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Influence of rearing tank colour on Asian catfish, magur (*Clarias magur*) and pangas (*Pangasius pangasius*) larval growth and survival

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ABSTRACT

Larval growth and survival are significantly influenced by the various biotic and abiotic factors. Rearing tank background colour is one such factor affecting the larval production in finfish hatcheries. The present study evaluated the effect of five tank background colours (black, white, blue, green and red) on growth and survival of larvae of two commercially important freshwater catfish species, *Clarias magur* (magur) and *Pangasius pangasius* (pangas) in a completely randomized experimental design in triplicate. The larvae of magur (9.33 ± 0.15 mm; 3.85 ± 0.05 mg) and pangas (10.07 ± 0.27 mm; 3.31 ± 0.08 mg) were stocked at a density of 45 and 30 larvae per tank, respectively in 15 L tanks. Experimental duration was 28 days for both the species. The results revealed that the final weight, weight gain, daily weight gain, and specific growth rate (SGR) of larvae of magur were significantly ($P < 0.05$) higher in white background coloured tank whereas, pangas shown the best performance ($P < 0.05$) in black tank. Thermal growth coefficient (TGC) of magur and pangas were recorded significantly higher in white and black coloured tank, respectively. Larval survival was significantly ($P < 0.05$) higher in black (97.04 ± 1.96%; $F_{(4, 10)} = 2.95$, $P = 0.002$) tank for magur and green tank (87.78 ± 4.84%; $F_{(4, 10)} = 8.28$, $P = 0.003$) for pangas. Whereas green and black tank colour were significantly reduced the larval survival of magur and pangas, respectively. This study clearly indicates that tank background colour had a significant impact on the larval growth and survival in both the species studied. It was also noticed that the tank colour effect is species specific. The study thus showed that black background tank colour for magur and green tank for pangas are more suitable for the higher production of catfish larvae in hatchery.

1. Introduction

Catfish represents 12% of teleosts and 6.3% of all vertebrates (Wilson and Reeder, 1993; Moyle and Cech Jr, 2004; Wilson and Reeder, 2005). It includes several commercially important families such as Clariidae, Pangasidae, Bagridae, Ictaluridae and Siluridae. Many species from these families have popularly cultured in Asia, North America, Europe and Africa. Catfish are valuable as a good source of protein and fatty acid and have greater market demand in many countries (Tripathi, 1996; Argungu et al., 2013). Catfish are mostly endangered or threatened (IUCN, 2012; Giri, 2017). They are very diverse, and show unique characteristics in their feeding pattern, growth performance and spawning type. The magur, *Clarias magur* and the pangas (yellowtail catfish), *Pangasius pangasius* have secured striking attention in freshwater aquaculture industry in India owing to high adaptive capacity and ability to culture in high stocking density compared to carps. The market price (US \$5-8 kg^{-1}) of these catfish is high due to consumer demand and therapeutic value (Debnath, 2011; Sahoo et al., 2016). Induced breeding was standardized and widely practiced for quality larval production for both magur and pangas. The main factors, which directly affect the larval growth and survival rate are water quality (Das et al., 2015; Sahoo et al., 2016; Boyd, 2017), diet composition (Awaïss and Kestemont, 1998; Giri et al., 2000; Sahoo et al., 2003; Hamre et al., 2013), broodstock size (Ataguba et al., 2012; Ferosekhan et al., 2019), stocking density (Baskerville-Bridges and Kling, 2000; Sahoo et al., 2010; Paramanik et al., 2014), cannibalism

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(Hecht and Pienaar, 1993; Baras and Jobling, 2002; Baras et al., 2010), light (Downing and Litvak, 1999; Giri et al., 2002; Han et al., 2005; Lund et al., 2010; Sierra-Flores et al., 2016) and tank background colour (Rotllant et al., 2003; Monk et al., 2008; Okada et al., 2015; Sierra-Flores et al., 2016; Wang et al., 2016; Ninwichian et al., 2018). Among these factors, tank wall colour significantly affects the growth performance of the fish by impeding the vision of larvae to detect and catch their prey (El-Sayed and El-Ghobashy, 2011; Maciel and Valenti, 2014; Bera et al., 2019). At the same time, it is the least studied parameter in the larval production. There were only few studies explaining about the influence of tank background colour on larval performance and health including Australian snapper, *Pagrus auratus* (Doolan et al., 2009), thin lip mullet, *Liza ramada* (El-Sayed and El-Ghobashy, 2011), Amazon river prawn, *Macrobrachium amazonicum* (Maciel and Valenti, 2014), Pacific bluefin tuna, *Thunnus orientalis* (Okada et al., 2015), goldfish, *Carassius auratus* (Eslamloo et al., 2015), Milk fish, *Chanos chanos* (Bera et al., 2019). However, the effect of tank background colour on larval growth, survival and fry production is not studied for Asian catfish species such as magur and pangas. Therefore, the objective of the present study was to evaluate the effect of tank colour on growth performance and survival of these commercially important catfish species during their early life stage and it will be an immense importance for species conservation and for sustainable aquaculture.

