バングラデシュにおける2種インドゴイ,Catla catlaとCirrhinus cirrhosus,の天然および人工種苗の成長比較

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Tsukuba Business-Academia Cooperation Support Center, Agriculture, Forestry and Fisheries Research Council Secretariat
A Comparison of Growth Performance of Indian Major Carps, *Catla catla* (Hamilton) and *Cirrhinus cirrhosus* (Bloch) from Natural and Hatchery Sources in Bangladesh

Biswa Kumar Biswas1, Saifuddin Shah2, Kenji Takii1,* and Hidemi Kuma1

**Abstract:** Indian major carps, *Catla catla* and *Cirrhinus cirrhosus* from natural source of river were compared with hatchery source under the backdrop of popular claims of reduced growth rate of seed originated from the hatcheries. The seeds of natural and hatchery sources were originated from the river Halda, Chittagong, and local fry market, Jessore, Bangladesh, respectively. Rearing trial was performed for 8 weeks in 3 m³ net cages set in an earthen pond. Fishes were sampled fortnightly for measuring body weight and length. *C. catla* fry from the natural source revealed 1.6% specific growth rate (SGR), 62.4% feed conversion efficiency (FCE), 1.5 condition factor (CF) and 93.3% survival, significantly higher than the fry from the hatchery with 0.8%, 28.0%, 1.4 and 89.3%, respectively. Also, *C. cirrhosus* from natural source revealed 2.0% SGR, 77.2% FCE, 1.1 CF and 94.7% survival, significantly higher than the fish from hatchery source with 0.8%, 24.3%, 1.0 and 90.7%, respectively. This could be attributed to breeding and broodstock management without proper genetic norms and practices often inviting inbreeding problems. Countermeasures for reducing inbreeding in brood stock populations are urgently required for the development of aquaculture industry.

**Key words:** Growth performance; Inbreeding; Indian major carps; Rearing development; Riverine and hatchery stock

Fish and Fisheries play an important role in the social and economic life of Bangladesh in terms of income, nutrition, employment and foreign exchange earnings. It contributes around 63% of national animal protein consumption, 4.91% to the GDP and 5.10% to foreign exchange earning through export (DoF, 2003a). Bangladesh is ranked as sixth largest aquaculture producing country with its estimated production of 856,956 t in 2003-4 (FAO 2005). The present per capita annual fish consumption in Bangladesh stands at about 14 kg/year against a recommended minimum requirement of 18 kg/year; hence there is still need to improve fish consumption in the country. At present annual total fish production using pond culture is about 393,959 t (DoF, 2005). Three Indian major carps namely, *Labeo rohita*, rohu; *Catla catla*, catla; *Cirrhinus cirrhosus*, mrigal and one exotic carp, *Hypophthalmichthys molitrix* are the principal pond aquaculture species accounting for more than 78% of total pond production in Bangladesh (ICLARM, 2002). As principal species, catla and mrigal contributed 140,576 t and 120,014 t respectively in 2004 in Bangladesh (DoF, 2003a). Previously the demand for seeds of Indian major carps were principally met by the supply from the natural breeding grounds but recently the production has been reduced to almost nil (1%) in 2003 (DoF, 2003b). This could be attributed to the degradation of natural habitats through environmental

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changes and human intervention like construction of dams and hydro-power plants, over fishing, pollution, loss of connectivity etc. Presently 99% of the spawn is being produced through induced breeding from more than 800 hatcheries established in the private and public sectors in Bangladesh (DoF, 2003b). The hatcheries mainly pay attention to their quantity with very little concern for quality. Eknath (1991) reported a similar situation of spawn production of the Indian major carps in India. Whereas genetically good quality fish seed is a prerequisite for successful fish culture industry. The deterioration in quality of hatchery produced seedlings is a much discussed issue in the fisheries sector of Bangladesh (Rait et al., 2002). Reduced growth due to the effects of inbreeding has been reported in many countries around the world in several species of fish including common carp, channel catfish, zebra fish, tilapia (Padhi 2000, Bondari and Dunham, 1987; Padhi and Mandai, 1994; Chapell, 1979; Dunham et al., 1982; McGinty, 1984, 1987).

The present study encompasses the natural source from the river Ha1da (distantly located, isolated freshwater tidal river originating in the hilly region at the eastern part of Bangladesh), which was the main source of seedlings of major carps for aquaculture across the country before introduction of fry-breeding in hatcheries in 1980s. This river represents perhaps the only sweet water source in the world where the professional fishermen can collect fertilized eggs from the river bed and arrange for hatching them later on (Alam, 2003). There is no of claim including slower growth rates, early maturity etc by the farmers of Bangladesh about the hatchery produced seedlings as compared to the seedlings obtained from the natural stocks of rivers. However, the seedlings produced from this river are claimed as the most pristine in quality in Bangladesh. But there is lacking of information on the comparative growth performance under controlled condition between seedlings from hatchery and this river to clarify the extent of claims by the culturist. The present trial is deemed to provide valuable information in comparative seedlings quality between river and hatchery origin.

