Compensatory growth response of freshwater prawn (Macrobrachium rosenbergii) polycultured with Indian major carp, Catla (Catla catla)

Abstract
With a view to evaluate the compensatory growth response, production and survival of prawn (Macrobrachium rosenbergii) and catla (Catla catla) under polyculture system, an experiment was conducted at the Faculty of Fisheries Field Laboratory in Bangladesh Agricultural University campus from 20 March 2006 to 20 June 2006. The experiment was consisted of three treatments with three replications for each. The three treatments were: fed to satiation twice a day (T1), fed every alternate day (T2) and fed every two days of interval (T3). SABINCO prawn feed was used as supplementary diet for the experiment. The stocking densities for prawn and catla were 40/dec. and 12/dec., respectively. The initial weights at stocking were: 50 g for catla in all the treatments, and 5.8, 6.4 and 6.2 g for prawn in T1, T2 and T3, respectively. The water quality parameters were almost similar in all treatments and also were within an acceptable range of fish culture. The survival rate for catla was 100.0% in T1, 91.6% in T2 and 83.3% in T3, while for prawn was 85.0% in T1, 71.0% in T2 and 69.0% in T3, respectively. The average weight of prawn was much lower in T2 and T3 than those in T1. The best FCR value was found in T1 (1.80) followed by T2 (1.85) and T3 (1.98) in this order. The average highest gross yield was obtained from T1 (1656 kg/ha) followed by T2 (1077 kg/ha) and T3 (1127 kg/ha), while the production of prawn was T1 (791 kg/ha), T2 (517 kg/ha) and T3 (429 kg/ha), respectively. However, no significant differences were found in the total yield in T1 and T2. The total costs of production for the three treatments were: T1 (125.93 Tk/kg), T2 (143.21 Tk/kg) and T3 (146.71 Tk/kg), while the profits were: T1 (104.07 Tk/kg), T2 (55.86 Tk/kg) and T3 (24.60 Tk/kg) in which the benefit cost ratio were found to be 1:0.83, 1:0.39 and 1:0.17, respectively. The results indicate that every day feeding had provided good growth and economic returns and thus seemed to be most practicable and viable feeding options for prawn-fish polyculture. Therefore, prawn-fish polyculture with regular feeding provides satisfactory growth and production.

Keywords: polyculture, feed, growth response, fish, Macrobrachium rosenbergii

Abbreviations: PL, post larvae; BAU, Bangladesh agricultural university; FCR, feed conversion ratio; ANOVA, analysis of variance; DO, dissolved oxygen; SGR, specific growth rate

Introduction
Fish is an essential daily food item for the people of Bangladesh and as such demand for fish is increasing with the increase of human population. In the early sixties, per capita annual fish consumption was 12 kg per person, which presently comes down to 9.0 kg in spite of the significant growth in fish production. Now, fish has not remained as bountiful as in the past due to man-made and natural ecological alterations, over fishing and resource use conflicts occurring over the last two or three decades. This has disturbed the nation and many have been realizing the fact that alike any other natural resource, fish also need scientific management, if it is to be sustained. However, the elements of fish culture have been introduced more recently and the country is in the process of slowly changing the source of fish production from hunting to an aquaculture pursuit. Though the production has increased, the present per capita fish intake (28 g/day) is still below the recommended amount (49 g/day) and the annual growth rate is gradually decreasing.1 On the other hand, due to population growth, the demand for fish has been increasing tremendously, which is very difficult to overcome without having concerted efforts on getting increased production. As augmentation of fish production from rivers and estuaries is quite difficult, we need to depend on pond aquaculture for increased production and supply of fish, employment generation and poverty alleviation in the rural areas of Bangladesh. Moreover, the farmers can manage and utilize the small water bodies properly and can minimize the production cost by adopting aquaculture system. Aquaculture sector is expected to contribute to the reduction in gap between demand and supply of fishery products in the country. In addition to domestic demand, export market is equally important for the country to ease the balance of payment.

