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Effects of stocking density on the growth and breeding performance of broodfish and larval growth and survival of shol, *Channa striatus* (Bloch)

M. F. A. Mollah, M. S. A. Mamun, M. N. Sarowar and A. Roy
Department of Fisheries Biology and Genetics, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

Abstract

Two experiments were conducted with a view to assessing the effects of stocking densities on the growth and breeding performance and larval growth and survival of *Channa striatus*. The first one was carried out with a view to find a suitable stocking density of *Channa striatus* at which they could spawn while the second experiment dealt with the effect of stocking density on growth and survival of the produced larvae. The first experiment was carried out in nine equal-sized chambers of raceway separated by netted wooden frame with an area of 1.83 ×1.12m^2 each. The effective water depth in each of the raceway chambers was maintained at 1.2m. The broodfish were stocked at 4 (357.22g/m^2), 6 (541.78g/m^2) and 8 (719.18g/m^2) at 1:1 male-female ratio and fed with washed and chopped poultry viscera twice a day and with live silver carp fry twice a week. No significant (P>0.05) difference in weight and specific growth rate was observed among the broodfish reared under different stocking densities during the experimental period of 80 days. The broodfish stocked at a density of 357.22g/m^2 and 541.78g/m^2 spawned naturally in their respective chambers. The fish stocked at 541.78g/m^2 showed the best breeding performance. The second experiment was carried out with 4-5 days old larvae in 9 bowls of 10l capacity divided into three treatments having 20, 40 and 60 larvae each *i.e.* the stocking density were of 2, 4 and 6 larvae/l respectively. Larvae of treatment I which was stocked with 2 larvae/l showed significantly higher growth rate from the 7th day of the experiment and maintained the same trend up to the end of the experiment (*i.e.* 21st day) compared to other treatments. Larvae of treatment I also showed significantly higher health condition (13.31±0.69mg/mm) and survival rate (80.00±3.00) compared to those of the other two.

Keywords: Stocking density, growth rate, survival rate, breeding performance, *Channa striatus*.

Introduction

Bangladesh is fortunate to have an extensive and huge water resources scattered all over the country in the form of small ponds, beels, lakes, canals, small and large rivers, and estuaries covering an area of about 3.34 million hectare (Mazid, 2002). Diversified fisheries resources are available in Bangladesh, including 260 freshwater fish species, 22 exotic fish species, 24 freshwater prawns, 475 marine fish species and 36 marine shrimps (DoF, 2005). Aquaculture has been gaining tremendous popularity in Bangladesh since independence. The total fish production of the country is 24.40 million ton of which 39% comes from aquaculture (FRSS, 2008). The main culturable species are Indian major carps and some exotic fishes but there remains many other potential species yet to be brought under aquaculture.

The long term success of any fish culture operation, however, depends on the proper domestication of the cultured fish species. *Channa striatus*, locally known as shol, is a commercially important species and along with other species of the genus *Channa*, it contributes 4.2% of the total fish produced in Bangladesh (FRSS, 2008). The flesh of this fish is firm, white, practically boneless, and has the most agreeable flavour. It is one of the main food fishes in Thailand, Indo-China and Malaysia. The heavy dark skin is good for soup and is usually sold separately (Davidson, 1975). It is cultivated in India, Pakistan and Thailand. Its flesh is claimed to be rejuvenating, particularly during convalescence from serious illness and as a post natal diet (Wee, 1980). It is widely consumed for its nutritional value as well as for its beneficial effect in wound healing (Wee, 1982; and Mat Jais *et al.*, 1994). It is also well known for its therapeutic effect in wound healing and pain reduction due to osteoarthritis (Michelle *et al.*, 2004). Because of its various medicinal value people of China, Singapore and Thailand show special aptitude towards shol.

