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GROWTH STUDIES OF *SYSTOMUS SARANA*, *MYSTUS VITTATUS* AND *MACROBRACHIUM ROSENBERGII* REARED UNDER FRESHWATER POND IN BAMBOO-NET CAGE SYSTEM

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ABSTRACT : In the present study, growth, survival rate and production of *Systomus sarana*, *Mystus vittatus* and *Macrobrachium rosenbergii* were examined under freshwater pond condition in bamboo-net cage for a period of 150 days. Six numbers of cages (2 × 1.5 × 1 m of each cage)were installed in the pond with help of bamboo poles at Faculty of Fishery Sciences campus in Kolkata, West Bengal, India. The cages stocked with fingerlings of *S. sarana* (1.79±0.24 cm), *M. vittatus* (4.72±0.49 cm)and post-larvae of *M. rosenbergii* (5.64±0.54 cm) and uniform stocking density maintained @ 50 no m^{-2}throughout the experimental periods with one replicate cage for each species and the experiment designated as C_1, C_2 and C_3 respectively. Pelleted feed were fedtwice a day @ 10% of the body weight for initial 15 days; thereafter @ 5% of the body weight rest of the experiment.The water quality parameters were found suitable range for fish culture in all the cages. *S. sarana* showed significantly ($p<0.05$) higher specific growth rate in terms of weight than *M. vittatus* and *M. rosenbergii*. But average growth rate of *M. rosenbergii* was significantly ($p<0.05$) higher than that of *S. sarana* and *M. vittatus*. The maximum survival percentage was recorded in *M. vittatus* (93.0±3.0%) followed by *P. sarana* (88.0±3.0%) and *M. rosenbergii* (85.0±7.0%). The production per unit area of the cages was maximum in *M. rosenbergii* (1.90±0.16 kg m^{-2}) followed by *M. vittatus*(0.75±0.01 kg m^{-2}) and *S. sarana* (0.73±0.02 kg m^{-2}). *M. rosenbergii* showed highest benefit cost ratio (2.01) followed by *S. sarana* (1.28) and *M. vittatus* (1.23).

Key words : Bamboo-net cage, growth performance, production, *Systomus sarana*, *Mystus vittatus, Macrobrachium rosenbergii*.

INTRODUCTION

Cage culture practices is a very important and interesting techniques which maximizes the sustainable biomass production in a per unit area. The cage culture accounts for a very high production of many fishes and crustaceans (Haq *et al*, 2011). Species, which have been successfully reared in cages worldwide, are catfish, trout, tilapia, stripedbass, red drum, bluegill sunfish and carp. The cages also have been used to replace ground nurseries for rearing fry in India (Jana, 2004). By integrating the cage culture system into the aquatic ecosystem, the carrying capacity per unit area is maximized, ensuring the optimum growth by removing the metabolic wastes, excess feed and faecal matters. Henceforth, cage culture is a low impact farming practice with high economic returns (Vikas *et al*, 2010).

Cage aquaculture is gaining popularity throughout the world due to number of advantages over the conventional methods of fish farming. Fish species in cages are easy to manage, advantageous to rear selective fishes and easy to harvest (Dham, 1975). Like other intensive fish culture systems, in cage culture, selection of species is also important since all the species are not suitable and economical viable for all culture system.

In West Bengal, the report of cage culture in integrated pond is very scanty. The fresh water aquaculture is facing a lot of threats due to introduction of non-native species by the farmer's fields. Promotion of non-native fish culture in cages to avoid any interference with the native species will be a solution of the problem. In addition, intensification of aquaculture with 3-6 species combination eradicates the high value small indigenous threatened fishes like *Puntius* sp., *Mystus* sp. and other high value carps, catfishes and prawns. Culture of these high value fish and shell-fishes in cages along with existing composite fish culture will be a viable solution for the conservation of ichthyofaunal diversity of the state.

Ample literature are available throughout the world regarding fish cage culture (Christensen, 1994; Rahman, 2006 and Rahmah, 2009) and prawn cage culture (Tidwell *et al*, 1999; Marques *et al*, 2010; Cuvin-Aralar *et al*, 2007 and 2013) to maximum the productivity. There is very little literature available on cage farming in integrated pond. The present study was undertaken to assess the growth studies of *Systomus sarana*, *Mystus vittatus* and *Macrobrachium rosenbergii* in bamboo-net cage farming system under composite freshwater pond condition.