Aquaculture is an age old practice in Bangladesh. Based on the habitat, there are two types of aquaculture in Bangladesh viz., freshwater and coastal aquaculture. Freshwater aquaculture is comprised mainly of pond aquaculture, especially polyculture of carps having native and exotic origin. Coastal aquaculture is comprised primarily of shrimp farming. Presently, high valued shrimp from coastal aquaculture is the main export earning commodity. Aquaculture system has now stepped towards semi-intensive type. Small scale resource-poor farmers have adapted to the improved traditional and semi-intensive farming system.

The major indigenous species for aquaculture in Bangladesh are comprised of catla (Catla catla), rohul (Labeo rohita), mirgal (Cirrhinus

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mrigala) and calibaush (Labeo calbasu), while the exotic species in aquaculture are silver carp (Hypophthalmichthys molitrix), grass carp (Ctenopharyngodon idella), common carp (Cyprinus carpio), Thai pangas (Pangasius hypophthalmus), tilapia (Oreochromis niloticus), sharpunti (Barbonymus gonionotus) etc.

Polyculture, the simultaneous culture of several species of fish with different feeding habits, is an efficient means of increasing fish production. The success of this system lies in the choice of right combination of fish species. The basic principle of polyculture is applied for the best utilization of natural foods of different strata and zones without any harm to each other. It is a fact that polyculture may produce an expected result if ponds are stocked with species having different feeding habits in proper ratios based on the assumption that fish growth is an expression of their reaction to among other things, the sources of natural food in the environment. Polyculture can improve pond environmental conditions, first of all by feeding conditions for fish, oxygen budget of ponds and control of aquatic weeds. The key technique of polyculture is based on the relationship between participatory organisms at different levels of food chain of the environment. Selection of fish species plays an important role for any culture practice. Stocking density of different fish species in a polyculture system also plays a vital role on overall production.

The economy of Bangladesh is largely dependent on aquaculture. From this point of view, fish and fisheries are inseparable from the culture and heritage of Bangladesh. They play a significant role in the country’s socio-culture and economic life, providing food, employment and foreign exchange. Fish is the main source of animal protein to the people of Bangladesh where about 63% of the animal protein supply is provided by the fish. Annual fish production in 2003-2004 was 2.10 million mt, which were 1.26 million MT in 1995-96 and 0.95 million in 1991-92. About 63,377 mt fish and fisheries products are exported to foreign countries and earned about Tk. 25,371 million in 2004-05 fiscal year. The contribution of fish and fisheries products in foreign exchange in 5.76% and contribution to GDP was 4.92% in 2003-04.

In 1988-89 fiscal year, Bangladesh earned Tk. 3,820.5 million by exporting frozen shrimp and prawn and this volume rose up to Tk.14, 478.0 million in 2001-2002 fiscal year. At the same fiscal year frozen shrimp and prawn alone contributed about 92.73% of the total export values through the export of various fisheries commodities. Around 1.2 million people (10% of the total population) are directly involved with fisheries activities and about 3.08 million are involved indirectly. About 13% of the rural households are involved in this sector and it provides employment opportunity to about 7% of the total population.

Now the slogan “quality seed and quality feed” is the prerequisite for better production in aquaculture operation. So, the importance of feed in aquaculture has increased with the intensification of fish culture and now fish production fully depends on quality feed. Feed cost is the highest single operational cost in all kinds of aquaculture. On the other hand, use of complete artificial diet is not possible in the country's socio-culture and economic life, providing food, employment and foreign exchange.

The major objectives of the present study were to know the influence of feeding and feeding rationing on the growth and production of fish and prawn under polyculture system and to develop a suitable technique to increase the production by minimizing the feed cost.

Materials and methods

Location of the experiment

The present research was carried out at the faculty of Fisheries field laboratory in Bangladesh Agricultural University, Mymensingh (Figure 1) during the month of March 2006 to June 2006.