Mature males and females of *C. striatus* generally spawn in the flood plains with low water in the monsoon with comparatively low fecundity (De Silva, 1991). Artificial breeding have been attempted on this species by several researchers with considerable success (Duong, 2004; Haniffa *et al.* 2004; Haniffa *et al.* 2000; Thakur *et al.* 1974). Several species of *Channa* larvae and fry have been investigated in terms of growth and survival when reared with *Artemia* nauplii, decapsulated *Artemia* cysts, *Moina micrura* etc. and interesting results have been obtained (Marimuthu and Haniffa, 2006). But cannibalism appeared to be the most common problem in rearing the fry of snakeheads (Ng and Lim, 1990).

The production of *C. striatus* from the natural waterbodies is declining day by day in one hand and the aquaculturists are unable to go for its captive production for want of seeds on the other. Consequently, seeds of this species are often collected from the natural habitat which is unpredictable. Moreover, this practice may seriously deplete the natural stock in near future. Further, because of harmful effects of pesticides, chemicals and industrial wastes natural spawning grounds are being destroyed day by day. Unfortunately no work has yet been done for developing the induced breeding and fry rearing techniques of *C. striatus* in Bangladesh. It is, therefore, important to establish the induced breeding and fry rearing techniques to ensure sufficient production of seeds of this species. Considering the above realities the present research work was aimed to study the effects of different stocking densities on the growth and breeding performance of the broodfish and larval growth and survival of *C. striatus*.

Materials and Methods

The first experiment was conducted in a raceway system for a period 80 days from 17 April to 06 July 2008 and the second experiment was performed in the wet laboratory for 21.

Experiment I. Effects of stocking density on growth and breeding performance of the broodfish C. striatus

C. striatus were collected from the wild sources (Plate I). About 90 broods comprising of both male and female were collected for the experiment and kept in cisterns for 15 days for conditioning. Healthy, strong and more or less equal sized fish were used for the experiment. Weight of the individual fish was recorded in gram. Prior to stocking of broodfish, the raceway system was washed and cleaned thoroughly and filled up with water. Each chamber was separated from the other with the nylon net attached with a wooden frame. All nine chambers were covered by nylon net to protect the broods from jumping out. The area of each chamber was 1.83 ×1.12 m^2. Depth of water in the raceway was maintained at 1.2m. Water hyacinth was kept floating at the corner of each chamber with the help of bamboo frame attached with float as a shelter for the fish. Water hyacinth also helped to keep the water cool and clean. There were three treatments for optimization of the stocking density for breeding performance of the broodfish. Nine chambers of the raceway were divided into three groups. Each group was considered as one treatment having three replications each. Each of the three replications of treatment I, II and III were stocked with 4 (357.22g/m^2), 6 (541.78g/m^2) and 8 (719.18g/m^2) broodfish respectively at 1:1 sex ratio. The ambient temperature of the raceway system was 27-28^{0}C.

The broods were fed with cleaned and chopped poultry viscera twice daily *ad libitum*. Live silver carp fry of 0.85±1.0 g size were also supplied twice in a week. Sampling was carried out fortnightly in order to measure weight and length of the broodfish. During sampling all the fish from each chamber were caught with the help of scoop net. The weight of each fish was taken with an electric balance. At 15 days interval during sampling the entire raceway was cleaned and refilled with new water. Temperature, dissolved oxygen (DO) and pH of water in each chamber under each treatment were recorded.
In order to study the effect of stocking density on the growth of the broods, following parameters were studied.

i. Weight gain (g) = Mean final weight- mean initial weight.
ii. Specific growth rate:

$$\text{SGR (\% day)} = \frac{\text{Log}_e W_2 \text{ - Log}_e W_1}{T_2 - T_1} \times 100 \quad \text{(after Brown, 1957)}$$

Where, W_1= The initial live body weight (g) at time T_1 (day)
W_2= The final live body weight (g) at time T_2 (day)

Experiment II. Growth and survival of the larvae of *C. striatus* reared under three stocking densities