In this investigation, attempts were made to test the comparative growth performance in terms of body weight gain, feed intake, feed conversion efficiency, specific growth rate, survival rate, condition factor etc of two Indian major carp species, catla and mrigal originated from the river Halda, Chittagong and local fry market Jessore.

**Materials and Methods**

*Experimental fish*

The seedlings of catla and mrigal of riverine strain were collected from the nursery operators, the river Halda. The seedlings of hatchery strains were obtained from the local fry markets, Jessore, on July 26, 2002. The seedlings were conditioned to reduce transport stress in concrete tanks before stocking into 3 m³ net cages (2 m × 1 m × 1.5 m) set in a pond. The sampling sites and working areas are shown in Fig. 1.

![Fig. 1. The map of Bangladesh showing the origin (○) of *Catla catla* and *Cirrhinus cirrhosus* (23°10' N, 89°11' E).](image)
Experimental design

The experiment was conducted at the hatchery and brood pond facilities of Bangladesh Aquaculture Research and Dissemination Service, at Arabpur Fish Farm, Puratan Kashba, Arabpur, Jessore, Bangladesh (23°10'N, 89°11'E). The pond was about 0.35 acre (50 × 32 m) and rectangular in shape. Bottom topography of the pond was mostly plain.

The average initial body weight and length of the seedlings of Halda riverine strains were 3.3 g and 6.18 cm, and 3.8 g and 7.14 cm for catla and mrigal, respectively. The average initial body weight and length of seedlings of hatchery strains were 3.3 g and 6.15 cm, and 3.9 g and 7.19 cm for catla and mrigal, respectively. The 75 seedlings of each species from the hatchery and riverine were stocked in each net cage with triplicate for the experiment. They were fed on a commercial diet with crude protein 24% and crude lipid 4.5%, (Saudi Bangla Fish Feed Ltd, Mymensingh, Bangladesh). This diet was given on a feeding tray placed into the net cage, twice daily at 09:00 and 16:00 and 6 days per week for 8 weeks from August 1 to September 26, 2002. Daily feeding rate was 3% of body weight and adjusted after each fortnightly sampling. Before sampling, they were starved for 24 h, anesthetized with 10% Benzocaine (Jonaki Scientific Stores, Dhaka, Bangladesh) at 1 ppt and their body length and weight was measured to the nearest 0.1 cm and 0.1 g, respectively. Fishes were randomly sampled from the net cages with a scoop net and were placed into aerated water. Pond fertilization was done with cow dung and also with a mixture of mustard oil cake, urea and triple super phosphate at the ratio of 10:2:1, respectively to maintain the pond biomass.

Pond Water Quality

To maintain the quality of the pond water at an acceptable level, all parameters such as DO, pH, hardness, ammonia, nitrite, alkalinity, CO₂, temperature and transparency were monitored regularly by using a HACH test kit (Model FF2, HACH Company, Colorado, USA). The test was performed between 09:00 to 11:00 throughout the experiment. The daylight for the experiment ranged 12-14 h a day. Regular scum cleaning was done to avoid clogging of the plastic netting with algal materials and feces. Frequent flushing was also done for better aeration of the pond. Liming was done for pond hygiene maintenance by reducing acidity of water.

Calculation and statistical analysis

The data obtained from the experiment were analyzed for the specific growth rate (SGR), feed conversion efficiency (FCE) and condition factor (CF) using the following formula:

\[
\text{SGR} (\%) = 100 \times \frac{\ln W_2 - \ln W_1}{\text{time (days)}},
\]

where, \(W_1\) and \(W_2\) indicate the initial and final weight (g), respectively.

\[
\text{FCE} (\%) = 100 \times \frac{\text{wet weight gain (g)}}{\text{dry feed intake (g)}}
\]

\[
\text{CF} = \frac{100 \times W/L^3}{\text{wet body weight (g)}}, \text{ where } W = \text{wet body weight (g)} \text{ and } L = \text{body length (cm)}
\]

Data were expressed as the mean ± S.D. of the three replicates. The means were compared by Student's \(t\)-test with a 95% significance level.

Results

Pond water quality

The pH (7.0 - 8.0), DO (5.5 - 7.5 mg/l), hardness (180 - 260 mg/l), alkalinity (230 - 255 mg/l), temperature (28 - 33°C) and transparency (25 - 30 cm) of pond water during the experiment were within suitable ranges for catla and mrigal.