![Figure 1 Map showing the location of the experimental site.](image)

Experimental ponds

The experiment was conducted in 9 earthen ponds with 1.5 meter of water depth. The size of each experimental pond was 1.0 decimal.

Catchment basin

The catchment area of the study was at the Bangladesh Agriculture University, Mymensingh, located at the North-West part of Bangladesh (24.71'E and 90.42'N). It is typically the tropical zone of the county. Average lowest temperature (11°C) was recorded in the month of January, while the highest temperature (33.4°C) was in April. The Soil quality of the catchment area was clay and clay-loamy. There was a very little scope of contamination in the experimental area. Only the inorganic fertilizer and bottom soil was the source of potential contaminants in the experimental ponds.

Experimental design

The experiment was commenced with the establishment of groups of fish according to the following feeding regime. Each treatment had three replications.

Feeding trials of different treatments were as follows:

a. Treatment 1: No deprivation, hand feeding to satiation twice per day.

b. Treatment 2: 1 day deprivation, followed by 1 day feeding (1:1).

c. Treatment 3: 2 days deprivation, followed by 2 days feeding (2:2).

Pond preparation

Aquatic weeds, and other undesirable fish and organisms were removed from the ponds manually. All the ponds were prepared...
and embankments were repaired by excavating the bottom and were kept exposed to sunlight, and lime was then applied to the ponds at the rate of 1 kg/dec. After 3 days of liming, ponds were filled with underground water through a flexible plastic pipe from a deep tube-well. Then the ponds were fertilized with inorganic (Urea and TSP @ 200 g/dec and 100 g/dec, respectively) and organic fertilizer (Cow dung @ 2.5 kg/dec), and left for 7 days to allow the development of natural foods in the healthy pond ecosystem.

Fingerling and post larvae (PL) collection and stocking

Netting was done in the experimental ponds to remove aquatic insects 3 days before stocking. Fingerlings were collected from Jhalak hatchery, Gouripur, Mymensingh. In this experiment, good quality fingerlings and juveniles were selected, and then transported in the oxygenated polythene bags to the field laboratory of the Faculty of Fisheries, Bangladesh Agricultural University (BAU), Mymensingh. Before releasing the fingerlings and juveniles into the experimental ponds, the initial length and weight of fishes and prawns were recorded in ‘cm’ and ‘g’ with the help of a measuring scale and a sensitive portable battery operated balance (Model HL 400EX), respectively. Prior to releasing the fish fingerlings in the ponds, they were acclimatized with the pond water for half an hour.

Feeding

Pelleted feed (SABINCO fish feed limited, Trisal, Mymensingh) at the rate of 5% body weight of prawn was applied for during the experiment. On each feeding day, the prawns were fed at 9.0 am and 5.0 pm. The proximate composition of the used feed is shown in Table 1.

Table 1 Proximate composition of feed used in the experiment

<table>
<thead>
<tr>
<th>Components</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>11</td>
</tr>
<tr>
<td>Protein</td>
<td>25</td>
</tr>
<tr>
<td>Lipid</td>
<td>4</td>
</tr>
<tr>
<td>Ash</td>
<td>17</td>
</tr>
</tbody>
</table>

Fertilization

The experimental ponds were inspected twice daily between 8.00 am to 9.00 am and between 4.00 pm to 5.00 pm to observe any abrupt change in water condition or behavior of fish and prawn. All the treatments were subjected to the same regime of feeding and fertilization. All ponds were fertilized with Urea and T.S.P. at the rate of 100 g/dec. at weekly intervals. After stocking of fish and prawn, liming was done at the rate of 0.5 kg/dec. in all the ponds at fifteen days of interval.

Sampling of fish and prawn

The fishes and prawns were sampled fortnightly by using a cast net and in each sampling, ten fishes and prawns were weighed separately to assess the health condition of fish and their growth, using a portable electrical balance (Model OHAUS).

