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Life cycle and fecundity of freshwater snail, *Viviparus bengalensis*, produced in integrated multi-trophic aquaculture ponds

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Abstract

Life cycle and fecundity of freshwater snail (*Viviparus bengalensis*) were studied for a period of three months in nine integrated multi-trophic aquaculture (IMTA) ponds. Average size and depth of the ponds were 40 m^2 and 1 m, respectively. The experiment consisted of three treatments in triplicate. Snail was sampled at 7-day intervals using Ekman Dredge. An adult snail carried approximately 30-40 juveniles. Fecundity of a snail was found 37±2.0 and 39±1.0 in T_2 and T_3, respectively, and life cycle completed within 40-42 days. The physico-chemical parameters were found more or less similar in the treatments and were within the suitable ranges for snail culture. The findings of the experiment indicate that IMTA pond is a suitable habitat for snail culture.

Keywords: Fecundity, juvenile, life cycle, *Viviparus bengalensis*, IMTA pond

1. Introduction

Aquaculture is the farming of freshwater and salt water organisms, such as finfish, mollusks, crustaceans, aquatic plants etc. The contribution of aquaculture to the total fish production of Bangladesh is over 55% [1], and more than 11% of the total population is employed in different sectors of Fisheries and Aquaculture [2]. In case of global contribution, one half of the commercially produced fish, mollusks, crustaceans and aquatic plants that are directly consumed by human come from aquaculture. Different types of aquaculture are in practice in Bangladesh *viz.* monoculture and polyculture of finfish, shellfish aquaculture, integrated culture systems, etc. for the production of aquatic foods. Farmers face many problems in such farming practices. However, integrated farming involving aquaculture broadly is the sequential linkage between two or more activities, of which at least one is aquaculture. A wide range of integrated aquaculture systems are practiced in Asia and Europe, where one of the recent examples is integrated multi-trophic aquaculture (IMTA) [3]. The IMTA concept should also be understood within an integrated land based aquaculture ecosystem approach. IMTA system produces not only valuable biomass, but also provide waste reduction and removal services. Like fish, other aquatic organisms (e.g. mollusks) can play a vital role in supplying protein to human food indirectly. There are about 362 species of mollusk, of which 336 are marine and 26 are freshwater, living in generally low lying aquatic habitats in Bangladesh [4]. The freshwater snail (*V. bengalensis)* is a widely distributed mollusk in Bangladesh, which could be cultured in different aquatic systems. Snail culture started in IMTA ponds at the Department of Aquaculture, Bangladesh Agricultural University (BAU), Mymensingh for eradicating poverty and malnutrition of indigenous people [5]. Although most of the Bangladeshi do not eat snail, the tribal people consume it as a tasty food item. It is considered highly digestible and rich in vitamins, protein, fat and minerals, especially calcium. It contains various nutrients ranging from 5.86 to 19.53% crude protein, l.27 to 5.56% ash, 1.05 to 2.44% fat and l.80 to 6.91% nitrogen free extract [6]. Some innovative farmers have started snail culture in the fish farms in the Mymensingh region (the home of aquaculture of Bangladesh) in view to producing snail to use as a protein supplement for preparing fish feeds [7]. There is very little information available on the life cycle and fecundity of the pond snail (*V. bengalensis*). Clear knowledge on the life cycle and fecundity of the snail is an essential task for bringing this potential species in aquaculture. Therefore, the present experimental study was undertaken to identify the male and female snails, estimate fecundity and observe the life cycle of the freshwater snail (*V. bengalensis*) produced in IMTA ponds.

2. Materials and Methods

2.1 Duration of the Study

The experimental study was carried out for a period of 90 days commencing from 4 July 2012 at BAU, Mymensingh-2202, Bangladesh.

2.2 Description of the study area and experimental ponds

The experiment was carried out in nine earthen experimental ponds which were situated to the Southwest corner of the Faculty of Fisheries, BAU, Mymensingh. The ponds were more or less similar in size and shape (rectangular), and were well exposed to sunlight and air. The average area and depth were 40 m^2 and 1 m, respectively. The ponds had inlet and outlet systems; however, those were sealed with polythene sheets during the experimental period so that water could not be exchanged between the ponds.

2.3 Experimental design

The experiment consisted of three treatments (T_1, T_2, and T_3). Each of the treatments had three replications (Table 1).