Catla

At the end of the growth trial, the final weight (\(n = 210\)) of riverine strain showed a significant difference from hatchery strain (Table 1); the weight of the riverine strain was 1.5 times higher than that of hatchery strain. Similarly weight gain, SGR, total feed intake and FCE were 3, 2, 1.3 and 2.3 times higher than that of hatchery strain, respectively (Table 1). The CF and survival rate for riverine strain was higher than those of hatchery strain (Table 1). Changes in mean body weight of the two strains during the rearing period are given in Fig. 2. The mean body weight of riverine strain continued higher and increased drastically after 42 days of rearing as compared with that of hatchery strain.
Table 1. Growth performance of *Catla catla* from two different sources of origin

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Riverine (Halda)</th>
<th>Hatchery</th>
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<tbody>
<tr>
<td>Initial body weight (g)</td>
<td>3.3 ± 0.1</td>
<td>3.3 ± 0.2</td>
</tr>
<tr>
<td>Final body weight (g)</td>
<td>7.9 ± 0.3a</td>
<td>5.2 ± 0.2b</td>
</tr>
<tr>
<td>Weight gain (g)</td>
<td>304.0 ± 24.2a</td>
<td>103.3 ± 16.4b</td>
</tr>
<tr>
<td>SGR (%)</td>
<td>1.6 ± 0.1a</td>
<td>0.8 ± 0.1b</td>
</tr>
<tr>
<td>Total feed intake (g)</td>
<td>486.4 ± 26.8a</td>
<td>370.0 ± 8.6b</td>
</tr>
<tr>
<td>FCE (%)</td>
<td>62.4 ± 3.0a</td>
<td>28.0 ± 5.0b</td>
</tr>
<tr>
<td>CF</td>
<td>1.5 ± 0.0a</td>
<td>1.4 ± 0.0b</td>
</tr>
<tr>
<td>Survival rate (%)</td>
<td>93.3 ± 1.3a</td>
<td>89.3 ± 1.3b</td>
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Values in a row with different letters are significantly different (n=2, P<0.05).

1SGR (%) = 100 × (lnW2-lnW1)/time (days).
2FCE (%) = 100 × wet weight gain (g)/dry food intake (g).
3CF = 100 × W/L3.

Fig. 2. Trend of growth of *Catla catla* strain from riverine and hatchery source.

Table 2. Growth performance of *Cirrhinus cirrhosus* from two different sources of origin

<table>
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<tr>
<th>Parameter</th>
<th>Riverine (Halda)</th>
<th>Hatchery</th>
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<tr>
<td>Initial body weight (g)</td>
<td>3.8 ± 0.1</td>
<td>3.9 ± 0.2</td>
</tr>
<tr>
<td>Final body weight (g)</td>
<td>12.0 ± 0.3a</td>
<td>6.0 ± 0.2b</td>
</tr>
<tr>
<td>Weight gain (g)</td>
<td>565.4 ± 30.3a</td>
<td>114.8 ± 33.7b</td>
</tr>
<tr>
<td>SGR (%)</td>
<td>2.0 ± 0.1a</td>
<td>0.8 ± 0.2b</td>
</tr>
<tr>
<td>Total feed intake (g)</td>
<td>732.1 ± 65.9a</td>
<td>471.4 ± 12.5b</td>
</tr>
<tr>
<td>FCE (%)</td>
<td>77.2 ± 3.0a</td>
<td>24.3 ± 6.6b</td>
</tr>
<tr>
<td>CF</td>
<td>1.1 ± 0.0a</td>
<td>1.0 ± 0.0b</td>
</tr>
<tr>
<td>Survival rate (%)</td>
<td>94.7 ± 1.3a</td>
<td>90.7 ± 1.3b</td>
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Values in a row with different letters are significantly different (n=2, P<0.05).

1SGR (%) = 100 × (lnW2-lnW1)/time (days).
2FCE (%) = 100 × wet weight gain (g)/dry food intake (g).
3CF = 100 × W/L3.

Fig. 3. Trend of growth of *C. cirrhosus* strain from riverine and hatchery source.

**Mrigal**

The final weight (n=213) of riverine strain was found to be 2 times higher than that of hatchery strain (Table 2). Similarly weight gain, SGR, total feed intake and FCE were 5, 2.5, 5 and 3.2 times higher than those of hatchery strain, respectively (Table 2). Survival rate and CF of riverine mrigal was higher than those of hatchery strain (Table 2). Changes in mean body weight gain for the strains of mrigal during the rearing period were given in Fig.3. The weight gain was remarkably higher for riverine strain from the start of the experiment than the hatchery strain.

