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Economic utilization of water for *Labeo rohita* Hamilton seed production in a portable FRP carp hatchery

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ABSTRACT

An experiment was conducted to quantify the volume of water required for spawning and hatching operation of Rohu (Labeo rohita Hamilton) in a portable Fiber Reinforced Plastic (FRP) carp hatchery at Central Institute of Freshwater Aquaculture (CIFA), Bhubaneswar. Minimum water requirements for breeding and hatching operations were quantified to be 6.946 and 82 cubic meter, respectively by using flow meter (Star log Version 4, Data Logger Management Software, Model 6308A/AUE, the Australia) in which Minimum and maximum velocity and flow rates were measured in breeding and hatching pool. The minimum water requirement for the whole process was quantified to be around 90 cubic meters for a production of 1 Million spawn. Water qualities like temperature (26 to 28°C), dissolved oxygen (4.4-4.8 ppm), NH4+, pH (7.03 and NO3- (0.3-0.6 ppm) were recorded during the process. The present study thus pave a way for judicious use of available water in the hatchery unit.

Key words: Rohu, spawning and hatching operation, FRP hatchery, velocity distribution

INTRODUCTION

Indian Major Carps are the important groups of fishes cultured in the Indian subcontinent and accounts for more than 95% of the world aquaculture production (Kalla et al., 2004). Rohu (*Labeo rohita*) belongs to family Cyprinidae, found commonly in rivers and freshwater lakes in and around the South Asia and South-East Asia. Hatchery production statistics released by the Food and Agriculture Organization of the United Nations (FAO) revealed that 58 billion fry or fingerlings were produced in 1996, i.e., almost 160 million juveniles per day. Of these, 99% were finfish (FAO, 1999).

The fish feed and seed are considered as major concerns for the fish farmers. Fish feed is considered to be one of the major prerequisites for successful fish farming (Jhingaran, 1969). A major share of India's fish seed supply comes from riverine collections which comprises a mixture of undesirable species of fishes. The developing eggs need a continuous high oxygen concentration. The oxygen consumption of eggs is negligible in the initial stages, but increases very considerably as development progresses. Maximum oxygen is required just before hatching. It has been found that reduced dissolved oxygen (DO) retards the development of fish embryo, while high oxygenated water accelerates the process (Kinne and Kinne, 1962). Dissolved oxygen level of 4.2-6.8 mg l-1 is considered to be the best for development of the eggs. According to Tapiador et al. (1977), D.O. concentration of more than 4 mg l^{-1} is considered to be good for the development of eggs. The prime requirements for the development of eggs are proper oxygenation and water devoid of poisonous gasses (Waynarovick and Horvath, 1980). Dwivedi and Zaidi (1983) indicated that water quality and meteorological conditions have a critical role in the hatching success and spawn are extremely sensitive to water quality. Generally, two doses are administered: the first dose is the introductory or preparatory dose and the second dose is the decisive or final dose. The use of exogenous hormones to induce ovulation and spawning of fishes is well established (Lam, 1982) and different doses of hormones and sex steroids tried for various clariid catfishes gave varied responses. Further, clean and plankton free water is another basic requirement in hatcheries. Water for hatcheries operation should be filtered properly as filamentous algae can be a great nuisance in hatcheries. Deposition of silt on egg surfaces and gills of spawn prevents proper diffusion of oxygen through the gill membrane or egg cells. During the developmental processes, the eggs excrete certain harmful materials, such as CO_2 and NH_3 which, if allowed to accumulate, may poison the eggs. Therefore, it is essential to maintain a constant flow of water to remove the extraneous debris and other filthy materials from the surface of developing eggs. A sudden flow of strong water current through the incubator may destroy all the eggs within a short period. Proper water flow velocity helps in even distribution of fertilized eggs in the water and keeps them moving slowly. According to Sengupta et al.(1984), initially, a flow rate of 2.5 $l\ s^{-1}$ is to be maintained in a hatchery. The egg membrane is thinner in early stage of development of eggs. Therefore, to prevent the premature hatching, the flow is reduced to 2 $l\ s^{-1}$. After the embryos are hatched, the flow is again increased to 3.5 $l\ s^{-1}$ to prevent the newly hatched hatchlings from sinking. Oxygen deficiency could be one of the reasons for mortality in certain parts of the incubator devices where the exchange of water is poor or nil. Unsuitable temperature also kills the eggs, usually during embryonic development. Sahoo et al. (2006), estimated the total capital expenditure about four million rupees incurred in detailed design and infrastructure development for different facilities including water supply of a carp seed production complex for 30 lakhs of eggs per cycle for a period of one year. FRP hatchery plays a major role to meet the gap between the ever increasing demands of seeds in the off seasons. Continuous seed supply has got some scientific loopholes like off season mating, water availability etc. The quantity of water is an important factor to be taken into consideration, since the hatchery water becomes polluted due to dissolved organic matter and must be replaced. Recirculation of the already used water would be re-usable only if a suitable cleaning mechanism is incorporated into the overall water circulation system. The recirculatory system is usually too complicated and expensive to maintain and afford by marginal fish farmers. In this back drop, an experiment was executed to assess the minimum flow rate required for hatching operation in the carp hatchery and to quantify the total water requirement in a portable FRP carp hatchery for rohu.