2. Material and methods

2.1. Broodstock management and larval production

The broodstock of magur and pangas were reared separately in the earthen pond (400 m^2) at ICAR-Central Institute of Freshwater Aquaculture, Bhubaneswar, India. Broodfish were fed with fish meal contained pellet diet (protein 40% and lipid 10%) at 2% of body weight. Both the broodstock were examined for the gonadal maturity. The well matured male and female broodstock were selected for induced breeding to produce required larvae, following the standard protocol previously described (Ferosekhan et al., 2015; Sahoo et al., 2016; Sahoo and Ferosekhan, 2018; Ferosekhan et al., 2019).

2.2. Experimental fish and rearing condition

The 4 day post hatch (dph) magur larvae (n = 675) with a mean initial length of 9.33 ± 0.15 mm and weight of 3.85 ± 0.05 mg and pangas larvae (n = 450; 4dph) with a mean length of 10.07 ± 0.27 mm and weight of 3.31 ± 0.08 mg were used for the experiments. Both the species were studied side by side in two separate set of experiments but maintained under same water quality and rearing conditions. The healthy larvae of both the catfish species were randomly stocked in black, white, blue, green, and red background coloured circular plastic (15 L) tanks in triplicates. The stocking density was 45 and 30 larvae per tank for magur and pangas, respectively. The experimental tanks were kept in indoor system and round clock aeration provided during the entire study period. The experimental tanks were maintained under natural photoperiod and the study was conducted for four weeks (28 days: 4 to 32 dph) period. In general, four weeks rearing period from hatching would be an ideal duration to produce fry, which is more suitable for transport and nursery stocking. All the experimental tanks were cleaned twice daily with 50% water exchange to provide good quality environment for the larvae. Both the magur and pangas larvae were fed with newly hatched *Artemia* nauplii at ad-libitum two times per day based on the consumption rate and always maintained 1–2 Artemia nauplii per ml of water from 4 dph to 32 dph. Feed (artemia nauplii) acceptability in all the experimental tanks were regularly checked for both species larvae through visual observation by presence of artemia in the larval gut (slight reddish).

2.3. Water quality management

The water quality parameters such as temperature, dissolved oxygen, and pH were monitored daily and the carbon-dioxide, total alkalinity, total hardness, total ammonia and nitrate were recorded twice in a week for all the tanks by following standard procedure (APHA, 2005).

2.4. Evaluation of larval growth performance and survival

Larval growth parameters such as total length (mm) and wet weight (mg) were measured using measuring scale and calibrated digital electronic weighing balance (XS 105, Mettler Toledo), respectively. Larval mortality and cannibalism were monitored every day to estimate survival parameters. In case of pangas, mortality was counted by the presence of dead larvae in the experimental tanks, whereas cannibalism was calculated by the missing larvae in the tank i.e., number of cannibalism = total initial stocked larvae – (alive larvae + dead larvae). The thermal growth coefficient was calculated as described by Jobling (2003).

$$\text{Weight gain (mg)} = \text{Final weight (mg)} - \text{Initial weight (mg)}$$

$$\text{Daily weight gain (mg)} = \frac{\text{Final weight (mg)} - \text{Initial weight(mg)}}{\text{Duration of rearing period (days)}}$$

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

$$\text{Thermal growth coefficient (TGC)} = \frac{\left[(\text{Final weight (mg)})^{\frac{1}{3}} - (\text{Initial weight (mg)})^{\frac{1}{3}}\right]}{\text{Mean water temperature (°C) X duration of rearing period (days)}} \text{ X } 1000$$

$$\text{Fulton's condition factor} = \frac{\text{Weight of the larvae (mg)}}{\text{Length of the larvae (mm)}^3}\text{X100}$$

$$\text{Yield (mg L}^{-1}) = \frac{\text{Final weight (mg) x Number of survived larvae}}{\text{Water volume (litre)}}$$

