	Chemical name	Dose	Purpose of use
01	Renamycine	1 cap/ 1 aquarium	Fungal treatment
02	Water care	3 drops/ litter of water	Chlorine removal
03	Star aqua spot blue	1 drop/ litter	Fungal white spot, Drossy, Fin rot etc.
04	Star 100 gold	1 gm/ 50 litter of water	Bacterial infection, tail and fin rot, Surface wound, Hole in the head etc.
05	Star fish vitamin	1 drop/ 1 litter	Color and health development
06	Star aquarium salt	2mg / 20 litter water	Disinfectant

Livelihood opportunities through ornamental fisheries

The hobby of ornamental fish keeping is gaining popularity in the country and it is estimated that a hand sum amount of the urban house-holds are keeping and aquarium. Dhaka is the main place of ornamental fish trade contributed a major portion of the Bangladesh's ornamental fish trade 85%. Perhaps the opportunity of gainful employment underlines at all levels of activities in the ornamental fish industry, namely, production, marketing and exports. In different peri-urban area particularly Feni, Jessore, Bogura, about 1000 families are involved in this ornamental fish business including breeding, rearing, live food collection and culture, feed preparation, aquarium plant propagation and trade, accessories and decorative material

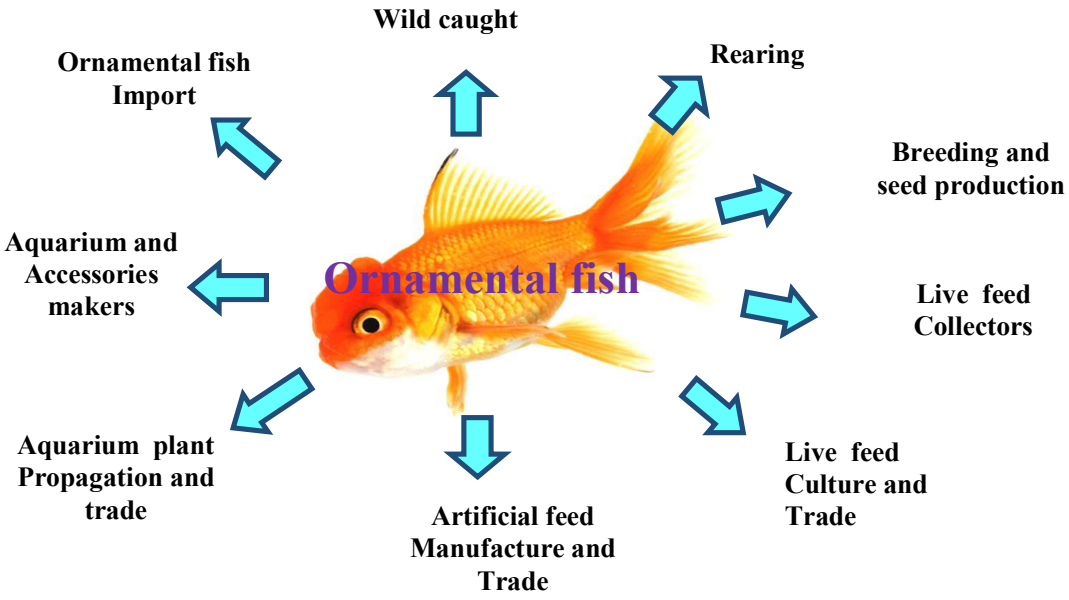


Fig 22. Population involved with ornamental fish business in Bangladesh

Wild caught
To serve our country the wild-caught species collected from the streams, pond, beel, haor and rivers of Bangladesh. The price in local hobby is varying between of Tk. 3-50/-.

Rearing
Rearing of ornamental fish mainly considered the exotic species along with some indigenous species popular in domestic market. In view of exploring the agribusiness opportunities of ornamental fisheries, rearing of exotic ornamental fish is likely to fetch higher and steady returns as compared to collection of fish from wild catch due to their better quality, lower risk of mortality while transportation. Also, raising and supplying of exotic ornamental fish under captive breeding would reduce the pressure on volume of wild catch and therefore, would complement the conservation efforts of native ornamental fish species. Present estimation has been made considering three popular exotic ornamental fish, namely, gold fish (*Carassius auratus*), angel fish (*Pterophyllum scalare*), gourami, cichlids etc.

Breeding and seed production
Throughout Bangladesh near about 1, 000 families are involving in fish breeding and culture industry. Dhaka is the major hub of the ornamental fish in Bangladesh for breeding and trading.

Live feed collection, culture and trade
Live food includes Cyclops, Moina, Daphnia, Artemia, Tubifex or sludge worm, mosquito larvae, earthworm etc. It is an important and vital food sources for ornamental fish especially in larval stage. Several peoples are involved in this sector.

Artificial feed manufacture and trade
Approximately 80% of fish keeping hobbyists feed their fish exclusively prepared foods that most commonly are produced in flake, pellet or tablet form. This artificial feed preparation and marketing

also are a very good alternative livelihood opportunity for rural people. Not only artificial feed but they also prepared sun dried, freeze dried or artificial heat dried natural food like dried bloodworm, dried Daphnia, dried Tubifex, dried Artemia cyst, Dried Daphnia egg etc.

Aquarium plant propagation and trade

To provide the natural habitat and environment inside the aquarium, aquarium plant like *Vallisneria* sp., *Cabomba* sp., *Echinodorus* sp., *Hydrila* sp., *Cryptocoryne* sp., *Pistia* sp., water lilies etc. has huge demand in this sector. In consideration of this improving and demanding market of aquarium plant around 200 families of peri-urban area of Bangladesh.

Aquarium and accessories maker

Aquarium accessories preparations are a very well opportunistic livelihood option for rural people. They can make aquarium decorative materials e.g. aquarium air pump, different types of filter, fish net, gravel vacuum, heater, air stone, wooden log, colourful stone and gravel, artificial plant, decorative air stone cum toys, showpiece etc. Mainly house wives, Elderly women are involved in this small scale industry as their alternative livelihood. From this industry they can earn Tk. 2000-10000/month.

Decision tree to determine which species are suitable for the ornamental fish trade

Once it has been established that a species is suitable for the trade, it then needs to be determined if specimens should be collected from the wild or produced in aquaculture.

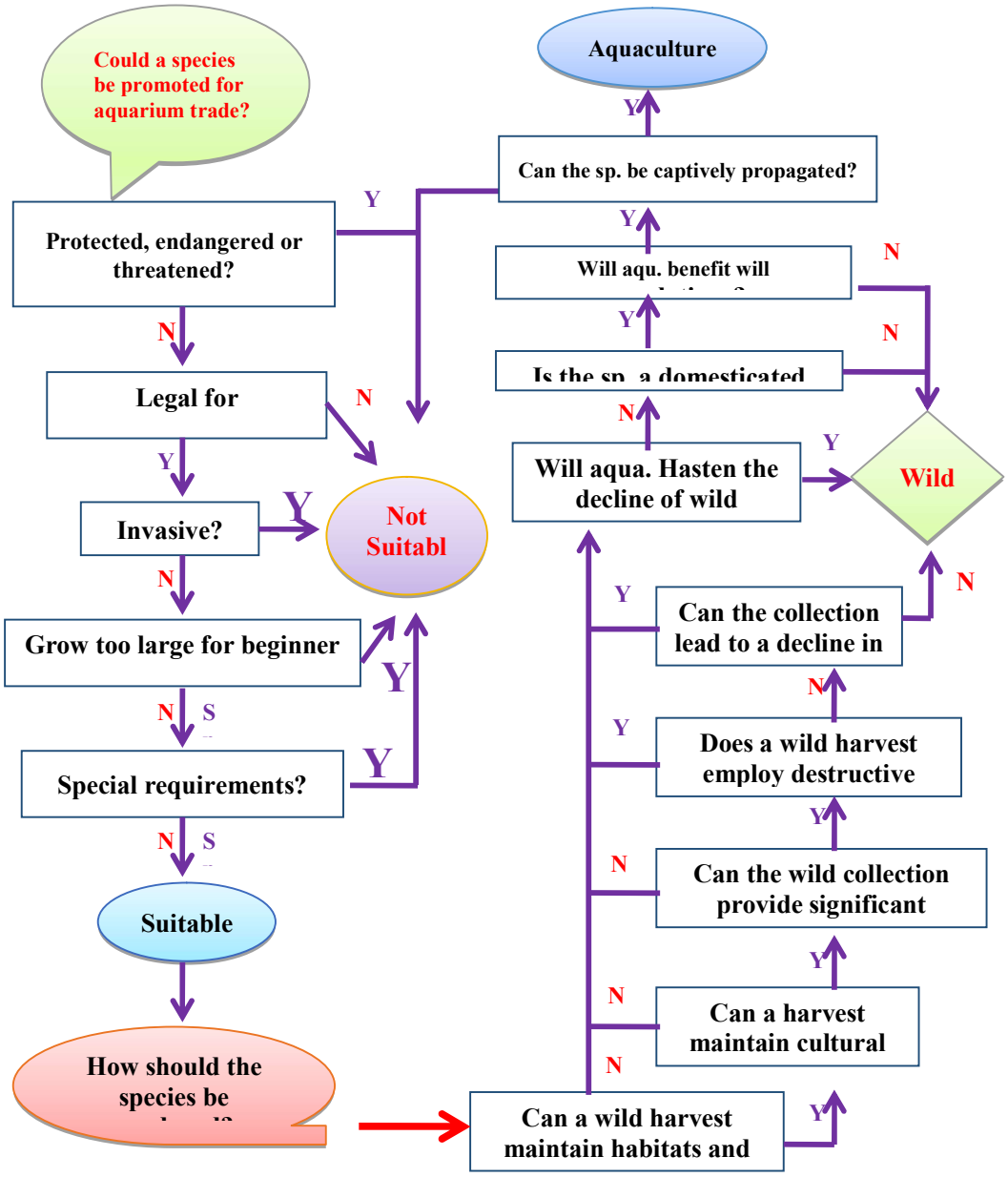


Fig. 23. Decision tree to determine which species are suitable for the ornamental fish trade (left side) and if those fish should be produced in wild fisheries or aquaculture (right side). Species on the decision arrows indicates that specialists in the hobby have the ability to care for these animals. This is a theoretical construct, and does not account for how historical market forces have shaped current acquisitions.

Each production system has positive and negative attributes, and one goal of acquisition will be to maximize the positive production attributes of each species. The first questions of this decision assess if a wild fishery maintains ecosystems, cultural traditions, or economic benefits to local

communities. Next, one must determine (1) if wild collections destroy habitats, and conversely, (2) if aquaculture can be used in a ranching manner, or (3) if aquaculture can be linked to a decline of wild populations. The salient feature of this decision is not to merely reduce impacts of the production of aquatic organisms, but rather pro-conservation interventions should be highlighted and embraced. Finally, there are questions if the species is domesticated or genetically modified, with genetically modified organism (GMO) fish requiring captive propagation.

The decisions about which species should or should not be in the trade, along with the means by which they are produced, are both questions which public aquariums should not only convey to their visitors, but also practice in their own acquisition decisions. Debating which freshwater fishes should or should not be wild captured is a moot point. The overwhelming aquaculture production of these species is a result of the interplay of technology, logistics, demand, and knowledge. However, deconstructing the current state of affairs compared to an idyllic condition can provide information on what acquisition strategies could be implemented to improve the sustainability of the trade. The status quo should not be the implicit assumption that all species should be produced in aquaculture. By assessing how production should be distributed, novel solutions become apparent and when such approaches are applied to fisheries, significant gains can be made while sacrificing little. Although freshwater fisheries provide small percentage of the individuals within the current trade, those that still do exist provide positive examples, which can be used to drive development of sustainable fisheries practices in other regions, and ideally within marine environments. Public aquariums can interface with consumers to educate them about the environments from where their pets originate, as well as understand that sustainable collection of fishes is one strategy to maintain biodiversity both within the trade, as well as of the wildlife that remains in the species' natural habitat.

Major network of ornamental fish production

The major fish production networks are given below (Figure 24).

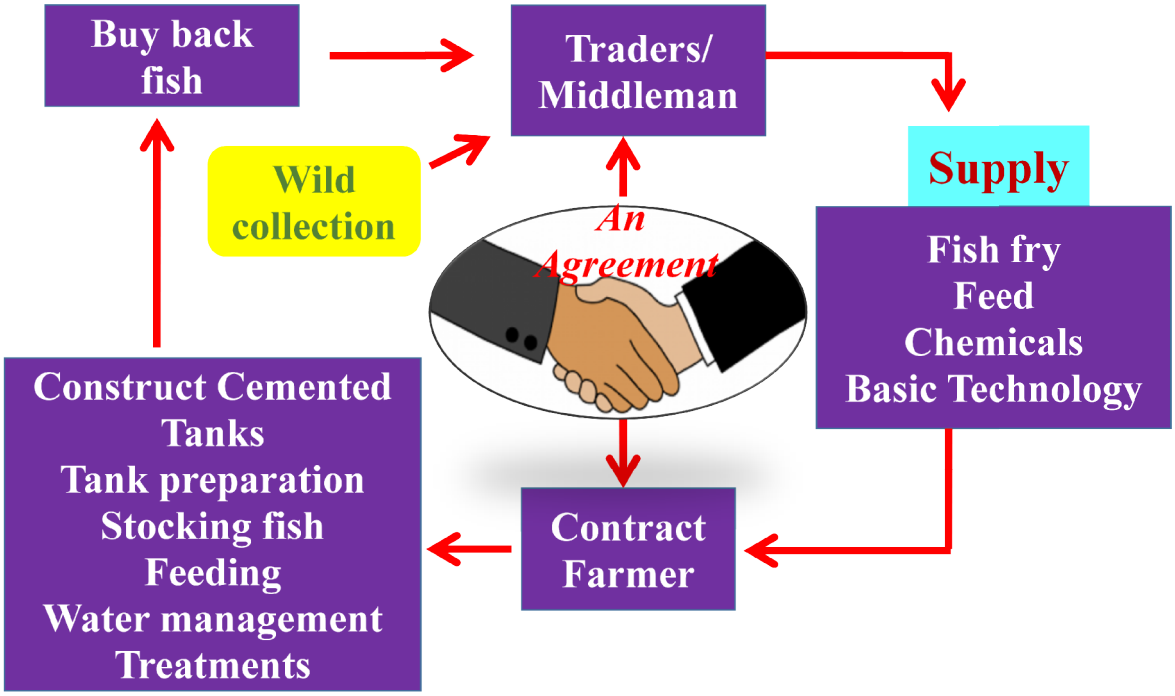


Fig. 24. Major network of ornamental fish production

Economics of ornamental fish business

The traders of the Katabon market area were found to invest an average of BDT 19.21 Lakh in the starting of their business (Table 6). The total cost of the traders includes variable costs and fixed cost. The fixed cost of the trader was the rent of the shop per month. Variable cost includes the cost of fish, electricity, salary of workers etc. (Fig. 25).

