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Effect of water depth with respect to survival of *Clarias magur* (Hamilton, 1822) larvae in two tier larval rearing system

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Abstract
The present investigation was carried out to standardize the water depth for better survival of *Clarias magur* larvae in both first tier and second tier system. The experiment consisted of three water depth *viz*; (6 cm – T_1, 8 cm – T_2 and 10 cm – T_3) in triplicates and rear up to 10 dph. The second tier experiment was conducted with three water depth *Viz*: T_1 (6"), T_2 (7") and T_3 (8"). The first tier rearing system showed the non-significant difference (P>0.05) between the treatments in terms of body length. However, the body weight gain was significant between T_3 and both T_1 and T_2. The second tier system showed growth and Survival was observed significant difference (p<0.05) among the treatment. Low water depth 6 cm in first tier rearing system and water depth of 06" showed better growth and higher survival percentage especially for *Clarias magur* larval rearing in second tier rearing unit. It is obvious from the study that the water depth affected the survival rate of magur larvae rearing.

Keywords: *Clarias magur* larvae, water depth, growth, survival, two tier rearing system

1. Introduction
C. magur, not *C. batrachus* and these two are different species. These findings are discussed by Indian fish taxonomists in reputed national journals [26]. Recently provided genetic evidence and showed that *C. magur* and *C. batrachus* are genetically distinct from each other [7].
The declining production of fish from natural water bodies becomes a real challenge to aquaculture to provide fish protein to the increased human population. Hence, utilization of freshwater bodies with species diversification along with simple and low-cost techniques may be the fore-runner activities for the enhanced fish production in future times. *Clarias magur*, one of the representative species of catfish species, is a coveted fish with high market demand deserving its potential culture under aquaculture policies of the country.
Fish larvae are the smallest self-supporting vertebrates and in order to increase their chances of survival, they need to complete their morpho-functional system so as to escape predation and to obtain food [23]. The transition from endogenous to exogenous feeding for fish larvae is one of the most essential and critical stages in essential for high rearing success on providing zooplankton (live feed) for a commercial scale rearing system [10, 14]. The main objective of the culture of finfish and shellfish is to maximize survival and growth rates at minimum cost. In many aquaculture operations today, feed accounts for over half the operating cost. The production of aquaculture species can be economical only when its qualitative and quantitative feed requirements are known and the formulation of nutritionally balanced low cost diets are possible [30, 11, 15].

2. Material and methods
2.1 Fish
Fish used for the experiment were larvae of Magur (*Clarias magur*, Hamilton, 1822). The newly hatched larvae were collected from ICAR-Central Institute of Fisheries Education, Balabhadrapuram Kakinada Centre. The four days old larvae (4th days post hatch) were used for the experimental purpose and distributed # DP in the hatching tub (6, 8 and 10 cm tubs) for three days till the yolk sac was completely absorbed.

2.2 Feeding

The *Clarias magur* larvae were completely fed *ad libitum* with zooplankton at the rate of 10 % Of body weight twice daily (10.00 and 17.00 Hrs.).

2.3 Experimental design

The First tier experiment was conducted in indoor tubs (Hatching cum rearing tub) of 1.25 x 0.5 x 0.2 m size and filled with water up to a depth of 6 cm (T_1), 8 cm (T_2) & 10 cm (T_3) for a period of 10 days. The indoor tubs have two outlets (diameter 0.5") for maintaining flow through system and tubs were be filled with freshwater through common 0.5" PVC perforated pipe which was placed over the tubs at a height of 1.5 ft. to facilitate water showering in each tub with maintain 2 lit. /hr. water flow. *Clarias magur* hatchling 3 or 4 dph (days post hatch) were stocked in each treatment @ 3000/tub in triplicates. Aeration in each tub was provided with air stone to promote a homogeneous distribution of feed in the water column and tubs were siphoned daily during morning hours before feeding to remove fecal residues. The size of larvae and survival were to be recorded by taking measurements (length & weight) on the 10^{th} day. At the end of the experiment, all the tubs were dewatered and a number of magur fry in each treatment was counted. The second tier experiment was conducted in the indoor tub (rearing tub) of 3 x 0.6 x 0.45m size and filled with water up to 6" (T_1), 7" (T_2) & 8" (T_3). Magur fry were stocked @ 1000/tub. Aeration in each tank was provided with the air stone to promote a homogeneous distribution of feed in the water column.

