ABSTRACT
Induced breeding of Bagrid catfish, *Mystus tengara*, is not widely practiced in Bangladesh, and seed is not readily available. The study was conducted to identify the optimum range of water quality parameters to best induced breeding results in a hatchery in Pabna district, Bangladesh. Fish breeding and other related work have been done in the hatchery. The (mean ± SD) temperature, dissolved oxygen, and pH were ranged from 29.75±1.22°C to 33.94±0.18°C; 4.40±0.57 to 5.39±1.06 mg/l; and 7.10±0.14 to 7.40±0.28 in brood pond and 26.50±0.71°C to 31.00±1.41°C; 3.80±0.14 to 5.50±0.42; and 7.00±0.00 to 7.30±0.42 in overhead tank, respectively. The highest fertilization rate (80%) was observed in brood pond water at the 7th and 8th weeks at temperatures of 33.94±0.18°C and 32.00±1.07°C, as well as oxygen concentrations of 5.20±1.41 mg/l, 4.60±0.14 mg/l, and pH values 7.20±0.14, 7.20±0.00, respectively. In the 9th week of the experiment, the temperature, dissolved oxygen, and pH values of 28.00±1.41 mg/l, 5.50±0.42 mg/l and 7.00±0.00, respectively, were shown to have the highest hatching rates. A strong positive correlation was found among dissolved oxygen, temperature, fertilization rate, and hatching rate. Particularly, the brood raising pond's water quality parameters showed a strong positive correlation with fertilization rate. On the other hand, water quality parameters of the overhead tank showed a strong positive correlation with hatching rate. This study will help hatchery technicians in comprehending the requirements for *M. tengara* species induced breeding in terms of water quality.

INTRODUCTION
Bagrid catfish belong to the family bagridae, which is under the Asian striped dwarf catfish, a native and commercially important small indigenous fish species of Bangladesh (Mitu and Alam, 2016). Bagrid includes a lot of species all over the world. In Bangladesh, these are locally named after Tengra, shing and Magur, etc. People like bagrid catfish for their taste, enriched nutrients and availability throughout the whole year. Many vitamins and minerals are found in this species, such as sodium, potassium, calcium, iron, iodine, zinc, magnesium, and phosphorus (Hossain, 1999; Rao et al., 1999). Among Mystus sp., *M. tengara* is the most important native species of Bangladesh. But the main problem with bagrid catfish is the scarcity of seed in Bangladesh. Bagrid catfish have great potential if one could start producing seed (Wahab et al., 2003). Due to various factors like overexploitation, habitat destruction, and pollution, these species are facing a lot of threats. As a result, their numbers are decreasing day by day. Nowadays, these fish are costly because they are not available in the market. Induce breeding is not widely practiced in Bangladesh, though some hatcheries have begun in a limited number of locations. So, fruitful research is needed to develop good induced breeding techniques for *M. tengara*.

The factors which affect the fish health and activity in an aquaculture production system are water quality parameters. This means that we must specify the variables of water quality that are fundamental to culture. Fish rely on water to meet all of their demands on a daily basis. Different fish can survive themselves and reproduce at different levels of temperature, pH, oxygen concentration, salinity, hardness, and other water quality characteristics. Temperature is one of the most important breeding factors. Fish perform well during induced spawning procedures in water temperatures ranging from 26 to 28 degrees Celsius. Captive breeding of fish is the way through which we can protect any endangered wild species from being destroyed and make species available (Fleming, 1994). Earlier, a number of researchers have documented information on the feeding and breeding biology of Mystus sp. related to some information that was documented in previous reviews by some researchers, but till now, review reports are rarely found on the internet. So, with this in mind, this research has been planned to gather some information in order to induced breeding *M. tengara*. At the optimal DO level of fish habitat, the feeding rate was optimal (Boyd and Tucker, 1998). As a result, dissolved oxygen is important in fish breeding. Both alkaline and acidic conditions are lethargic to fish, such as pH 4, and pH 11, which is the death point of fish (Boyd, 1982). So, cell function and body activity also depend on pH. Finally, water quality parameters play a great role in fish breeding as fish totally depend on different water quality parameters. The breeding season for this catfish species starts in May and ends in September (Gupta and Banerjee, 2013).

The best month for the induced breeding of *M. tengara* will be identified in this research. As induced breeding of *M. tengara* is not practiced across a wide range, this species is going to be extinct in coming days. Research may help to conserve and protect this endangered species.