Table 1: Description of the experimental design

Treatments	Replicates	Description
T_1	R_1, R_6, and R_7	Carps 19,760/ha (catla: silver carp: rui: mrigal = 3: 1: 2: 2). One cage of 1 m^3 was set stocking with 100 *shing*.
T_2	R_2, R_5, and R_8	Carps 19,760/ha (catla: silver carp: rui: mrigal = 3: 1: 2: 2), snail: stocking density 62 kg/ha. One cage of 1 m^3 was set stocking with 100 *shing*.
T_3	R_3, R_4, and R_9	Carps 19,760/ha (catla: silver carp: rui: mrigal = 3: 1: 2: 2), snail: stocking density 62 kg/ha. One cage of 1 m^3 was set stocking with 100 *shing*. Water spinach: cultured on four plastic floating trays.

2.4 Compost preparation

Compost was prepared on the pond dike by digging a pit in the dike and a polythene sheet (3 m long) was placed in the hole so that the raw materials do not contact directly with soil. Before stocking snails and carps in the pond, pre-stocking compost was prepared mixing mustard oil cake, urea, cow dung and water hyacinth at the ratio of 4: 1: 4: 2, respectively. Mustard oil cake was powdered and water hyacinth was chopped into small pieces before mixing with cow dung. Urea was dissolved in water before adding to the mixture to be homogenously mixed with other materials. The required amount of water was added to the composting materials and kept for fermentation for about 3 days. After completing fermentation, compost was applied in the ponds (680 kg/ha).

Table 2: Amount of raw materials for making pre-stocking compost

Materials	Amount (kg/ha)
Mustard oil cake	247
Cow dung	247
Urea	62
Water hyacinth	124

2.5 IMTA pond preparation

Ponds were dried completely and undesirable organisms such as aquatic weeds, small fishes etc. were removed manually. Broken dikes were repaired by removing the excess bottom mud. Lime ($CaCO_3$) and compost were applied at 250 and 680 kg/ha during pond preparation, respectively.

2.6 *Hapa* set up for life cycle observation

Two *hapa* were set up in T_2 and T_3. Every *hapa* was rectangular in shape, and sized was 0.60×0.15×0.45 m. Banana leaves, bamboo sticks, plastic pipes were placed in the *hapa* to protect the snails from direct sun light.

2.7 Stocking of snail and Feeding

After setting the *hapa*, 100 adult snails were stocked in each *hapa*. The range of average lengths of adult snails were 2.4 to 2.6 cm and average weight were 2.6 to 2.9 g. Compost was supplied to the *hapa* for satisfactory growth and breeding of snails. The experimental IMTA ponds were monitored daily to observe any changes in the culture environment and condition of the experimental species. As the IMTA ponds were stocked with craps and *shing* along with snail, a supplementary feed consisting of rice bran and wheat bran (1: 1) was applied twice daily at 3-5% of body weight at 09:00 AM and 04:00 PM.

2.8 Collection system of snail for sampling

Snails were collected at 7-day intervals. Ekman dredge (15×15 cm) was used to collect snail from the pond bottom. Adult snails were sampled from each *hapa* for the observation of egg, embryo and juvenile in the laboratory.

2.9 Investigations in the laboratory

2.9.1 Identification of male and female:

For the identification of male and female snails, operculum, tentacle, body shaped, length and weight were measured. Electronic balance (Model: HKD-620AS-LED), measurement scale, forceps, niddle and Magnus biological microscope (Model: MLX-B) were used for the measurement.

2.9.2 Egg, embryo and juvenile observation:

Egg, embryo and juvenile were identified by using magnifying glass and Magnus biological microscope.

2.9.3 Observation on young snail:

Young snails were collected from plastic pipe and bamboo pole, which were placed in the *hapa*. Measuring scale and electronic balance were used for its measurement.

2.9.4 Observation on adult snail:

Adult snails were collected from plastic pipe, bamboo pole and net. Measuring scale and electronic balance were used for the measurement of length and weight.

2.10 Water quality parameters

Water quality parameters were analyzed fortnightly at the suitable place near the pond site between 9.00 and 10.00 AM during the experimental period. Water temperature was measured by a Celsius thermometer (Precision = 0.1˚C), pH was measured by pH testing kit and dissolved oxygen was measured by the dissolved oxygen testing kit.