Study on water quality parameters: Water quality parameters (temperature, dissolved oxygen, pH etc.) of the experimental ponds were monitored and recorded at every ten days interval throughout the culture period. All the parameters were measured using surface water at the pond site.

Methods used for water quality analysis

1) Water temperature (°C)

Temperature of pond water (°C) was recorded with the help of a thermometer (YSL Model 58, USA) between 9.00 am and 10.00 am.

2) Dissolved oxygen (ppm)

Dissolved oxygen was measured directly using a portable water proof digital oxygen meter (HANNA Instrument Model: HI-9142, Portugal), from 9.00 am to 10.00 am.

3) Transparency (cm)

Transparency was measured with a secchi disc of 20 cm diameter between 9.00 am and 10.00 am.

4) Hydrogen ion concentration (pH)

pH was determined with the help of a portable pH meter (HANNA Instruments, Model:HI-9142, Portugal) between 9.00 am and 10.00 am.

Harvesting of fish and prawn

After 90 days of rearing, the fishes and prawns were harvested on June 20, 2006. Primarily harvesting was done by repeated netting using a berjal. Final harvesting was done by dewatering the ponds with low lift Pedrollo pump (2 HP). During harvesting all the fishes and prawn were counted and weighed individually for each pond to assess the survival rate and production.

Analysis of experimental data

Experimental data collected during the whole experimental period were analyzed as follows:

a. Weight gain (g)

Weight gain = Mean final fish weight - Mean initial fish weight

b. Percent weight gain (%)

Percent weight gain = \( \frac{\text{Mean final fish weight} - \text{Mean initial fish weight}}{\text{Mean initial fish weight}} \times 100 \)

c. Average daily gain (ADG)

\[ ADG = \frac{\text{Mean final fish weight} - \text{Mean initial fish weight}}{T_2-T_1} \]

d. Specific growth rate (SGR) (% per day)

\[ SGR (\% \text{day}) = \frac{\log W_f - \log W_i}{T_2-T_1} \times 100 \] (After Brown, 1957)

Where,

\[ W_i = \text{Initial live body weight (g) at time } T_1 \text{ (day).} \]

\[ W_f = \text{Final live body weight (g) at time } T_2 \text{ (day).} \]

\[ T_2-T_1 = \text{Time interval} \]

e. Estimation of production of fish and prawn

Total production = No. of fish harvested × Average final weight of fish.

f. Estimation of survival rate (%)

The survival rates of fish and prawn for each treatment were estimated on the basis of number of fish harvested at the end of the experiment. The survival rate was calculated as

\[
\text{Survival rate (\%)} = \frac{\text{No. actual of fish survived}}{\text{No. initial of fish stocked}} \times 100
\]

g. Feed conversion ratio (FCR)

\[
\text{FCR} = \frac{\text{Total feed consumed}}{\text{Total live weight gain}}
\]

Cost benefit analysis

Cost-benefit ratio was calculated by the following formula:

\[
\text{Total cost (Tk.)} = \text{Fertilizer} + \text{Lime (Tk.)} + \text{Feed (Tk.)} + \text{Fry (Tk.)} + \text{Miscellaneous (Tk.)}
\]

\[
\text{Miscellaneous (Tk.)} = \text{Labor} + \text{Maintenance cost}
\]

\[
\text{Total yield (kg/ha)} = \text{Gross production}
\]

\[
\text{Total income (Tk.)} = \text{Commodity selling price per unit} \times \text{Total yield}
\]

\[
\text{Total net income (Tk.)} = \text{Total income (Tk.)} - \text{Total cost (Tk.)}
\]

\[
\text{Rate of return (\%)} = \left( \frac{\text{Total income}}{\text{Total cost}} \right) \times 100
\]

\[
\text{Benefit cost ratio} = \frac{\text{Total income}}{\text{Total cost}}
\]

Statistical analysis

A one-way ANOVA (analysis of variance) was applied for statistical analysis of the data. Computer handling for data analysis was done by statistical package state graphics version. Significance was assigned at 0.05% level.