1 Department of Fisheries, Faculty of Agriculture, Rajshahi University, Rajshahi, Bangladesh.
2 Department of Fish Biology and Genetics, Faculty of Fisheries, Sylhet Agricultural University, Sylhet-3100, Bangladesh.
3 Corresponding author's e-mail: kazirbabyakther@gmail.com
From this point of view, this fish species is unique because it's a native species. From this sense of importance, this experiment carries a great value. So the motive of the research was to find the best optimum range of water quality parameters for induced breeding of bagrid catfish.

METHODS AND MATERIALS

Study side
The experiment was conducted at the renowned Tebunia BRAC Fish Hatchery in northern Bangladesh.

Brood collection from pond
On induced breeding date, mature male brood was identified by physically observing the slightly pointed genital papilla. On the other hand, mature females were identified by a swollen abdomen and squeezing slightly along the ventral side of the fish to come out of eggs.

Induced breeding Mystus tengara
A synthetic inducing agent (salmon gonadotrophin releasing hormone) was applied to the broods of both the male and female. The male was induced through injection after one of our female injections and was kept in the tanks. Before injecting the hormone, the weights of the brooders were taken and recorded. The female and male weights ranged from 50 to 90 grams and 40 to 70 grams, respectively. The same hormonal doses were used for the whole year for this experiment. The hormonal doses of female fish were 0.8 mg/kg body of fish, and it was 0.4 mg/kg body of fish for male fish. Hormone was applied to the fish’s body through the pectoral fin during the evening time. After injection, the fish were released into marked tanks in 1:1 (male: female). Within 10–14 hours, all the females ovulated the eggs in the tank. A hapa was prepared by georgette cloth and set up in the bottom of a cemented rectangle tank to transfer the eggs after fertilization into the hatching jar. Fertilization rate and hatching rate were also measured by using the following formula:

i. Fertilization (%) = (No. of fertilized eggs*100)/Total number of eggs (Alam et al., 2006)

ii. Hatching (%) = (No. of hatchling*100)/No. of eggs in subsample (Islam et al., 2011)

Measurement of water quality parameters
As mentioned in the above section, temperature, pH, and dissolved oxygen were measured both in the brood rearing pond and overhead tank water. Temperature was monitored twice daily, whereas pH and dissolved oxygen were tested twice weekly, but two times (morning and afternoon) on a particular day. Additionally, up until hatching out, these water quality parameters were twice daily measured in the hatching jar.

Case summary of induced breeding of Mystus tengara
The fertilization rate (%) and hatching rate (%) were calculated in this experiment to find out the relationship of induced breeding M. tengara with water quality parameters. After the collection of eggs, 1 gram eggs were taken and separated to determine the number of fertilized and unfertilized eggs. The fertilization rate and hatching rate were calculated by using the formula mentioned earlier. A descriptive chart related to breeding activities of Mystus tengra is shown in tables 2 and 3.

Data analysis
The collected data were compiled, tabulated, and analyzed in the proper order before being statistically analyzed. The effects of water quality parameter data in inducing the breeding of Mystus tengara were correlated and ANOVA tested by using Microsoft Excel 10 and SPSS version 26.

RESULT

Water quality parameters
Three water quality parameters, such as temperature, pH, and DO, were considered in this experiment. The mean temperature varied from 29.75±1.22 to 33.94±0.18 °C in pond water and 26.50±0.71 to 31.00±1.41 °C in overhead tank water, respectively. Mean dissolved oxygen varied from 4.40±0.57 to 5.35±1.06 in pond water and 3.80±0.14 to 5.50±0.42 in overhead tank water.
water respectively. The pH was also measured in the experiment. It varied from 7.10±0.14 to 7.40±0.28 in pond water and 7.00±0.00 to 7.30±0.42 in overhead tank water, respectively. Water quality parameters in the study were recorded to find out their relationship with inducing breeding and suggest the best water quality parameters to hatchery owners to increase their production. After getting the result, they can overcome the water quality parameters problems to increase production as per their requirements.

