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Research Article

Effects of different stocking densities on growth, survival and water quality parameters of *Puntius sophore* in the metallic tray

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ABSTRACT

This research was conducted to determine the effects of different stocking densities on the growth, survival, and water quality parameters of *Puntius sophore* larvae. There were three stocking densities groups marked as T1, T2 and T3, each having three replications. The larvae of experimental fish were reared in metallic trays at a stocking density of 300 (T1), 400 (T2) and 500 (T3) individuals/m^3 for 21 days. The percent length gain, weight gain and SGR (%/day), health condition, survival rate of larvae of all three treatments were determined. The water temperature was recorded 25 to 27.50ºC during experimental period. Among the groups, T2 having 400 larvae/m^3 showed comparatively better result in terms of percent length gain (268.19%), health condition (47.11%), and survival rate (78.00%). Therefore, the stocking density of T2 is recommended for the rearing of the larvae of jat punti fish for profitable and sustainable aquaculture considering the economic aspect. Further study and research would bring necessary improvements in the larval rearing techniques (eco-friendly) of jat punti to face the challenge of food crisis and meet the financial benefits.

INTRODUCTION

Fish is an important source of protein and micronutrients of Bangladeshi people especially poor rural people. Fish consumption of these people is largely dominated by the small indigenous fish species (SIS), which grow maximum up to the size of 25 cm or 9 inches in mature or adult stage of their life cycle (Roos *et al.*, 2003; Kohinoor *et al.*, 2005; Ali *et al.*, 2016). SIS once found abundantly in the wetlands of Bangladesh, but due to the overexploitation, pollution, habitat destruction, siltation, disease and introduction of exotic verities, they are now become increasingly scarce and expensive (Toufique and Belton, 2014; Ali *et al.*, 2016). Therefore, considerable number of researches have been made to introduce SIS in aquaculture to enhance their conservation as well as production. Sixteen SIS reported to have the culture potential in Bangladesh. Among these, *Puntius sophore* (Hamilton, 1822) is of special interest to the aquaculturists owing to its high level of nutritional values (Felts *et al.*, 1996; Kohinoor *et al.*, 2005).

P. sophore is a small cyprinid (minnow) found in rivers, streams and ponds of South-east Asian countries i.e. Bangladesh, India, Pakistan, Nepal, Myanmar, Bhutan, and Afghanistan including China. It commonly known as ‘pool barb’ or ‘spot-fin swamp barb’ and locally known as ‘jat punti’. The species is surface-pelagic, shoaling and herbivore in nature (Sarkar *et al.*, 2019; Froese and Pauly 2017). Their preferred breeding grounds are shallow marginal waters and peak breeding season is monsoon. Gravid female available during May-June, and fry available during the month of June-September (Rahman, 1989). Proximate composition analysis of *P. sophore* revealed that it contains high amount of proteins and minerals, which is very beneficial to human health (Mahanty *et al.*, 2014).

To the best of our knowledge, there is no previous study regarding the stocking density of pool barb, although there are several studies on importance of its culture (Kohinoor *et al.*, 2001), combination in polyculture (Kohinoor *et al.*, 2005; Wahab *et al.*, 2003) and nutritional aspects (Mazumder *et al.*, 2008). Therefore, the objectives of this research were to identify and quantify stocking density effects on growth, survival and water quality parameters of *P. sophore* larvae.

MATERIALS AND METHODS

Experimental site and larvae collection

A 21 days long experiment was conducted at the Fisheries Field Laboratory Complex of the Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh, Bangladesh. Prior to artificial breeding for this experiment, brood fishes were purchased from different places of Mymensingh district (Fig. 1) and transferred into the laboratory.