**Discussion**

The lower growth performance of hatchery stocks indicated improper or poor management of stocks in hatcheries and ignorance of genetic aspects on the part of the hatchery workers (Allendorf and Phelps 1980 and Ryman and Stahl 1980). In Bangladesh almost all hatchery facilities do not have adequate number of ponds to raise their brood fishes. The hatchery operators usually maintain a small effective number of brood (N0), do not maintain their pedigree records and thus produce adverse effect on the gene pool of hatchery stock (Allendorf and Uttar, 1979; Tave and Smitherman, 1980; Ryman and Stahl, 1980; Cross and King, 1983; Stahl,
1983; Verspoor, 1988 and Tave, 1999). Evidence of inbreeding depression and negative selection in hatchery practices for growth has been reported in domesticated stocks of Indian major carps in India and Bangladesh (Ekknath and Doyle, 1990, Basavarju et. al 1997; Hussain and Mazid, 1999). It is now obviously necessary to maintain recommended number of brood, at least 50 for short term and 500 for long term works according to FAO (FAO/UNEMP, 1981); however, Taniguchi (2003) suggested 50, Tave (1993) recommended 52, Ryman and Stahl (1980) suggested at least 60 for genetic stability in the population for long term.

The faster growth rate was accompanied not only by greater food intake but also by significantly higher FCE (P < 0.05) for both riverine strains. This phenomenon clearly indicates that the physiological state of the nature-originated seeds is superior in quality. This could be explicated as good genetic quality of the seeds (Padhi and Mandai, 1999). This stock could be referred as one of the best candidates for the future replenishment of hatchery stocks.

In this experiment, the growth rate of the two species irrespective of their origin was low compared to the fish growth under natural and farm conditions. A similar trend of growth was also reported in Indian major carps (Ravi and Devaraj, 1991; Benkappa and Varghese, 2003; Ramchandra and Ray, 2004). This could be explained that the Indian major carps are sensitive to environmental conditions and do not attain maximum growth in a confined environment, compared to other hardy species, such as tilapia and common carp (Benkappa and Varghese, 2003). The similar trend was also observed by another experiment with three Indian major carps namely catla, mrigal and rohu collected from two major rivers of Bangladesh, the Padma and Jamuna compared with hatchery (Biswa, 2003). However, the growth differences in this case were more pronounced than that study. This could be due to no contamination of this river strains with other population of major carps as the river is most isolated freshwater and no spawning grounds of major carp were reported within that region except Halda. In a genetic population study, Islam and Alam (2004), and Alam and Islam (2005), reported the Halda river population are superior in quality than any other origin in Bangladesh. The stocking density for 3 m² net cages was not optimized and so there may have negative effect on growth due to behavioral interaction or physiological response to density of the reared species (Mohanty, 2004). Although catla is the fastest growing species among the three Indian major carps, this species grew slower than mrigal in this experiment. This could be due to bottom feeder mrigal performed superior feed utilization capacity (Sinha, 1998); the feed was given on a tray placed inside the net cage. However, surface feeder catla usually fed on natural food (plankton) adapted more slowly with the diet supplied, and also a part of food settled on the bottom of the tray was difficult for them to utilize initially. There was little or no plankton inside the cage to support catla.

In this experiment, the higher CF in riverine strain than the hatchery originated strain suggested that the reverine strain was in good condition which, in turn, resulted in higher growth performance (Danzmann et al., 1988). The observed lower survival rate of both strains from hatchery is also a clear indication of inbreeding in the population (Hussain and Mazid, 1999; Bondari and Dunham, 1987; Padhi and Mandai, 1994).

In conclusion, the results obtained from this first ever controlled investigation revealed that the riverine strain seedlings performed significantly better than the hatchery strain seedlings in terms of growth performance. The results highly prove the wide spread claims of the farmers and aquaculturists for poor performances of the Indian major carps in Bangladesh. The most plausible causes of lower growth performance of hatchery strains are poor management practices, small size of brood fish, lesser number of broods used in the hatchery and lack of maintenance of genetic diversity of the stocks as discussed earlier. If a good attention is paid on these areas in hatchery practices with domestic and international research cooperations, the valuable populations of the Indian major carps would also perform better.
can be protected mostly from being genetically damaged through improper practices of breeding and seed production.

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バングラデシュにおける2種インドギイ、Catla catlaとCirrhinus cirrhosus、の天然および人工種苗の成長比較

Biswajit K. Biswas・Saifuddin Shah・澁井健二・熊井英水

バングラデシュにおけるインドギイ2種 Catla catla と Cirrhinus cirrhosus の天然および人工種苗の成長について比較した。南西部 Jessore の淡水養殖池に 3 m³の網生簀を設置し、それぞれの稚魚を収容して8週間飼育したところ、いずれの魚種でも天然種苗の成長率、飼料効率、肥満度および生残率は人工種苗より優れていた。この人工種苗の低い飼育成績は、養殖業者の親魚群の遺伝子管理や近親交配に関する低い認識に起因しており、今後の養殖業の発展に不可避の検討課題であることが示唆された。