2.4 Evaluation of larvae growth, survival and water quality

Clarias magur larvae were sampled (Hatching cum rearing tubs) on 10^{th} days of culture to assess their growth performance (length, weight). At the end of the first tier experiment, all the tubs were dewatered and a number of fish in each experimental tubs was sampled. Parameter were considered for growth measurement i.e. Length, weight, survival rate and length weight relationship. At the end of the experiment, all the tubs were dewatered and a number of fish in each experimental tubs was counted. In the second tier (rearing system) fish larvae were sampled on 10^{th}, 15^{th}, 20^{th}, 25^{th} and 30^{th} days of the rearing period to assess their growth performance (length, weight). Ten larvae from each treatment were randomly sampled. Six different parameters were considered for growth measurement i.e. length, weight, percentage gain in weight, FCR, FER, SGR, PER and survival rate. At the end of the experiment, all the tubs were dewatered and all the numbers of an animal in each experimental tubs were counted.

$$\text{Percent gain in weight} = \frac{\text{Final weight (mg)} - \text{Initial weight (mg)}}{\text{Initial weight (mg)}} \times 100$$

$$\text{Food conversion ratio} = \frac{\text{Dry Weight of food given (mg)}}{\text{Wet Weight gain of fish (mg)}}$$

$$\text{Food efficiency ratio} = \frac{\text{Wet Weight gain of fish (mg)}}{\text{Dry weight of food given (mg)}}$$

$$\text{Specific growth rate (\%)} = \frac{\ln \text{Final Weight (mg)} - \ln \text{Initial Weight (mg)}}{\text{Number of Days}} \times 100$$

$$\text{Protein efficiency ratio} = \frac{\text{Net weight gain (mg)}}{\text{protein in feed (\%)}}$$

$$\text{Survival (\%)} = \frac{\text{Total number of harvested}}{\text{Total number of stocked}} \times 100$$

2.5 Water quality parameters

Through-out the rearing period dissolved oxygen, pH and water temperature were recorded *in situ*, whereas total alkalinity, total hardness and dissolved inorganic nutrients (ammonia nitrogen, nitrite - nitrogen) were analysed in the laboratory by following standard protocols [1].

2.6 Statistical analysis

The data recorded for evaluation of different treatments were statistically analysed using SPSS 16 Version for analysis of variance (ANOVA) order to test the significance at a chosen level of significance (p=0.05). The analysis were a further test with Duncan Multiple Range Test if treatments mean were statistically significant.

3. Results

3.1 Physico-chemical water quality parameters

Water quality is critical in the fish culture system since fishes are highly sensitive to the changes in the aquatic environment and thus, it determines to a great extent the success or failure of a fish operation [25]. Optimum quality ensures maximum survival and growth of the fish larvae. The selected water quality parameters depicted in Table 1. The water quality such as water temperature (^{0}C), dissolved oxygen (mgL^{-1}), pH, total alkalinity (mgL^{-1}), total hardness (mgL^{-1}), ammonia and nitrite – N (mgL^{-1}) of different treatments were within the permissible range as observed due to regular water exchange and provision of continuous aeration. The recorded mean values of all these parameters were within the acceptable limits for fish growth and health. In all the treatments water temperature ranged between 24.67 – 25.00^{0}C (T_1), 24.67 – 25.67^{0}C (T_2) and 24.67 – 25.33^{0}C (T_3), pH values were recorded within the range of 7.10 – 7.87 (T_1), 7.39 – 8.00 (T_2) and 7.05 – 8.10 (T_3) in different treatments. The concentration of dissolved oxygen was 5.80 – 6.66 mg/l (T_1), 5.90 – 6.93 mg/l (T_2) and 5.80 – 6.33 mg/l (T_3) The experimental water was slightly alkaline and total alkalinity in different treatments ranged between 88.33 – 96.00 mg/l (T_1), 88.00 – 96.67 mg/l (T_2) and 88.33 – 95.00 mg/l (T_3), ammonia and nitrite-N in water was found to be negligible, throughout the experimental period and the value were within the recommended range for rearing of *Clarias magur* larvae in flow through hatchery system and not affected by the two tier rearing system (Table 1).