MATERIALS AND METHODS

The present experiment was conducted in a composite fish culture pond of 1 ha area with an average water depth of 2 m located at Faculty of Fishery Sciences campus in Chakgaria (22.47^0 N and 88.40^0 E) of district Kolkata, West Bengal, India. Six cages with one replicate of each were installed randomly with the help of bamboo poles around the entire pond without hampering the existing culture system. Caged fish, *S. sarana* and *M. vittatus* were fed with 30% protein and *M. rosenbergii* with 40% protein containing commercial floating peletted feed. First 15 days the feed was given @ 10% of the body weight and then onwards @ 5% of the body weight splitting into twice a day.

Cage construction

The cage frame was made from locally available bamboo, which was found cheaper than wood, steel and polyvinyl chloride (PVC) and lasts for 3 years with minor renovation. Each cage is a cubical box shaped with 2 × 1.5 × 1 m in size. A platform has made at the bottom of each cage by bamboo sticks to avoid mud entrance into the cages. The cage has installed into the pond with the help of four bamboo poles tightly fixed with ropes at each corner. All the cages were covered with fine meshed net to prevent the fishes go outside of the cages. The top of the cages were covered with net to prevent the fishes from jumping outside of the cages.

Seed collection, stocking and culturing

The fingerlings of two fishes and post-larvae of prawn were procured from Canning fish farm of South 24 Parganas district, West Bengal. All the species were acclimatized in happa, kept in pond for 72 hr prior to stocking without any food. Fingerlings of *Systomus sarana* (1.79 cm length and 0.86 g weight), *Mystus vittatus* (4.72cm length and 3.77g weight) and post-larvae of *Macrobrachium rosenbergii* (5.64 cm length and 2.70g weight)were stocked at uniform stocking density of 50 no m^{-2} with one replicate cage for each species and the experiment designated as C_1, C_2 and C_3 respectively. The culture experiment was conducted for 150 days. Pelleted feeds were provided splitting into 2 times in a day @ 10% of the body weight for initial 15 days; thereafter @ 5% of the body weight throughout the experiment. The water quality parameters, length and weight of the each species were recorded from initial day and thereafter every fortnight interval up to 150 days. The fortnightly sampling were designated as D_1, D_2, D_3, D_4, D_5, D_6, D_7, D_8, D_9, D_{10} and D_{11} for 1 day, 15 days, 30 days, 45 days, 60 days, 75 days, 90 days, 105 days, 120 days, 135 days and 150 days, respectively. Thirty numbers of fin or shell fish from each cage were sampled randomly at every fortnight for taking length and weight. At the end of the experiment entire fin and shell fish were caught by net from the cages. The final length, weight and total production of the experimental fin and shell fish were estimated. Mortality of the species was recorded daily and dead species, if any, were removed immediately to avoid rotting.

Determination of biological parameters

Biological parameters like length and weight of respective species, survival rate, specific growth rate, average growth rate and economic performance of each species were estimated. The length (cm) and weight (g) of each species were measured with the help of a caliper scale and electronic balance. Specific growth rate (% in length and % in weight) per day (SGR-L and SGR-W) of the sampled fish were calculated according to the following formulas (Ricker, 1997).

SGR (% in length/day) = $\text{Log}L_2 - \text{Log}L_1$ / duration of culture × 100.

SGR (% in weight/day) = $\text{Log}W_2 - \text{Log}W_1$ / duration of culture × 100.

Where,

L_1 and W_1 = Initial length (cm) and body weight (g).

L_2 and W_2 = Final length (cm) and body weight (g).

Average growth rate (% per day) = Mean final weight - mean initial weight / duration of culture × 100.

Survival rate = Number of fish harvested / number stocked × 100

The formula used for determining Benefit Cost Ratio (BCR) was as below:

BCR = Gross income / total cost.

Data generated in this study were statistically examined by suitable statistical analyses using Microsoft Excel (version 12.0.4518.1014, 2007). Length-weight regression, analysis of variance (ANOVA) and pair comparison in between the different days of culture was done to assess the performance of cage culture experimental fish along with the existing composite fish farming system.

