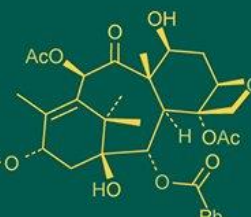
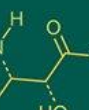
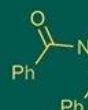


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Influence of varied durations and intensities of aeration on the growth performance and survival of Asian catfish, *Clarias batrachus* larvae

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Abstract

A study was conducted to evaluate the effect of varied durations and intensities of aeration (air flow rates) on growth and survival of *Clarias batrachus* larvae in hatchery condition. Ten experimental treatments of different durations (24, 12, and 6 h) and intensities (3.75, 2.50 and 1.25 ml min⁻¹ L⁻¹) of aeration combination along with the control (without aeration) were tested. The different durations of aeration showed a marked effect on the growth performance and survival of magur larvae. Significantly ($p < 0.05$) highest growth was recorded at the aeration intensity of 1.25 ml min⁻¹ L⁻¹ in combination with three durations (24, 12, and 6 h) compared to the other two aeration levels. Similarly, the survival rate (84-85%) was significantly higher for magur larvae reared in the mild aeration intensity of 1.25 ml min⁻¹ L⁻¹ in combination with three durations (24, 12, and 6 h). Water quality parameters of TAN and nitrite levels were relatively lower for higher duration of aeration (24 h) and irrespective of the intensities, and it was observed that the control group had a higher level of nitrogenous wastes. Hence, the result of the present study indicates that a minimum of 6 h aeration with a low air flow rate of 1.25 ml min⁻¹ L⁻¹ would be sufficient for the larval rearing of magur for higher seed production in hatchery phase.

Keywords: Aeration, catfish, larvae, *Clarias batrachus*, oxygen, water quality

Introduction

Clarias batrachus is one of the promising cultivable air-breathing catfish in Asian countries and it is considered as a candidate species for aquaculture diversification in Indian aquaculture. Its hardy nature in adverse ecological condition, response to high density culture and higher market price are some of the potential characteristics for adopting the grow-out culture in Asia (Thakur and Das, 1986; Areerat, 1987; Chandra and Banerjee, 2003) [20, 2, 5]. The reduction in its population due to over exploitation from the natural water enlist it as a near threatened species on the IUCN red list. Hence it is difficult to get sufficient seed from natural water bodies for undertaking its culture. So captive production of seed remains the only ultimate choice for continuous supply of seed. But the early mortality leading to heavy loss in hatchery is often seen during larvae culture of this catfish. The delicate larvae of *C. batrachus* need utmost care for better growth and survival during their nursery phase. Biotic as well as abiotic factors are sometimes also responsible for this loss. The absence of air-breathing organ till 10-11 days after hatching enforces the hatchery manager to use aeration in the rearing tanks for better rearing performance as also seen in some of the study on the larval rearing of catfishes (Sahoo *et al.*, 2004, 2010, 2012; Ferosekhan *et al.*, 2019, 2020) [14, 15, 16, 8, 9]. Aeration plays a key role, and it is considered as one of the important inputs to take care of the changes of water quality and bring them to tolerable limits during rearing of different fish species (Qayyum *et al.*, 2005; Boyd, 1982) [13, 4]. Some authors were also in opinion of the negative effect of intense aeration on growth, health and feeding during fish rearing (Ellis *et al.*, 1997; Toledo *et al.*, 2002; Sakakura *et al.*, 2007) [7, 21, 17]. Provision of aeration in excess of the requirement often leads to loss of considerable energy and increase the production cost (Pawar *et al.*, 2009) [12]. Hence the necessity of aeration in shape of duration and/or intensity needs to be evaluated in different life stages of fish species to explore the beneficial effect during their rearing. However, little attention has been paid to evaluate the duration and intensity of aeration in the growth performance of this catfish larvae.

Therefore, the present study attempts to evaluate the duration of aeration in combination with the intensity (airflow rate) during larval rearing of *C. batrachus* to understand the best combination for optimal growth and survival.