Table 6: Economic status of ornamental fish business in Dhaka city

Particulars	Total fixed cost	Total variable cost	Total cost	Total returns	Net returns
	Taka in Lakhs				
Avg.	8.78	10.43	19.21	28.03	8.82

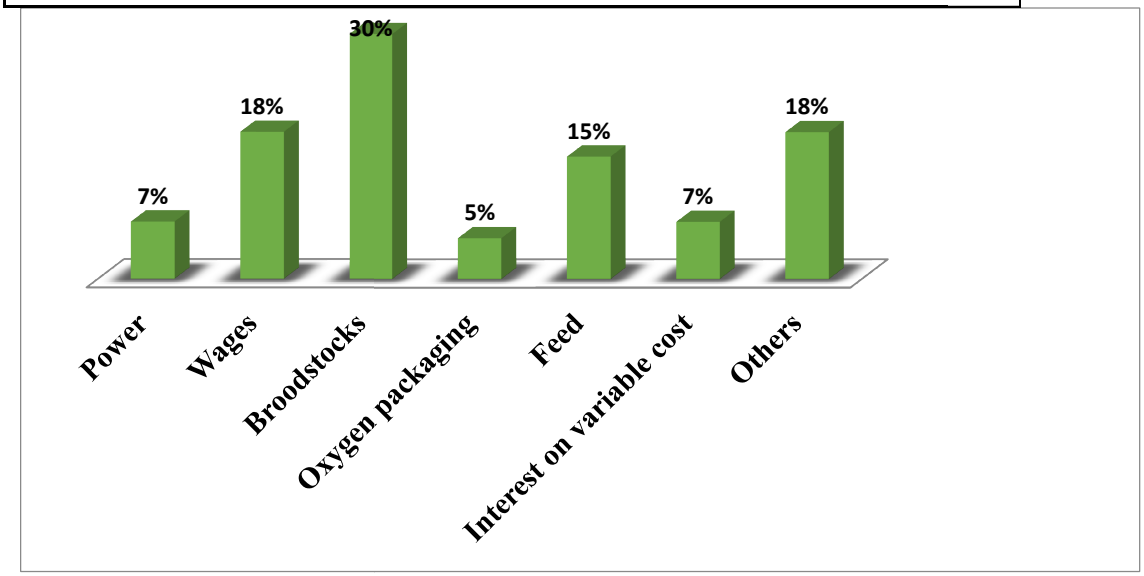


Fig 25. Different costs (%) of the ornamental fish traders

SWOT analysis for the ornamental fish industry in Bangladesh

A summary of SWOT analysis is shown in Figure 26. These various changes are necessary in order to achieve a sustainable ornamental fish industry in Bangladesh.

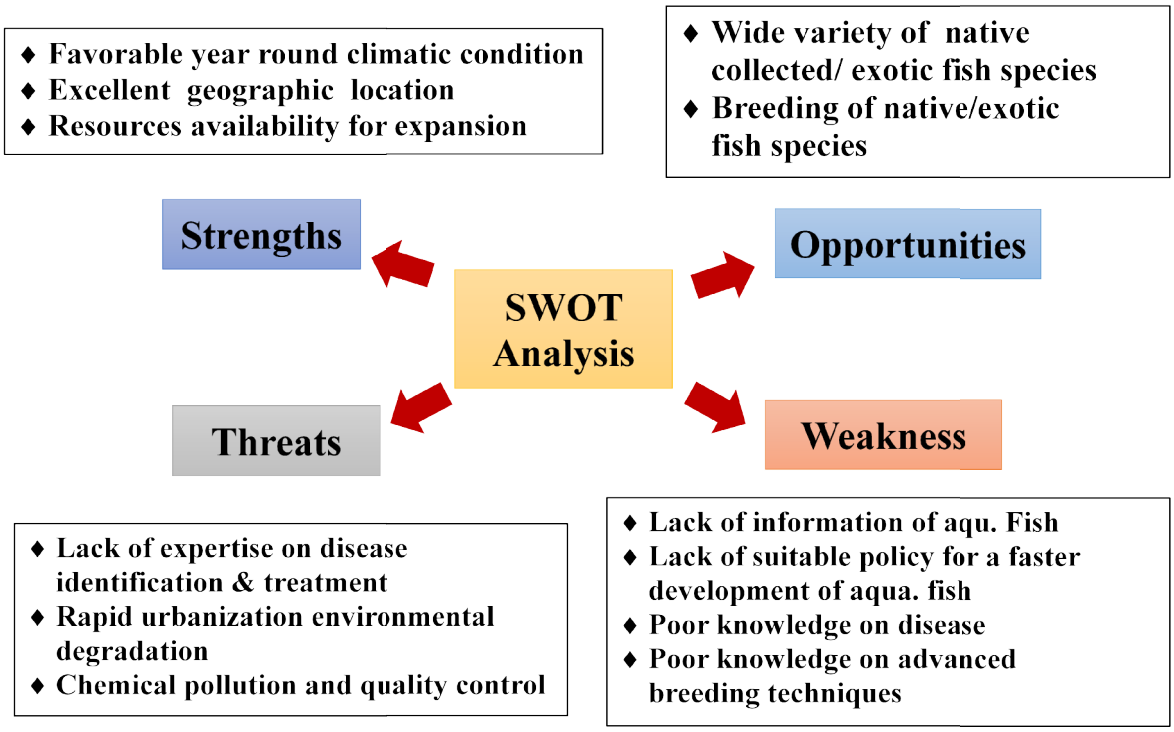


Fig 26. SWOT analysis for the ornamental fish industry in Bangladesh

Rhetorical appearance, attractive movement, and notion for mental pleasure inspired human being towards keeping ornamental fishes in different places like home, office, hospital. For these reasons keeping ornamental fish is increasing day by day all over the world including Bangladesh. With the rising demand there is a related concern for business. The economic importance of ornamental fish business in developing countries like Bangladesh can have a vital role in shaping the livelihood of people as well as total national economy. The present study was conducted to know the present status of ornamental fish business in Bangladesh which includes 4 divisional cities of Bangladesh namely Dhaka, Mymensingh, Chottrogram, and 7 district of Rajshahi division namely - Rajshahi, Bogura, Pabna, Naugaon, Natore, Shirajgong and Joypurhat. Katabon in Dhaka division is considered as the center point of ornamental fish trade in Bangladesh. Different stakeholders including importer, wholesale, retailer, breeder and buyer could easily found there. This single market controls the whole business of ornamental fishes in Bangladesh related to price and supply. The rest of the shops in different division and district cities are dependent on the Katabon market in Dhaka. For better knowing of the whole business procedure one ornamental fish hatchery in Feni was also visited.

Reasons for choosing ornamental fish business included personal hobby, interest, and family business (50%) and due to having previous experience of working with others (33%). Alongside this two major reasons the profitability and the rising demand takes this business to an apex. Although in maximum district cities even in some divisional shops integrates some other sort of pets along with ornamental fish selling.

The international trade in ornamental fishes involves more than 2000 species (Khan *et al.*, 2001), and the movement of hundreds of millions of fish annually. The vast majority of ornamental fishes in aquarium trade is of freshwater origin and farm raised (Chapman, 2000; Cato and Brown, 2003).

In the present study a total of 78 fancy rhetorical fish species including fifteen indigenous species were found available at different shops. The size of these fishes ranges from small to medium. Price of ornamental fishes depends on the variety of species, time of production, demand, its availability and size. Price can vary as much as 25 BDT to 1-2 lack BDT.

Although the ornamental fish keeping as pet begins in early 90s it gained massive momentum in recent years. Different offices, business places, hospitals are now keeping fish to amuse the people. In house small aquarium gained drastic attention in last 2/3 years. The major buyer are now the below 30 years of people, among them most are below 20. This shows that young generation and who are in context of Bangladesh are not economically independent are the majority. For this reason the low priced fishes are often preferred.

Whittington *et al.* (2007) presented that internationally one billion of ornamental fish are treaded each year and 100 countries are involved with ornamental fish business worldwide. Ornamental fish trading is a global business which gained momentum is recent few decades including Bangladesh. However there are three importers in Katabon who import and supply ornamental fishes throughout the country (Parvin, 2010). Main source of the imported fishes are Thailand, Malaysia, Singapore, India, Australia and some other countries. Besides the live fishes, feed, aerator, medicine and other equipment are also in the importing chart.

Demand of ornamental fish with vibrant color and relatively less priced. Gold fish, comment, angel, guppy, platy, molly shows that are small sized and low priced fishes are more demandable. The most demandable species of ornamental fishes are gold fish and comet which are sold more than 70%.

Kohls and Uhi (1980) narrated marketing system may be the connecting link bridge between specialized producers and consumers. Marketing channels are alternative routes of product flows from producers to consumers. It is both physical distribution and an economic bridge designed to facilitate the movement and exchange of commodities form the farm t consumers. It is composed of alternative product flows (marketing channel) and numerous business activities (marketing function). The marketing channel may be short or long for a particular commodity depending on the quality of the marketed products, nature and size of consumers and producers.

Ornamental fish trading system consists of marketing channel and marketing functions of different intermediaries. An efficient marketing system is essential for earning fair profit for the fingerlings producers and traders. Ornamental fish marketing channel passes through a number of intermediaries such as hatchery owners, wholesalers, retailers and aquarium keepers. Four types of marketing channels were found during the surveying for present study.

Around 80% ornamental fish were from local sources (Kamrangir Char, Feni, Jessore, Chottrogram and Bogura) and only 20% were imported from abroad (e.g., Thailand, India, Malaysia, Singapore and Australia).

Katabon market is the only wholesale market of ornamental fish. The retailers from all over the Country collect ornamental fish from this market. Marketing channels were associated with ornamental fish trading. The ground suppliers of ornamental fish in Bangladesh are the importer and hatchery owner of different district of Bangladesh. The trader of Katabon market collects ornamental fishes from both importers and local hatchery owners collect from them and then sell to aquarium keeper.

The marketing channels start with importer and local hatchery owner and ends with aquarium keeper. The local hatchery owners collect their brood fish from the importer. Everybody collect fish

directly and there is no middleman involved in the marketing channel. In a relevant work Malek (2007) stated about seven marketing channels for fish seed marketing in Mymensingh. Quddus (1991), Mia (1996) and Rahman (2003) identified same marketing channel in Mymensingh, Netrokona and Gazipur.

Problems and Recommendations

Major problems

There are some problems present in the aquarium fishes business in our country. Some major problems are given below:

- There is a lack of information on the status of aquarium fish species currently traded in our country and lack of integration with other fish trading activities.
- To identify profitable market channels and potential development of markets for selling aquarium fish in other Bangladeshi cities and rural town.
- Lack of knowledge about disease and treatment for the diseases of aquarium fish.
- Lack of suitable policy for a faster and more sustainable development of aquarium fish production in our country.
- No adequate research based information on the behavior, feeding and breeding technology under the local condition appeared to be very important for this business to get its due momentum and market share.
- Lack of knowledge regarding native ornamental fishes.
- Lack of acceptability of Bangladeshi aquarium fish in the world's market.
- Finally, lack of credit facilities for this important sector.

Recommendations

To overcome mentioned problems and to achieve the goals, we should put great emphasis on the following recommendation:

- Identification of profitable marketing channels and potential development of markets for selling aquarium fish.
- Development of crossbreeding techniques to improve the variety of different aquarium fish species.
- Introduction of improved fish breeding technology for popular wild fish species as well as native species.
- Identification of disease contamination and the treatment solution for aquarium fish and make it available in the market.
- Improvement of culture techniques of different aquarium fish species.
- Study the potential of using and recycling urban waste water in producing certain aquarium fish species such as we can use mosquito fish to reduce the mosquitoes.
- Research effort to carry out a comparative feasibility study of aquarium fish cultivation against food fish farming systems for lower income households in Bangladesh.
- Research effort to set up a suitable policy for a faster and more sustainable development of aquarium fish production in our country.
- Development of a better brand name for Bangladeshi aquarium fish in the world's market.
- Allocation of credit from both the government and nongovernment for the development of this sector.

11.2 Breeding of Zebra fish (*Danio rerio)* in aquarium

Effects of sex ratio on the spawning success of Zebra fish

Sex ratio is the ratio of males to females in a population. In the present study, the effect of different sex ratio treatments on the spawning of Zebra fish was determined through the collection of eggs for about 1-12 weeks (Table 7). The spawning success was found higher at the earlier weeks and

lower in later weeks. The highest mean number of eggs (173±9.1) was observed at 1st week in T_3 (1m:3f) and the lowest (6±4.5) was found at 11th week in T_5 (3m:1f). The mean number of eggs at 1st week was significantly different than any other weeks. Eggs were collected from the T_2, T_3 and T_4 on each of the weeks, whereas interruptions in the collection of eggs were observed T_1 and T_5. Significant fluctuation in spawning was also observed in T_1 and T_5. On the other hand, mean number of eggs significantly reduced in T_1 and T_5 in the later weeks. In those weeks, the number of eggs reduced to zero.