3.3 Growth performance of Clarias magur larvae

3.1.1 First tier rearing system

The growth data of *Clarias magur* larvae of the first tier rearing system are depicted in Figures 1-2. The highest length (13.6±0.03 mm) was recorded in T_2 which was followed by T_1 and T_3 with respective length 12.5±0.1 and 12.2±0.12 mm. it would be seen from Figure 2 that the highest weight (38.0±1.15 mg) was in T_3 followed by T_1 and T_2 with respective weight 32.0±0.03 and 34.0±1.15 mg. It is obvious from the results (Figure 2) that the water depth affected the growth of larvae. The statistical analysis (ANOVA) for length gain showed that the length and different depth treatment was non-significant between treatments. However, the weight gain was significant between T_3 and both T_1 and T_2. Further, the growth gain was again non-significant between T_1 and T_2. No significant difference (p>0.05) with regards to a survival rate of the first tier rearing system. It would be seen from figure (3) that, the highest survival rate was observed in T_1 (95.00±1.07 %) followed by T_2 (92.11±0.86 %) and T_3 (88.11±1.28 %).

The length and weight measurements of the fish are related to each other. The descriptive statistics of length weight data is presented in Table 02 where the minimum and maximum recorded range of Total length (TL) varies from 12 – 13 mm in T_1, 13 – 14 mm in T_2 and 11 – 15 mm in T_3 as well as Total weight (TW) range varies from 32.0 – 32.1 mg in T_1, 32.0 – 36.0 mg in T_2 and 36.0 – 40.0 mg in T_3. However, the mean values of total length were 13±0.18 mm, 14±0.31 mm and 12±1.21 mm in T_1, T_2 and T_3 respectively and the total weight was 32.0±0.03 mg, 34.0±1.15 mg and 38.0±1.15 mg in T_1, T_2 and T_3 respectively. The length and weight were positively correlated in the treatments. The data on the coefficient of correlation (r) along with regression (r^2) equation for total length and total weight are presented in Table 03. As regards correlation of total body length with weight in different treatments. The value of a coefficient of correlation (r) was 0.282792 (T_1), 0.444977 (T_2) and 0.413837 (T_3) form these it is evident that the 'r' value was maximum in T_2 (13 – 14 mm) with water depth (08 cm) in the hatchery.

Fulton's conditioning factor (K) or Ponderal Index was also calculated. This expresses the degree of well-being, robustness, fatness in numerical terms. From this study, the value of K were K= 19.898 (T_1), K= 21.11943 (T_2) and K = 23.60407 (T_3) which were found positively correlated. These values also indicated the increased fat deposition in the body due to adaptability and high feeding activity of fish (Table 03).

3.1.2 Second tier rearing system

The highest length (19.80±0.0 mm) was recorded in T_1 which was followed by T_3 and T_2 with respective length 19.60±0.4 and 18.95±0.7 cm. It would be found highest body weight gain (101±1.4 mg) was in T_1 followed by T_2 and T_3 with respective weight 97±1.4 and 90.5±3.5 mg. It is obvious from the results (Table 4) that the water depth affected the growth of larvae. The statistical analysis (ANOVA) for length gain showed that the length and different depth treatment was significantly different (p<0.05) between treatments. However, the body weight gain was significant between T_1 and T_3. Further, the growth gain was again non-significant between T_2 with T_1 and T_3. The highest Percent weight gain (315.6±4.4 mg) was in T_1 followed by T_2 and T_3 with respective weight 294.3±16 and 245.4±18 mg. It is obvious from the results (Table 4) that the water depth affected the growth of larvae. The statistical analysis (ANOVA) for percent weight gain was significant between T_3 and T_1. Further, the growth gain was again non-significant between T_2 between T_1 and T_3.

The food conversion ratio of *C. magur* larvae has been shown in Table 4. For 30 days duration, it was found to be low FCR values observed (1.01±0.021) in T_1 followed by T_3 (1.16±0.056) and T_2 (1.17±0.035). A low FCR indicates better conversion of food into flesh. The better FCR (1.01±0.021) was recorded in T_1 (6" water depth) indicating better utilization of consumed food as compared to other treatments. The mean FCR value was significantly different (p<0.05) between treatments. The mean values of FER values were significantly different (p<0.05) between T_1 and T_3. The highest FER was recorded in treatment T_1 (0.98±0.021) followed by T_3 (0.86±0.042) and T_2 (0.85±0.028). Present study indicate that greater feed intake, the greater the growth response and food consumption is the growth limiting factor (Table 4).