Results

Water quality parameters

Temperature: The water temperature varied between 24.0 and 31.0°C in the ponds of T1. The highest average temperature (31.0°C) in T1 was recorded on May 9, 2006. In T2 ponds, the water temperature varied between 24.3 and 31.7°C. The average highest temperature (31.7°C) in T2 was recorded on April 29, 2006, while the lowest (24.3°C) was recorded on April 9, 2006. The average highest water temperature of T1, T2, and T3 were found to be 31.0, 31.5, and 31.4°C, respectively. The water temperature was found to fluctuate in all the treatments during the study (Figure 2).

pH

The pH values of water in all the experimental ponds under different treatment were varied between 7.1 and 8.3. In treatment T1, the average highest value of pH (8.3) was recorded on May 9, 2006, while the lowest (7.1) was recorded on April 9, 2006 (Figure 3). In case of T2 ponds, the pH of water varied from 6.8 to 8.4, within which the highest value (8.4) was recorded on June 28, 2006, while the lowest (6.8) was found on March 30, 2006. The pH values of T3 were found to be fluctuated sharply. The highest value (8.4) was recorded on 30 March 2006, while the lowest value (6.2) was found on June 18, 2006 (Figure 3).

Dissolved oxygen (DO)

The dissolved oxygen level was observed to be varied unevenly between 4.5 and 6.4 ppm in T1, 4.0 and 5.5 ppm in T2, and 3.2 and 4.5 ppm in T3 during the entire study period. Therefore, DO levels were obtained to be within the suitable range only in T1 and T2 in the present study. However, dissolved oxygen level was found to be fluctuated among all the three treatments (Figure 4).

Transparency

The water transparency values of the experimental ponds in all the treatments were varied from 28.5 to 44.0 cm. In case of T1, the highest transparency value (34.5 cm) was recorded on March 25, 2006, while the lowest (29.4 cm) on June 18, 2006. In T2, the highest value (31.2 cm) was recorded on March 25, 2006, while the lowest (29.5 cm) on June 18, 2006 (Figure 5).

Compensatory growth response of freshwater prawn (Macrobrachium rosenbergii) polycultured with Indian major carp, Catla (Catla catla)

Figure 5 Variations of water transparency in the experimental ponds under different treatments during the study period.

Growth and production performances of prawn and fish

Survival rate

The average survival of *M. rosenbergii* was estimated to be 85.0% in T₁, 71.0% in T₂, and 69.0% in T₃, while the survival of *C. catla* in T₁, T₂, and T₃ was found to be 100.0%, 91.6%, and 83.3%, respectively (Table 1) (Figure 6).

Figure 6 Stocking and Survival rate (%) of catla and golda (Macrobrachium rosenbergii) in the experimental ponds under different treatments.

Cumulative growth of *Catla catla*

After 90 days of culture, the average body weight of catla in the three treatments T₁, T₂, and T₃ were found to increase from 50 g to 292.0, 206.0 and 282.7 g, respectively. The growth performance was found to be better in T₁ than that in T₃, which might be due to the lower survival rate in T₃. The cumulative growth trends of catla in the ponds at the three treatments are shown in Figure 7.

Figure 7 Cumulative growth (g) performance of *Catla catla* obtained from different treatments.

Specific growth rate (SGR) of *Catla catla*

The daily growth rate or specific growth rate (SGR %/day) of *C. catla* by weight in all the treatments is presented in Figure 8. The SGR was 5.68%/day in treatment T₁, 4.28%/day in T₂, while 5.33%/day in T₃, respectively (Figure 8).

Figure 8 Specific growth rate (SGR %/day) of *Catla catla* obtained from different treatments.

The analysis of variance proved that the variation in the specific growth rate of catla obtained from different treatments were not significantly different (p<0.05) (Table 3).