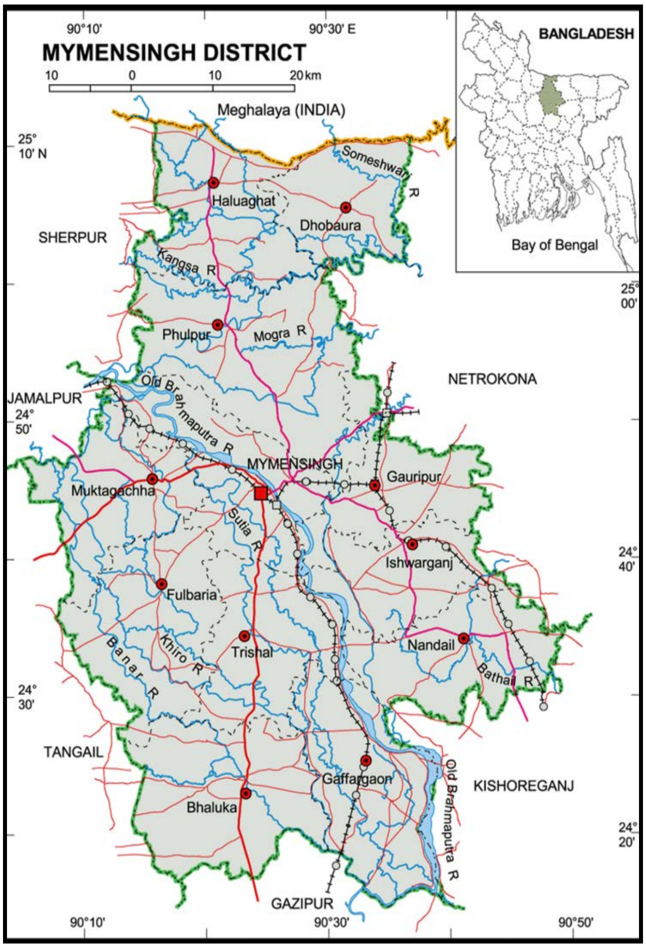

Fig. 1: Map showing *P. sophore* brood collection sites.

Experimental design

Six days old larvae were stocked in experimental tray at 300, 400 and 500 individuals/m^3 and named as T1, T2, and T3 respectively (Table 1). A continuous aeration was provided to manage the proper supply of oxygen (O_2).

Table 1. Stocking densities of the three different groups

Treatment	Replications	individuals/m^3
T1	3	300
T2	3	400
T3	3	500

Feed of the larvae and rearing technique

The larvae were fed with chopped live *Tubifex* worms twice (9.00 am and 5.00 pm) a day according to 10-15% of their body weight. They were considered satiated when they stopped eating or searching feed and hide under the shelter (broken part of earthen pots) within the howls. When the larvae were seemed satiated, the leftover feeds were siphoned out after approximately 15 minutes of their provision.

Measurement of physico-chemical parameters

Physico-chemical parameters of water such as dissolved oxygen (DO), temperature (ºC), carbon dioxide (CO_2), and pH were recorded from each tray every morning between 08:00 to 08:30 am. DO and pH were measured by a digital DO meter (YSIMODEL 58) and pH meter (Jenway, Model 3020) respectively, weekly. Temperature was recorded with an ordinary mercury centigrade thermometer. The CO_2 and ammonia nitrogen (NH_3-N) level was measured according to Alam *et al.* (2015).

Sampling procedure and parameters study

Every 7-days interval ten (10) randomly caught larvae from each tray were used to measure length and weight. Weight (mg) was estimated by an analytical balance and length (mm) was taken by placing of larvae on a petri dish placed upon a 1 mm graph paper. Sampling was done after slight starvation to avoid the biasness of weight due to presence of feed in the intestine. At the end of the experiment, total number of larvae in each tray was counted and percent survival was determined using a specific formula. To identify the health condition of larvae, weight was divided by length.

Length gain (mm) = Average final length - Average initial length.

Weight gain (mg) = Average final weight - Average initial weight.

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

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

$$\text{Specific growth rate, SGR (\% day}^{-1}) = \frac{\ln w_2 - \ln w_1}{T_2 - T_1} \times 100$$

Where, W2 = Final live body weight (mg) at time T2 (day)
W1 = Initial live body weight (mg) at time T1 (day)

$$\text{Health condition, HC} = \frac{\text{Weight of the larvae (mg)}}{\text{Length of the larvae (mm)}}$$

$$\text{Survival rate (\%)} = \frac{\text{No. of larvae survive}}{\text{Total no. of larvae stocked}} \times 100$$

Statistical analysis

All numerical datasets were analyzed through one-way analysis of variance (ANOVA) employing Duncan's Multiple Range Test by using SPSS software (version 17.0, Chicago, IL, USA). P value less than 0.05 ($P < 0.05$) is considered as the level of significance.