The specific growth rate (SGR) of experimental fish *C. magur* larvae has been shown in Table 4. It was highest (4.74±0.03) in T_1 (6") followed by T_2 with 7" (4.57±0.14) and T_3 with 8" (4.12±0.18). The mean values of SGR were significant at 5 % level (p<0.05) between T_1 and T_3. The PER values were significantly different (p<0.05) between T_3 with both T_1 and T_2. The respective values of PER in T_1, T_3 and T_2 were 8.04±0.14, 7.07±0.35 and 6.98±0.21. The increase in PER was high in treatments T_1 (with 6") followed by treatment T_3 (with 8") and T_2 (7").

Furthermore, the survival rate of larvae was calculated at the end of the experiment and statistically analysed result showed highly significant difference between the treatments. The highest survival was found in T_1 (60.00±5.6 %) followed by T_2 (52.50±2.1 %) and T_3 (39.00±8.4 %) (Table 4). It is obvious from the table 4 that the water depth affected the survival rate of magur larvae rearing.

4. Discussion

In the present study, water quality is critical in fish culture systems since fishes are highly sensitive to the changes in the aquatic environment and thus, it determines to a great extent the success or failure of a fish operation [25]. Larvae raring is an important step in the fish production cycle [2, 5, 6]. Optimum quality not only ensures optimum survival but the higher growth of fish larvae. In the present study, selected water quality parameter such as water temperature, dissolved oxygen, pH, total alkalinity, total hardness, ammonia and nitrite – N were given in Table 1. The recorded mean values of all these water quality parameters were within acceptable limits for fish growth and health [16, 17, 29]. The ammonia and nitrite-N in water were found to be negligible in all the treatments and the value were within the recommended range for the rearing of *Clarias magur* larvae in flow through the hatchery system. The Physicochemical water quality parameters of different treatments tubs were found that the water quality lies in the optimum range (Table 1).

In the present study has showed that, growth performance of *Clarias magur* larvae can be significantly influenced by water depth that strongly affected the growth and survival. The highest growth performance (length, body weight gain, specific growth rate, feed conversion ratio, feed efficiency ratio, protein efficiency ratio and survival) were recorded in low water depth treatments. Significantly highest length (13.6±0.03 mm) was recorded in T_2 which was followed by T_1 and T_3 with respective length 12.5±0.1 and 12.2±0.12 mm (Figure 1). The growth performance of *Clarias magur* larvae can be significantly influenced by water depth that strongly affects the growth and survival of larvae [4], it would be seen from Figure 2 that the significantly highest weight (38.0±1.15 mg) was in T_3 followed by T_1 and T_2 with respective weight 32.0±0.03 and 34.0±1.15 mg.

The second tier rearing system results are in contrast to report by Magaya *et al.* [18] growth performance (Body weight gain, percent weight gain and SGR) of *Clarias magur* with low water depth 6". Significantly highest Percent weight gain

(315.6±4.4 mg) was in T_1 followed by T_2 and T_3 with respective weight 294.3±16 and 245.4±18 mg. Similarly better growth was also noticed in *Clarias batrachus* Giri *et al.* [9}, *Pleteobagrus fulvidraco* Wang *et al.* [31]. A close link between the larvae quality in the early stages of rearing and survival and growth in further stages [5].

With regards to food conversion ratio, low FCR and high FER were recorded in *Clarias magur* fed with zooplankton in low 6" water depth followed by 8" and 7" water depth respectively whereas significantly no difference in FCR and FER values observed in both water depth except (T_1) 6". This indicates that the efficiency of feed conversion was not influenced by water depth. This might indicate that magur larvae low water depth might utilize than high water depth. PER are the main indices, which were used for food and protein utilization in aquaculture. The increase in dietary protein has significantly ($p<0.05$) improved FCR, FER and PER in experimental fish. It has been reported that food and protein utilization decreased beyond the maximal level of dietary protein and the requirements for maximal growth are always higher than the requirements for the least cost (optimal) production [32, 27, 12].