Table 2 Stocking and Survival rate (%) of catla and golda

<table>
<thead>
<tr>
<th>Treatment</th>
<th>No. stocked/ m²</th>
<th>No. harvested</th>
<th>Survival (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catla</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T₁</td>
<td>12</td>
<td>12</td>
<td>100.0</td>
</tr>
<tr>
<td>T₂</td>
<td>12</td>
<td>11</td>
<td>91.6</td>
</tr>
<tr>
<td>T₃</td>
<td>12</td>
<td>10</td>
<td>83.3</td>
</tr>
<tr>
<td>Golda</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T₁</td>
<td>40</td>
<td>34</td>
<td>85.0</td>
</tr>
<tr>
<td>T₂</td>
<td>40</td>
<td>29</td>
<td>71.0</td>
</tr>
<tr>
<td>T₃</td>
<td>40</td>
<td>28</td>
<td>69.0</td>
</tr>
</tbody>
</table>

Table 3 Analysis of variance (ANOVA) for the specific growth rate (SGR %/day) of *Catla catla*

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>P-value</th>
<th>F crit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between groups</td>
<td>39930.65</td>
<td>2</td>
<td>19965.32</td>
<td>3.85356</td>
<td>0.035361</td>
<td>3.402826</td>
</tr>
<tr>
<td>Within groups</td>
<td>124331.4</td>
<td>24</td>
<td>5180.475</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>164262</td>
<td>26</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cumulative growth of *Macrobrachium rosenbergii*

The cumulative growth of *M. rosenbergii* by weight obtained from the three treatments is presented in Figure 9. A gradual increasing trend was seen in all the treatments throughout the culture period. The initial average body weight of shrimps in T₁, T₂, and T₃ was 5.8, 6.4 and 6.3 g, respectively, which became 94.2, 73.8 and 63.0 g in T₁, T₂ and T₃, respectively. T₁ showed a comparatively higher growth pattern than the other two treatments.

Figure 9 Cumulative growth (g) performance of *Macrobrachium rosenbergii* obtained from different treatments.
Compensatory growth response of freshwater prawn (Macrobrachium rosenbergii) polycultured with Indian major carp, Catla (Catla catla).

Specific growth rate (SGR) of Macrobrachium rosenbergii

The daily growth rate or specific growth rate (SGR) of M. rosenbergii by weight in all the treatments is presented in Figure 10. The highest growth rate of 5.2%/day was observed in T1, followed by 4.7%/day in T3 and 4.6%/day in T2, in that order. Comparatively high growth was obtained in T1 than those in other two treatments.

Average daily growth of Catla catla

The average daily growth of C. catla was observed to be 3.24, 2.88 and 3.14 g in T1, T2 and T3, respectively. The highest average daily growth in T1 was 3.66 g during the 90 days of culture while the lowest value was 1.96 g during the 60 days of culture. In T2, the highest average daily growth was 2.5 g during the 60 days of culture and the lowest was 0.96 g during the first 10 days of culture. In T3, the highest daily growth rate was 3.19 g during the 60 days of culture and the lowest 1.39 g was during the 20 days of culture. The average daily growth of the three treatments is shown in Figure 11.

Average daily growth of Macrobrachium rosenbergii

The average daily growth of M. rosenbergii was observed to be 1.05 g, 0.82 g and 0.70 g in T1, T2 and T3, respectively. The highest average daily growth for T1 was found to be 1.82 g during the 90 days of culture and the lowest value was 0.39 g during the 10 days of culture. In T2, the highest average daily growth was found to be 1.17 g during the 70 days of culture and the lowest was 0.18 g during the first 10 days of culture. In T3, the highest daily growth rate was 1.44 g during the 90 days of culture and the lowest 0.24 g was during the 10 days of culture. The average daily growth of the three treatments is shown in Figure 12.