RESULTS

Physico-chemical condition of water

During the experimental period temperature (°C), DO, CO_2, NH_3-N and pH were recorded and summarized in Table 2.

Temperature (°C)

The water temperatures were more or less similar throughout the experimental period. The values of water temperature were found ranged from 25.0 to 27.5°C, 25 to 27°C and 26 to 27°C in T1, T2 and T3 respectively. The lowest water temperature 25.0°C was found in T1 and T2 and the highest water temperature 27.5°C was also found in T1 (Table 2).

DO (ppm)

The values of dissolved oxygen ranged from 4.3 to 4.8 ppm, 4.5 to 5.20 ppm and 4.2 to 4.9 ppm in T1, T2 and T3 respectively (Table 2). The lowest value of dissolved oxygen 4.20 ppm was found in T3, whereas the highest 5.20 ppm was found in T2.

pH (Hydrogen ion concentration)

The values of pH ranged from 6.7 to 7.1, 6.9 to 7.0 and 6.8 to 7.2 in T1, T2 and T3 respectively. The lowest value of pH (6.7) was found in T1 and the highest value 7.2 was found in T3 (Table 2). There was no remarkable variation of pH throughout the experiment.

CO_2 (ppm)

The values of carbon dioxide concentrations ranged from 2.0 to 2.70, 2.0 to 2.6 and 2.0 to 2.60 ppm in T1, T2 and T3 respectively (Table 2). The lowest carbon dioxide value 2.00 ppm was found in all three groups but the highest value was found in T1.

NH_3-N

The result showed that the values of NH_3-N ranged from 0.05 to 0.40, 0.04 to 0.25 and 0.01 to 0.18 ppm in T1, T2 and T3 respectively. The lowest NH_3-N value 0.01 ppm was found in T3 and the highest 0.40 ppm was found in T1 (Table 2).

Growth and survival of the larvae in three stocking densities

The initial average weight and length of the larvae were 35.76 ± 0.06 mg and 1.54 ± 0.08 mm, 35.55 ± 0.03 mg and 1.47 ± 0.02 mm and 36.83 ± 0.04 mg and 1.68 ± 0.04 mm in T1, T2 and T3 respectively.

Table 2: Mean values of water quality parameters found in different treatments

Parameters		Treatments		
		T_1	T_2	T_3
Temperature (°C)	Range	25-27.5	25-27	26-27
	Mean ± SE	26.38 ± 0.77	26.38 ± 0.73	26.25 ± 0.75
pH	Range	6.7-7.10	6.9-70	6.8-7.20
	Mean ± SE	6.95 ±0 .78	6.95 ± 0.68	6.98 ± 0.81
Dissolved oxygen (ppm)	Range	4.30-4.80	4.50-5.20	4.2-4.9
	Mean ± SE	4.60 ± 0.16	4.93 ± 0.18	4.65 ± 0.62
CO_2 (ppm)	Range	2-2.70	2-2.6	2-2.6
	Mean ± SE	2.45±0.62	2.38±0.65	2.28 ± 0.68
Depth (cm)	Range	0.05-7.50	0.03-8.50	0.03-8.00
	Mean ± SE	2.04±.88	2.25±.95	2.06 ± 0.89
Ammonia nitrogen (ppm)	Range	0.05-0.4	0.04-0.25	0.01-0.18
	Mean ± SE	0.23±0.10	0.16±0.035	0.07 ± 0.031

Overall weight and length

The final average weight of the larvae of T1, T2 and T3 were 152.95 ± 0.14 mg, 154.05 ± 0.24 mg and 140.71 ± 0.79 mg respectively and the final average length was 5.64 ± 0.05 mm, 5.79 ± 0.03 mm and 3.74 ± 0.06 mm, respectively.