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

$$\text{Mortality rate (\%)} = \frac{\text{Number of larvae stocked–Number of survived larvae}}{\text{Number of larvae stocked}} \text{ X100}$$

$$\text{Cannibalism rate (\%)} = \frac{\text{Number of cannibalism}}{\text{Number of larvae stocked}} \text{ X100}$$

$$\text{Coefficient of variation (CV) of length (\%)} = \frac{\text{Standard deviation of length}}{\text{mean length (mm)}}\text{X100}$$

$$\text{Coefficient of variation (CV) of weight (\%)} = \frac{\text{Standard deviation of weight}}{\text{mean weight (mg)}}\text{X100}$$

2.5. Data analysis

All the data were expressed as mean ± standard error (SEM). All the data variables were checked for normality (Kolmogorov-Smirnoff test) and homogeneity of variance (Levene's test), and the data which were not shown normal distribution then those data were arcsine transformed to perform statistical analysis. All the percentage data values were subjected to arcsine transformation and analysed for significance of variance. All the parameters were analysed by one-way analysis of variance (ANOVA) followed by Duncan's multiple range tests to determine the significant differences between the means using IBM-SPSS statistics version 20. The P values of < 0.05 and < 0.01 were considered to represent the significance level between treatment groups.

3. Results

3.1. Water quality parameters

The water quality values of the magur and pangas larval rearing tanks were recorded and the water temperature ranged from 24 to 26 °C, the dissolved oxygen level varied from 4.5 to 5.2 mg L^{-1}, carbon-di-oxide was 1.5–3 mg L^{-1} and the pH ranged from 7.3 to 7.8, total alkalinity was 90–110 mg L^{-1} as $CaCO_3$, total hardness ranged 80–115 mg L^{-1} as $CaCO_3$, total ammonia and nitrites were maintained below 0.04 and 0.05 mg L^{-1}, respectively for both the catfish larvae.

3.2. Growth performance and survival index

3.2.1. Clarias magur

The growth performances of the magur larvae exhibited significant differences among the tank background colours. One-way ANOVA results showed a marginally significant interaction among treatments in case of final weight ($F_{(4, 10)} = 3.47$, $P = 0.05$), weight gain ($F_{(4, 10)} = 3.47$, $P = 0.05$), and daily weight gain ($F_{(4, 10)} = 3.49$, $P = 0.05$). Duncan post-hoc test revealed that the final weight (111.04 ± 5.72 mg), weight gain (107.19 ± 5.72 mg), daily weight gain (3.83 ± 0.2 mg) were significantly higher ($P < 0.05$) in white background tank compared to other treatments (Table 1; Fig. 1). No significant differences could be observed in the growth parameters (final weight, weight gain, daily weight gain, and specific growth rate (SGR)) of the larvae reared in black, blue, green and red coloured tanks. The final body length also showed no significant difference ($P > 0.05$) among treatment groups. The SGR was significantly ($F_{(4, 10)} = 3.46$, $P = 0.05$) higher in white tank but black, blue, red and green tank had no significance difference among them (Table 1). Thermal growth coefficient (TGC) was marginally significant and higher in white coloured (4.62 ± 0.12) tank (Fig. 2) whereas larvae reared in green tank had lowest TGC. The condition factor was found to be significantly higher for white tank. The coefficient of variation (CV) of length and weight did not show any differences between the different colour tanks (Table 1). The survival rate ($F_{(4, 10)} = 2.95$, $P = 0.002$) showed significant interaction among the treatments and was significantly higher in black background (97.04 ± 1.96) tank (Fig. 3). The larval yield ($F_{(4, 10)} = 14.96$, $P \leq 0.001$) was found to be highly significant in white tank background compared to other colour tanks.

3.2.2. Pangasius pangasius

The body weight gain of pangas was significantly higher in black background tank ($F_{(4, 10)} = 13.47$, $P < 0.001$) (Fig. 4) compared to other treatments. Similar results were also noticed in the final weight ($F_{(4, 10)} = 13.47$, $P < 0.001$), daily weight gain ($F_{(4, 10)} = 13.47$, $P < 0.001$), SGR ($F_{(4, 10)} = 12.14$, $P < 0.001$), TGC ($F_{(4, 10)} = 12.74$, $P < 0.001$) (Fig. 5), and condition factor ($F_{(4, 10)} = 2.37$, $P = 0.12$) for black tank (Table 2). The CV of length and weight ranged 7.93–12.8% and 18.44–28.82%, respectively and no significant ($P > 0.05$) difference was observed among the treatments (Table 2).