Material and Methods

Experimental design: The larvae were obtained by induced breeding of *C. batrachus* in the catfish hatchery of ICAR-Central Institute of Freshwater Aquaculture (ICAR-CIFA), Bhubaneswar, India. Thirty uniform sized circular plastic tubs (20 L capacity) were used for the study. The tubs were uniformly filled with 15 l water and were provided with aeration. Four days old larvae (9.6 ± 0.17 mm in length and 6.42 ± 0.19 mg in weight) were stocked at 5 individuals L^{-1} randomly into triplicate tubs. The larvae were subjected to ten experimental treatments of different durations and intensity (air flow rates) combinations, following a completely randomized design (Table 1). The duration of aeration in the different treatment groups was maintained by using an aeration regulator and different air flow rates were adjusted with a Thermo-anemometer AN100 (Extech

Instruments, India®).

Feeding and cleaning of tanks: The experimental tubs were cleaned once daily during morning hour and 50% water was replenished without much disturbances to the larvae. The larvae were fed *ad libitum* with freshly produced *Artemia nauplii* during an entire experimental period of 14 days.

Growth parameters and percentage survival: Twenty-five fish from each tub were taken as the sample size at the end of the experiment for the assessment of growth performance (final length & final weight). The length and weight gain percentage, specific growth rate (SGR) and survival were estimated by using standard formulae as follows:

$$\text{Length gain\%} = \frac{(\text{final length} - \text{initial length})}{(\text{initial length})} \times 100$$

$$\text{Weight gain\%} = \frac{(\text{final weight} - \text{initial weight})}{(\text{initial weight})} \times 100$$

$$\text{Specific growth rate (\% day}^{-1}\text{)} = \frac{[\text{Ln (Final weight (mg))} - \text{Ln (Initial weight (mg))}]}{\text{Duration of rearing period (days)}} \times 100$$

$$\text{Survival rate (\%)} = \frac{\text{Number of survived larvae}}{\text{Number of larvae stocked}} \times 100$$

Water quality parameters: Water samples from each tub were taken in the morning every alternate day before cleaning the rearing tanks to record the pH, dissolved oxygen, total alkalinity, hardness, total ammonia nitrogen and nitrite-nitrogen. These parameters were analyzed in the laboratory following a standard method (APHA, 2005). Water temperature and dissolved oxygen were recorded daily with a dissolved oxygen meter (MERCK, Germany).

Statistical Analysis: One-way and Two-way analysis of variance was used to compare all the treatments. Duncan's Multiple Range Test was performed at 95% significance level to compare the treatment means for different parameters in SPSS 24.

Results and Discussion

The water quality parameters of the rearing tanks exposed to different durations and air intensities are presented in Table 2. Provision of aeration during fish rearing is usually followed with an aim to improve the water quality and variability of water quality, limiting the fish production (Boyd, 1982) [4]. No marked variations in the water quality parameters of temperature, pH, total alkalinity and hardness were observed except dissolved oxygen, TAN and nitrite in the present study. Durations and intensities of aeration had a significant ($p < 0.05$) effect on the dissolved oxygen, TAN and nitrite concentrations. However, the tanks exposed to 24 h aeration with an intensity of $3.75 \text{ ml min}^{-1} L^{-1}$ had significantly higher ($p < 0.05$) dissolved oxygen concentration compared to the control and other treatment groups (Table 2). More infusion of air at high intensity for longer duration might be responsible for the increased oxygen level in the tanks. Other water quality parameters observed in this study were within the range as reported for other catfishes (Sahoo *et al.*, 2004; Sahoo *et al.*, 2010;

Srivastava and Raizada, 2012) [14, 1519].