Table 1: Summary of average value of three water quality parameters (Temperature, pH and DO) both in pond and overhead tank water.

| Months | week | Mean Temperature and std. deviation | Mean dissolve oxygen and std. deviation | Mean pH and std. deviation |
|--------|------|--------------------------------------|----------------------------------------|---------------------------|
|        |      | Pond (°C)                             | Overhead tank (°C)                     | Pond (mg/l)               | Overhead tank (mg/l) |
| April  | W1   | 29.75±1.22                           | 26.50±0.71                            | 4.60±0.85                 | 4.30±0.14            | 7.20±0.28 | 7.00±0.00 |
|        | W2   | 30.14±0.48                           | 27.00±1.41                            | 5.00±1.13                 | 4.50±0.14            | 7.20±0.00 | 7.10±0.14 |
|        | W3   | 31.19±1.25                           | 28.00±1.41                            | 5.25±1.06                 | 4.50±0.14            | 7.20±0.00 | 7.20±0.28 |
|        | W4   | 32.14±1.84                           | 28.00±1.41                            | 4.90±1.27                 | 4.20±0.14            | 7.30±0.14 | 7.20±0.00 |
| May    | W5   | 31.81±0.75                           | 28.00±1.41                            | 5.25±1.06                 | 4.50±0.28            | 7.20±0.00 | 7.20±0.00 |
|        | W6   | 33.57±0.45                           | 27.00±1.41                            | 5.00±0.70                 | 4.70±0.42            | 7.40±0.28 | 7.00±0.00 |
|        | W7   | 33.94±0.18                           | 27.00±1.41                            | 5.20±1.41                 | 4.60±0.14            | 7.30±0.14 | 7.30±0.14 |
|        | W8   | 32.00±1.07                           | 28.00±1.41                            | 4.95±1.48                 | 5.00±0.14            | 7.20±0.00 | 7.00±0.00 |
| June   | W9   | 31.31±0.59                           | 28.00±1.41                            | 4.90±0.57                 | 5.50±0.42            | 7.20±0.00 | 7.00±0.00 |
|        | W10  | 30.29±0.39                           | 28.00±1.41                            | 5.35±1.06                 | 5.20±0.28            | 7.30±0.14 | 7.10±0.14 |
|        | W11  | 30.94±0.98                           | 28.00±1.41                            | 5.30±1.27                 | 5.20±0.28            | 7.40±0.28 | 7.10±0.14 |
|        | W12  | 31.07±0.19                           | 28.00±1.41                            | 5.15±0.92                 | 3.80±0.14            | 7.30±0.14 | 7.10±0.14 |
| July   | W13  | 32.00±0.27                           | 29.00±1.41                            | 4.60±0.57                 | 4.00±0.14            | 7.20±0.28 | 7.00±0.00 |
|        | W14  | 31.64±0.24                           | 29.50±0.71                            | 4.90±0.14                 | 3.80±0.42            | 7.20±0.00 | 7.30±0.42 |
|        | W15  | 32.19±0.65                           | 30.00±1.41                            | 4.65±0.21                 | 4.00±0.14            | 7.20±0.00 | 7.20±0.00 |
|        | W16  | 31.56±0.56                           | 31.00±1.41                            | 4.40±0.57                 | 4.00±0.14            | 7.10±0.14 | 7.00±0.00 |

Fertilization rate
The fertilization rate in this experiment was calculated in total over 16 weeks. It varied from 54 to 80%. The lowest was 54% during the first week because the male *Mystus tengara* was weak, while the temperature was 29.75±1.22°C and 26.50±0.71°C, DO was 4.60 ±0.85 mg/l and 4.30 ±0.14 mg/l, and pH was 7.20±0.28 and 7.00±0.00, in the pond water and overhead tank, respectively. Fertilization was highest at weeks 7 and 8, when the temperature, DO, and pH were 33.94±0.18°C and 27.00±1.41°C, 5.20 ±1.41 mg/l and 4.60 ±0.14 mg/l, 7.30±0.14 and 7.30±0.14, in pond water and overhead tank, respectively. But the highest number of eggs was found in weeks 9 and 10 (Table 2).