The experiment was conducted for 21 days with 9 bowls located at the wet laboratory. Each bowl was 21 cm deep having an internal diameter of 32cm with an effective water holding capacity of 10l. Nine bowls were divided into 3 treatments, treatment I, II and III each having three replications. Each bowls under the treatment I, II and III were stocked with 4/5 days old larvae (Plate II) at a density of 20, 40 and 60 *i.e.* 2, 4 and 6 larvae/l respectively. The larvae were fed with chopped Tubificid worms twice (9.00 am and 5.00 pm) a day up to satiation. They were considered satiated when they stopped eating or searching food and hide under the shelter (broken part of earthen pots known as *chara*) within the bowls. When the larvae seemed satiated the left over food were siphoned out after approximately 15 minutes of their provision. Special care was taken to ensure 24 hour supply of water from porous pvc pipes for providing continuous aeration to the larvae. The bowls were cleaned twice daily to remove dirt from the bottom. At the time of cleaning the bowls, dead fry, if any, was removed and the number was recorded. Ten larvae were randomly selected from each bowl to record the length and weight. Sampling was carried out at 7 days interval. The weight (mg) was taken in an analytical balance and the length (mm) was measured by placing the larvae on a petridish placed on a 1 mm graph paper. Sampling was done before application of food to avoid the biasness of weight due to presence of excessive food. Weight (mg) of the larvae of each treatment was divided by the length (mm) of the larvae which indicate the health condition of the larvae. After completion of the experiment total number of larvae of each bowl was counted and the percent survival was calculated. Weight and length gain, specific growth rate of larvae were measured following the formulae stated earlier.

The gain in weight and length, specific growth rate of broodfish and larvae, health condition, and survival rate of the larvae were all tested using one-way analysis of variance (ANOVA). Significant results (P>0.05) were further tested using Duncan's Multiple Range Test (DMRT) to identify significant difference between means. This statistical analysis was performed with the aid of the computer software SPSS.

Results and Discussion

Experiment I. Effects of stocking density on growth and breeding performance of the broodfish C. striatus

The initial average weight of the broodfish of treatment I, II and III were 183.08 ±39.61g, 185.11 ±70.27g and 184.29 ±38.75g respectively while the final average weight were 203.83 ±43.15g, 197.61 ±72.73g and, 195.20 ±39.90g respectively (Table 1). The highest weight gain (20.75±2.54g) and specific growth rate (0.14 ±0.01) were shown by the fish stocked at a density of 357.22g/m^2 (treatment I). No significant difference in weight gain and specific growth rate of broodfish were observed among the treatments.

After rearing for eighty days, it was found that the broodfish of one replication of treatment I and two replications of treatment II stocked with 6 (*i.e.* 541.78g/m^2) broodfish spawned naturally in the respective chambers. However, the broodfish of treatment III stocked with 8 (*i.e.* 719.18g/m^2) fish did not spawn. The fertilized eggs were found to stick to the roots of water hyacinth and hatched after about 18-20 hours at the ambient temperature of 27-28ºC in the raceway chambers. After lowering the depth of water, about 4-5 days old larvae were collected from the raceway by netting. The broods of treatment II showed the best performance in terms of spawning.

Table 1. Weight gain (g) and specific growth rate of broodfish of *Channa striatus* reared for a period of 80 at three different stocking densities

Parameters	Treatment I (Stocking density 357.22g/m^2)	Treatment II (Stocking density 357.22g/m^2)	Treatment III (Stocking density 357.22g/m^2)
Initial average weight (g)	183.08 ±39.61	185.11 ±70.27	184.29 ±38.75
Final average weight (g)	203.83 ±43.15	197.61 ±72.73	195.20 ±39.90
Weight gain	20.75±4.54	12.50±2.46	10.91±1.15
Specific growth rate (%)	0.14 ±0.01	0.08 ±0.005	0.07 ±0.01

The results obtained in terms of weight gain of broodfish indicated that the difference was not statistically significant meaning that none of the three stocking densities tested (*i.e.* 357.22g/m^2, 541.78g/m^2 and 719.18g/m^2) was high enough to impose any limiting effect on the growth of the fish. So, this is an area that requires some more research with higher stocking densities to optimize stocking density in terms of growth. Stocking density is an important parameter in fish culture operation, since it has direct effects on growth and survival and hence production (Backiel and Lecren, 1978).