Table 7: Effects of different sex ratio on the spawning of Zebra fish as per week

Treatment	Sex ratio (male:female)	Weeks											
		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th
		Number of eggs (mean ± SD)											
T_1	1:1	14±.03^{a}	24±7.02^{a}	20±7.5^{a}	26±6.2^{a}	23±5.6^{a}	17±4.02^{a}	22±2.6^{a}	18±3.6^{a}	00^{a}	00^{a}	00^{a}	00^{a}
T_2	1:2	40±7.0^{b}	58±4.5^{b}	26±7.5^{a}	19±8.3^{a}	28±5.5^{a}	65±6.0^{c}	32±4.5^{b}	61±7.5^{b}	30±6.0^{b}	21±6.5^{b}	34±7.0^{b}	29±5.5^{b}
T_3	1:3	173±9.1^{c}	127±7.0^{d}	65±6.1^{b}	83±7.5^{b}	61±4.1^{b}	75±10.5^{c}	37±5.5^{b}	64±9.4^{b}	69±9.06^{c}	14±5.5^{b}	24±5.6^{b}	31±4.5^{b}
T_4	2:1	127±7.6^{d}	118±6.5^{d}	53±5.6^{b}	73±6.5^{b}	52±9.8^{b}	45±8.0^{b}	37±7.5^{b}	64±7.5^{b}	43±7.6^{bc}	19±6.5^{b}	20±8.5^{b}	23±7.5^{b}
T_5	3:1	105±9.2^{c}	79±8.0^{c}	35±6.5^{a}	38±6.6^{a}	56±7.0^{b}	18±4.1^{a}	37±5.3^{b}	38±7.0^{a} ^{b}	37±7.0^{b}	10±4.1^{a}	6±4.5^{a}	00^{a}

Values are presented as mean ± SD. Different alphabet superscripts showed significant differences among treatments within weeks ($p<0.05$)

The mean number of eggs was also varied among different sex ratio treatments. The highest mean number of eggs (821±67.11) was observed at T_3 (1m:3f) and the lowest (162±31.81) at T_1 (1m:1f) (Fig. 27). In case of spawning, there was significant ($p<0.05$) difference among spawning treatment groups in the number of eggs spawned. The mean number of eggs at T_3 was significantly ($p<0.05$) different from other treatments.

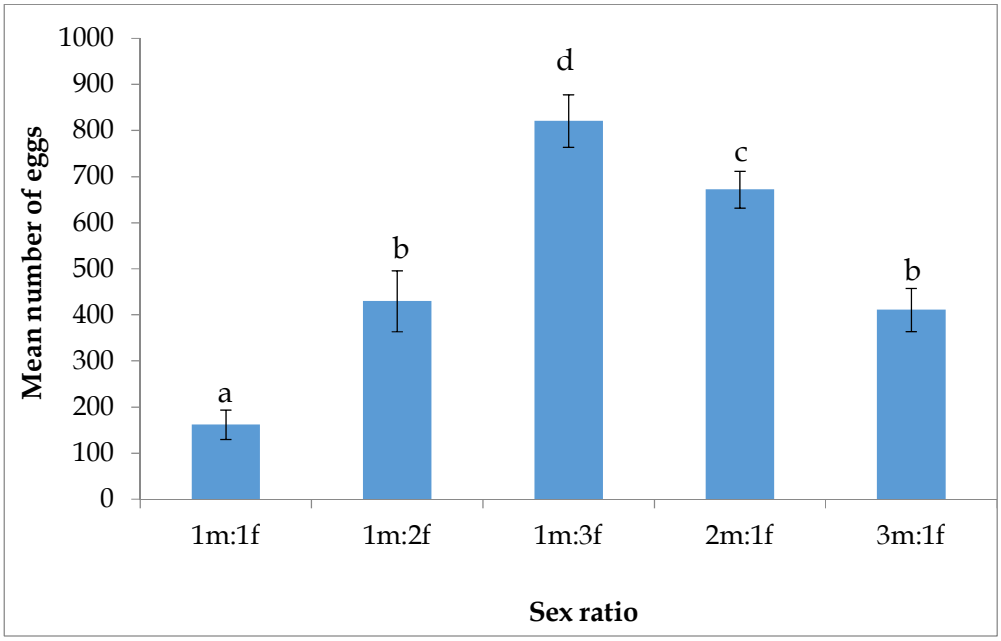


Fig 27. Mean number of eggs of Zebra fish at T_1 (1m:1f), T_2 (1m:2f), T_3 (1m:3f), T_4 (2m:1f) and T_5 (3m:1f). Different alphabet superscripts showed significant differences among the treatments ($p<0.05$)

Effects of sex ratio on the egg deposition frequeny of Zebra fish

The frequeny of egg deposition was also varied in different sex ratio. In this study, spawning frequecy was measured as the mean number of eggs produced at each day of a week. Egg deposition was found to be highest at T_3 (1m:3f) and lowest in T_1 (1m:1f) (Table 8). The highest mean number of eggs per day (24.6±1.5) was observed at T_3 (1m:3f) and the lowest (2.6±1.8) was found at T_1 (1m:1f). Egg deosition at T_3 was significantly ($p<0.05$) different than other treatments.

Table 8. Effects of sex ratio treatments on egg deposition of Zebra fish as per day

Treatment	Sex ratio	Number of eggs per day (Mean±SD)
T_1	1m:1f	2.6 ± 1.8^{a}
T_2	1m:2f	5.7 ± 1.0^{a}
T_3	1m:3f	24.6 ± 1.5^{c}
T_4	2m:1f	18.1 ± 1.1^{bc}
T_5	3m:1f	15.5 ± 1.3^{b}

Values are presented as mean ± SD. Different alphabet superscripts showed significant differences among treatments ($p<0.05$)

The egg deposition frequency of Zebra fish was varied with sex ratio and days dependant manner (Fig. 28). The highest mean number of eggs (62±3.01) was observed at T_3 (1m:3f) at the

1st day and the lowest (3±1.5) at T_1 (1m:1f) at the 2nd day (Fig. 28). Eggs collected from the T_3 (1m:3f) varied significantly ($p<0.05$) from the other treatments within days. Eggs were collected from the T_3 and T_4 on the daily basis whereas interruption of egg collection was observed at T_1, T_2 and T_5. Significant fluctuation of spawning was also observed in T_3 and T_4. On the other hand, mean number of eggs significantly reduced in T_1, T_2 and T_5 in the alternate day. In that day, the number of eggs was reduced to zero.

The egg deposition frequency of Zebra fish at different treatments was compared between 7 days and it presented in the Fig. 28.

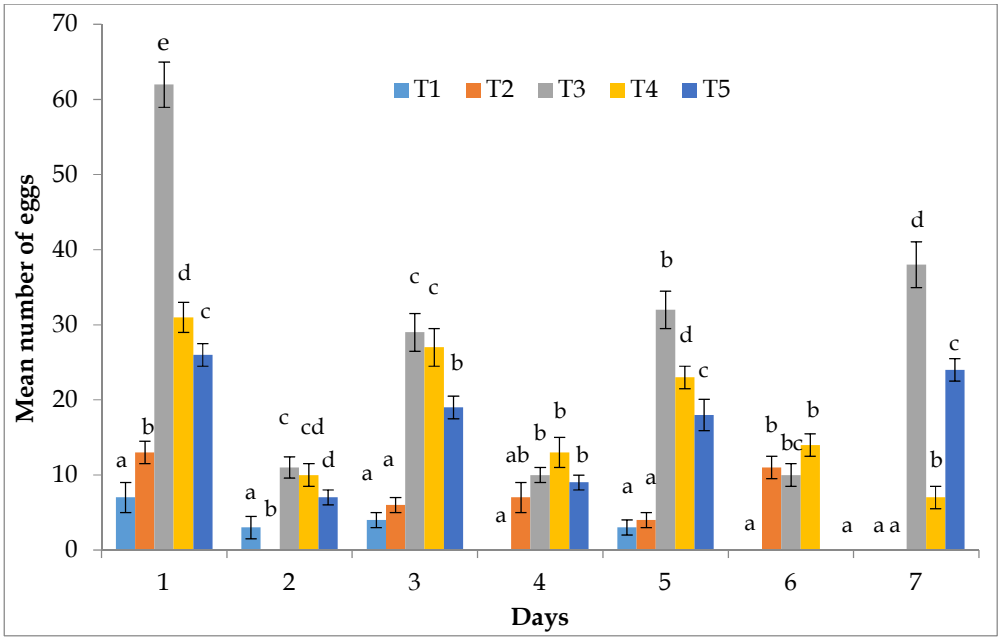


Fig 28. Frequency of egg deposition in different treatments at different days. Different alphabet superscripts showed significant differences among treatments ($p<0.05$)

Egg lay day interval of Zebra fish per week

The egg lay day interval of Zebra fish was recorded for 12 weeks. The interval was highest (4.9±.2) at 12th week and lowest (1.5±.2) at 1st week (Fig. 29). The egg lay day interval at 1st week ($p<0.05$) was significantly different than any other weeks.

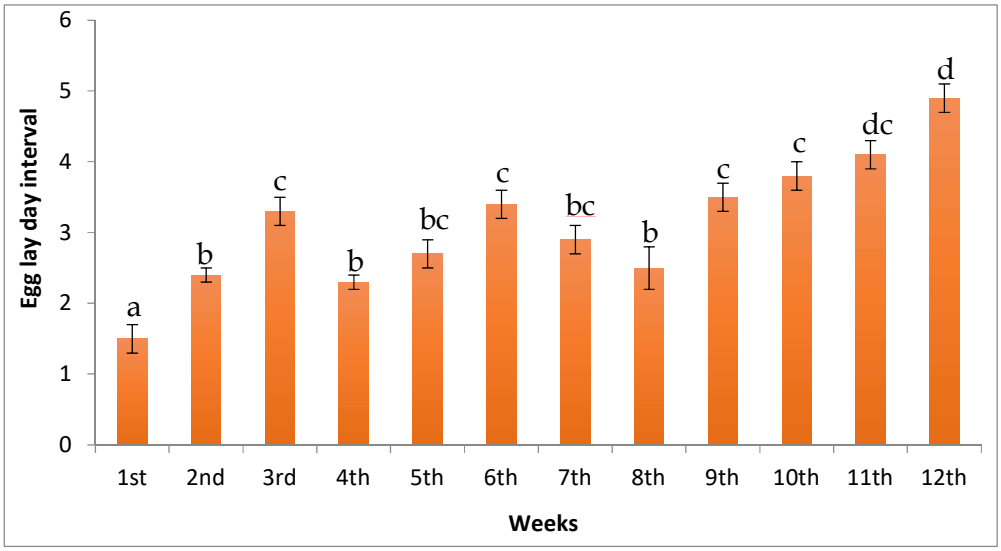


Fig. 29: Frequency of egg lay day interval of Zebra fish per week. Different alphabet superscripts showed significant differences among weeks ($p<0.05$)

Effects of sex ratio on egg lay day interval

The egg lay day interval was also varied among different sex ratio treatments. The spawning interval was highest 4.5 (±.26) at T_1 (1m:1f) and the lowest 1.9 (±.21) was observed at T_3 (1m:3f) (Fig. 30). The interval at T_3 was significantly ($p<0.05$) different from other treatments.

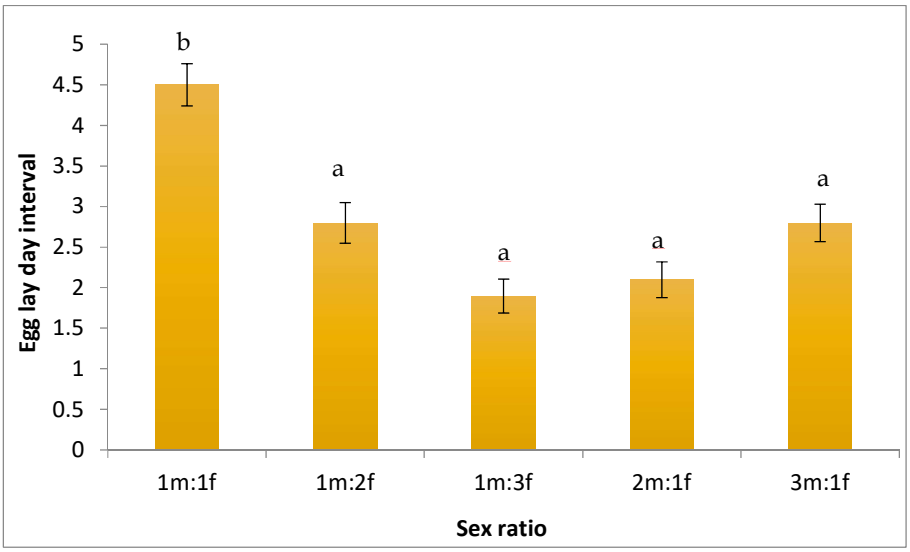


Fig 30. Frequency of egg lay day interval of Zebra fish in treatments. Different alphabet superscripts showed significant differences among treatments ($p<0.05$)

Effects of sex ratio on spawning success of Zebra fish at different water temperatures

The spawning of Zebra fish was observed at T_1 (1m:1f), T_2 (1m:2f), T_3 (1m:3f), T_4 (2m:1f) and T_5 (3m:1f) under different water temperature. The spawning of sex ratio treated ornamental Zebra fish also varied among different water temperature. The highest mean number of eggs (173±4.0) was observed at T_3 (1m:3f) when the average water temperature was 29°C and the lowest (8.7±2.5) was observed at T_5 (3m:1f) when the average water temperature was 21°C. On the other hand, the egg deposition significantly reduced to zero in T_1 (1m:1f) when the average water temperature was 21°C (Table 9). The mean number of eggs at 29°C was significantly ($p<0.05$) highest than other temperatures.