Feed conversion ratio

The production of M. rosenbergii in all the treatments is presented in Figure 13. Total production (kg/ha) of M. rosenbergii in T1, T2 and T3 was found to be 791.00, 517.34 and 429.48, respectively while for C. catla that was 865.48, 559.70 and 698.19 in T1, T2 and T3, respectively. The gross production (kg/ha) of M. rosenbergii and C. catla was found to be the highest (1,615.48) in T1 followed by T2 (1,077.00) and T3 (1,127.48).

Feed conversion ratio: Feed conversion ratio obtained from the treatments is shown in Figure 14. FCR in T1, T2 and T3 was 1.98, 1.8 and 1.85, respectively.
The dissolved oxygen contents in the experimental ponds throughout the study were ranged from 3.2 to 6.4 ppm. The result obtained in the present study was more or less agree with those of Wahab et al., who recorded dissolved oxygen ranging from 3.4 to 7.79 ppm, Kohinoor reported dissolved oxygen from 2.0 to 7.4 ppm and Uddin from 2.2 to 8.8 ppm, and they also reported that, this range of dissolved oxygen is good for fish production, and water having dissolved oxygen below 5 ppm is unproductive. It may be concluded that dissolved oxygen content in the ponds under present study was more or less suitable for fish production.

**Water transparency**

The recommended level of water transparency for prawn farming is between 35 and 60 cm. The water transparency was higher than the recommended values during the culture period in all the ponds during this study. The lower daily growth rate of *M. rosenbergii* in all the treatments may be due to the high water transparency as well as the decline of natural food organisms. Boyd recommended a transparency range of 15–40 cm as appropriate for pond fish culture. Wahab et al. reported that the transparency of productive water bodies should be 40 cm or less. However, the transparency in the present experimental ponds was slightly higher than the recommended level for the carp-golda polyculture.

**Growth and production performances of catla and prawn**

**Stocking and survival of fish and prawn:** In case of prawn (*M. rosenbergii*), the survival rates (85.0%, 71.0% and 69.0%) obtained at a stocking density of 40/dec in the present study are more or less similar to those of D’Abramo et al., who noted that the survival rate of prawn was ranged from 54.3% to 89.0% in earthen ponds. Siddiqui and Al-Hinty obtained the survival rate of fresh water prawn (*M. rosenbergii*), which was varied from 71.0% to 93.0%. Islam et al. reported that a stocking density of 90 PL/dec was optimum in India. Ang investigated the potential of *M. rosenbergii* culture in Malaysia and obtained the total production of 977 kg/ha/158 days cycle with a survival rate of 32.4% at the stocking density of 10PL/m². Daniels et al. reported the higher survival rates of 73.7% to 81.9% in *M. rosenbergii* when fed with formulated diet in earthen ponds. The survival of *C. catla* was high and ranged from 83.3% to 100.0% in all the treatments, which is more or less similar to that of Miah et al. The use of inorganic and organic fertilizer, and supplemental feed might have resulted in good survival for the fish in all the treatments in the present study. Similar results have also been reported by Lakshmanan et al. However, the highest survival (100.0%) found in T1 was higher than that obtained by Ali et al. 

**Growth of fish and prawn**

In the present study, the non-significant difference in growth between T1 and T2 was probably due to the fact that prawn could not compensate their growth due to feed deprivation. While the existence of significant difference among the three treatments was due to different feeding methods. Chand et al. reported that the daily weight gains of catla, rohu and prawn were 3.29, 2.79 and 0.21 g/day, respectively. The results of the present study were higher than the findings of Sadek and El-Gayer, who found that the daily weight gain of *M. rosenbergii* was ranged between 0.318 and 0.319 g. The maximum SGR was found in T1 (5.2) and minimum in T2 (3.2) in the present study, which was in some extent higher than the findings.
of Sharma and Reddy, might be due to stocking of juveniles and everyday feeding. Islam et al. reported that this variation in SGR might be due to the culture environment, feeding trial, stocking densities and season of the study.

**Feed conversion ratio**

The FCR values obtained from different treatments in the present study for catla and prawn were more or less similar to the values reported by Siddique et al. The FCR of T1 (1.98) is highly satisfactory when compared with the findings of Liao and Biswas.