In nature mature males and females of *C. striatus* spawn in the shallow waters of the flood plains during the rainy seasons and their fecundity fluctuates from 78,060 to 79,463 eggs/kg body weight of females (De Silva, 1991). The present study was thus carried out in the rainy season to bring about a natural urge of reproduction in the experimental fish. Artificial breeding is done administering carp PG (pituitary gland) hormones intramuscularly at a rate of 5 mg/kg for female. 2000IU/kg HCG together with 1mg Pituitary gland have also been used with success to precipitate ovulation in female (Duong, 2004). The fertilization rate appeared to be variable with different inducing agents eg. 60-70% with PG extract, 65-79% with HCG, 75-80% LHRHap and 95-98% with ovaprim (Haniffa *et al.* 2000). The giant murrel *C. marulius* is known to build a cup-like nest in the bottom of water having not more than 1.2m depth (Thakur *et al.* 1974) and *C. punctatus* frequently jumps above the water surface as a part of courtship (Haniffa *et al.* 2004). Similar behaviours were observed with the *C. striatus* broodfish in the chambers of the raceway. The result of the present study revealed that the broodfish of treatment II showed best spawning performance among the three treatments. However, this result does not bear much significance because the stocking densities tested did not affect the growth and perhaps the gonadal development. Further work for optimization of broodfish stocking density and gonadal development may generate information of special interest.

During the experimental period temperature, dissolved oxygen and pH were recorded. Temperature, pH and dissolved oxygen of water in raceway chambers under different treatments ranged between 27.5 and 28.3^{0}C, 6.8 and 7.5, and 5.3 and 6.0mg/l respectively. All the parameters were within the desirable limit to support fish growth throughout the experimental period.

Experiment II. Growth and survival of the larvae of C. striatus reared under three stocking densities

The 2nd experiment was conducted to observe the effect of the stocking densities on the growth and survival of the produced larvae of *C. striatus*. Three replications of treatment I, II and III were stocked with 20, 40 and 60 larvae *i.e.* 2, 4 and 6 larvae/l respectively. The gains in weights and lengths of the larvae were 552.56±30.74mg, 373.40±11.39mg, 305.16±8.46mg and 32.08±0.10mm, 25.95±0.15mm, 23.20±1.21mm respectively in treatment I, II and III. The highest weight and length gain and specific growth rate were found to be 552.56±30.74mg, 32.08±0.10mm and 19.62±0.25 respectively in treatment I (stocked with 2 larvae/l). The length gain of larvae of treatment I was significantly higher than those of treatment II and III. However, the difference between treatment II and III was not significant. Similar result was obtained in case of specific growth rate of the larvae reared under three stocking densities.

Health condition of the larvae of *C. striatus* in treatment I, II and III were 13.31±0.69mg/mm, 10.60±0.26mg/mm, and 9.43±0.16mg/mm respectively (Table 1). Treatment I was significantly (P>0.05) different from those of treatment II and III in terms of health condition where there was no significant difference between the larvae of treatment II and III. The best result was performed by treatment I followed by treatment II and III. The survival rate was found to be 80.00±3.00, 74.66±2.88 and 71.33±4.16 in treatment I, II and III respectively after 21 days of experimental period (Table 1). The larvae of treatment I showed significantly higher survival rate compared to those of treatment II and III. The difference between the survival rates of larvae of treatment II and III was not significant. Temperature, pH and dissolved oxygen in bowls under different treatments were 27.5°C and 28.5°C, 6.9 and 7.1, 5.7 and 6.0 mg/l respectively.

A feeding frequency of 2 times/day 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 workers. Mollah and Tan (1982) reported that feeding frequency has a direct impact on the growth and survival of catfish (*Clarias macrocephalus*) larvae. According to these authors feeding frequency of 3 times/day was proved best for rearing the larvae of *Clarais macrocephalus.* On the other hand Mollah and Nurullah (1988) after detailed study recommended a feeding frequency of 2 times/day as the most suitable for rearing of *Clarias batrachus* larvae.