Weight and length gain

The larvae gained 57.75 ± 0.30, 59.01 ± 0.01 and 56.75 ± 0.30 mg of weight at 1st sampling which was increased to 112.84 ± 0.57, 112.56 ± 0.26 and 101.17 ± 0.64 mg at 2nd sampling. Similarly, the weight gain increased to 152.95 ± 0.14, 154.05 ± 0.24 and 140.71 ± 0.79 mg at 3rd sampling in T1, T2, and T3 respectively (Fig. 2a). The length gain of the larvae at 1st sampling in T1, T2, and T3 was 1.67 ± 0.08, 1.67 ± 0.01 and 1.08 ± 0.03 mm respectively, which was increased to 2.75 ± 0.11, 2.79 ± 0.03 and 1.96 ± 0.08 mm at 2nd sampling and finally 4.10 ± 0.04, 4.11 ± 0.06 and 2.24 ± 0.04 mm at 3rd sampling (Fig. 2c). The growth patterns of the larvae in different groups are shown as weight gain and weight gain percent (Fig. 2a, 2b) and length gain and length gain percent (Fig. 2c, 2d). The percent length gain and percent weight gain were found 268.19 ± 16.09 and 427.72 ± 1.10 in T1, 155.21 ± 1.75 and 395.81 ± 2.46 in T2 and 245.53 ± 8.70 and 418.23 ± 1.16 in T3 (Fig 2b and 2d). Statistical analysis indicated that percent length gain, weight gain and SGR of larvae of T1 and T2 were significantly higher ($p < 0.05$) than those of T3. The results of T1 (300 individuals/m^3) and T2 (400 individuals/m^3) were almost identical or similar ($p > 0.05$). Therefore, considering the economic aspects, it can be recommended that the stocking density of 400 individuals/ m^3 is better for the rearing of the larvae up to fry stage of *P. sophore* for profitable and sustainable aquaculture.