2.11 Data analysis

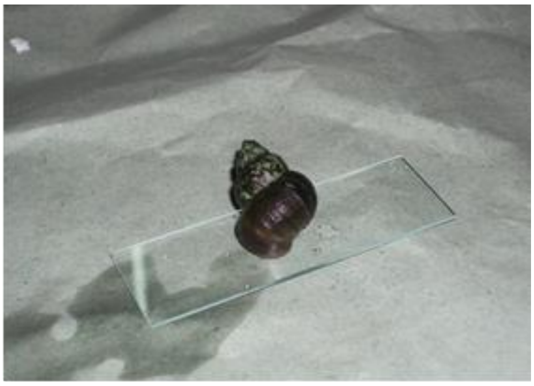
The data collected during the experimental period were analyzed and one way analysis of variance (ANOVA) was performed to test significance of variations among the treatment means. A statistical software, SPSS (Statistical Package for Social Sciences), was used for the analyses. The descriptive data was presented in tabular and graphical forms [8].

3. Results

3.1 Identification of male and female:

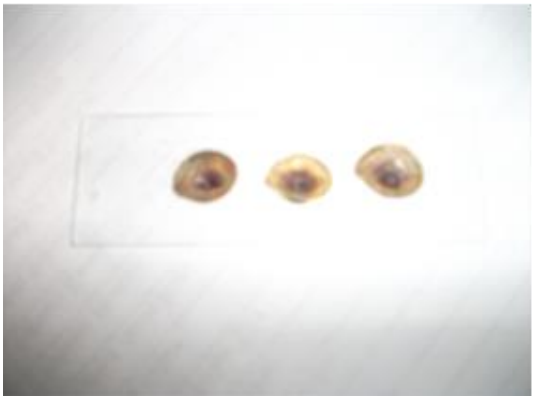
It was found that freshwater male snails were smaller than females. The shell of males was a little smaller and slimmer than that of the females. Male's tentacles were shorter and thicker, and opercula were inner in position and more curved than that of the females. Average length and width of males were 24 mm and 26 g, respectively (Plate A and B).

Plate A: Male snail

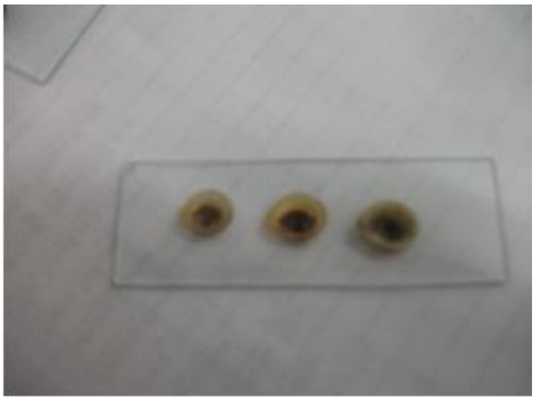


B: Female snail

Freshwater female snail was larger and heavier than male of the same age. Tentacles were longer in females as well. Operculum of female was at outer site of mouth and operculum was not curved shaped. Average length and weight of female snail were 26 mm and 28 g, respectively (Plate C and D).



C: Operculum of female snail



D: Operculum of male snail

3.2 Sex ratio and production of snail

It was found that the number of male and female ratio was almost equal (1:1) in all the treatments. No snail was stocked in T_1. Average production of males and females was 2325±1006 and 5814±822 in T_2 and average production of male and female was 4069±822 and 7558±822 in T_3 (Fig 1).

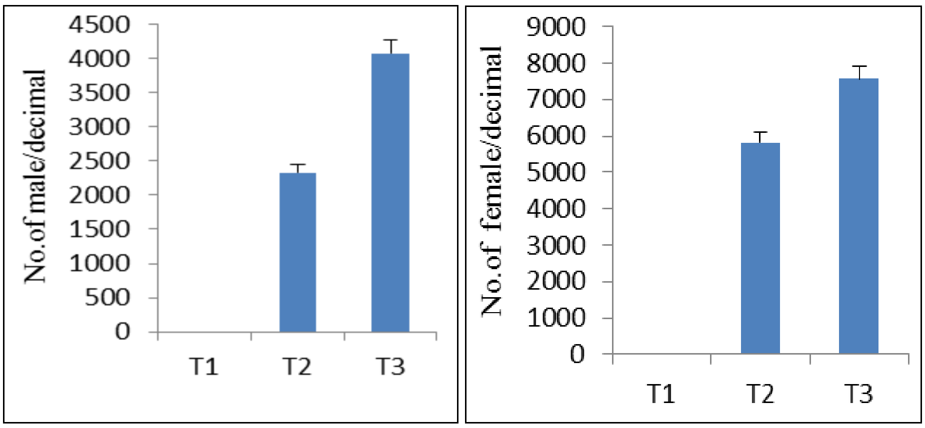


Fig 1: Mean (±SD) production of male and female per 40 m^2 in different treatments.