Table 2: Amount of eggs, total number of eggs from ten fishes in every week, amount of spawn from fertilized and number of total spawn.

| Treatment (T) | Weeks | Wt. of fish (gm) | No of Female | Total weight of female (gm) | Amount of eggs (gm) | Total Number of eggs | Amount of spawn (gm) | Total number of spawn |
|---------------|-------|------------------|--------------|-----------------------------|---------------------|----------------------|----------------------|-----------------------|
| April         | W1    | 50-100           | 10           | 750                          | 50                  | 30000                | 17                   | 9250                  |
|               | W2    | 50-100           |              | 70                           | 42000               | 26                   | 15080                |
|               | W3    | 50-100           |              | 100                          | 60000               | 40                   | 24000                |
|               | W4    | 50-100           |              | 120                          | 72000               | 55                   | 30800                |
| May           | W5    | 50-100           |              | 120                          | 72000               | 62                   | 34100                |

Hatching rate
The hatching rate was an important part of this experiment, and it was calculated in total over 16 weeks. The highest hatching rate was recorded at week 9 and that was 81.29% due to high dissolve oxygen (5.50±0.42 mg/l) in overhead tank water, which showed a strong positive correlation with hatching rate (Table 4) (Figure 2). On the other hand, the lowest hatching rate was 49.36% and was recorded on the week of the 14th due to low dissolved oxygen (3.80±0.42 mg/l) in the overhead tank. A spawn number was also calculated in this experiment. The highest number of spawn was found in week 9 and the lowest in week 1 (Table 2).
Table 3: Summary of average value of three water quality parameters (Temperature, pH and DO) both in pond and overhead tank water.

| Months | week | Fertilization Rate (%) | Hatching rate |
|--------|------|------------------------|---------------|
| April  | W1   | 54                     | 58.77         |
|        | W2   | 60                     | 59.84         |
|        | W3   | 63                     | 63.49         |
|        | W4   | 64                     | 66.84         |
| May    | W5   | 70                     | 67.65         |
|        | W6   | 76                     | 68.35         |
|        | W7   | 80                     | 70.00         |
|        | W8   | 80                     | 71.80         |
| June   | W9   | 75                     | 81.28         |
|        | W10  | 78                     | 76.15         |
|        | W11  | 78                     | 75.21         |
|        | W12  | 75                     | 70.28         |
| July   | W13  | 70                     | 62.20         |
|        | W14  | 65                     | 49.36         |
|        | W15  | 60                     | 63.33         |
|        | W16  | 55                     | 60.00         |

Relationship of temperature with fertilization rate (%) and hatching rate (%)

The relationship between temperature, fertilization rate, and hatching rate was calculated using arithmetic and logarithmic formulas. A positive correlation was found among pond temperature, fertilization rate, and hatching rate, and a negative correlation was found among tank water temperature, fertilization rate, and hatching rate (Table 4). Fertilization started to increase with the increase in pond water temperature and continued up to week 8, then it started to decrease again (Figure 1). The lowest fertilization rate was recorded in the first and last weeks. The temperature reached 33.94°C in the pond, but the fertilization rate was in stable condition (Figure 1). The best fertilization rate (70-80%) in this experiment was identified in the 31-34°C range of temperature (Figure 1) and a strong positive correlation was found between pond water temperature and fertilization rate (Table 4). On the other hand, the overhead tank water temperature showed a different scenario. There was a negative correlation between the overhead tank water temperature and the hatching rate. Overhead tank water temperature was considered for hatching rate because tank water has a direct impact on hatching rate in the hatchery.

The hatching rate was lower at the beginning of the experiment because of the low temperature. Hatching rates have started to increase with the increase in temperature. It was the highest at 28°C (Figure 2). But the hatching rate started to decline again with the temperature increase (Figure 2). There was found to be a strong negative correlation between overhead tank water and hatching rate (Table 4). So, 28°C was the best temperature to get the highest hatching rate (70-81%) in this experiment. Fertilization rate and hatching rate had a positive correlation (Table 4) with each other at a 0.01 level of significance.
Table 4: Mutual correlation among temperature in overhead tank, fertilization rate, hatching rate, DO in overhead tank, DO in pond water, temperature in pond water, pH in pond water and pH in tank water