In the present study an effort has been made to optimize the quantity of water use during the hatching process of rohu. Efforts have been made to quantify the minimum water requirement for the whole process; and to maintain a minimum flow rate so that, neither the eggs should settle at the bottom of incubator nor should they collide with each other.

MATERIALS AND METHODS

Description of the study area, available infrastructure, water quality monitoring, experimental set-up, methodology and procedures are briefly discussed in this section.

Study area and infrastructure

The trial was undertaken at one of the portable FRP carp hatchery units of the Central Institute of Freshwater Aquaculture (CIFA), Bhubaneswar. The infrastructure such as breeding pool, hatching pool, spawn collection tank, water storage tank, water outlet etc (Fig.1) required for the experiment are available at the institute. The important water quality parameters such as temperature, dissolved oxygen (DO), pH, ammonia, nitrate etc. were monitored during the hatching operation (ref. of APHA).

The Chronological operations during the experiment

Brooders were collected prior to the breeding process from riverine source. Healthy brooders free from any diseases were taken for this purpose (Fig. 3.8). By weight male and female should be equal. On the other hand; the number of males should be twice that of the females. The broods were transported by hamack (Canvas bags) filled with water to avoid stress to the brooders. The important water quality parameters viz. temperature, dissolved oxygen (DO), pH, ammonia, nitrate etc. were monitored during the hatchery operation. The arrangement of suitable water supply units for breeding and hatching pools were done. Induced breeding in the breeding pool was carried out. Spawns to the hatching pool were transferred. Hatching operation through the continuous flow of water carried out.

Detailed Processes during Hatching Operation

First hatching operation with minimum discharge

In our study a minimum discharge of 0.25 l s^{-1} was used for hatching and observations were recorded at three different depths, viz. surface (at a depth of 32 mm), mid-depth (450 mm) and bottom (832 mm depth).This minimum discharge may be accepted as optimum as the eggs did not settle at the bottom and also maintained a hatching efficiency of 80- 85%. A total of 9 points at three depths and three radial distances inside the tank, namely, near the wall of the tank, at the middle of the tank and near the screen were selected for taking observations. Different observations such as velocity, temperature, depth and flow rate of water were recorded in the hatching pool and the survival rate of fertilized eggs was assessed for three different hatching operations.

Hatching and assessment of Survivability

Hatching took place within 14 to 18 hours based on the maturity of brooders and water quality parameters. During hatching operation, velocity and discharge were measured with the help of a flow meter. Velocity distribution was measured in nine points, at different radial and vertical locations. Survivability assessment was also done by manual counting with the help of a petri dish. Both spawning and hatching were carried out at different discharges to determine the minimum possible discharge for carrying out these operations. Attempt was made to determine the minimum discharge at which the eggs should not settle at the bottom and the water quality parameters in terms of DO, NH_4-N, NO_3-N and pH could be maintained.

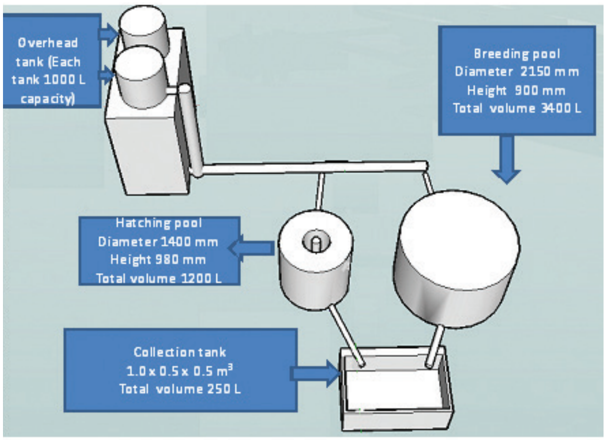

Fig.1. Hatchery unit (front view)