In the present study, poor survival rate (88.11±1.28) in 10 cm water depth. However, no significant difference between the treatments. From the result on survival rate (Figure 3), it would be seen than survival rate significantly reduced with increasing water depth. In the second tier rearing system results of the study revealed that with increased of water depth the rate of survival of larvae decreases. From the statistical calculation, it was found that there were significant differences ($P<0.05$) among the average survival rate of the larvae reared in different water depths. Still, less survival rate was found in the water depth of 7" and 8" (Table 4). This finding was coinciding with the results of Behera [4] and Pal *et al.* [24], where he mentioned that the water depth of larval rearing *Clarias magur* should be less than 6" (around 15.24 cm). Further, this was also supported by Mollah *et al.* [19]. But the present finding was not in agreement with the finding of Mookherjee and Mazumdar [20], where they mentioned the water depth of the larval rearing tank should be more than 10 inches (around 25cm).

The length and weight were positively correlated in the treatments. Allometric growth was also reported by Mosaad [21] and Ibrahim *et al.* [13] for *Clarias magur* in 10 cm water depth with ‘b’ value of 0.291264. The data on the coefficient of correlation (r) along with regression (r^2) equation for total length and total weight are presented in Table 3. As regards the correlation of total body length with weight in different treatments. Banerjee *et al.* [3], have also reported similar trends of relationship and r value for early stages of *Danio dongila*. Form these study evident that the ‘r’ value was maximum in T_1 with low water depth (06 cm). Fulton’s condition factor (K) represents the health condition or well-being of fish. The fish having value of more than 1 in condition factor are said to be good in health condition [22, 28]. In the present study, the value of ‘K’ in all treatments of *C. magur* was found to be more than 1 which indicated the good health condition of fish in the present study (Table 3).

Table 1: Range and mean (± Standard error) values of selected water quality parameters

Parameters	Treatments					
	T_1		T_2		T_3	
	Range	Mean (±SE)	Range	Mean (±SE)	Range	Mean (±SE)
Temperature (^{0}C)	24.67 – 25.00	24.73±0.07	24.67 – 25.67	25.23±0.19	24.67 – 25.33	25.13±0.13
pH	07.10 – 07.87	07.51±0.13	07.39 – 08.00	07.69±0.10	07.05 – 08.10	07.65±0.19
Dissolved oxygen (mg/l)	05.80 – 06.66	06.20±0.14	05.90 – 06.93	06.24±0.21	05.80 – 06.33	06.15±0.09
Total Alkalinity (mg/l)	88.33 – 96.00	91.00±1.63	88.00 – 96.67	91.00±1.47	88.33 – 95.00	91.00±1.13
Hardness (mg/l)	81.67 – 86.67	85.00±1.03	83.33 – 91.67	87.00±1.54	80.00 – 88.00	85.00±1.40
Ammonia – nitrogen (mg/l)	ND	ND	ND	ND	ND	ND
Nitrate – nitrogen (mg/l)	ND	-	ND	-	ND	-

T_1 – 6 cm/ 6", T_2 – 8 cm/ 7" and T_3 – 10 cm/ 8"
ND – not detectable

Table 2: Length weight relationship of *Clarias magur* larvae in different water depth rearing tubs

Treatments	Water depth	Length (mm)			Weight (mg)		
		Min	Max	Mean (±SE)	Min	Max	Mean (±SE)
T_1	06 cm	12	13	13±0.18	32.0	32.1	32.0±0.03
T_2	08 cm	13	14	14±0.31	32.0	36.0	34.0±1.15
T_3	10 cm	11	15	12±1.21	36.0	40.0	38.0±1.15

Table 3: Length weight relationship of *Clarias magur* larvae with different water depth in hatching cum rearing tubs

Treatments	Water depth	a	b	r	r^2	K value
T_1	06 cm	27.84976	0.055356	0.282792	0.56558	19.89782
T_2	08 cm	0.83152	1.421583	0.449777	0.89955	21.11943
T_3	10 cm	18.3712	0.291264	0.413837	0.82764	23.60407

Table 4: Effect of different water depth on growth performance of *Clarias magur* larvae in the second tier larval rearing system

Treatments	Growth parameters							
	Length (mm)	Body weight gain	Percent Weight gain	FCR	FER	SGR	PER	Survival rate
T_1	19.80±0.0^a	101±1.4^a	315.6±4.4^a	1.01±0.021^a	0.98±0.021^a	4.74±0.03^a	8.04±0.14^a	60.00±5.6^a
T_2	18.95±0.7^{ab}	97±1.4^{ab}	294.3±16^b	1.17±0.035^b	0.85±0.028^a	4.57±0.14^b	6.98±0.21^a	52.50±2.1^{ab}
T_3	19.60±0.4^b	90.5±3.5^b	245.4±18^b	1.16±0.056^b	0.86±0.042^b	4.12±0.18^b	7.07±0.35^b	39.00±8.4^b