Table 9**:** Effects of different sex ratio on the spawning of Zebra fish as per water temperature

Treatment	Sex ratio (male:female)	Average water temperature (°C)								
		21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**
T_1	1:1	0^{a}	11 ± 2.6^{a}	17.7 ± 4.5^{a}	19.3 ± 3.1^{a}	20.7 ± 2.5^{a}	22 ± 4.2^{a}	22.3 ± 4.1^{a}	24.7 ± 4.1^{a}	32.3 ± 3.1^{a}
T_2	1:2	23.3 ± 2.5^{c}	25 ± 2.1^{b}	32.3 ± 3.5^{b}	37 ± 2.1^{b}	24.7 ± 3.5^{a}	19.3 ± 2.5^{a}	25.3 ± 4.1^{a}	43.6 ± 4.0^{b}	54.2 ± 3.5^{b}
T_3	1:3	14.3 ± 3.5^{c}	60.3 ± 3.5^{d}	33 ± 3.0^{b}	71.3 ± 3.3^{c}	61.3 ± 2.5^{b}	82.3 ± 3.0^{d}	65.3 ± 3.5^{d}	125.7 ± 4.1^{d}	173 ± 4.0^{e}
T_4	2:1	19 ± 2.0^{c}	64 ± 4.1^{d}	32.7 ± 2.5^{b}	44.7 ± 3.5^{b}	52 ± 4.0^{b}	72.7 ± 3.5^{c}	53.3 ± 3.5^{c}	118.6 ± 4.5^{d}	126 ± 5.0^{d}
T_5	3:1	8.7 ± 2.5^{b}	35 ± 3.0^{c}	13.3 ± 2.5^{a}	17.6 ± 2.5^{a}	55.3 ± 4.4^{b}	38.3 ± 3.5^{b}	34.3 ± 3.0^{b}	79 ± 3.2^{c}	106 ± 4.1^{c}

Values are presented as mean ± SD. Different alphabet superscripts showed significant differences among treatments within different temperatures ($p<0.05$)

The effect of temperature on the spawning success of Zebra fish was determined through the collection and counting of eggs from the aquaria. The mean number of eggs was found maximum at higher temperature and gradually decreased when the temperature was low. The highest mean number of eggs (430±10.5) was observed at 29°C and the lowest number (28±4.2) was found at 21°C. The mean number of eggs at 29°C was significantly ($p<0.05$) higher than other temperatures (Fig. 31).

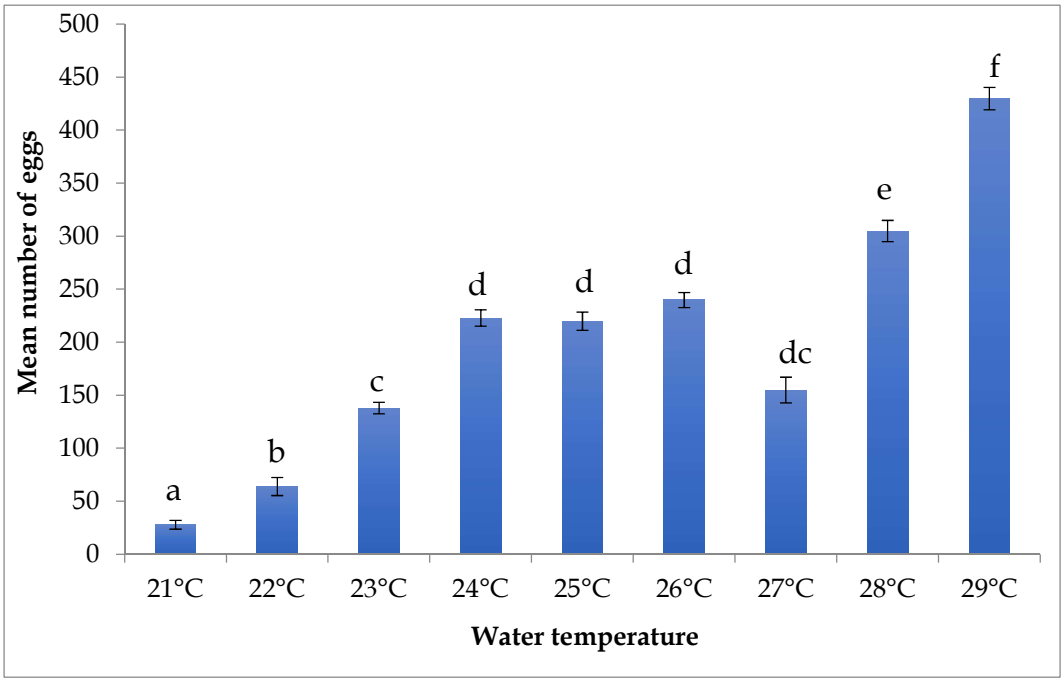


Fig. 31: Mean number of eggs spawned at different temperatures. Different alphabet superscripts showed significant differences among different temperatures ($p<0.05$)

Effects of different temperatures on egg lay day interval

The egg lay day interval of Zebra fish under different temperatures was recorded for 12 weeks. The spawning interval of Zebra fish also varied among different water temperatures (Fig. 32). The average interval between spawning at different temperatures was ranged from 1.6 days to 4.1 days. The average egg lay day interval was 4.1 days when the temperature was 21°C and interval reduced to 1.6 days when the temperature was increased to 29°C. The average spawning interval at 29°C significantly ($p<0.05$) varied at different temperatures.

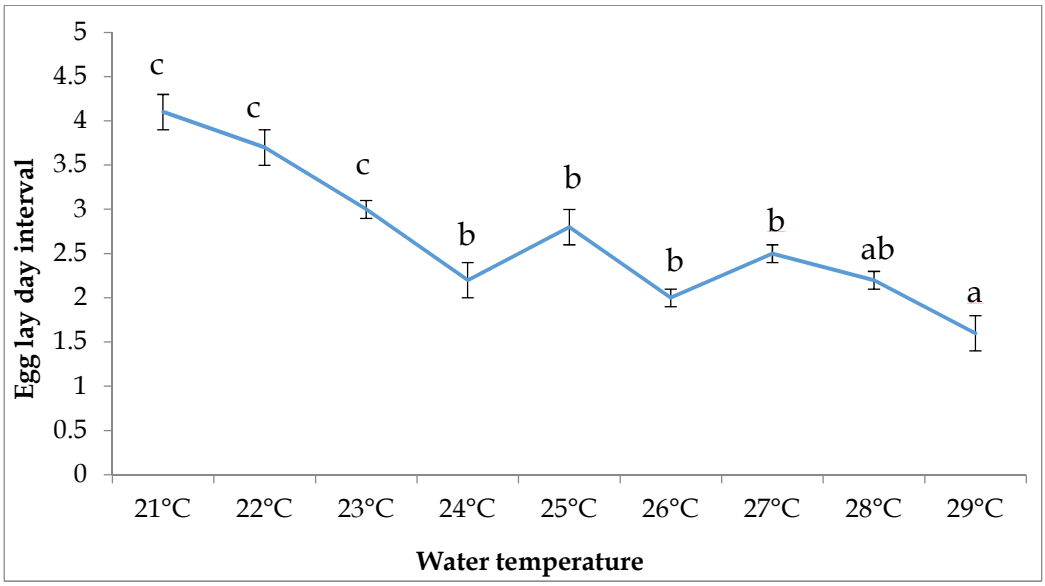


Fig. 32: Frequency of interval between spawning of Zebra fish left continuously together at different water temperatures. Different alphabet superscripts showed significant differences among temperatures ($p<0.05$)

Bangladesh is a riverine country endowed with vast aquatic resources. All these resources are enormous with variety of ornamental fish species. As our native ornamental fish, Zebra fish is an ideal model organism available in the upper reaches of rivers, floodplain, irrigation ditches and rice fields of Bangladesh. The demand of Zebra fish as an ornamental fish as well as a research model is increasing in laboratories worldwide. It is Zebra fish that has a huge business opportunity as a diversified sector. So, the guidelines for successful spawning in the laboratory settings may contribute to the elevation of Zebra fish production.

In the present study, naturally spawned fertilized eggs of wild type Zebra fish were collected from the glass aquaria, separated from the marbles, and transferred into a bowl for counting the eggs. Zebra fish successfully spawned in all treatments in the sex ratio trials. The sex ratio trials were designed to determine if a sex ratio exists that maximizes the spawning of Zebra fish in the laboratory settings.

In the present experiment, it was found that sex ratio has significant effect on the spawning of Zebra fish (*D. rerio)* in the laboratory settings. The spawning success was highest at T_3 (1m:3f) and the lowest at T_1 (1m:1f). When the sex ratio was female biased, egg production increased significantly compared to the equal sex ratio. Earlier study proves that sex ratio bias (1:2 female: males) had no effect on Zebra fish reproduction (Spence and Smith, 2005). Reproductive success in sand goby (*Pomatoschistus minutes*) were affected by changes in the sex ratio, males became less competitive for mates in a female-biased environment compared with a male-biased environment (3:6 male: female vs. 3:6 female: male sex ratio) (Kvarnemo *et al*., 1995). Male Guppies *Poecilia reticulata* received more responses to mating tactics (sigmoid displays, sneak attempts, and interference) from females at a sex ratio of 2:4 compared with 1:5 female:male (Jirotkul, 1999a). In wound fin *Plagopterus argentissimus* three different sex ratios (1:1, 1:3, 1:5; female:male) did not significantly affect fertilization success (Webb *et al*., 2017). Reproductive efficiency of Zebra fish in breeding tanks in one of three sex ratios (1 male:1 female; 3 males:1 female;1 male:3 females) did not differ among groups, but aggression (evaluated according to presence of shed scales) was more frequently observed in the male-dominated treatment group (Ruhl *et al*., 2005). This variation in results demonstrates the unique behaviors displayed by different fish species and several striking differences compared to previous studies, which may be due to differences in the fish (wild

versus domesticated), environmental conditions (tank size, population density, habitat complexity), or both. Like goby, the spawning success of Zebra fish was also affected by changes in sex ratio.

The present results showed that the egg deposition frequency of Zebra fish has also fluctuated on the daily basis. Sex ratio had significant effect on the spawning at different days, as eggs were collected from the female and male dominant treatment on the daily basis. On the other hand, interruption in the spawning was observed in the equal sex ratio (1m:1f) where spawning was reduced to zero. Zahangir *et al.* (2015) also found similar results in case of Zebra fish egg production due to pH.

In this study, another important observation was that sex ratio also has significant effect on the interval between egg lay days. The average egg lay day interval ranged from 1.9-4.5 days. The interval was found lowest at T_3 (1m:3f) where the average spawning interval was 1.9 days. In previous study, inter-spawning intervals ranged from 1-6 days, with a mean of 1.5 days, producing clutches ranging from 1 to over 700 eggs, with a mean of 185 (Spence and Smith, 2006). Zebra fish can be encouraged to breed throughout the year, with females spawning every one to two or three days, and all mature ova being released during a single hour (Matthews *et al.,* 2002). This interval is likely to be greater when the environment (water quality, diet, social situation, etc.) is sub-optimal or if the fish are used for production frequently.

Like previous study on Zebra fish, sex ratio has also played a worth role on the egg lay day interval per week. Zebra fish spawned more frequently at an interval of 1.5 days in the earlier weeks whereas twelve weeks later the interval increased to 4.9 days. It was previously reported that single pairs of Zebra fish (*Brachydanio rerio*) 12 months old, spawned at an interval of 1.9 days when the male and female were left continuously together. Three months later the spawning interval had increased to 2.7 days, suggesting that age is a factor in determining the spawning cycle (Eaton *et al*., 1974b). These similarities in results indicate that the egg lay day interval of Zebra fish significantly varies with sex ratio and age dependent manner.

The spawning success of Zebra fish in the laboratory settings was highest at T_3(1m:3f) when the average water temperature was 29°C. It was previously reported that water temperature during early life (from spawning up until after metamorphosis) has a drastic influence on the sex ratio of Zebra fish with male-biased populations produced at lower temperatures (22°C, 87.1% males) and female-biased ones at higher temperatures (31°C, 82.4% females) (Dimitris *et al*., 2012). The possible explanation for these results indicates that the spawning success may be related to both sex ratio and temperature.

Additionally, it was resulted from this experiment that water temperature has direct effect on the spawning of Zebra fish in the laboratory settings. The average water temperature for spawning was in the range of 21-29°C. There was significant difference in spawning among different water temperatures. The highest mean number of eggs was observed at 29°C and the lowest at 21°C. The mean number of eggs at 29°C was significantly higher than other temperature. The mean number of eggs was decreased with the decrease of water temperature. It was previously reported that an ideal temperature for both breeding and development of the embryos of Zebra fish is 28.5°C (Bilotta, 1999). Temperature range of 27-28.5°C is necessary for optimal breeding conditions. Temperatures below 25°C and above 30°C reduce the breeding capability of the fish and thus the numbers of embryos produced (Vargesson, 2007). Water temperature had significant ($p<0.01$) effect on egg production in case of monosex Nile Tilapia. Egg production decreased with the increase of water temperature. Maximum number of eggs was produced at 25°C and minimum number at 33°C (Faruk *et al.,* 2012). These results prove that water temperature plays an important role in fish spawning.

It was evident from the results that Zebra fish egg laid day interval exhibited fluctuations when eggs were collected from different water temperatures. The average interval between spawning at different temperatures was ranged from 1.6-4.1 days. The average egg lay day interval 1.6 days was observed at 29°C and prolonged to 4.1 days at 22°C. Previous study reported that Zebra fish exhibit a precise ovarian cycle of 5 days when maintained at 26°C. The females mate and lay eggs every 5 days. Although eggs may be obtained at any time from 5 to 45 days after the previous laying, the optimal period is from 5 to 10 days if viable eggs are desired. If

the temperature is increased to 29°C, the duration of the cycle is further reduced to 2 days. If the temperature is reduced to 22.5°C, egg-laying is inhibited (Hisoka *et al.*, 1962). These similarities in results indicate that Zebra fish may be spawned more frequently when maintained at higher temperature.