RESULTS AND DISCUSSION

Flow requirement for spawning

Different observations such as velocity, temperature and flow rate of water were taken in the breeding pool and the survival rate of fertilized eggs was assessed by using different discharges on different dates. At a discharge of less than 0.28 l s^{-1}, the eggs started settling at the bottom and thereby most of them died within a short period. Therefore, observations were recorded for the minimum discharge at which the eggs did not settle. From the observations it was found that a minimum flow rate of 0.28 l s^{-1} through the breeding pool was sufficient for spawning. For this discharge, the average velocity through the outlet pipe ranged between 359 and 371 mm s^{-1} and almost a constant survivable rate of 80-85% was obtained. A discharge higher than this led to wastage of water and did not produce higher survival rate of fertilized eggs. A discharge lower than this resulted in settling of number of eggs at the bottom of the tank and finally most of them died. Therefore, a discharge of 0.28 l s^{-1} can be regarded as the optimum discharge for release and fertilization of carp eggs for the specified size of the breeding pool.

Flow requirement for hatching

Hatching of the eggs was carried out with several discharges on several days. Discharge, velocity of flow, different water quality parameters were measured and hatching efficiencies were assessed to arrive at the minimum water requirement for hatching operation. However, details of the first hatching operation with minimum discharge are only presented in this paper. The observed data on the surface, mid-depth and bottom for different locations are presented in Table 1. It can be seen from Table 1 that for a flow rate of 0.25 l s^{-1} through the hatching pool, the average velocity gradually increases from wall of the tank towards the centre (screen of the tank). The variation in surface velocity was ranged 52 to 74 mm s^{-1} from the outer wall towards the screen. But with depth the velocity increased up to the middle and then reduced towards the bottom. Velocity at surface of the tank was higher than bottom of the tank in the same vertical column. The measured velocity was actually the resultant of the tangential and the radial velocities. Water enters into the inner chamber through the screen for finally discharging out through the stand pipe. Therefore, radial velocity was recorded to be highest near the screen. This might have caused the stratification of velocity distribution along the radial distance from the centre and as a result the velocity distribution was not uniform in a horizontal plane. The velocity distribution in the hatching chamber presented in Fig. 2 and 3.

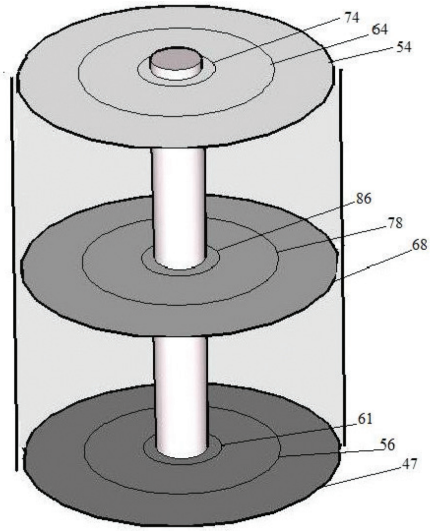

Fig. 2. Velocity (mm s^{-1}) distribution for a discharge of 0.25 l s^{-1}at different levels of the hatching pool

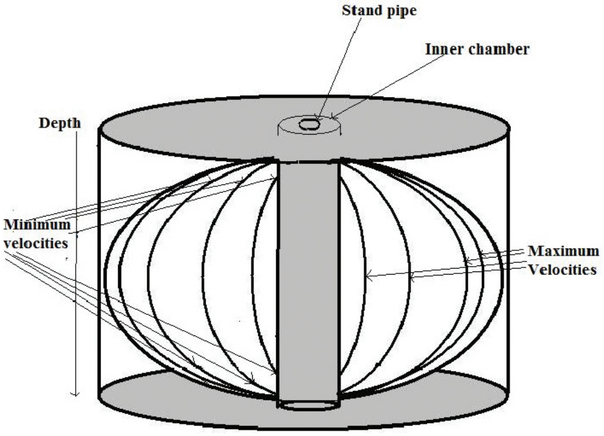

Fig. 3. Three dimensional velocity distributions in a hatching pool

The vertical velocity distribution was also not uniform. The hatching chamber is made of conical shape and vortex formation takes place in the flow phenomena. Apart from that water enters into the inner chamber through the middle of the inner wall fitted with the screen. As a result maximum velocity is obtained at the center. Although as per the flow phenomenon in an open channel, the maximum velocity is expected at the top, it does not occur in this case as the top of the inner wall is closed to water flow.