3.3 Juvenile production in IMTA ponds

3.3.1 Fecundity

Total number of juvenile wsa 37±2.0 and 39±1.0 per snail in T_2 and T_3, respectively (Fig 2).

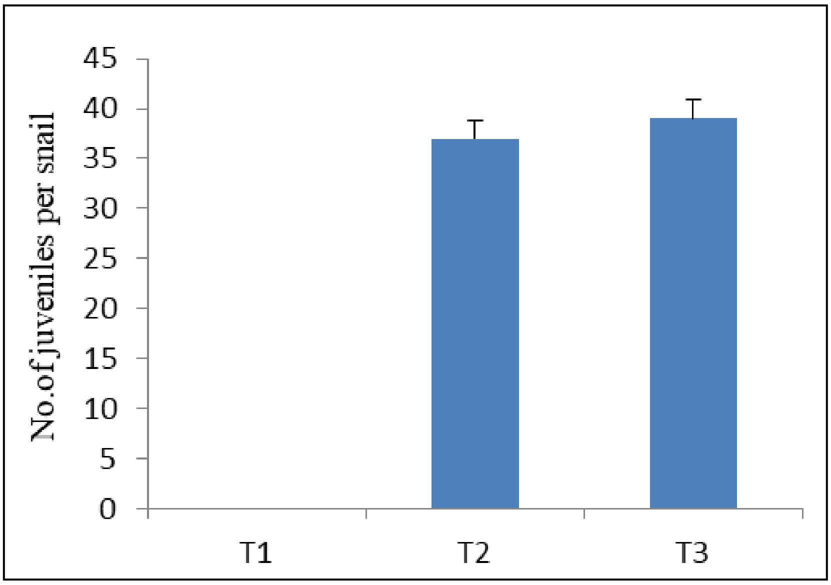


Fig 2: Fecundity of snail in different pond condition treatments.

3.3.2 Production of juvenile
Number of juvenile was 65,703±2644 and 68,028±1744 per 40 m^2 of pond area in T_2 and T_3, respectively (Fig 3).

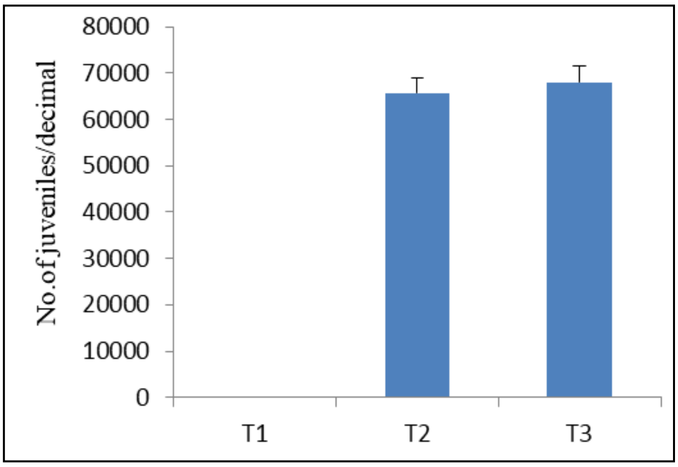


Fig 3: Average production of juveniles in different treatments.

3.3.3 Snail production
No snail was stocked in T_1. The average production of snail was 8,140±1007 and 9,303±1006 individuals/40 m^2 in T_2 and T_3, respectively (Fig 4).

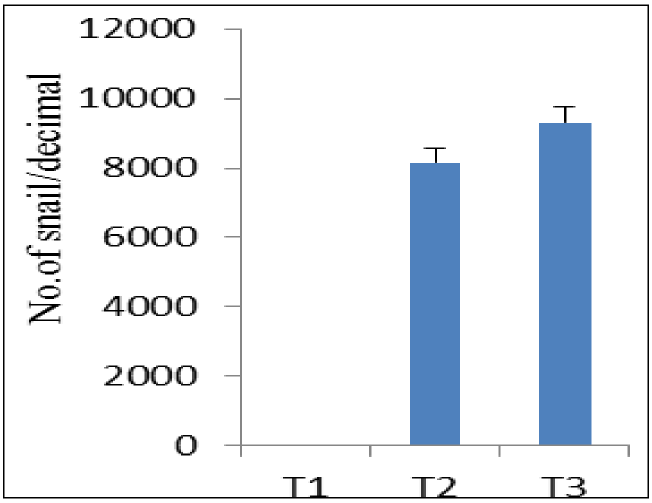


Fig 4: Snail production in different treatments.