| Correlations          | Temp. (Pond) | Fertilization Rate | Hatching rate | DO (pond) | DO (tank) | Temp. (Tank) | pH (Pond) | pH (pond) |
|-----------------------|--------------|--------------------|---------------|-----------|-----------|--------------|-----------|-----------|
| Temp. (Pond) Pearson Correlation | 1 | .388 | .084 | .006 | -.087 | .074 | .274 | .281 |
| Fertilization Rate Pearson Correlation | .388 | 1 | .729** | .647** | .581* | -.325 | .621* | -.006 |
| Hatching rate Pearson Correlation | .084 | .729** | 1 | .495 | .789** | -.309 | .466 | -.277 |
| DO (pond) Pearson Correlation | .006 | .647** | .495 | 1 | .488 | -.504* | .594* | .404 |
| DO (tank) Pearson Correlation | -.087 | .581* | .789** | .488 | 1 | -.431 | .341 | -.289 |
| Temp. (Tank) Pearson Correlation | .074 | -.325 | -.309 | -.504* | -.431 | 1 | -.507* | .058 |
| pH (Pond) Pearson Correlation | .274 | .621* | .466 | .594* | .341 | -.507* | 1 | .085 |
| pH (pond) Pearson Correlation | .281 | -.006 | -.277 | .404 | -.289 | .058 | .085 | 1 |

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Figure 2: Relationship between temperature and Fertilization rate

Relationship of Dissolved oxygen (DO), fertilization rate, and hatching rate

Dissolved oxygen is an important factor in inducing breeding. The data for the relationship among dissolved oxygen is in tables 01 and 03. Fertilization rate and hatching rate showed a strong positive correlation with dissolved oxygen. A strong positive correlation was found among pond water oxygen, tank water oxygen, and fertilization rate. This correlation of pond water dissolve oxygen with fertilization rate was significant at 0.01 level and 0.05 level. The fertilization rate was significant at the 0.05 level of significance, but the hatching rate was the highest on weeks 7 and 8, when the pond water oxygen level was around 5 mg/l, and the highest range of fertilization rate (70-80%) was recorded within 4-5.5 mg/l of dissolved oxygen in the pond. The fertilization rate was increased with the increase of dissolve oxygen (Figure 4), but it sometimes fluctuated with the fluctuation of water quality parameters because all the water quality parameters are mutually correlated. Dissolve oxygen from 4 mg/l to more than 5.5 mg/l was recorded as the optimum for the brood pond in this experiment. The relationship of hatching rate with dissolved oxygen in overhead tank water was clearly visible. The hatching rate started to increase with the increase of dissolved oxygen in tank water (Figure 5). The highest level of hatching rate (81.29%) was recorded in week 9 when the temperature and dissolve oxygen of overhead tank water for that week were 28oC and 5.5 mg/l. Although the temperature was optimal in week 14, the hatching rate was the lowest (49.36%) due to the lower amount of dissolve oxygen (3.8 mg/l) in that week. There was a strong correlation between hatching rate and dissolving oxygen (Table 4).

Figure 3: Relationship between temperature and Hatching rate.

Relationship of pH, fertilization rate, and hatching rate

The pH of pond water showed a positive correlation with fertilization rate; on the other hand, the pH of tank water showed a negative correlation with hatching rate (Table 4). The fertilization rate was stable up to pH 7.20,
and started to increase with the increase of pH. The fertilization rate fluctuated with the increase of pH due to the fluctuation of water quality parameters (Figure 06). But the pH of tank water showed a different scenario. The hatching rate started to fall with an increase in pH (Figure 7). It was hard to understand the solo effect of pH on the induction of breeding of *Mystus tengara*, but it had a combined effect on the breeding system.

Relation of weeks and month in induced breeding

The hatching rate started to increase from the first week of April and continued up to the 9th week. The hatching rate started to fall after the 9th week, and it was good up to the 13th week. Considering the level of hatching rate in the middle of May to June, it was identified as the best time to get the productivity of *Mystus tengara*. However, April to July was identified as the breeding season of *Mystus tengara* based on their fertilization rate and hatching rate, but May and June are the best times to induce breeding (Table 3, Figure 8).

DISCUSSION

There are few studies specifically on the effects of water quality parameters on induced breeding Mystus sp. Qasim & Qayyum (1962) recorded that June to September was
This experiment was designed and performed to generate some information on the effect of water quality parameters on the induced breeding of *Mystus tengara*. Salmon gonadotrophin releasing hormone was used in this experiment.

**CONCLUSION**

The results of the current research add to the understanding of how water quality conditions affect *Mystus tengara*’s induced breeding. This investigation’s list of water quality parameters will be useful to the hatchery’s owner and technician. All of the metrics were recorded under outdoor circumstances. This experiment will clearly make the evident of water quality requirements for hatchery operations and brood management *Mystus tengara*.

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