RESULTS

Specific growth rate (SGR) and average growth rate (AGR)

The fortnightly mean specific growth rate in terms of weight (SGR-W) of *S. sarana*, *M. vittatus* and *M. rosenbergii* during 150 days of cage culture period is provided in Fig. 1. In *S. sarana*, initial SGR-W was high (5.37±1.03), then it was gradually significantly decreased to 90 days culture period and found no significant variations during D_8 and D_{11} (2.31 ± 0.08 and 1.98 ± 0.06) days of culture. The SGR-W of *M. vittatus* was less (1.28±0.87) at initial days of culture as compared to *S. sarana*, but it was somewhat steady throughout the culture period (1.28 to 0.97). In *M. rosenbergii* the initial SGR-W was found high (3.42±0.93) but showed similar trend of growth rate like *S. sarana*.

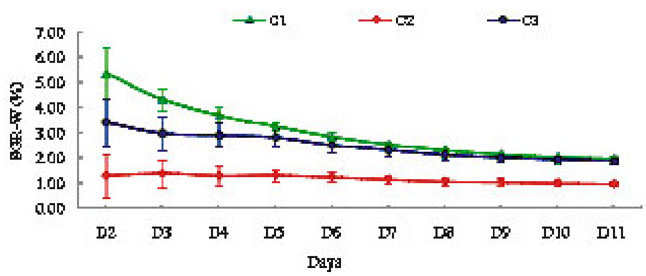

Fig. 1 : Fortnightly mean specific growth rate (% in weight/day) of *S. sarana*, *M. vittatus* and *M. rosenbergii* during 150 days of culture period.

The mean specific growth rate in length (SGR-L) of *S. sarana* was found maximum during 30 days sampling (2.66±0.87) and was found lowest at the end of the culture period (1.41±0.15). The SGR-L was found to be higher in *S. sarana* as compared to other two species throughout the culture period. Unlike *S. sarana*, the SGR-L of *M. rosenbergii* was also observed high during 30 days of sampling (1.29±0.34) and lowest was observed the end of the culture period (0.80±0.07). The SGR-L of *M. vittatus* was less at initial days of culture as compared to *S. sarana*, but, it was found steady and with very little variations throughout the culture period (Fig. 2).

The average growth rate (%/day) of *S. sarana* (7.23-10.39%) and *M. vittatus* (5.39-8.19%) was found almost similar and steady throughout the culture period. But in

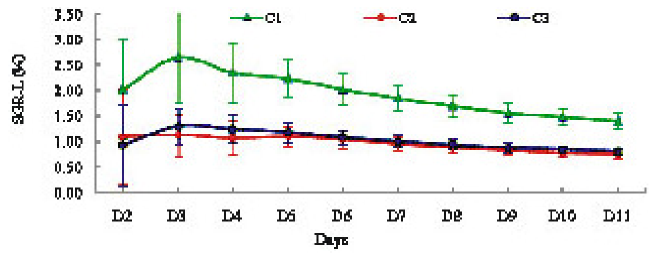

Fig. 2 : Fortnightly mean specific growth rate (% in length/day) of *S. sarana*, *M. vittatus* and *M. rosenbergii* during 150 days of culture period.

case of *M. rosenbergii,* the average growth rate gradually increased with increase of the culture period. Through the growth rate was less (8.96%) during first fortnight sampling but increased at 27.82% at the end of the culture period i.e. last fortnight (Fig. 3).

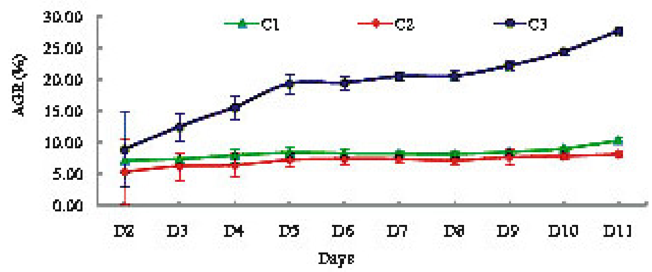

Fig. 3 : Fortnightly mean average growth rate (%) of *S. sarana*, *M. vittatus* and *M. rosenbergii* during 150 days of culture period.

Survival percentage

The survival percentage of *S. sarana*, *M. vittatus* and *M. rosenbergii* during the entire period of culture (150 days) is presented in Fig. 4. The maximum survival percentage was recorded in *M. vittatus* (93.0±3.0%) followed by *S. sarana* (88.0±3.0%) and *M. rosenbergii* (85.0±7.0%).