3.4 Life cycle of *V. bengalensis*
V. bengalensis is an ovoviviparous freshwater snail. Five stages were observed in its life cycle. Three stages are completed within the snail body. They are live-bearing animals; keep the eggs inside the shells and release hatched out. Life cycle of the pond snail can be presented as follows (Fig 5).

3.4.1 Stage 1: Egg
Approximately 40 to 50 lumps like eggs were found in a female snail. The egg was oval shaped and covered by a soft membrane which was found deeply water colored. An individual egg was seen hexagonal shaped under microscope. Eggs were found within special cavity in the mother snail, where they remain protected. Eggs hatch out inside the adult where the baby snail is fed inside the adult body.

3.4.2 Stage 2: Embryo
It is the second stage of life cycle of *V. bengalensis*. Embryo was also covered with a thin layer that is able to move one side to another in a jelly like structure. It was not visible with naked eyes rather observed under the microscope. Embryo is as soft as egg and whitish in color. Small tentacles were visible.

3.4.3 Stage 3: Juvenile
It was found that one adult snail carried approximately 30-40 Juveniles. Juveniles were soft and whitish in color and with a complete body shape. Average length of juveniles ranged from 0.3 to 0.4 mm and average weight was 0.8 mg. Juveniles take 7 to 8 days to reach the young stage.

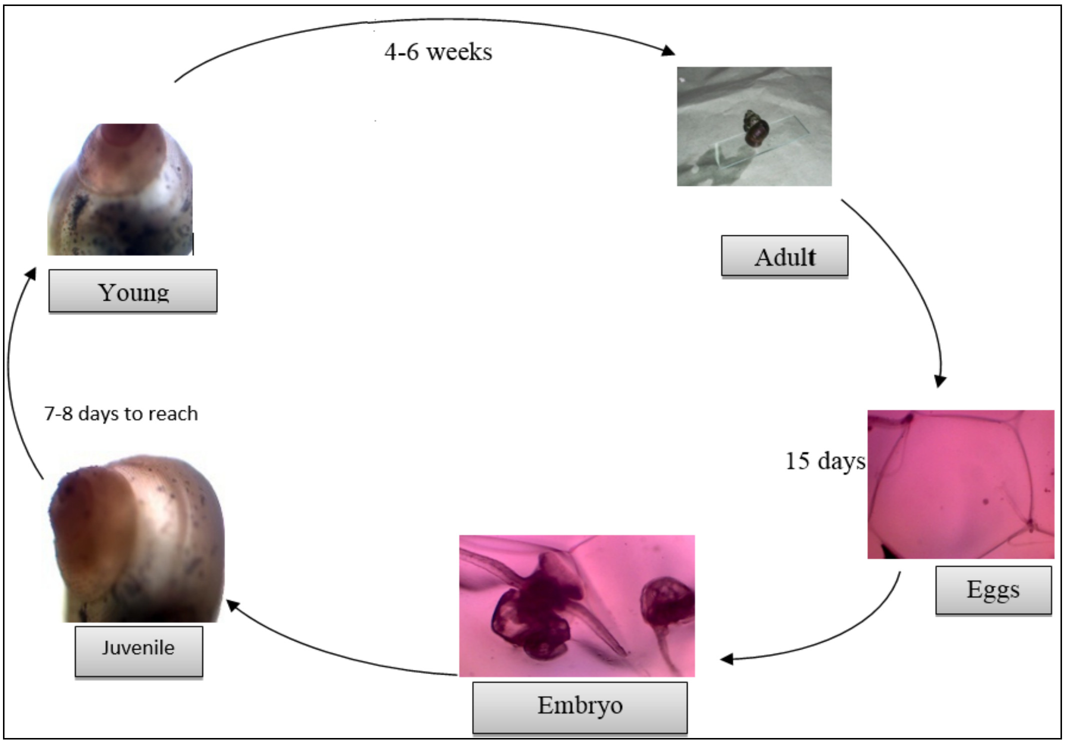


Fig 5: Life cycle of *V. bengalensis.*

3.4.4 Stage 4: Young
The young snails crawl out of the mother's cavity when they had consumed stored nutrients and grow about 0.63 cm long. Young snails were found attached to bamboo sticks, plastic pipe and banana leaf, those floated on the water surface. It was found that a young takes 4 to 6 weeks to reach the adult stage.