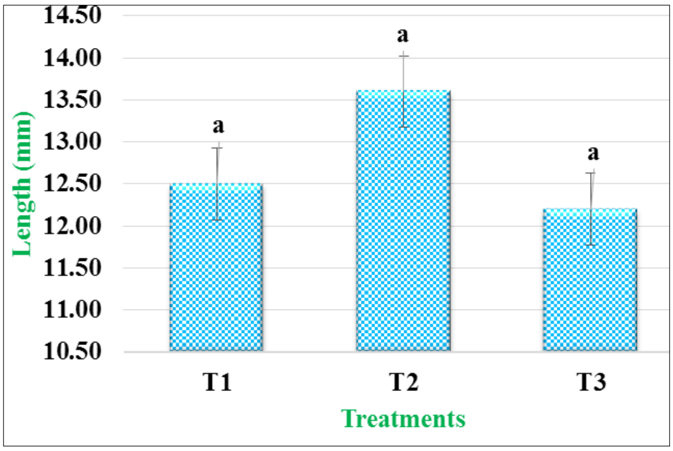

Fig 1: Effect of different water depths on length (mm) of *C. magur* larvae in the first tier larval raering (10 DPH)

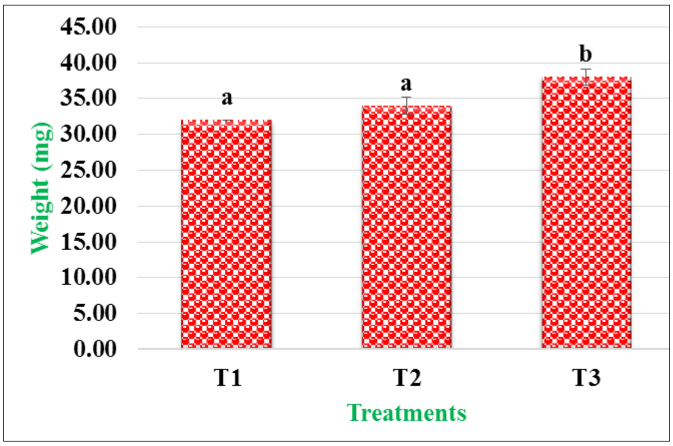

Fig 2: Effect of different water depths on weight of *C. magur* larvae in the first tier larval raering (10 DPH)

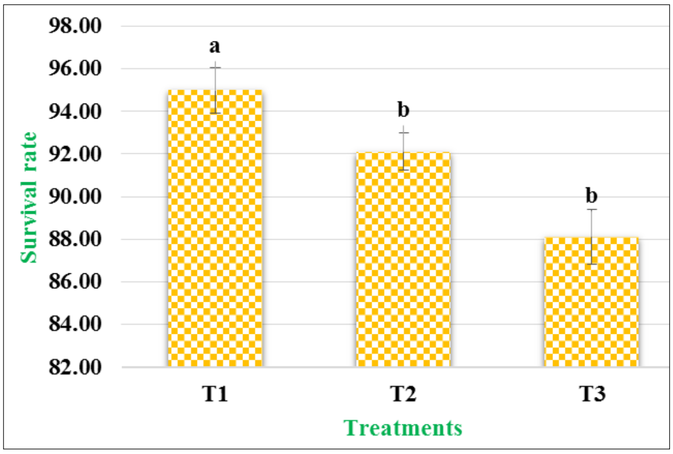

Fig 3: Effect of different water depths on survival rate of *C. magur* larvae in the first tier larval raering 10 (DPH)

5. Conclusion

This study clearly showed that the *Clarias magur* larvae survival performance was significantly improved by a two tier rearing system. From the present study it is also clear that the highest growth and survival was in the lowest water depth treatment and lowest in higher water depth. Our finding on the higher survival rate of the *Clarias magur* could lead to better understanding of the water depth, which night be useful for improving the growth and survival of *Clarias magur* larvae. The overall result of this study it is concluded that a water depth of 6 cm for (up to 10 dph) first tier rearing system and 6" for second tier rearing system can be recommended for the higher survival of *Clarias magur* larvae.

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