Tubificid worms are very popular live food used for feeding larvae of carnivorous and omnivorous fish species (Bucher, 1977). Considerably better growth and survival rates of larvae were observed with Tubificid worms over formulated feeds in a number of catfish species such as *Clarias batrachus* (Alam and Mollah, 1988; Mollah and Nurullah, 1988), *Clarias macrocephalus* (Mollah and Tan, 1982), *Clarias lazera* (Hogendoorn, 1980), *Heteropneustes fossilis* (Haque and Barua, 1987; Gheyas, 1998 and Akter *et al*., 2001). Therefore, live food Tubificid worms were used as feed for the larvae during the present experiment to keep the biasness as minimum as possible and to make sure that the difference in results obtained was only due to the difference in stocking density. Different species of *Channa* are found to respond well in terms of growth and survival when reared with *Artemia* nauplii, decapsulated *Artemia* cysts, *Moina micrura* etc. (Qin *et al*., 1997; Marimuthu and Haniffa, 2006). However, tubificid worms were preferred over *Artemia* because of economical consideration.

Stocking density is a very important factor for larval rearing. Haylor (1992) mentioned that the growth rate of African catfish (*Clarias gariepinus*) larvae was significantly affected by the initial density at which they were stocked. Hecht and Appelbaum (1987) conducting experiment with the larvae and juveniles of *Clarias gariepinus* concluded that growth and survival was density dependant and that live food was preferred to formulated feed.

Cannibalism is the most common problem leading to show survival during snakehead culture (Ng and Lim, 1990). Snakehead can easily consume a smaller fish of more than half its length (Diana *et al.*, 1985). In our study, lowest survival was observed in treatment III, where cannibalism was found to take place. Even if the larvae are fed *ad libitun*, cannibalism can still occur if large deviation in fish size exists. Cannibalism may be minimized through size sorting to remove large individuals on a regular basis (Qin *et al*., 1997).

Rahman (2001) conducted an experiment to study the effect of stocking density on growth and survival of *Ompok pabda* and recommended a stocking density of 4 larvae/l as best as far as the growth and survival are concerned. A stocking density of 4 larvae/l also gave the highest growth and survival in *Clarias batrachus* (Barua, 1990). So, the stocking density of 2 larvae/l giving the best result in terms of length gain, weight gain, specific growth rate and health condition of *C. striatus* larvae is less than those of *Ompok pabda* (Rahman, 2001) and *Clarias batrachus* (Barua, 1990) reported earlier. Therefore, the suitable stocking density giving desired growth and survival of larvae of different species is different, *i.e*. species specific. Further study to bring necessary refinement in the breeding performance and larvae rearing techniques is needed before the technique is finally served to the ultimate users.

Table 2. Weight gain, length gain and specific growth rate of *Channa striatus* larvae under different treatments during 21 days experimental period

Parameters	Treatment I (Stocking density 2 larvae/l)	Treatment II (Stocking density 4 larvae/l)	Treatment III (Stocking density 6 larvae/l)
Initial average weight (mg)	9.10 ±1.30	9.10 ±1.30	9.10 ±1.30
Final average weight (mg)	561.66 ±83.44	382.50 ±48.93	341.30 ±61.50
Weight gain	552.56 ±30.74	373.40 ±11.39	305.16 ±8.46
Initial average length (mm)	10.10 ±0.54	10.10 ±0.54	10.10 ±0.54
Final average length (mm)	42.18 ±1.24	36.05 ±2.24	33.30 ±3.30
Length gain	32.08 ±0.10	25.95 ±0.15	23.20 ±1.21
Specific growth rate (%)	19.62 ±0.25	17.79 ±0.14	16.86 ±0.12
Health condition	13.31±0.69	10.69±0.26	9.43±0.16
Survival rate (%)	80.00±3.00	76.66±2.88	71.33±4.16

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