The intensities of aeration along with the durations showed positive effect on growth performance and survival of larvae in the present study (Table 3 and Fig 1). The growth parameters like final length and weight, length and weight gain, and specific growth rate were significantly ($p > 0.05$) higher in all the treatments compared to control group except T₁. The persistence of anaerobic conditions due to low oxygen level in the rearing medium might be one of the causes for lower growth and survival in the control group, even though other water quality parameters were within the safe range. Several studies also demonstrated the importance of aeration to ensure oxygenation during fish rearing in ponds or hatchery for higher growth and survival (Backhurst and Harker 1988; Qayyum *et al.*, 2005; Sakakura *et al.*, 2007) [3, 13, 17]. The final length of larvae reared in the tanks provided with $1.25 \text{ ml min}^{-1} L^{-1}$ flow rate and in combination irrespective of durations was the highest ($p > 0.05$) compared to other two air flow rates with their respective duration combinations. The final weight also followed the similar as that of the final length. Generally, it is observed that *C. batrachus* larvae start browsing at the bottom as soon as the artemia settles but do not have much preference for the artemia in the water column in a normal condition. Hence, the larvae could not feed well due to non-settlement of artemia at the tank bottom due to turbulence created by strong air flow in the tank (T₂), which might be the cause of poor larval growth in high intensity airflow. While working at six levels of aeration during rearing of *Epinephelus septemfasciatus* larvae, Sakakura *et al.*, (2007) [17] reported that strong aeration resulted in the lowest growth and feeding incidence. The significant reduction in growth performance in higher aeration intensity in the present study is in conformity with the results on the studies conducted in *E. coioides* larvae (Toledo *et al.*, 2002) [21] and *Pangasius hypophthalmus* larvae (Slembrouck *et al.*, 1998) [18]. The larvae of *C. batrachus* have the tendency to settle at the bottom and congregate at few places in the tank bottom. The

larvae get disbursed due to air flow rate and try to satisfy their behaviour, and hence need energy in regular basis, which might be another reason for lower growth in strong aeration. The percentage gain in length and weight of larvae in the tanks provided with $1.25 \text{ ml min}^{-1} \text{ L}^{-1}$ air flow in all combinations of duration were the highest ($p>0.05$) compared to other treatments. The lower SGR value either in control or in $3.75 \text{ ml min}^{-1} \text{ L}^{-1}$ air flow in 24 h aeration duration could be due to lower growth compared to other treatments. When the larvae were subjected to different air flow rate, the larvae exposed to $1.25 \text{ ml min}^{-1} \text{ L}^{-1}$ in combination with three durations showed highest ($p>0.05$) survival compared to other two aeration intensity treatments (Fig 1). The high mortality in strong aeration groups might be due to continuous disturbance and causing stress to the larvae. Several experimental studies had also revealed and dome-shaped relationship between turbulence levels and

survival of fish larvae (Cury and Roy, 1989; Kimura *et al.*, 2004; MacKenzie *et al.*, 1994) [6, 10, 11].

Table 1: Experimental treatments of different durations and intensities of aeration

Treatment	Aeration	
	Duration (h)	Intensity (Airflow rate, $\text{ml min}^{-1} \text{ L}^{-1}$)
T ₀ (Control)	0	0
T ₁	24	3.75
T ₂	24	2.50
T ₃	24	1.25
T ₄	12	3.75
T ₅	12	2.50
T ₆	12	1.25
T ₇	6	3.75
T ₈	6	2.50
T ₉	6	1.25

Table 2: Water quality parameters of the rearing tanks exposed to different durations and intensities of aeration during an experimental period of two weeks (means $\pm$ S.E, n = 3)