11.3 Breeding of Gold fish (*Carassius auratus*) in tanks

Breeding behavior of Gold fish in the breeding tank

Courtship behavior was observed in both male and female fish by Samsung galaxy camera (13 mega pixel) in the laboratory condition. The colors of the fishes improve, and even the most sluggish of fish became extremely active. Males followed the female touching it frequently. A special behaviour was noticed in males to attract the female for courtship by encircling the female in order to retain her in a given area. The excited male came closer to the female, but the female remained quite passive moving gracefully avoiding the approaching male. But the active male chased the female and frequently touched the head of the female also. After a day or two of aimless chasing, the spawning drive begins in earnest. The drive consists of the males pursuing the females to and fro across the tank. The drive, which continued for about two or three hours, until the female was stripped of eggs, was an attempt on the part of the male to bump the abdomen of the females. Finally, the female sink to the bottom of the tank. By means of his snout the male lift the female until she was on top of the plants and all most out of the water. It was now that the eggs were released. They were released in batches and each batch was immediately fertilized by male (Fig. 33).

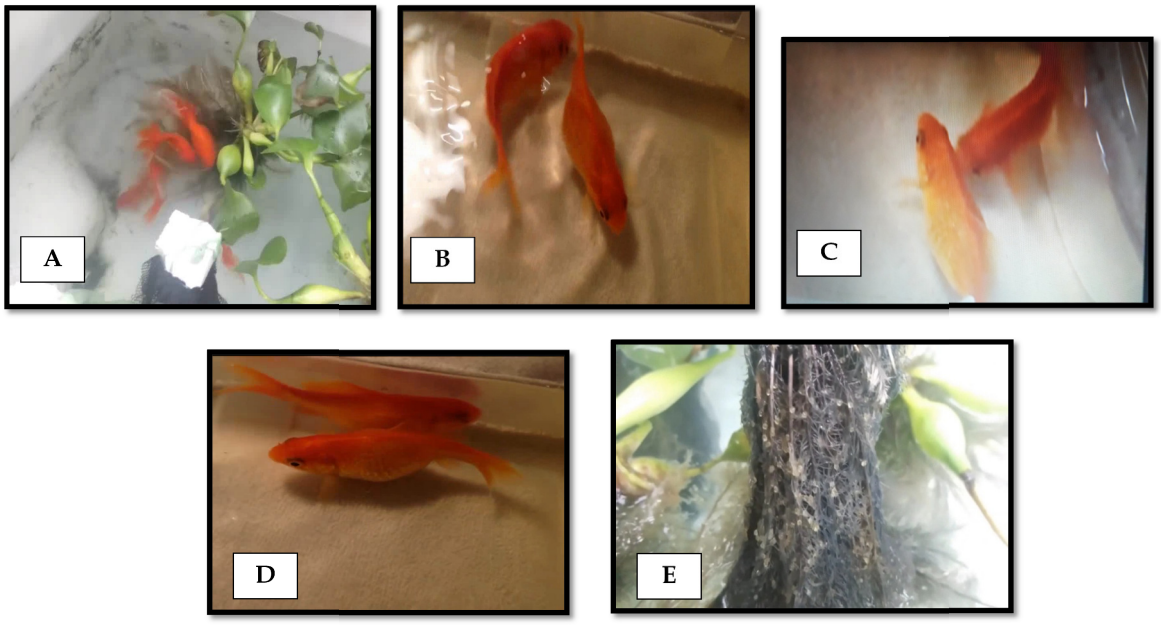


Fig. 33. Photographs showing breeding behavior of Goldfish; male chasing the female (A), courtship behavior (B), male touching the head of female (C), male hitting vent of female (D) and adhesive eggs (E)

After spawning the male and female remained calm in one corner of the tank and did not show any signs of hostility when the eggs were collected. Goldfish was not good parents and unless they were separated from the eggs they begin to eat the eggs.

Effect of temperature on Goldfish breeding

The effect of temperature on egg production of Goldfish was determined through the collection of eggs and counting them. Egg production was found higher at lower temperature and gradually decreased with the increase of temperature. There was significant difference among different water temperatures for egg production. All numbers of eggs (1750) were observed at 22-23°C. The mean number of eggs at 22-23°C was significantly ($p<0.05$) higher than other temperatures (Fig. 34**)**.

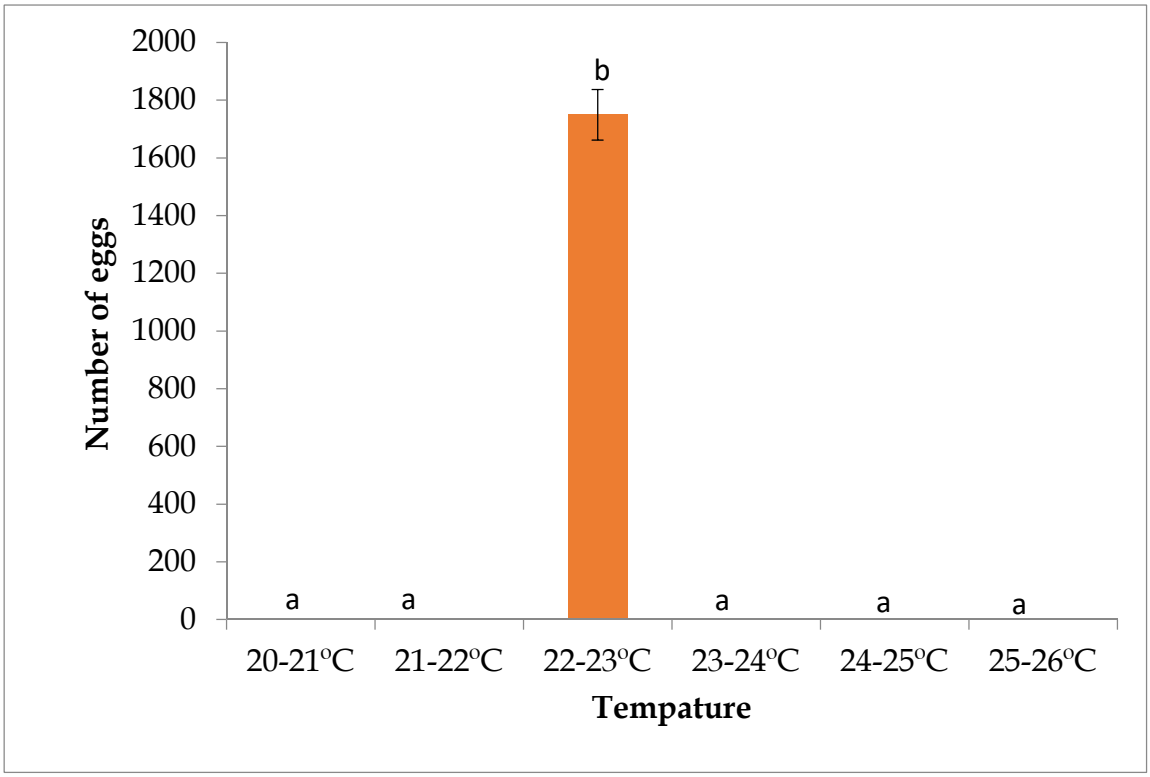


Fig 34. Effect of water temperature on the breeding of Goldfish. Different superscripts of letters showed significant differences ($p<0.05$)

Effect of pH on Goldfish breeding

The highest pH value was observed in treatment T_2 and the lowest pH value was observed in treatment T_1. The mean values of water pH were 7.14±0.08 in T_1, 7.24 ±0.07 in T_2, 7.17±0.14 in T_3, 7.18±0.08 in T_4 and 7.2±0.02 in T_5, respectively (Fig. 35). There was no significant difference ($p<0.05$) among treatments.

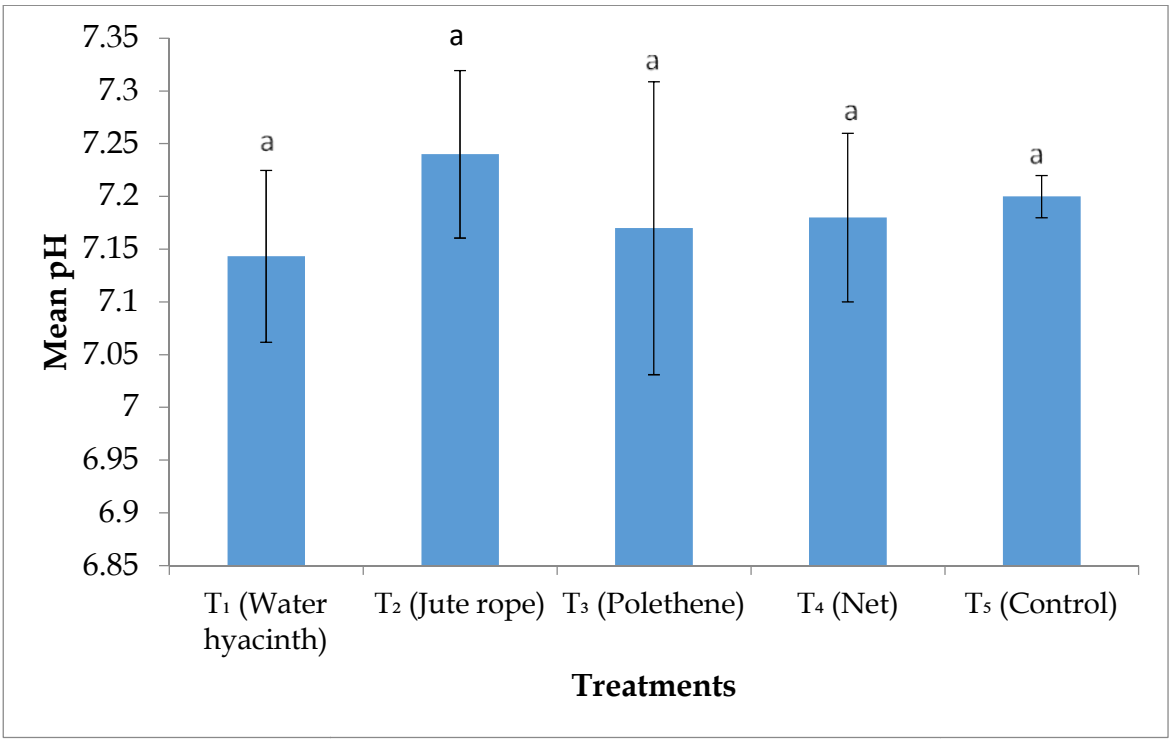


Fig. 35. Effect of pH in different treatments on the breeding of Goldfish. Different superscripts of letters showed significant differences ($p<0.05$)

Effect of dissolved oxygen on Goldfish breeding

Oxygen was an important factor in respiration and metabolism processes in any animal. Dissolved oxygen was varied in all treatments. Dissolved oxygen was dropped in T_1 compared to other treatments (Fig. 36). The ranges of oxygen concentrations in different treatments were from 5.65 to 6.226667 mgL^{-1} with the highest (6.22 mgL^{-1}) value in T_5 and the lowest (5.65 mgL^{-1}) in T_1. The mean values of dissolved oxygen concentration in T_1, T_2, T_3, T_4, and T_5 were 5.65, 6.02, 5.95, 5.00 and 6.22, respectively (Fig. 36). The mean number of dissolved oxygen in treatment T_5 was significantly ($p<0.05$) higher than other treatments.

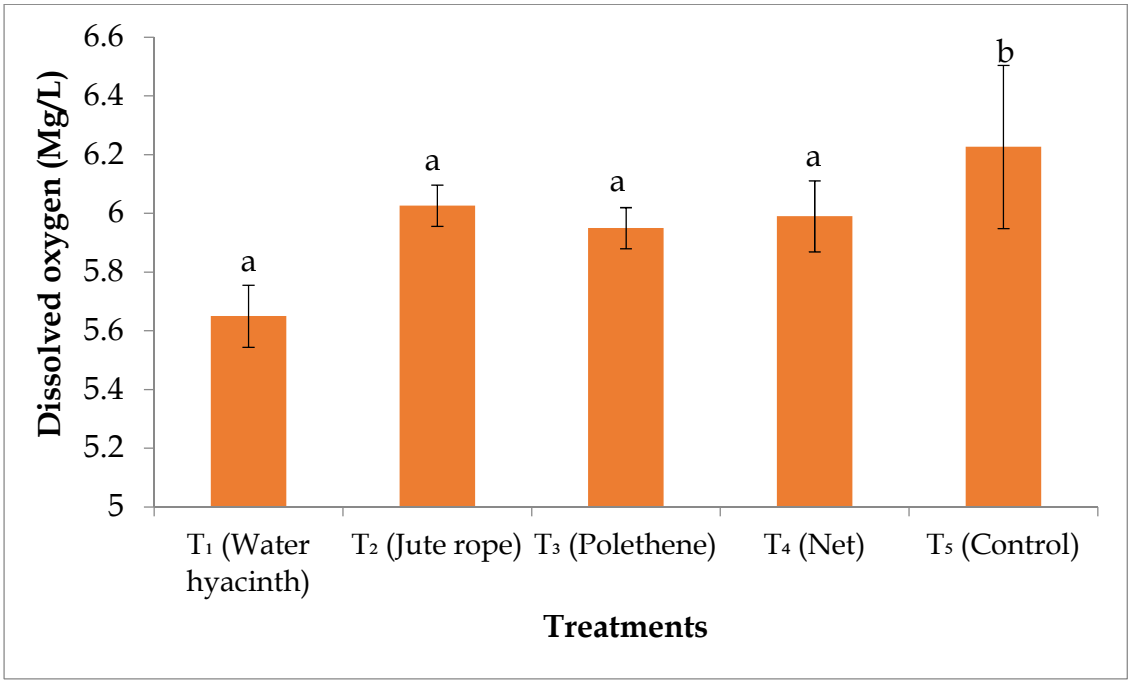


Fig 36. Effect of dissolved oxygen on the breeding of Goldfish in different treatments. Different superscripts of letters showed significant differences ($p<0.05$)

Effect of different substrates on the ovulation of Goldfish

Spontaneous ovulation in Goldfish was synchronized with photoperiod and influenced by water temperature and substrates. Goldfish kept in water without substrate (T_5) do not ovulate. The mean numbers of eggs were observed as 148.66±18.03, 231.66±17.55, 356.66±40.41, 146.33±22.72 and 0±0 in treatments T_1, T_2, T_3, T_4, and T_5, respectively. The highest number of eggs was recorded in treatment T_3 and no egg was recorded in treatment T_5 (Fig. 37 and 38). Substrates may be an effective stimulus for ovulation in carps. The mean number of eggs in treatment T_3 was significantly ($p<0.05$) higher than other treatments.