3.4.5 Stage 5: Adult
The average length and weight of an adult snail were found between 24 and 26 mm, and 26 and 29 mg, respectively.

3.5 Water quality parameters
Physico-chemical parameters of water such as temperature, pH, and dissolved oxygen were more or less similar in different treatments. The water quality parameters were recorded fortnightly between 9.00 and l0.00 AM during the experimental period (July-September). The results are shown in the Table 4.

Table 4: Mean values of water quality parameters in different treatments during the study

Parameters Treatments	Temperature (°C) (Mean±SD)	pH (Mean±SD)	Dissolved oxygen (mg/l) (Mean±SD)
T_1	28.87±0.58ºC	7.65±0.71	7.16±0.68
T_2	29.28±0.62ºC	7.48±0.45	6.50±0.86
T_3	29.62±1.0ºC	7.59±0.14	6.16±0.68

4. Discussion
4.1 Identification of male and female
Freshwater female snails are larger and heavier than male at the same age. The shell of the male is little bit smaller and slimmer than that of female shell. The female shell is larger [9-10]. The tentacle of male is shorter and thicker than that of female tentacle. The female tentacle is longer [11]. The female operculum is present at outer site of the mouth. On the other hand, male operculum is positioned at inner site of the mouth [12].

4.2 Production of juveniles in IMTA ponds
Juvenile carrying capacity per snail (i.e. fecundity) was found 37±2.0 in T_1 and 39±1.0 in T_3. The fecundity was found higher in T_3 might be due to better environmental conditions in IMTA ponds. IMTA systems create congenial habitat for aquatic organisms. Wastes produced in the waters are used up by the stocked species of different trophic levels [13]. The result reflects the finding of [14]. On the other hand, fecundity of freshwater giant snail ranges from 50 to 100, which is higher than that of the freshwater pond snail, *V. bengalensis* [15].

4.3 Production of juveniles
The highest production of juvenile was found in T_3 followed by T_2, might be due to the ecosystem function of IMTA systems in T_3 [16].

4.4 Life cycle of *V. bengalensis*
An adult freshwater snail takes approximately 4 to 6 weeks. The whole life cycle is completed through five stages, namely egg, embryo, juvenile, young and adult. According to [17] temperature ranging from 25 to 38 ºC is optimal for the embryonic development and reproduction of the snail, *Lymnaea natalensis*. [18] Observed that *Pomacea canaliculata* (Goldan apple snail) takes about 60 days to complete life cycle in irrigated fields. Accordig to [19], *Pila globasa* (Apple snail) completed life cycle in 45 days in freshwater ponds, canals and water-togged areas. The above discussion reveals that *V. bengalensis* takes comparatively short period of time to complete life cycle than other species of snails.

4.5 Water quality parameters
4.5.1 Water temperature (ºC)
In the present study, the average values of water temperature varied from 28.87±0.58ºC to 29.62±1.0 ºC, which is more or less similar with the findings of [20] who recorded average temperatures between 30.14±1.36ºC and 30.34±1.37ºC from six experimental ponds.

4.5.2 pH
The mean values of pH in three treatments ranged from 7.48±0.45 to 7.65±0.71. The findings of the present study match closely with the findings of [21] who obtained the average values of pH ranging from 7.48±0.13 to 7.76 ±0.10 in a freshwater snail culture experiment. Similar findings also reported by [20].

4.5.3 Dissolved oxygen (DO) (mg/l)
The calculated values of dissolved oxygen concentration in the present study varied from 6.16±0.68 to 7.16±0.68 mg/l. [22] stated that the optimum dissolved oxygen content for growth was 6.2±0.7 mg/l in ponds and 5.6± 0.5 mg/l in lakes, which indicates that the finding of the present study is within the acceptable range required for snail culture. [19] observed slightly lower values of dissolved oxygen in experimental ponds.

5. Conclusion
Geographically, Bangladesh provides suitable environments for mollusks culture and IMTA ponds are the potential habitats for the production of freshwater snail which has encouraging economic and biological values. It might be treated as protein source for fish feed formulation, its shell might be used for producing edible lime, and villagers can feed snail to the pet birds. Freshwater snail also has edible values among many tribal groups in Bangladesh and in some Southeast Asian countries as well. The information related to life cycle and fecundity of snail essentially contributes to the development process of snail culture in aquaculture ponds.

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