Treatment	Temperature ($^{\circ}\text{C}$)	pH	DO (mg L^{-1})	Total alkalinity (as $\text{CaCO}_3 \text{ mg L}^{-1}$)	Total hardness (as $\text{CaCO}_3 \text{ mg L}^{-1}$)	Total ammonia nitrogen (mg L^{-1})	Nitrite-nitrogen (mg L^{-1})
T ₀ (Control)	28.16 $\pm$ 0.14	8.30 $\pm$ 0.06	3.8 $\pm$ 0.11 ^a	177.0 $\pm$ 0.8	174.3 $\pm$ 1.3	0.44 $\pm$ 0.007 ^b	0.029 $\pm$ 0.0069 ^b
T ₁	27.71 $\pm$ 0.21	8.43 $\pm$ 0.03	7.6 $\pm$ 0.13 ^d	175.1 $\pm$ 0.8	172.8 $\pm$ 0.8	0.18 $\pm$ 0.006 ^a	0.003 $\pm$ 0.0003 ^a
T ₂	27.86 $\pm$ 0.26	8.33 $\pm$ 0.03	7.4 $\pm$ 0.11 ^d	175.6 $\pm$ 1.2	172.6 $\pm$ 1.6	0.20 $\pm$ 0.004 ^a	0.004 $\pm$ 0.0002 ^a
T ₃	28.02 $\pm$ 0.10	8.27 $\pm$ 0.03	7.1 $\pm$ 0.11 ^d	178.0 $\pm$ 1.3	175.3 $\pm$ 1.3	0.19 $\pm$ 0.003 ^a	0.005 $\pm$ 0.0002 ^a
T ₄	27.55 $\pm$ 0.60	8.33 $\pm$ 0.09	6.7 $\pm$ 0.12 ^c	176.1 $\pm$ 1.5	173.4 $\pm$ 1.6	0.24 $\pm$ 0.002 ^a	0.006 $\pm$ 0.0002 ^a
T ₅	27.89 $\pm$ 0.01	8.37 $\pm$ 0.03	6.4 $\pm$ 0.10 ^c	177.8 $\pm$ 0.9	174.8 $\pm$ 0.9	0.23 $\pm$ 0.003 ^a	0.007 $\pm$ 0.0002 ^a
T ₆	27.66 $\pm$ 0.28	8.25 $\pm$ 0.13	6.1 $\pm$ 0.11 ^c	176.8 $\pm$ 0.9	173.8 $\pm$ 0.7	0.22 $\pm$ 0.002 ^a	0.009 $\pm$ 0.0002 ^a
T ₇	28.13 $\pm$ 0.09	8.28 $\pm$ 0.11	5.6 $\pm$ 0.13 ^b	179.7 $\pm$ 1.3	176.7 $\pm$ 1.5	0.29 $\pm$ 0.002 ^{ab}	0.009 $\pm$ 0.0003 ^a
T ₈	28.14 $\pm$ 0.12	8.23 $\pm$ 0.12	5.5 $\pm$ 0.12 ^b	175.1 $\pm$ 1.1	171.8 $\pm$ 1.9	0.28 $\pm$ 0.005 ^{ab}	0.010 $\pm$ 0.0004 ^a
T ₉	28.27 $\pm$ 0.09	8.33 $\pm$ 0.09	5.2 $\pm$ 0.11 ^b	177.7 $\pm$ 1.0	174.3 $\pm$ 1.1	0.31 $\pm$ 0.008 ^{ab}	0.009 $\pm$ 0.0012 ^a

Values in the same column sharing a different superscript differ significantly ($p<0.05$)

Table 3: Effects of durations and intensity air flow rates on growth parameters of *C. batrachus* larvae (means $\pm$ S.E, n = 3)