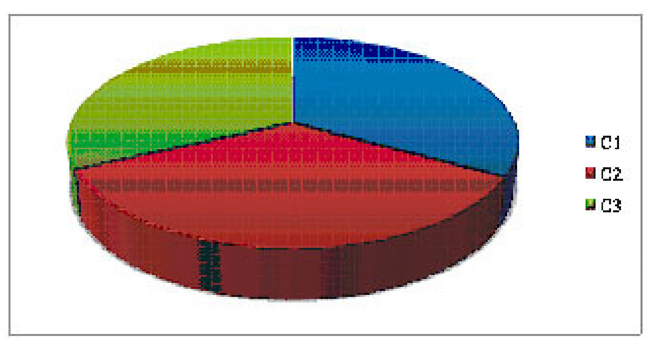

Fig. 4 : Mean survival percentage of *S. sarana*, *M. vittatus* and *M. rosenbergii* during 150 days of culture period.

Production

The production (kg m^{-2}) of *S. sarana*, *M. vittatus* and *M. rosenbergii* in cages is presented in Fig. 5. The production per unit area of the cages was maximum in *M. rosenbergii* (1.90±0.16 kg m^{-2}) followed by *M.*

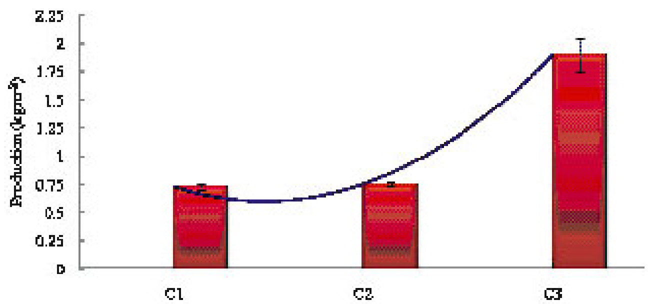

Fig. 5 : Production (kg m^{-2}) of *S. sarana*, *M. vittatus* and *M. rosenbergii* during 150 days of culture period.

vittatus (0.75±0.01 kg m^{-2}) and *S. sarana* (0.73±0.02 kg m^{-2}) during 150 days of culture with stocking density 50 no m^{-2}. The initial sizes of fingerlings were 1.79±0.24cm for *S. sarana* and 4.72±0.49cm for *M. vittatus*, whereas, the initial size of post larva (PL) of *M. rosenbergii* was 5.64±0.54 cm. The highest benefit cost ratio was recorded for *M. rosenbergii* with 2.01 followed by *S. sarana* (1.28) and *M. vittatus* (1.23).

DISCUSSION

Costa-Pierce *et al* (1989) reported average production of 12.83 kg m^{-2} of common carp stocked at 50 fish m^{-2} with 97.6% survival rate. Ahmed *et al* (2002) reported average standing stock biomass of *Cyprinus carpio* at 7 .82, 12.83 and 11.58 kg m^{-2} with the survival rate of 98.9%, 97.6% and 94.4% and food conversion ratios of 4.51, 3.82 and 4.21 when stocked at 25, 50 and 75 no. m^{-2} during 240 days culture period. A survival rate of 72.28% for *Catla catla*, 77.71% for *Labeo rohita* and 72.30% for *Cirrhinus mrigala* were observed by Das *et al* (2009) at cage culture in Dahod reservoir of Bhopal during 120 days culture period. Ronald *et al* (2014) reported 87% and 82.9% survival rate of tilapia in the stocking density of 4000 fry m^{-3} and 5330 fry m^{-3}. They also mentioned that increasing the stocking density of Nile tilapia fry beyond 2670 fry m^{-3} significantly affects the survival rate.

As per New (2000) juveniles of *Macrobrachium rosenbergii* at an initial stocking size of 0.25 g in temperate zone ponds grow 26 g in 4.4 months culture period when stocked at 8 prawn m^{-2}. Ranjeet and Kurup (2002) could found mean weight at harvest of *Macrobrachium rosenbergii* was 36.7 g during 8 months culture period at a much lower stocking density (6 prawnsm^{-2})in polders. Cuvin-Aralar *et al* (2007) reported survival rate of 55.3%, 54.0%, 52.7% and 36.9% in the stocking densities for 15, 30, 60 and 90 prawns m^{-2} respectively with yield per crop 450 to 1089 gm^{-2} yr^{-1} in cages of freshwater lake. The specific growth rate and daily growth rate was significantly higher in lower stocking densities (15 prawns m^{-2}) compared with the other higher stocking densities (30, 60 and 90 prawns m^{-2}) for 150 days culture period. Cuvin-Aralar *et al* (2013) found that the weight, percent weight increases, daily growth rate, specific growth rate, yield and feed conversion ratio (FCR) were significantly better in *Macrobrachium rosenbergii* reared in 1 mm mesh size compare to 5 mm net mesh in lake based cages.