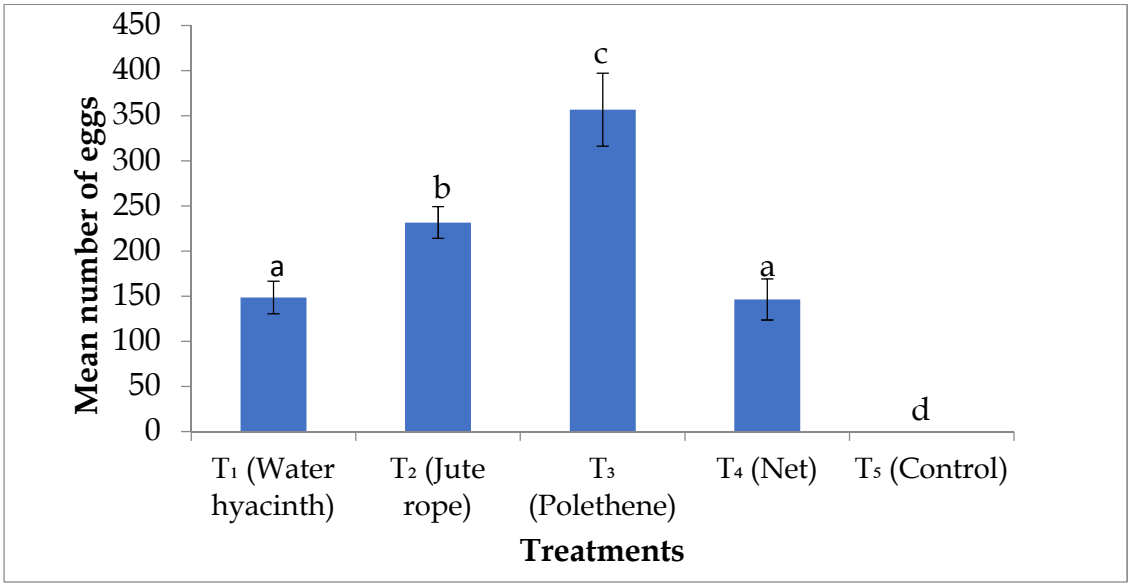


Fig. 37: Effect of substrates on the egg production of Goldfish. Different superscripts of letters showed significant differences ($p<0.05$)

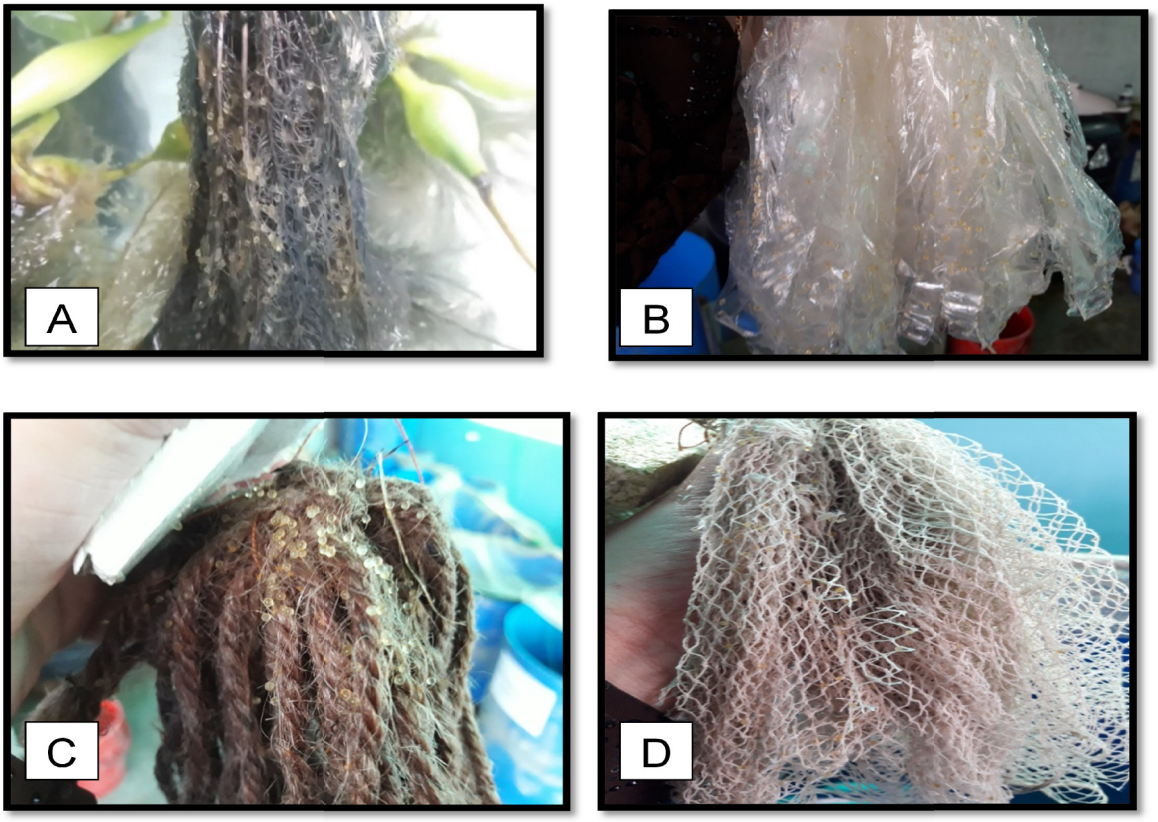


Fig. 38: Photographs showing different types of substrates with adhesive eggs; water hyacinth (A), Jute rope (B), polythene (C) and Net (D)

Effect of substrates on fertilization rate

Fertilization in Goldfish was also stimulated by substrate. There were five treatments as T_1, T_2, T_3, T_4, and T_5 to determining the fertilization rate of egg. The highest number of fertilized eggs was recorded in treatment T_3 and the lowest was recorded in treatment T_1 (Fig. 39) and no fertilization in control. Exposure to substrate for treatments T_1, T_2, T_3, and T_4 significantly increases the ovulation so that fertilization was occurred in these treatments. Goldfish kept in water without substrate (T_5) did not ovulate; as a result fertilization was not occurred in treatment T_5.The mean numbers of fertilized eggs were observed as 107.33±11.01, 202.66±14.18, 323±43.26 and 123.33±17.55 in treatments T_1, T_2, T_3 andT4, respectively.

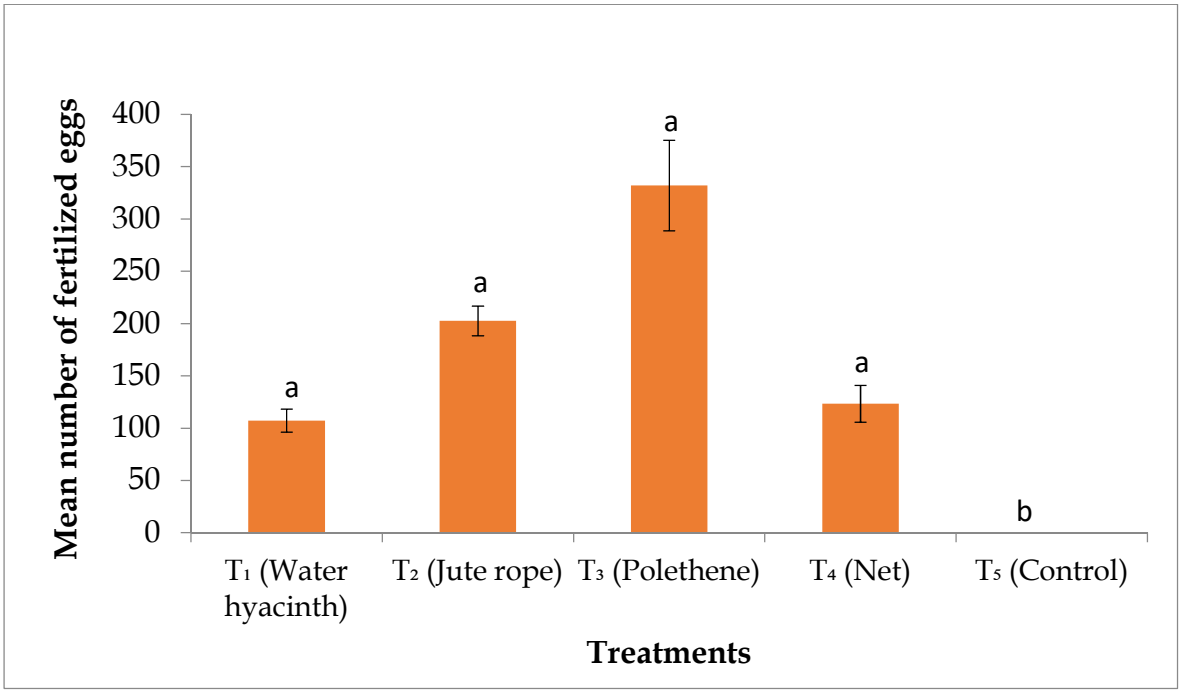


Fig. 39 Effect of substrates on fertilized eggs in different treatments. Different superscripts of letters showed significant differences ($p<0.05$)

The fertilization rates of eggs were found 72.47, 87.52, 93 and 84.41 in corresponding substrates - water hyacinth, jute rope, polythene and net. The mean fertilization rates (%) were observed as 72.47±8.0.05, 87.52±0.00, 484, 93±10.01 and 84.41±0.01 in treatments T_1, T_2, T_3, and T_4, respectively. The highest fertilization rate was recorded in treatment T_3 and the lowest was recorded in treatment T_1 **(**Fig. 40). The mean number of fertilization rate in treatment T_3 was significantly ($p<0.05$) higher than other treatments.

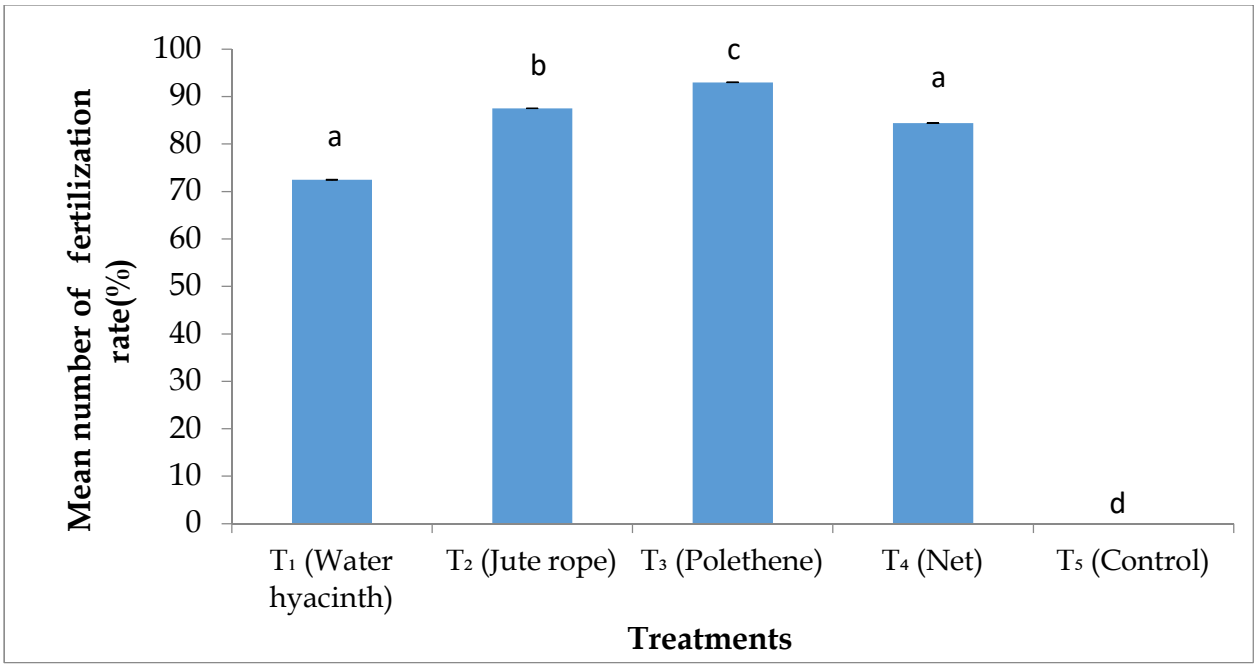


Fig. 40. Effect of different substrates on fertilization rate in different treatments. Different superscripts of letters showed significant differences ($p<0.05$)

Effect of substrates on hatching rate

Substrates were regarded as natural factor which influence the hatching rate. The mean hatching rates (%) were observed as 85.37±0.10, 95±0.04, 95.01±0.10 and 91±0.04 in treatment T_1, T_2, T_3 and T_4, respectively. The highest hatching rate was recorded in treatment T_3 **(**Fig. 41). But the mean number of hatching rate was not significantly ($p<0.05$) different among treatments.

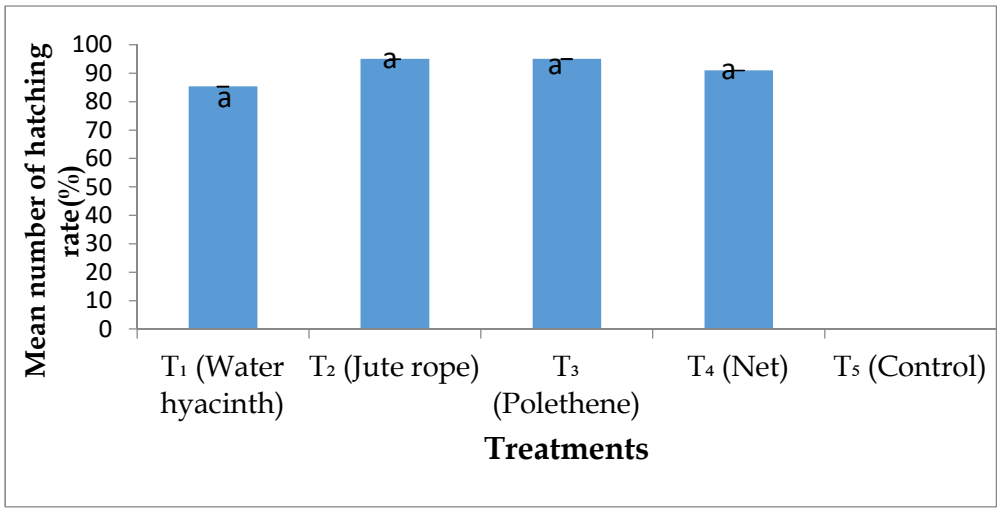


Fig. 41. Effect of substrates on hatching rate in different treatments. Different superscripts of letters showed no significant differences among treatments in concentrations ($p<0.05$).