Table1. Velocity Distribution at Different Depths and Locations in the Hatching Pool for a Discharge of 0.25 l s^{-1} during First Hatching Operation

Date and Time	Velocity, mm s^{-1}		
	At 32 mm depth	At 450 mm depth	At 832 mm depth
Near the outer wall of the tank			
05-08-08 07: 00: 00	52	68	45
05-08-08 07: 01: 00	54	68	45
05-08-08 07: 02: 00	52	67	48
05-08-08 07: 03: 00	53	67	48
05-08-08 07: 04: 00	54	66	47
At the middle of the tank			
05-08-08 07: 07: 00	64	77	54
05-08-08 07: 08: 00	65	78	54
05-08-08 07: 09: 00	67	76	55
05-08-08 07: 10: 00	66	78	55
05-08-08 07: 11: 00	66	77	57
Near the screen			
05-08-08 07: 15: 00	74	85	62
05-08-08 07: 16: 00	73	85	60
05-08-08 07: 17: 00	73	84	61
05-08-08 07: 18: 00	72	87	59
05-08-08 07: 19: 00	73	86	62

Observations on water quality parameters

Observations on changes in water quality parameters like dissolved oxygen, pH, ammonia (NH_4-N), nitrate (NO_3-N) due to breeding and hatching were recorded. The above parameters of the incoming water as well as after breeding and hatching were recorded. They are presented in Table 2.

Table 2. Water quality parameters before and after breeding and hatching

Sl No	Incoming water quality ppm				Water quality after breeding, ppm				Water quality after hatching, ppm			
	DO	pH	NH_4-N	NO_3-N	DO	pH	NH_4-N	NO_3-N	DO	pH	NH_4-N	NO_3-N
1	4.8	7.03	0.3	0.6	4.7	7.03	0.4	0.7	4.4	7.03	0.6	0.8
2	4.7	7.03	0.3	0.5	4.6	7.03	0.4	0.6	4.3	7.03	0.6	0.7
3	4.8	7.03	0.2	0.6	4.7	7.03	0.3	0.7	4.4	7.03	0.5	0.8

It can be seen from Table 2 that all the water quality parameters are within the tolerable range. The minimum DO requirement is about 4 ppm, whereas, the outflow water either from breeding or hatching pool has higher DO. The optimum pH requirement was between 6.5-7.5 whereas, the actual pH during the experiment is 7.03 and it does not change during either breeding or hatching. Maximum tolerable limit of NH_4-N or NO_3-N was 1.0 ppm. The actual values of 0.3 to 0.8 ppm after breeding or hatching are well within the tolerable limit. It can be concluded from the observation that the minimum velocity of water was the limiting factor. Once that is attained, water quality parameters are automatically maintained provided that the incoming water has qualities at least equal to that of the experimental water. From the above observations, the minimum water requirement for the FRP type of hatchery developed by CIFA, Bhubaneswar for one million Spawn production of *Labeo rohita* L. was calculated and is presented below.

Water requirement in the breeding pool

i. Initial filling = 2950 l
ii. For 5 hours showering = 1980 l
iii. Water requirement for 2 hours spawning = 0.28 x 7200= 2016 l
iv. Total water requirement in the breeding pool = 2950 +1980 + 2016 = 6946 l.

Water requirement in the hatching Pool

Initial filling of hatching pool = 1275 l

Minimum average flow rate in hatching pool = (0.25+0.245+0.255)/3 = 0.25 l s^{-1}

Eggs hatch out at in 14-18 h and remain in the pool for 72 h.

Total time of operation in the hatching pool = 72 +18 = 90 h

Total water requirement in hatching pool = 1275 + (0.25 x 3600 x 90) = 82,275 l.

Therefore, total water requirement for breeding and hatching operation = 6946 l+ 82,275 l = 89,221 l = 90 m^3 (approx).

CONCLUSION

Following conclusions can be drawn from the study;

i. Optimum flow rate required for breeding operation in the carp hatchery was 0.28 l s^{-1}
ii. Optimum flow rate required for hatching operation in the carp hatchery was 0.25 l s^{-1}
iii. Optimum water requirement in hatchery for production of one million spawn = 90 m^3
iv. Water quality parameters do not affect the hatching efficiency as long as there is continuous flow through the tank to keep the eggs floating. Therefore, there is a possibility of reuse of water for hatching operation.

Apart from this, there are scopes for further research such as:

i. Experiment may be conducted by using more numbers of different types of hatching and breeding pools so that the results will be more generalized and acceptable,

ii. Efforts should be made for reuse of water (more than once) in the hatchery system without treatment,

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