Krishnan and Jalalludin (1983) also reported a production rate of 206.7 g m^{-2} for *P. indicus* and 271 g m^{-2} for *P. monodon* in floating rectangular cages in backwaters of Kovlam. Shanmugam *et al* (1995) reported the production rate 197.5 gm^{-2} for cage-reared shrimp, *P. indicus*. Sivanandavel and Soundarapandian (2013) studied influence of cage shapes on growth, survival and production of white shrimp and found that higher growth of 22.1 g, survival rate of 92% and production rate of 406.6 g m^{-2} was achieved in rectangular cages compared with square and circular one for 100 days of culture periods.

Rahman *et al* (2006) observed that density of 150fish m^{-3} produced the best production and farm economics of sutchi catfish, *Pangasius sutchi* (Fowler, 1937) in cage culture. They also mentioned that, gross and net yields were significantly different and were directly influenced by stocking density but the specific growth rate, survival rate and feed conversion rate were unaffected. Borthakur and Goswami (2007) reported overall survival rate from 87.14 to 91.42% with specific growth rate from 1.46 to 1.81 in *Clarias batrachus* (Linnaeus) fed with three test diets in cage culture in a floodplain wetland of Assam. Rahmah *et al* (2009) mentioned that, rearing bagrid catfish *Mystus nemurus* (Cuvier and Valenciennes, 1840) more than 20 but less than 50 larvae l^{-2} with the availability of shelter will give the highest survival rate during larval rearing. Rahman *et al* (2012) reported in *Mystus cavasius* final weight, final length, weight gain, length gain, specific growth rate and survival were significantly higher when fingerlings were stocked at 200 000 ha^{-1} compared to 250 000 and 300 000 ha^{-1} during 56 days of culture period. Rahman *et al* (2017) studied impact of stocking density and economic returns of stinging catfish on cage culture system and reported BCR were 0.83±0.03, 1.00±0.01 and 0.75±0.02 with survival rate of 57.33±4.73, 59.50±1.73 and 48.0±1.20% at the stocking density of 100, 200 and 300 fish m^{-2}, respectively.

The physico-chemical parameters of water have great influence on maintain of a good and healthy aquatic environment and production of sufficient fish food organisms. Zhang *et al* (1987) observed that the physico-chemical parameters are largely determined by the pond size, shape, depth, fish species, stocking density etc. In the present study, these factors were within the acceptable ranges for fish culture. The pH values were slightly alkaline, which indicates good productivity of pond water. For pond fish culture the suitable range of pH is 6.5 to 8.5 (Boyd, 1992). In the present study, pH values varied from 7.90-7.80, 7.93-7.75 and 7.80-7.75 for C_1, C_2 and C_3 cages, respectively. The dissolved oxygen in the cages were generally fluctuated and ranged from 6.52-6.48, 6.42-6.33 and 6.47-6.38 mg l^{-2} for C_1, C_2 and C_3 cages, respectively. Though there was some variation of hardness 264.33-281, 275.67-290.67 and 271.50-285.50 mg l^{-2} for C_1, C_2 and C_3 cages respectively and were also found favourable for fish culture. The water transparency value ranged from 45.15-38.07, 47.97-38.13 and 45.87-38.40 cm for C_1, C_2 and C_3 cages, respectively. Wahab *et al* (1995) found transparency depth ranging from 15–74 cm in polyculture pond. In the present study, Secchi disk visibility in the cages were low in the end of the culture period, which indicates heavy rain fall disturb the transparency.

CONCLUSION

The cage culture of *Systomus sarana*, *Mystus vittatus* and *Macrobrachium rosenbergii* along with existing composite fish farming system is a very new concept in fresh water aquatic environment. Fast growing and high value indigenous fin and shell fishes are wealth for the fish farmers, but they are declining day by day and few of them already in threatened. The problem may be solved by the introduction of cage culture in the prevailing composite farming systems due to limited water resources. After standardization of suitable methods farmers may produce fry and fingerlings of desirable species along with existing culture system. Present study based on growth performance of three species, further studies should be carried out on suitable stocking densities, cage size, different feeding regimes and different conditions to promote pond cage aquaculture in the state. The present study was carried out in a captive pond so further investigation should be conducted in open water body as well as concern should be taken to increase maximum economic return by manipulating stocking densities of different species.

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