In the present study breeding was set into plastic drum after adding the substrate. Substrates were introduced into the plastic drum for hiding purposes and also for holding the adhesive eggs. The courtship behaviour had been shown by the breeders at the bottom of the breeding tank. After the first impulse of excitement, the males made advancement towards the female. Both the males showed participatory behaviour. Males followed the female touching it frequently. A special behaviour was noticed in males to attract the female for courtship by encircling the female in order to retain her in a given area. After the female was tired out and released her eggs. She was released hundreds of eggs, with some sources claiming thousands. Like all cyprinids, Goldfish eggs are sticky and adhere to substrates. After the eggs were attached, the male was released milt over the eggs and fertilizing them. The eggs were then hatch in 48-72 hours. Richardson (1995), has been worked on biological impacts of an exotic fish *Carassius auratus*, introduced into shallow seasonally anoxic ponds and observed same breeding behaviour. Haniffa *et al.* (2007) observed breeding behaviour of koi carp which was more or less similar to the present study. Breeding usually happens after a significant change in temperature. Goldfish are prolific breeder and are bred commercially for sale to pet shops throughout the world and in Bangladesh as well.

The present study indicates that water temperature had direct effect on the breeding of Goldfish in the laboratory settings. The average water temperature range for ovulation was at 22-23°C. There was significant difference in ovulation among different water temperature. All the eggs were observed at 22-23°C temperature. The mean number of eggs at 22-23°C was significantly higher than other temperature. Water temperature plays an important role in the spawning of Goldfish. Egg productions were decreased with the increase of water temperature. It was previously reported that an ideal temperature for both breeding and development of the Goldfish embryos is 12-26°C (Stacey et al., 1979). Water temperature had significant ($p<0.05$) effect on ovulation. The findings of the present study were more or less similar to Cooper (2006), who stated that the water temperature ranged between 22 ºC to 29 ºC was for the rearing of gold fish fry. Ortega-salas and Royes-Bustamante (2006) observed that suitable temperatures for aquatic animal productions were 21 ºC to 30 ºC.

Maximum numbers of eggs were produced by Zebra fish at 25°C and minimum number at 33°C (Faruk *et al.,* 2012).This variation of temperature occurs due to bright sunlight and hot weather.

Goldfish was seemed to enjoy a mildly alkaline pH of 7.2-7.6. They were just fine in pH well outside of this range, as long as it remains stable. As with most fish, Goldfish were not able to well in fluctuating pH. The present study indicates that pH had direct effect on the breeding of Goldfish in the laboratory settings. From the present study the average pH for spawning was in the range of 7.14-7.24. There was significant difference in spawning among different water pH. The highest numbers of eggs were observed at pH 7.24 and the lowest numbers of eggs were observed at pH 7.14. The mean number of eggs at pH 7.24 was significantly higher than other pH. The pH has an important role in the ovulation of Goldfish. Egg productions were decreased with the decrease of water pH. The pH was regarded one of the important chemical factors that effect on some developmental stages of fish, especially on the larval stages. The results of the present study are more or less similar to the findings of Cooper (2006). He has been reared gold fish successfully in pH ranges among 6.0 to 8.3 in different types of filter system. Islam (2007) has reported that the suitable ranges of pH for carp fish culture are 6.8 to 8.27. Mahmud (2011) has observed that pH ranges from 7.2 to 7.4 are suitable for induced breeding, embryonic and larval development of comet Goldfish (*Carassius auratus).*Gao *et al.* (2011) has examined the survival, fertilization, hatching times, and hatching rates of Far Eastern catfish *Silurus asotus* at pH ranging from 2 to 13 under laboratory conditions. Eggs could be fertilized at pH 3-12. Hatching only occurred at pH 4-10, with the highest hatching rate at pH 7 (52%) and the lowest at pH 10 (24%).

The gases which were found in natural water the most important and critical one was oxygen. From the present study the average ranges of oxygen concentration in different treatments (T_1 -T_5) were from 5.65 to 6.23mg/L with the highest (6.23mg/L) value in T_5 and the lowest (5.65 mg/L) in T_1. The amount of dissolved oxygen was high in control treatment without substrate. Due to the lacking of substrate fish did not ovulate. As a result the rate of dissolved oxygen consumption is comparatively lower. The amount of dissolved oxygen was low in water hyacinth treatment because water hyacinth was consumed dissolved oxygen. It was necessary to maintain the continuous dissolved oxygen at optimum levels of above 4 to 8 mg/L according to Boyd (1998). Hossain (2007) has recorded that dissolved oxygen ranges from 5.1-8.7 mg/L are suitable for embryonic and larval development of Thai pangas. From the present result suggested that 5.65-6.23 mg/L are suitable for gold fish breeding.

Present study has demonstrated that substrate may have effect on the spawning of gold fish. Female Goldfish was ovulated spontaneously in contact of substrate. Goldfish produce adhesive eggs which are released and adhere to the floating and submerged substrate. The highest numbers of eggs were recorded in polythene substrate. In control treatment, the females were not showing any breeding behavior because there was no substrate even though sexually active males were present. It may be inhibition of breeding performance without substrate. The result of the present study found that substrate may serves both as a spawning substrate and as an essential cue for spawning behavior. The mean number of eggs in treatment T_3 was significantly ($p<0.05$) higher than other treatments. Yamamoto (1966), stated that ovulation in Goldfish was stimulated by aquatic vegetation. Stacey (1979), reported that spontaneous ovulation in Goldfish was synchronized with photoperiod and influenced by water temperature and aquatic vegetation. Few sexually mature females kept under long photoperiod (16L8D) and when transferred from cold (13±1ºC***)*** to warm (21±1ºC***)*** water they ovulated spontaneously. Exposure to artificial aquatic vegetation for as little as one light phase significantly increases the proportion of fish ovulating in warm water. Fish kept in cold water without vegetation do not ovulate; the addition of vegetation induces ovulation, Aquatic vegetation may be an effective stimulus for ovulation in fish which spawn on this vegetation. Haniffa *et al.* (2007) used substrate in the breeding of koi carp in which substrate was introduced into the breeding tank for hiding purpose as well as holding the adhesive eggs. Our study also has showed that not only aquatic vegetation (water hyacinth substrate) but also artificially made vegetation (substrates) may affect spawning and egg lying. Polythene substrate showed better result than water

hyacinth. It may be the transparent colour of polythene which may serve as concealment of eggs. Therefore female lay as large number of eggs. The off-white colour jute rope substrate also triggered ovulation more or less similar to polythene.

The present study indicates that substrate had direct effect on the breeding of Goldfish. There were five treatments for determination of the fertilization rate of eggs. The fertilization rate of eggs were found by the present works were 72.47, 87.52, 93 and 84.41% in corresponding substrate water hyacinth, jute rope, polythene and net. In treatment T_5, the females were not showing any breeding behavior because there was no substrate. The highest fertilization rate was recorded in transparent polythene substrate. The hatching rate of eggs found by the present works were 85.37%, 95%, 95.01% and 91% in corresponding substrate water hyacinth, jute rope, polythene and net. The highest hatching rate was also recorded in transparent polythene substrate. Off-white colour jute rope gave the 2nd highest fertilization and hatching rate. Rahaman *et al.* (2011) observed embryonic and larval development stages of Comet gold fish (*Carassius auratus*) in mature males and females by administering hormone of double dose in female and a single dose in male by intramuscular injection of ovaprim at a dosage of 0.5, 0.7, 1.0 and 1.2 ml/kg body weight. Spawning was observed six hours after the injection at ambient temperature (18-22 ºC). Fertilization rate of eggs were found 50.34, 51.47, 47.30 and 48.24 % respectively with the response of 0.5, 0.7, 1.0 and 1.2 ml/kg of ovaprim. Hatching rates were found 44.35, 43.79, 39.83 and 36.00 % respectively with the same doses. The present study suggested that substrates may facilitate the fertilization and hatching of gold fish.

The ornamental fish sector is a widespread and global component of international trade, fisheries, aquaculture and development. However, the scope of this sector is vast in our country, but we cannot go ahead because of unconsciousness, lack of knowledge, lack of breeding techniques for ornamental fishes, lack of care of government and nongovernment institutions. This sector should be given priority with extra care because it may earn a lot of foreign exchange every year by exporting the native ornamental fishes that still unused in our country. In the event of economic growth all over the world, stress has become evident among all people. In order to get relived from stress, everyone has cultivated the habit of hobby as part and parcel of their way of life. It is understood that the hobby of mainly aquarium has been in practices in developed countries very well. However, this has been adopted in developing countries in the initial stage. In this context, it is imperative to see a problem in setting up business support as well as develop the market with suitable marketing strategies. It is true that there are problems reported in the maintenance of health of fish as well as reacting customers with modern equipment.

12. Research highlight/findings:

1. Baseline information on the present status of ornamental fish trade in Bangladesh
2. Development of the Zebra fish breeding technique in the laboratory settings
3. Development of the Goldfish breeding technique in the backyard hatchery

B. Implementation Position

1. Procurement:

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
(i) **Office equipment** a) Executive Table, b) Executive Chair, c) Visitor/Front Chair d) Bicycle	01, 01, 02, 02	**68000** 20000 10000 8000 30000	01, 01, 02, 02	**68000** 20000 10000 8000 30000	Achieved 100%
(ii) Computer and accessories a) Laptop b) Printer c) Scanner d) Digital camera	One each	**115000** 60000 20000 10000 25000	One each	**115000** 60000 20000 10000 25000	
Lab &field equipments i) Microscope with camera, electric balance ii) different types of glass aquarium, thermostat, glass and Plastic wears, pipette, tips etc. iii) Aquarium iv) Water pump v) Aerator	01, 01 20 02 02 Lump sum 30 02 01	**400000** 350000 50000 **200000** 100000 40000 20000 20000 20000 240000 50000 100000	01, 01 20 02 02 Lump sum 30 02 01	**400000** 350000 50000 **200000** 100000 40000 20000 20000 20000 240000 50000 100000	Achieved 100%
(c) Other capital items					

2. Establishment/renovation facilities:

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	
Construction of cemented cisterns	200000	Completed			
Pond construction and repair	250000	Completed			
Construction of overhead shed	400000	Completed			

3. Training/study tour/ seminar/workshop/conference organized:

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training					
(b) Workshop	35	15	50	1 D	Workshop on present status and future prospects for trading of ornamental fish
(c) Seminar	35	15	88	1 D	Same

C. Financial and physical progress

Fig in Tk

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
A. Contractual staff salary	406575	406576	370260	36316	90	Delayed disbursement of money from BAURES as well as from PIU-BARC, NATP
B. Field research/lab expenses and supplies	2510,425	2417903	2444613	-26710	-	
C. Operating expenses	350,000	341363	308017	33346	90	
D. Vehicle hire and fuel, oil & maintenance	200,000	200000	200000	0	100	
E. Training/workshop/seminar etc.	150,000	142500	42500	100000	30	
F. Publications and printing	150,000	70613	14250	56363	20	
G. Miscellaneous	150,000	33229	148510	-115281	-	
H. Capital expenses	583,000	617421	571228	46193	90	

D. Achievement of Sub-project by objectives: (Tangible form)

Specific objectives of the sub-project	**Major technical activities performed in respect of the set objectives**	**Output(i.e. product obtained, visible, measurable)**	**Outcome(short term effect of the research)**
a) Survey on present knowledge of ornamental fish trade in Bangladesh	Questionnaire survey to acquire the baseline information about the status of ornamental fish trade in Bangladesh, customers preference, their level of knowledge and needs conducted	Survey report, periodical reports, PCR, financial statements, bill and vouchers, best practice guideline	Best practiced guidelines for aquarium fish traders and fish pet communities developed

b) Development of breeding (induced/natural) techniques of some commercially important ornamental fishes.	4. Study on the development of the Zebra fish breeding technique in the laboratory settings 5. Study on the development of the Goldfish breeding technique in the backyard condition	Half yearly, annual reports, breeding photographs, photographs of fish fry, PCR, etc.	Breeding techniques of the Zebra fish and Goldfish in the laboratory or back yard conditions are developed
c) Develop a design for promoting ornamental fish business.	Questionnaire analysis and set a strategic ornamental fish business plan	Leaflet, PCR	Practice guidelines for the hatchery owners and unemployed youth

E. Materials Development/Publication made under the Sub-project:

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet/leaflet/flyer etc.	**1**		Substrate preference for the natural breeding of Goldfish in the backyard hatchery **(In Bengali)**
Journal publication	1		Substrate preference for the natural breeding of Goldfish in the backyard hatchery**.**
Information development			
Other publications, if any (**Thesis**)	4		1. Ornamental fish business in Bangladesh: Present status and future trends 2. Development of spawning technique of a popular ornamental fish, Zebra fish (*Danio rerio*) in the laboratory settings 3. Study of the substrate preference for the natural breeding of Goldfish in the backyard hatchery 4. Development of an induced breeding technique of a popular Blue gourami (*T. trichopterus*)

F. Technology/Knowledge generation/Policy Support (as applied):

i. Generation of technology (Commodity & Non-commodity)

Developed a breeding technique of the Zebra fish and Goldfish in the laboratory conditions

ii. **Generation of new knowledge that help in developing more technology in future**

Base line information of the ornamental fish trading in Bangladesh

iii. Technology transferred that help increased agricultural productivity and farmers' income

In house breeding technique of the Zebra fish and Goldfish

iv. Policy Support

Strategic plan to promote ornamental fish trading in Bangladesh

G. Information regarding Desk and Field Monitoring

i) Desk Monitoring (description & output of consultation meeting, monitoring workshops/seminars etc.):

a) Workshop on mid-term review of research progress under CRG support, fisheries division, BARC, 10-11 April 2018.
b) Annual review workshop on CRG sub-projects of fisheries division, BARC, 19-20 September 2018.

ii) Field Monitoring (time& No. of visit, Team visit and output):

a) Field monitoring - by the Monitoring team of PIU-BARC, NATP-2 dated on 7 March 2018 at BAURES and research laboratory of Fisheries Biology & Genetics, BAU. The team expressed satisfaction on the research output.