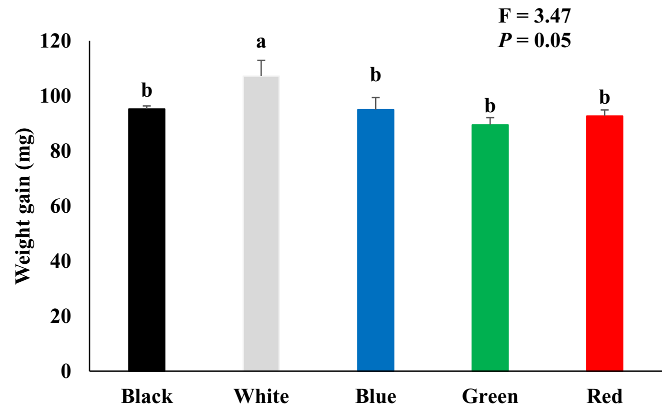

Fig. 1. Body weight gain (mg) of the magur larvae reared under different tank background colour during four weeks of experimental period. Mean values and standard error (mean ± SEM) are presented for magur ($n = 3$). Different superscripts in bar diagram of magur body weight gain indicate significant differences among different tank colour groups ($P < 0.05$, One-way ANOVA, Duncan Post-Hoc).

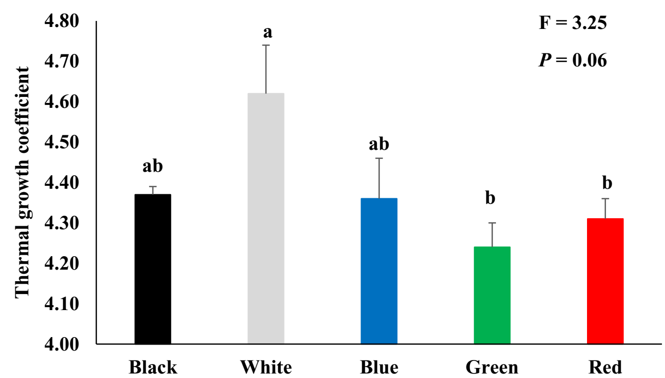

Fig. 2. Thermal growth coefficient of the magur larvae reared under different tank background colour during four weeks of experimental period. Mean values and standard error (mean ± SEM) are presented for magur (n = 3). Different superscripts in bar diagram of magur TGC's indicate significant differences among different tank colour groups ($P < 0.05$, One-way ANOVA, Duncan Post-Hoc).

Table 1
The growth performance of the *Clarias magur* larvae reared under different tank background colour during four weeks of experimental period.

	Black	White	Blue	Green	Red	$F_{(4, 10)}$	P
Final length (mm)	25.83 ± 0.43	25.11 ± 0.18	25.09 ± 0.22	25.92 ± 0.58	25.89 ± 0.19	1.42	0.30
Final weight (mg)	99.1 ± 1.11[b]	111.04 ± 5.72[a]	98.83 ± 4.40[b]	93.31 ± 2.63[b]	96.54 ± 2.22[b]	3.47	0.05
Daily weight gain (mg)	3.4 ± 0.04[b]	3.83 ± 0.2[a]	3.39 ± 0.16[b]	3.19 ± 0.09[b]	3.31 ± 0.08[b]	3.49	0.05
Specific growth rate (% day^{-1})	11.6 ± 0.04[b]	11.99 ± 0.18[a]	11.57 ± 0.16[b]	11.38 ± 0.1[b]	11.49 ± 0.09[b]	3.46	0.05
Condition factor	0.58 ± 0.03[b]	0.7 ± 0.05[a]	0.62 ± 0.03[ab]	0.54 ± 0.02[b]	0.56 ± 0.02[b]	3.99	0.03
CV for length (%)	8.31 ± 1.12	8.86 ± 0.89	7.24 ± 1.21	6.49 ± 0.66	7.82 ± 2.23	0.48	0.75
CV for weight (%)	27.53 ± 2.12	21.78 ± 0.51	34.39 ± 6.74	34.31 ± 4.17	25.13 ± 2.27	2.16	0.15
Yield (mg L^{-1})	288.43 ± 7.75[a]	300.48 ± 8.35[a]	280.5 ± 6.67[a]	234.12 ± 5.09[b]	253.29 ± 6.73[b]	14.96	< 0.001

Mean values and standard error (mean ± SEM) are presented for each parameter (n = 3). Different superscripts in a same row indicate significant differences among different tank colour groups for a given parameter ($P < 0.05$, One-way ANOVA, Duncan Post-Hoc).