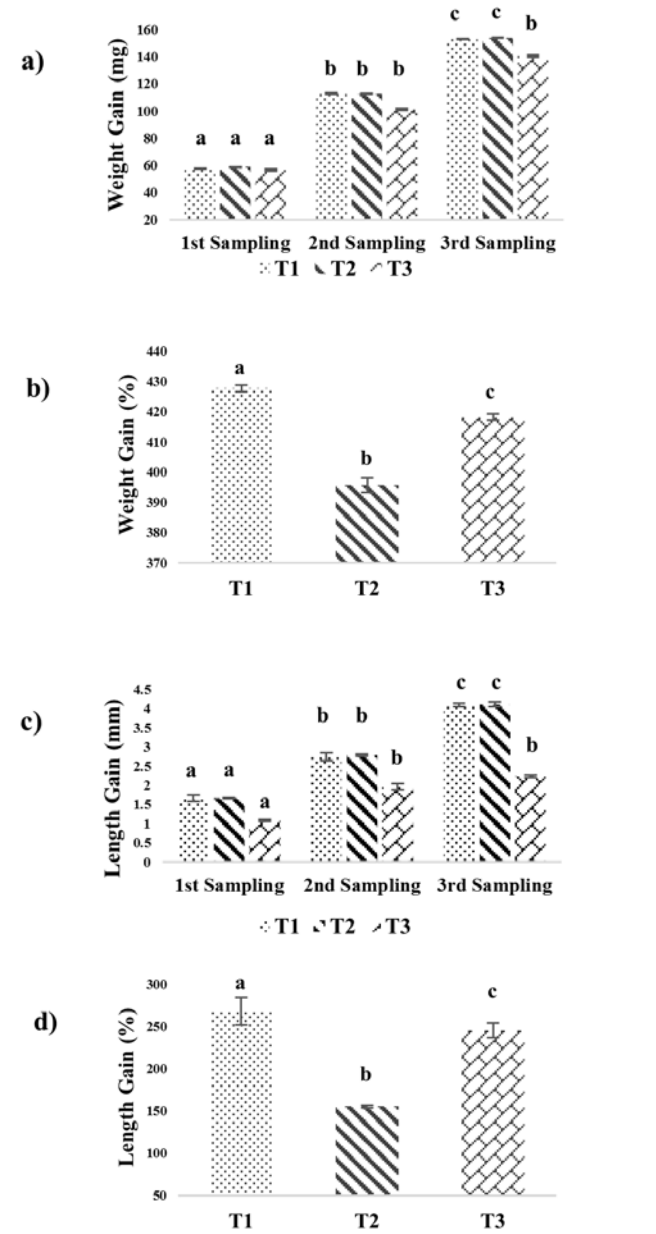

Fig. 2: Weight gain (a), weight gain percent (b), length gain (c) and length gain percent (d) of *P. sophore* in three different weeks.

Specific growth rate (% day^{-1})

The mean specific growth rates (SGR) of the larvae were found 17.75 ± 0.00%, 17.44 ± 0.02% and 17.78 ± 0.01% per day in T1, T2 and T3 respectively (Fig. 3a).

Survival rate (%)

The survival rate was found to be 74.67 ± 0.77, 78.00 ± 1.15 and 62.40 ± 0.69 in T1, T2 and T3 respectively after 21 days of experimental period. DMRT showed that T2 were significantly ($p < 0.05$) higher than that of T1 and T3 (Fig. 3b).

DISCUSSION

The experiment was conducted to obtain a desired stocking density of *P. sophore* larvae at which they could achieve best growth and survival in a favorable aquatic environment. Growth and survival of different fish species are regulated by diet and water quality parameters. Similar to the other aquatic organisms, environmental factors having influences on production and health status of *P. sophore* (Fry, 1971; Brett, 1979) that are prerequisite for a healthy aquatic environment and for production of the adequate fish food organisms.

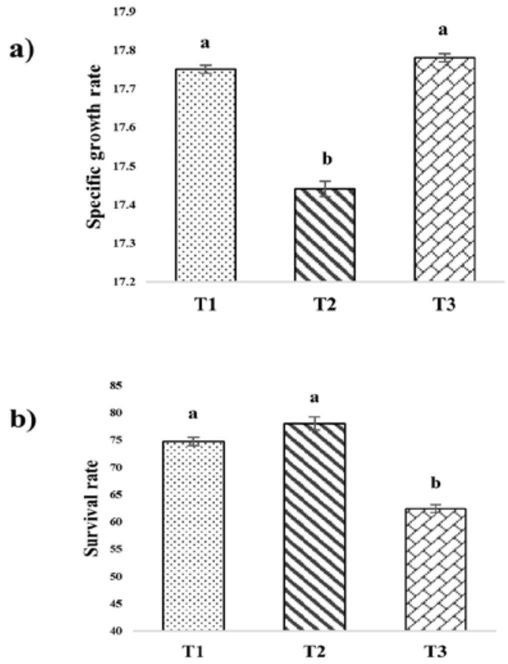

Fig. 3: Specific growth rate (a) and survival rate (b) of the larvae at the end of the experimental period.

Successful rearing of the larvae up to fry stage of jat punti in trays depends upon maintaining good water quality. Water has many physical, chemical and biological characteristics, but only a few are normally important and even fewer can be effectively controlled in rearing process for the larvae and fries. Water quality is influenced strongly by management factors including rearing species, stocking densities and the quality and quantity of the nutrients (Milstein, 1993). Decomposition and accumulation organic matter in the sediment and water columns affect water quality parameters in traditional earthen ponds without substances. In ponds with substances, decomposition and accumulation also occur in the ponds (Azim *et al.*, 2003).

Growth and survival rates decrease when temperatures were less than 22°C and more than 32°C (Sandifer and Smith, 1985). Rogers and Fast (1988) reported that prawns are stressed by temperature below 22°C. Similarly, the average values of water temperature were more or less close to the 27°C in each of the treatments, where the water temperature of experimental trays were 26-27.50°C during this experiment. As a tropical and sub-tropical country, the temperature found in these groups are more or less suitable for the rearing of the larvae. However, growth increased between water temperatures of 28 and 35°C, whereas optimum temperature is 30-32°C (Smith, 1945).