Treatment	Duration of aeration (hour)	Air flow rate ($\text{ml min}^{-1} \text{ L}^{-1}$)	Initial length (mm)	Initial weight (mg)	Final length (mm)	Final weight (mg)	Length gain (%)	Weight gain (%)	Specific growth rate (% d^{-1})
T ₀ (Control)	0	0	9.60 $\pm$ 0.17	6.43 $\pm$ 0.19	14.20 $\pm$ 0.20 ^a	18.97 $\pm$ 0.95 ^a	47.92 $\pm$ 2.10 ^a	195.07 $\pm$ 14.81 ^a	7.33 $\pm$ 0.34 ^a
T ₁	24	3.75	9.60 $\pm$ 0.17	6.43 $\pm$ 0.19	14.53 $\pm$ 0.14 ^a	18.81 $\pm$ 0.71 ^a	51.39 $\pm$ 1.48 ^a	192.62 $\pm$ 11.03 ^a	7.45 $\pm$ 0.26 ^a
T ₂	24	2.50	9.60 $\pm$ 0.17	6.43 $\pm$ 0.19	15.43 $\pm$ 0.16 ^b	23.86 $\pm$ 0.37 ^{bc}	60.76 $\pm$ 1.66 ^b	271.17 $\pm$ 5.69 ^{bc}	9.15 $\pm$ 0.11 ^{bc}
T ₃	24	1.25	9.60 $\pm$ 0.17	6.43 $\pm$ 0.19	16.85 $\pm$ 0.07 ^c	30.74 $\pm$ 0.27 ^d	75.52 $\pm$ 0.80 ^c	378.08 $\pm$ 4.20 ^d	11.09 $\pm$ 0.08 ^d
T ₄	12	3.75	9.60 $\pm$ 0.17	6.43 $\pm$ 0.19	15.25 $\pm$ 0.20 ^b	22.09 $\pm$ 0.62 ^b	58.85 $\pm$ 2.10 ^b	243.60 $\pm$ 9.66 ^b	8.55 $\pm$ 0.23 ^b
T ₅	12	2.50	9.60 $\pm$ 0.17	6.43 $\pm$ 0.19	15.73 $\pm$ 0.15 ^b	24.25 $\pm$ 0.77 ^{bc}	63.89 $\pm$ 1.54 ^b	277.13 $\pm$ 11.93 ^{bc}	9.17 $\pm$ 0.22 ^{bc}
T ₆	12	1.25	9.60 $\pm$ 0.17	6.43 $\pm$ 0.19	16.77 $\pm$ 0.45 ^c	30.55 $\pm$ 1.47 ^d	74.65 $\pm$ 4.66 ^c	375.13 $\pm$ 22.84 ^d	10.83 $\pm$ 0.35 ^d
T ₇	6	3.75	9.60 $\pm$ 0.17	6.43 $\pm$ 0.19	15.48 $\pm$ 0.13 ^b	24.42 $\pm$ 0.42 ^{bc}	61.28 $\pm$ 1.36 ^b	279.82 $\pm$ 6.49 ^{bc}	9.40 $\pm$ 0.13 ^c
T ₈	6	2.50	9.60 $\pm$ 0.17	6.43 $\pm$ 0.19	15.90 $\pm$ 0.16 ^b	25.71 $\pm$ 0.71 ^c	65.63 $\pm$ 1.67 ^b	299.82 $\pm$ 11.05 ^c	9.62 $\pm$ 0.25 ^c
T ₉	6	1.25	9.60 $\pm$ 0.17	6.43 $\pm$ 0.19	16.73 $\pm$ 0.23 ^c	30.22 $\pm$ 0.96 ^d	74.31 $\pm$ 2.43 ^c	370.01 $\pm$ 14.85 ^d	10.83 $\pm$ 0.26 ^d

Values in the same column sharing a different superscript differ significantly ($p<0.05$)

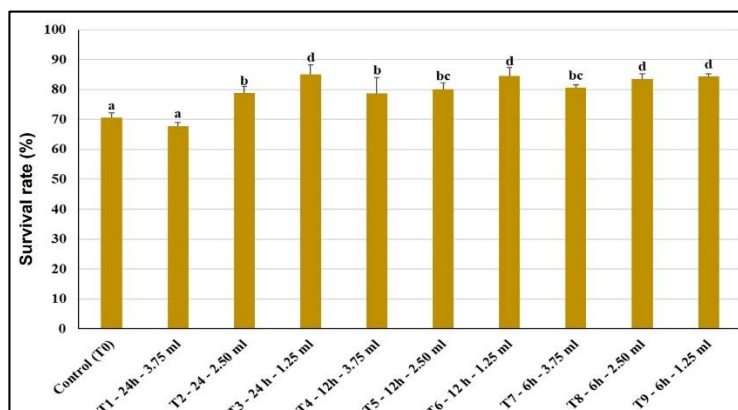


Fig 1: Effects of aeration durations and intensity rates on survival rate of *C. batrachus* larvae. Values in the same column sharing a different superscript differ significantly ($p<0.05$).

Conclusion

The present experiment suggests that aeration is necessary in the larval rearing for the supply of oxygen and aeration for 6 h with mild air flow rate up to $1.25 \text{ ml min}^{-1} \text{ L}^{-1}$ has beneficial effect for higher growth and survival of *C. batrachus* larvae to get improved seed production in hatchery phase. The successful rearing will not only help for a constant supply of seed for its aquaculture, but also will help as a conservation measure for this near threatened species.

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Author Contributions

Conceptualization: S. P. Kamble; Methodology: M.K. Bairwa; Formal analysis and investigation: A.K. Chaudhari; Writing original draft preparation: S. Ferosekhan; Writing: review and editing, Supervision: S. K. Sahoo.

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