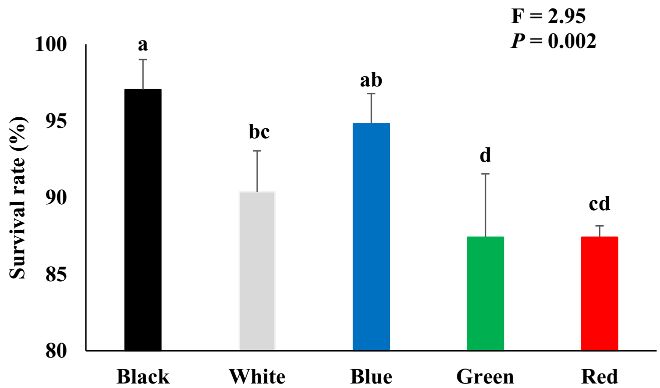

Fig. 3. Survival of the magur larvae reared under different tank background colour during four weeks of experimental period. Mean values and standard error (mean ± SEM) are presented for magur (n = 3). Different superscripts in bar diagram of magur survival (%) indicate significant differences among different tank colour groups ($P < 0.05$, One-way ANOVA, Duncan Post-Hoc).

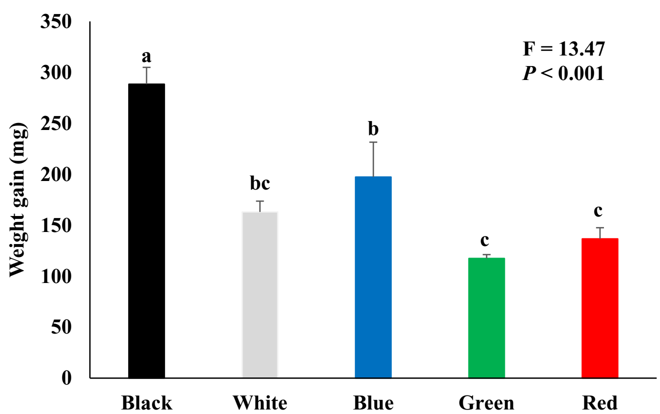

Fig. 4. Body weight gain (mg) of the pangas larvae reared under different tank background colour during four weeks of experimental period. Mean values and standard error (mean ± SEM) are presented for pangas (n = 3). Different superscripts in bar diagram of pangas body weight gain indicate significant differences among different tank colour groups ($P < 0.05$, One-way ANOVA, Duncan Post-Hoc).

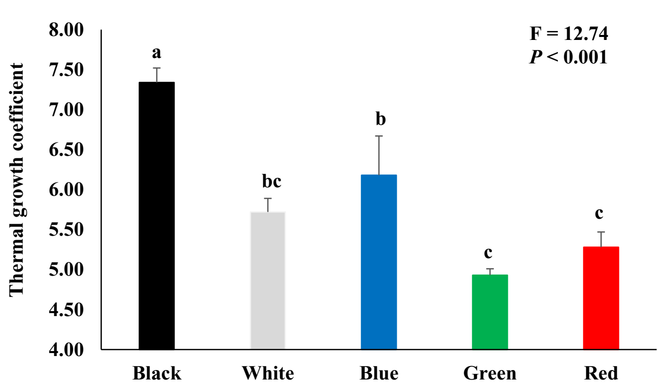

Fig. 5. Thermal growth coefficient of the pangas larvae reared under different tank background colour during four weeks of experimental period. Mean values and standard error (mean ± SEM) are presented for pangas (n = 3). Different superscripts in bar diagram of pangas TGC's indicate significant differences among different tank colour groups ($P < 0.05$, One-way ANOVA, Duncan Post-Hoc).

The survival ($F_{(4, 10)} = 8.28$, $P = 0.003$) was found significantly higher in green background tank (87.78 ± 4.84) and lower in black tank (21.11 ± 6.75) (Fig. 6). And, the larval yield ($F_{(4, 10)} = 3.73$, $P = 0.04$) was significantly higher ($P < 0.05$) in white, red and green background tank. At the same time, black colour tank exhibited significantly ($P < 0.05$) higher level of mortality (57%) (Table 2) and cannibalism (22%) (Fig. 7), which resulted lower survival in larvae reared in black tank (21%).