**Production of fish and prawn**

The highest production of prawn and catla in T1 and the lowest production in T3 were probably due to the fact that the growth rate of prawn has been inhibited because of the minimum utilization of supplementary feed. Ali et al. conducted a study to observe the effect of different periods of starvation and subsequent re-feeding on growth, survival and daily food demand etc. of prawn (M. rosenbergii) and catla (C. catla) and reported that prawn could be cultured at alternate day feeding protocol and thus feed cost should be substantially reduced. Mia obtained the highest production of prawn and fish as 122 and 4,200 kg/ha in the first year, and 96 and 3,945 kg/ha, respectively in the second year. He concluded that the low production might be due to low temperature. Huq et al. found the survival of prawn in monoculture and polyculture as 65% and 75%, respectively while the survival of both rohu and catla was 90%. They obtained the total production of prawn in monoculture and polyculture system as 606.8 and 605.2 kg/ha, while the production of rohu and catla in polyculture were 619.1 and 584.2 kg/ha, respectively. Jose et al. reported a gross production of 106-25 kg/ha of prawn from 160 days of culture in India, where M. rosenbergii was stocked at 10,000/ha with catla, rohu and mrigal (2:2:1) at a density of 1,000/ha. On the other hand, Islam et al. reported a production of 172 kg/ha/12 months, where M. rosenbergii was stocked at 15,000/ha with silver carp, catla rohu and mrigal (1.75:0.75:1.50:1.0) at a stocking density of 5,000/ha in each pond. Huq et al. reported a production of 428 kg/ha of prawn in 10 months, where prawn and fish density was 18,000/ha. Haque et al. used prawn stocking densities at 15, 20, 25, 30, 35 and 40/decimal in each treatment, and obtained the productions of 120.9 to 216.1 kg/ha/4 months, while that of carps was 2,248.8 to 2,359.2 kg/ha/4 months. The production range of prawn in the present study was higher than the findings of Haque et al. even with a low stocking density. This might be due to the lower stocking density of carp. In the present study, it was found that the growth and production of the prawn and carp were remarkably affected by supplemental feeding. The findings also revealed that the highest production in T1 was due to regular twice daily feeding and the lowest production was found in T3, where supplemental feed was applied once in every two days.

**Conclusion**

The results of the study revealed that prawn fed to satiation twice a day (T1) had better growth performances and survival than those of the other two treatments. In T2 (fed every alternate day) and T3 (fed every two days of interval), prawn could not compensate their growth and the average weight at final harvest was much lower than that of T1. Though, better FCR of prawn was seen in T3 followed by T1 and T2 but the mean weight at harvest was the highest in T1. Finally, the overall production of prawn was found to be the highest in T1 (791.0 kg/ha) and the lowest in T3 (429.5 kg/ha).

The net profit of prawn was much higher in T1. So, in terms of production cost and gross returns, T1 is more profitable than the other two treatments. In this way, farmers can get more profit and save the feed cost by maintaining proper feeding management. The study has provided evidence that prawn could be cultured in feeding regime with feeding at everyday with satisfactory growth and final production. Feed cost is perhaps the largest operational cost in all kind of aquaculture. So, it has become necessary to produce the maximum quantity of fish with minimum amount of feed to reduce the fish production cost to a greater extent. Prawn needs commercial pelleted feed to grow, while catla does not need any extra feed if they are released at a low density. However, to save feed cost, commercial diet should be used in a more efficient way. Moreover, the gross production of fish and prawn can be enhanced much with the minimum feed cost through adoption of proper culture practices, administration of good quality feed and maintenance of proper species combinations. However, it needs further studies with many more variables to develop the sustainable prawn-carp polyculture technology.

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**Conflicts of interest**

The author declares there is no conflict of interest.

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Compensatory growth response of freshwater prawn (Macrobrachium rosenbergii) polycultured with Indian major carp, Catla (Catla catla)


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