The stocking density affected the DO requirements in larval rearing and fry raising technique. In general, small fishes especially the larvae and fries require more DO than adult ones for their faster growth rate. Average DO level 3 ppm or less in normal water bodies like streams and lakes should be considered as hazardous or lethal for aquatic organisms. To maintain proper growth and physiological activities, DO levels should be 5 ppm or more for freshwater species (Ellis *et al*., 1946). The DO was found to vary from 4.2 to 5.2 ppm in different treatments in this experiment.

According to Swingle (1967), a pH ranges from 6.5 to 9.0 ppm is suitable for fish culture. In addition, fish can live in water having pH values of 4-5, with desirable range of 6.5-8.5 (Smith, 1945). Varma (1979) has recorded a pH range for *Channa striata* larvae of 4.25 to 9.40 with 100 percent survival over 72 hours, and 90 percent survival at pH 3.10 for the same period. Likewise, the range of pH values were found to vary from 6.7 to 7.2, which is higher than the above finding of Varma (1979) in this study.

Free CO_2 more than 20 ppm may be harmful to fishes and even lower concentrations may be equally harmful when dissolved oxygen concentrations are less than 3 to 5 ppm (Lagler, 1972). The range of CO_2 was found to vary from 2.00 to 2.7 ppm in this study. According to above recommendation it can be concluded that the CO_2 range found in the experiment was not harmful at all for the larvae.

The result showed that the values of NH_3-N ranged from 0.05 to 0.40, 0.04 to 0.25 and 0.01 to 0.18 ppm in T1, T2, and T3 respectively. The lowest value of NH_3-N (0.01 ppm) was found in T3 and the highest value of NH_3-N (0.40 ppm) was found in T1.

Stocking density is an important factor in fish culture operation, since it has direct effects on growth and survival and hence production (Backiel and Lecren, 1978). Powell (1972) reported that higher stocking density has harmful effects on the culture of fish growth, survival and production. The stocking density of T2 (400 individuals/m^3) showed the best results in case of percent length gain (268.19) and survival rate (78.00%). Whereas, in case of SGR (%/day) and health condition (mg/mm), group T1 and T2 demonstrated almost similar results in this study. Stocking density is a very important factor for larval rearing.

A feeding frequency of 3 times daily was adopted during the present experiment to avoid water fouling and ease of feed provision and other management. This feeding frequency was chosen after reviewing the results on larvae rearing aspects of some previous works. Coche and Bianchi (1979) stated that zooplankton is a suitable live feed for rearing of African sharp tooth catfish fry. Besides, Hogendoorn (1980) reported like other cultivated freshwater fish species, *Clarias gariepinus* larvae require artificial feed after yolk sac absorption. This report also demonstrated that at water temperature of 30°C, fingerlings attained an individual body weight of 10g within 7-8 weeks after yolk sac absorption. In this study, weight gain was found 152.95 mg, 95.04 mg and 105.16 mg for T1, T2, and T3 respectively after 3 weeks of feeding by *Tubifex* spp.

Stocking density is a very important factor for larval rearing. Rahman *et al.* (2001) conducted an experiment to study the effect of stocking density on growth and survival *Ompok pabda*. In the experiment, larvae were reared under different stocking densities viz. 4, 6, and 8 larvae/L considering T1, T2 and T3 respectively. In consideration of growth performance of the larvae although there was no difference among the treatments but survival rate was significantly higher in T1, than T2 and T3 due to mortality and cannibalism.

Therefore, the stocking density of 400 individuals/m^3 showed the best result in case of percent length gain (268.19%) and survival rate (78.00%). Considering the economic aspects, the stocking density of 400 individuals/m^3 would be profitable and sustainable aquaculture relative to T1 and T3.

CONCLUSION

Findings of this study clearly demonstrated the stocking density possesses influences on growth, survival and aquatic environmental parameters modulation. These factors of fish production are very closely related to each other, and any kind of alterations may hamper the whole system. In future, maintaining this optimum stocking density *P. sophore* production will be increased which will ensure higher profit for the farmers and food safety and security for the local people.

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