4. Discussion

4.1. Water quality parameters

Water quality of the larvae rearing system is a vital factor which enable hatchery operators to enhance the growth performance and produce healthy seeds (Sahoo et al., 2016; Boyd, 2017). Aquatic temperature exerts on the metabolic rate of animal, which results in altered growth of the larvae. The experimental tanks temperature was recorded as 24–26 °C for the magur and pangas larvae. The temperature and dissolved oxygen of the rearing tanks were within the acceptable range for the larval rearing of catfish (Sahoo et al., 2005, 2007, 2008). The pH values were also within the optimal limit for magur and pangas larval rearing (Sahoo et al., 2007, 2008, 2016). Observed value of the total alkalinity, total hardness, ammonia-nitrogen, and nitrite-nitrogen in the present study were within the ideal limit of larvae of magur and pangas (Srivastava and Raizada, 2012).

4.2. Growth performance

Growth of the larvae is not only attributed to the composition of the diet (Giri et al., 2000), but also the culture condition, volume of water searched for food by larvae per unit of time, cruising speed and active hours in a day (Hubbs and Blaxter, 1986). The tank colour facilitates the larvae for easy identification of feed and its effect varies with ontogeny and species. Some species may have better performance in black background tank (Jentoft et al., 2006; Bayrami et al., 2017) or white background (El-Sayed and El-Ghobashy, 2011), whereas few species did not shown any effect (Downing and Litvak, 1999a; Papoutsoglou et al., 2000). This difference could be due to the variation in the eye vision, forage behaviour and feeding pattern. The degree of contrast between the food and the background of the rearing tank or system is an important condition during larvae and fingerlings rearing (Downing and Litvak, 1999a; Naas et al., 1996) to obtain the better growth performance and higher survival in carnivorous fish (Sierra-Flores et al., 2016).

4.2.1. Clarias magur

The growth performance of the magur larvae were significantly influenced by the tank colour in the present study. The larvae reared in white background colour showed better growth performance compared to other coloured tanks. This may be due to the high contrast between the tank colour and feed, which enhance the visibility of feed in the light, resulting better food consumption, lower food conversion ratio and higher weight gain (Naas et al., 1996; Papoutsoglou et al., 2000). Similar results were reported in other species like Eurasian perch larvae (*Perca fluviatilis*) (Tamazouzt et al., 2000) haddock larvae (*Melanogrammus aeglefinus*) (Downing and Litvak, 1999a) and scaled carp (*Cyprinus carpio)* (Papoutsoglou et al., 2000). Moderate growth was recorded in black background tanks next to the white tank. The lower growth recorded in green and red background tank in the present study may be due to the lower contrast between the diet and tank colour, which might have modulated the physiology and behaviour of the larvae through the eye vision and sensory level. Larval stocking density plays major role in growth performance and survival of a given species. In *Clarias batrachus* larvae, when the stocking density was increased from 2000 to 5000 m^{-2}, the survival rate was significantly reduced

Table 2
The growth performance of the *Pangasius pangasius* larvae reared under different tank background colour during four weeks of experimental period.

	Black	White	Blue	Green	Red	$F_{(4, 10)}$	P
Final length (mm)	31.67 ± 1.89^{a}	29.31 ± 0.94^{ab}	31.25 ± 2.1^{a}	24.69 ± 0.1^{c}	26.3 ± 0.92^{bc}	4.82	0.02
Final weight (mg)	291.76 ± 16.44^{a}	166.37 ± 10.6^{bc}	200.65 ± 34.17^{b}	120.77 ± 3.74^{c}	139.98 ± 10.9^{c}	13.47	< 0.001
Daily weight gain (mg)	10.3 ± 0.59^{a}	5.82 ± 0.38^{bc}	7.05 ± 1.22^{b}	4.19 ± 0.13^{c}	4.88 ± 0.39^{c}	13.50	< 0.001
Specific growth rate (% day^{-1})	15.96 ± 0.2^{a}	13.97 ± 0.23^{bc}	14.55 ± 0.65^{b}	12.83 ± 0.1^{c}	13.35 ± 0.27^{c}	12.14	< 0.001
Condition factor	0.94 ± 0.12^{a}	0.68 ± 0.1^{b}	0.65 ± 0.02^{b}	0.8 ± 0.03^{ab}	0.77 ± 0.04^{ab}	2.37	0.12
CV for length (%)	10.14 ± 5.83	10.46 ± 0.1	7.93 ± 1.15	12.8 ± 0.9	8.68 ± 0.47	0.49	0.75
CV for weight (%)	28.82 ± 8.78	22.73 ± 2.32	18.44 ± 5.2	26.06 ± 1.89	19.32 ± 0.72	0.86	0.52
Yield (mg L^{-1})	120.08 ± 33.08^{b}	227.13 ± 12.16^{a}	158.9 ± 38.26^{ab}	211.21 ± 7.94^{a}	215.44 ± 0.96^{a}	3.73	0.04
Mortality rate (%)	56.67 ± 7.7^{a}	18.89 ± 4.84^{bc}	33.33 ± 14.53^{ab}	6.67 ± 1.93^{c}	11.11 ± 2.94^{bc}	6.69	0.007