H. Lesson Learned(if any)

i) There are huge opportunities for research & development on breeding, culture and entrepreneurship for ornamental fish (both indigenous and exotic).

I. Challenges (if any)

Research challenges

i) Gathering correct information from the interviewees.

Signature of the Principal Investigator

Date …31/12/2018

Seal

Counter signature of the Head of the organization/authorized representative

Date 31/12/2018

Seal

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K. Appendix 1: Questionnaire on

Present status of ornamental fish trade in Bangladesh, consumers preference, ornamental fish hatchery, culture system, marketing, disease and health care of ornamental fish, threats and weakness of ornamental fish business and livelihood of the ornamental fish seller etc.

Name of shop: Establishment year:
Name of owner:
Location: Address: Mobile no:

A. Information of Ornamental fish:

1.	What are you know about ornamental fish?	
2.	Which ornamental fish species are found in your shop?	
3.	Who supplied Ornamental fish to you?	
4.	How many indigenous ornamental fishes are found in your shop?	
5.	How many exotic ornamental fishes are found in your shop?	
6.	From where the ornamental fishes are brought?	

B. Information on Business:

1. What are the ornamental fish species (including their price and origin) do you sell?

S/L	Name of the species	Origin		Source			Price (tk. Per fish)
		Indigenous	Exotic (country)	FW	MW	BW	
1							
2							
3							

2. What are the non-fish species (including their price and origin) do you sell?

S/L	Name of the species	Origin		Source			Price (tk. Per piece)
		Indigenous	Exotic (country)	FW	MW	BW	
1							
2							

3. Do you sell accessories related to ornamental fish?

Yes	No

If yes, then what are they including their price?

S/L	Name of the accessory	Source		Price (tk. Per piece)
		Local	Exported (country)	
1				
2				

4. Do you sell feeds that are fed to the ornamental fish/non-fish species?
If yes, then what are the name, brand and price of those feed?

Yes	No

S/L	Name of the feed	Company/Brand	Source		Price (tk. kg)
			Local	Imported (country)	
1					
2					

5. Will you tell about the buying prices of the species that you sell?

S/L	Name of the species	Price
1		
2		

C. Consumer preferences in the domestic ornamental fish market:

1. Which fishes are more preferable to the consumers?

S/L	Name of the fish species	S/L	Name of the non-fish species
1		1	
2		2	

2. Which fishes are sold mostly?

S/L	Name of the fish species
1	
2	

3. What type of aquarium is chosen mostly by the consumer?

4. Who are the main customers of your shop?

	Male	Female
Age		

numbers		

(If) you are a whole seller to whom do you sell?

S/L	Fish shop	Middlemen
1		
2		
3		

5. What are purposes of buying do you know?

S/L	Purposes	Amount of selling
1	For office decoration	
2	For house decoration	
3	For keeping as pet	
4	For gift	
5	Unknown	

D. Ornamental fish hatchery:

1.	In which places of Bangladesh ornamental fish hatchery are found?	
2.	Where from broods are collected by the hatchery manager?	
3.	What is the operational management of an ornamental fish hatchery?	
4.	What types of inducing agents are used in breeding?	
5.	What are the number of ornamental fishes which artificial breeding is successful?	
6.	How many fish are showing secondary sexual characteristics?	
7.	What is the hatching rate of different ornamental fishes?	
8.	What is the rate of seed production per year?	

E. Ornamental fish culture system:

1.	In which place of Bangladesh ornamental fish culture is done?	
2.	What is the condition needed for the ornamental fish culture?	
3.	What kinds of environment are needed for aquarium fish?	
4.	Where from fish seeds are collected by the farmer?	
5.	Which fishes are more preferable to the farmer for ornamental fish culture?	
6.	Do you prepare your aquarium before releasing fry? Y/N	
7.	If yes, what is procedure?	
8.	What is the duration of culture period?	
9.	Did you treat your fish before releasing in your aquarium? Y/N	

10.	If yes, what chemicals and doses do you use?	
11.	What kinds of aerator are used by you for your aquarium?	
12.	Is there any necessity to change the water?	
13.	Is there used any chemical in water?	
14.	What are the feeding methods used by you?	
15.	What is the feeding frequency in a day?	
16.	Is there used any balanced diet? Y/N	
17.	If yes, What is the proximate composition of this diet?	
18.	What types of problem you faced during culture?	
19.	Have you used water treatment system?	

F. Ornamental fish markets/ store:

1.	Where is the ornamental fish market in Bangladesh?	
2.	Which one is the biggest market for ornamental fish in Bangladesh?	
3.	How much ornamental fish stores are available in Mymensingh district?	
4.	In which places of Bangladesh ornamental fish retail and wholesale market are found?	

G. Operating of ornamental fish store:

1.	When your store is opened and closed?	
2.	How much time is the average operating time of an ornamental fish store?	
3.	How many labors are works in your store?	
4.	What types of water are used by you for fish store?	
5.	Do you use any natural food? Y/N	
6.	If yes, What are the natural foods you used?	
7.	Do you use any pellet feed? Y/N	
8.	If yes, What types pellet feed are used by you?	
9.	Is there any necessity to use submerged plant in the ornamental fish store?	
10.	What type of submerged plant is used here?	
11.	What types of tank are used to store ornamental fish?	
12.	What types of equipment are needed to establish ornamental fish store?	
13.	What are the costs to buy equipments?	
14.	What is the total cost for establishing an ornamental fish store?	
15.	What is the profit per year to operate an ornamental fish store?	
16.	How much capital is needed for operating a pet shop?	

17...What is the peak season of your business?

……

……

H. Ornamental fish marketing channel:

1. What are sources of the indigenous species that you are selling?

From hatcheries (name)		From whole seller			
		Local		From other district	
1		1		1	

2		2		2	
3		3		3	

2. Do you import exotic species?

Yes	No

If yes, then where do you supply those ornamental species?

S/L	Name of the stores/shop	District
1		
2		
3		
4		
5		

If no, then what is the source of exotic species that you are selling?

S/L	From local whole seller (name and address)	Direct from importer (name of the company)
1		
2		

3. Is there any stakeholder found in ornamental fish distribution channel?

I. Source, type and composition of ornamental fish feed:

1.	In which place of Bangladesh fish feed are collected?	
2.	What types of feed are used?	
3.	Do you use local feed? Y/N	
4.	If yes, what feeds are used by you?	
5.	Do you use any imported feed? Y/N	
6.	If yes, What is the proximate composition of this feed?	

S/L	Name of the feed	Proximate composition
1		
2		

3		
4		

J. Transportation:

1. What is the transportation system do you use for transporting ornamental fish and non-fish species?

……

……

K. Disease and health care of ornamental fish:

1.	Do you have any disease problem? Y/N	
2.	If yes, What are the detailed about your fish disease?	

Disease	Clinical sign	Species	Effective Treatment	Prevalence (%)	Death (%)	Season

3.	Which diseases are outbreaks most?	
4.	Why these diseases are occurred?	
5.	What are the causative agents of these diseases?	
6.	Which steps should be taken by you to protect the fish from diseases?	
7.	Do you use chemicals/antibiotics against this disease? Y/N If yes, Give information of below table	

Trade Name	Active Ingredient	Purpose 0f Use	Method of Application	Dose	Source	Recovery (%)

L.

Threats and weakness:

1. What are the problems do you face operating this business?

……

……

2. Which are the obstacles for developing ornamental fish culture?

……

……

M. Strengths and opportunities of ornamental fish culture:

1.	Is ornamental fish culture profitable?	
2.	Is the culture increase day by day?	
3.	What is the profit comes in every year?	
4.	The ornamental fish culture of Bangladesh is feasible or not?	
5.	What are the opportunities of ornamental fish culture?	

6. What do you think about ornamental fish business?

……

……7. What is your future plan regarding ornamental fish business?

……

……

8. Do you get any advisory help from any government or non-government institute/organization?

……

……

9. Do you have any financial support from any government or non-government organization?

……

N. Business profit:

1. How much money do you invest on this business?

2. What is the total expenditure of your shop per month?

3. What is the amount that you earn each month?

O. Livelihood of ornamental fish culturist:

1. What is your name?			
2. Age			
3. What is your educational qualification?	Under SSC	HSC	Graduate (if, name of the institution)
4. What the reason behind your entering ornamental fish business?	Profitability	Personal interest	Others (mention)
5. When do start this store of ornamental fish?			
6. Do you have any other business or job?			

7. What is the number of member in your family?	
8. What is the savings?	
9... Are other members of their family related with farming?	

Business profit

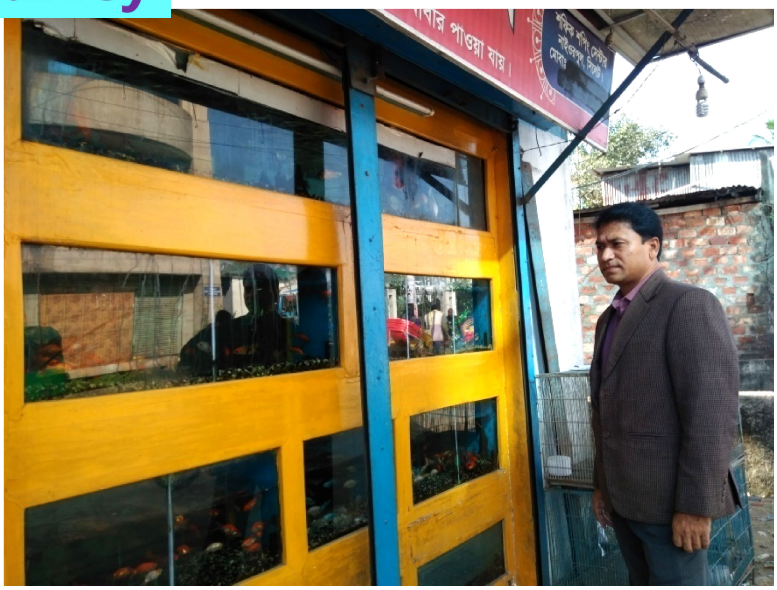
1. How much money do you invest on this business? …. …….
2. What is the total expenditure of your shop per month? ……
3. What is the amount that you earn each month? ……

Name of the collector:

_____
Signature of the collector

Appendix 2: Photographic display of activities done throughout the research

Field survey



Interviewing - PI

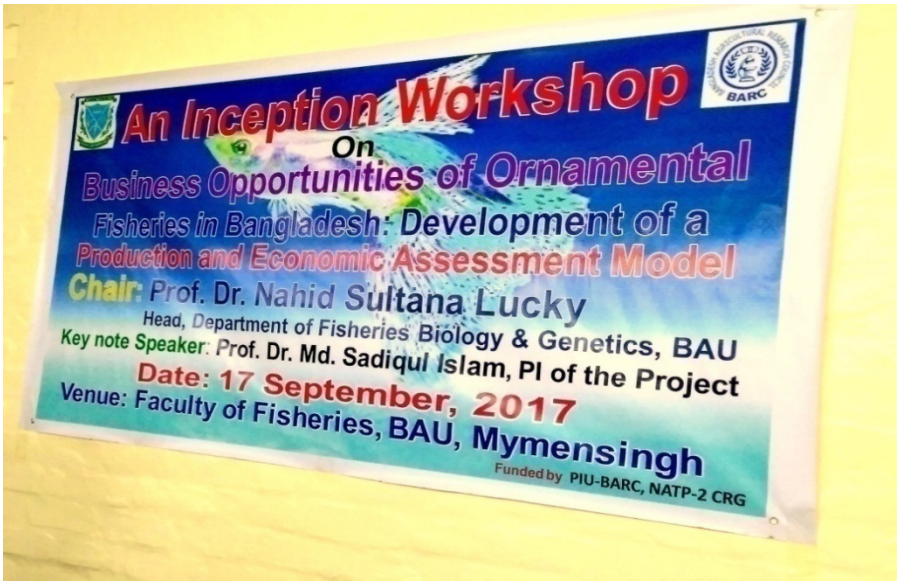
Interviewing – Students

Interviewing

Meeting with Socio-economist

Dr. AHM Saiful Islam

Dept. Agr. Econ., BAU


An Inception Workshop
On
Business Opportunities of Ornamental
Fisheries in Bangladesh: Development of a
Production and Economic Assessment Model
Chair: Prof. Dr. Nahid Sultana Lucky
Head, Department of Fisheries Biology & Genetics, BAU
Key note Speaker: Prof. Dr. Md. Sadiqul Islam, PI of the Project
Date: 17 September, 2017
Venue: Faculty of Fisheries, BAU, Mymensingh
Funded by PIU-BARC, NATP-2 CRG
BARC

Workshop


Goal
To develop ornamental fish farming for the unemployed youth
Objectives
• Conduct a socio-economic and baseline survey to know the present status of ornamental fish business in Bangladesh, its prospects and threats
• Development of production model for five commercially important and popular ornamental fish species
• Design strategies for promoting ornamental fish aquarium business

Photo documentation (Res. Work, Monitoring, Training, Field day etc.)

Species selected for the experiment

Red swordtail (*X. hellerii*),

Zebrafish (*Daniorerio),*

Goldfish (*C. auratus*),

Freshwater Angelfish *(P. scalare)* and

Blue Gourami*(T. trichopterus)*