Mean values and standard error (mean ± SEM) are presented for each parameter (n = 3). Different superscripts in a same row indicate significant differences among different tank colour groups for a given parameter ($P < .05$, One-way ANOVA, Duncan Post-Hoc).

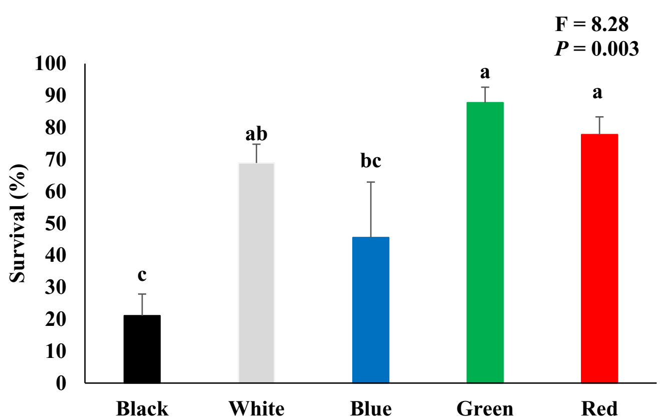

Fig. 6. Survival of the pangas larvae reared under different tank background colour during four weeks of experimental period. Mean values and standard error (mean ± SEM) are presented for pangas (n = 3). Different superscripts in bar diagram of pangas survival (%) indicate significant differences among different tank colour groups ($P < 0.05$, One-way ANOVA, Duncan Post-Hoc).

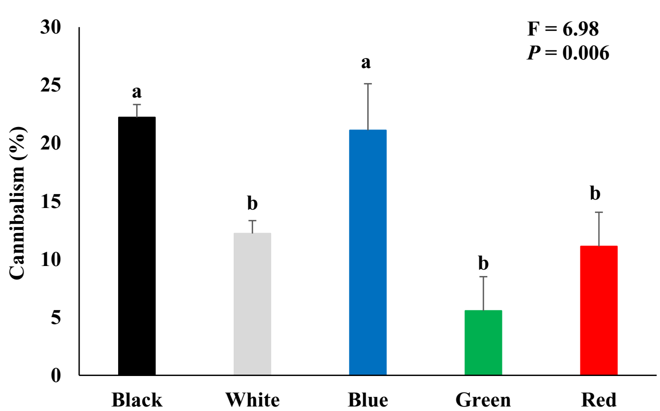

Fig. 7. Cannibalism of the pangas larvae reared under different tank background colour during four weeks of experimental period. Mean values and standard error (mean ± SEM) are presented for cannibalism (n = 3). Different superscripts in bar diagram of pangas cannibalism (%) indicate significant differences among different tank colour groups ($P < 0.05$, One-way ANOVA, Duncan Post-Hoc).

from 73% to 59% (Sahoo et al., 2004) and the growth rate was significantly reduced with the increasing level of stocking density. The lowest stocking density treatment exhibited the higher survival rate of 94% under dark rearing condition (Paramanik et al., 2014). The CV of length and weight results of the present study indicates that magur larvae shown homogenous growth pattern under this experimental condition. Some studies suggested that black background has more natural lighting condition (Naas et al., 1996) and better prey visibility for the successful feeding of larvae (Rabbani and Zeng, 2005) as compared to white background. The black background tanks had the second highest growth after the white tank, and black tank exhibited higher survival rate of 97%, followed by blue 95%, white 90%, red 87% and green 84%. The larvae reared in black colour tank turned to dark black body colour whereas in other tanks, the larvae were of light brownish red except white tank. According to a study, the white background tank seems to produce best contrast while feeding *Artemia* nauplii as it is red in colour (Shi et al., 2019) which improve feed consumption rate. This may be because of the retina of larvae consists of cones, whereas the rods appear at the later stage that assist the larvae to have enhanced visual to capture prey (Hubbs and Blaxter, 1986; Shand et al., 2008; El-Sayed and El-Ghobashy, 2011; Bera et al., 2019). However, further studies are required to ascertain the above concept of maximum absorbance of cone, which drives visual acuity in magur. Tank background colour also influences the skin pigmentation of the larvae (Meakin and Qin, 2012), which is due to camouflage response. The larvae reared in white background tank had paler body colour compared to the larvae reared in black and other tanks, the same was also observed in carp (Papoutsoglou et al., 2000). In general, larvae are sold in terms of count rather than body weight therefore survival rate significantly influence the larval production. The present study exhibited that magur larvae reared in black colour tank has produced higher larval count.

4.2.2. *Pangasius pangasius*

The pangas larval growth was influenced by the tank background colour which higher in black background colour tank. In carnivore fish, CV is considered as an important parameter which indicates the homogeneity of the population. In the present study, CV of length and weight results clearly indicates that pangas larvae exhibited homogenous growth and it might be due to provision of ideal rearing condition. Tank background colour has significant effect in cannibalism, which is evident from the present study. The larvae reared in black tank had the highest weight gain of 288.45 ± 16.44 mg with lowest survival rate of 21% (mortality rate 57% and cannibalism rate 22%) followed by blue, white, red and green, respectively. Early larval cannibalism occurred in pangas may be due to disrupted behaviour (population factor) and environmental parameters (Naumowicz et al., 2017) including tank wall colour. The massive mortality occurred in the larvae could be due to affected vision and stress. Pangas larvae possess oral teeth with sharp oral spine, which overhang from its mouth. This prevents the closure of mouth at the start of exogenous feeding. Hence, the larvae can grasp sibling during their contact at any location, which is also facilitated by the absence of pectoral fins. Similar cannibalism pattern was reported in striped catfish, *Pangasinodon hypophthalmus* (Baras et al., 2010). This tendency severely affects the survival rate due to cannibalism or injuring each other leading to high rates of mortality. Larval rearing in green tank could be helpful to reduce the mortality in pangas, as the highest survival rate (87.78%) was observed in green tank in the present study. However, there was two-fold reduction in larval growth in green background tank compared to black tank, due to higher survived larvae in green tanks compared to black tanks which had significantly lower larvae due to poor survival. The significantly lower number of survived larvae in the tank favoured the higher growth rate and body weight gain in the black coloured tank. Due to significantly higher mortality and cannibalism in black tank, so it is not recommended to use black tank to produce the pangas larvae in the captive condition even though the growth parameters were found to be higher in black tank. Similarly, in the yellow catfish (*Horabagrus brachysoma*) lower growth was observed at higher stocking density (3000–4000 larvae m^{-2}) group compared to lower stocking density (500–1000 larvae m^{-2}) reared larvae (Sahoo et al., 2014). The *P. hypophthalmus* also exhibited very low survival rate due to cannibalistic behaviour of the larvae (Subagja et al., 1999) at higher densities. The survival rate of *P. hypophthalmus* larvae was increased with the quantum of *Artemia* feeding (1 to 9 nos. ml^{-1}) rather than stocking density (Slembrouck et al., 2009). In the present study, pangas larvae fed with *Artemia* nauplii at ad libitum hence, larval survival was not influenced by the quantum of feeding but it was influenced by the tank colour.

5. Conclusion

The present study revealed significant effects of tank background colour on growth and survival of both *Clarias magur* and *Pangasius pangasius* larvae. The observed effects were species specific. This result clearly indicates that the black background tank for magur and green tank for pangas are more suitable for larval rearing of these catfish species. It is also important that green and red background tanks are not ideal for the larval rearing of magur, and also, the black, blue and white are not suitable for pangas larvae production. Further studies are required to investigate the effect of tank colour on the physiological and stress related changes in these catfish larvae.

Authors' contribution

Conceived and designed the experiment: SF SKS SSG BRP. Performed the experiments: SF SKS KR PV. Analysed the data: SF SKS KR NS. Contributed reagents/materials/analysis tools: NS SSG BRP. Wrote the paper: SF SKS KR PV.

Declaration of Competing Interest

Authors declare they do not have any conflicts of interest.

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