International Journal of Multidisciplinary Research and Development
Online ISSN: 2349-4182, Print ISSN: 2349-5979, Impact Factor: RJIF 5.72
Received: 03-02-2021, Accepted: 26-02-2021, Published: 27-03-2021
www.allsubjectjournal.com
Volume 8, Issue 3, 2021, Page No. 114-118

Culture potential of Brackishwater cat fish (*Mystus gulio*) with tiger shrimp (*Penaeus monodon*), freshwater giant prawn (*Macrobrachium rosenbergii*) and green back mullet (*Chelon subviridis*) under different stocking densities in coastal region of Bangladesh

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Abstract
An experiment was undertaken in nine experimental ponds to evaluate the impact of stocking densities of *Mystus gulio* on growth and production of *Penaeus monodon*, *Chelon subviridis* and *Macrobrachium rosenbergii* in polyculture. Three stocking densities of *M. gulio* were tested with three replications for each, *viz.*, 5000/ha (T1), 10000/ha (T2) and 15000/ha (T3). At the end of culture period, average final weight of *P. monodon*, *M. rosenbergii*, *M. gulio* and *C. subviridis* in T1 were significantly higher ($P<0.05$) than those in T2 and T3. Survival of *P. monodon* (64.9 %), *M. rosenbergii* (65.5 %) and *C. subviridis* (71.5 %) was highest in T2 whereas, survival of *M. gulio* (73.7%) was highest in T1 than other treatments. Among the treatments, significantly ($P<0.05$) highest total production obtained in T2 (1352.1 kg/ha), followed by T3 (1078.5 kg/ha) and T1 (955.2 kg/ha) in 150 days. Therefore, among all treatments, 10,000/ha stocking density of *M. gulio* would be the best recommendation for the poly culture with *P. monodon*, *M. rosenbergii* and *C. subviridis*.

Keywords: culture potentials, growth, *Mystus gulio*, production, stocking density

Introduction

Shrimp (*Penaeus monodon*), prawn (*Macrobrachium rosenbergii*), brackish water cat fish (*Mystus gulio*) and green back mullet (*Chelon subviridis*) are commercially important species. These species are supporting the coastal fisheries of Bangladesh to a great extent, both in point of commercial and local consumption view. Prawn and finfishes are harvested as bi-catch from extensive shrimp ghers. Though, the catfish has naturally being caught every year in fairly a large quantity, its catch is gradually declining due to combined effect of different factors, such as over-exploitation, destructive fishing pressure, loss of habitat, and different ecological modifications [1]. Freshwater prawn farming in Bangladesh has number of socio-economic advantages over shrimp farming. Unlike the shrimp farms which are normally large (average size above 10ha or 25 ha), and often pirated by non-resident elite owners, the prawn farms are mostly small (average size less than an acre) and operated by the landowners themselves. It has been observed frequently that total farm output increases through the inclusion of suitable fish and/or prawn in rice fields [1, 2]. Besides, prawn is yet not susceptible to the prevailing white spot virus disease that causes huge economic losses to the shrimp [3]. For all these reasons, prawn culture is socially more acceptable and economically viable. Green back mullet, *C. subviridis* (Val. 1836) is another promising species of brackish water mug i lid fish with a tropical Indo-pacific distribution. It is a euryha line and eury thermal fish. The high quality of flesh, high economic value and wide temperature and salinity tolerance capacity make this species popular for aquaculture in the intertidal ponds [4]. The culture practice of this fish in the coastal impoundments (locally called ghers) of Bangladesh is getting much popularity. These three species are having high market demand and delicious in taste and it has an emerging trend as an aquaculture species in the coastal Bangladesh for conservation and increasing supply of these fish. Virtually these three species are not cultured with specific design. Polyculture practice of these three species has not yet been developed. Although a freshwater species, in early stages prawn needs higher salinity level up to juvenile stage and can survive and grow normally in salinity up to 8 ppt. The year round salinity level of the South-West coastal region provided the opportunity for horizontal and vertically expansion of prawn farming is, therefore, enormous [5]. If prawn, brackish water catfish and green back mullet could be cultured along with shrimp, it would be an appropriate technique to minimize the disease outbreak for this species and would be helpful for minimizing the production risk. Previously, polyculture of shrimp and brackish water fin-fish [6], shrimp and some freshwater and hypo saline fin-fish [7] and shrimp, prawn and tilapia [8] has been reported. Considering the euryha line nature, green back mullet has potential for culture in both brackish water as well as freshwater ponds. Green back mullet may be very much suitable for culture with shrimp in brackish water *ghers*. Both green back mullet and prawn may help to safe the farmers as the main shrimp crop damage due to disease invasion. Documented information on polyculture of these three species is very rear. However, Study on polyculture technique of these three species considers research priority. Therefore, this study was conducted to diversify the cropping pattern of coastal shrimp *ghers* through introduction of polyculture system and increase productivity of shrimp *ghers* in the coastal area of Bangladesh.

Materials and Methods

Study area

The study was conducted in the pond complex of the Bangladesh Fisheries Research Institute (BFRI), Brackish water Station, Paikgacha located at 22° 28-22° 43' N, 89° 09'- 89° 23' E in Khulna district of Bangladesh. The experiment was carried out in nine earthen ponds of 0.1 ha each from 1st May to 1th October 2017.

Pond Preparation

Prior to stocking, the experimental ponds were dried and cleaned for unwanted weeds and species. Ponds were prepared following drying, liming (Cao@250 kg/ha) and then filling with tidal water up to a depth of one meter. The water of the ponds was treated with chlorine @20 ppm. The buffering capacity of water of the ponds was strengthened by applying dolomite @20 ppm. Fertilization with urea and TSP was done @2.5 ppm and 3.0 ppm respectively.

Stocking

Fries of shrimp (0.008g), prawn (0.037g) and green back mullet (0.14g) were stocked at the rate of 20,000, 10,000 and 10,000 individuals/ha respectively in each study pond whereas brackish water catfish (*M. gulio*) were stocked at a rate of 5,000, 10,000 and 15,000 individuals/ha under treatment-1 (T1), treatment-2 (T2) and treatment-3 (T3), respectively on 1st May 2017. Before stocking, the initial mean weights of the fingerlings were measured using sensitive digital balance (OHAUS, Model: CS-2000) and then released in in-pond nursery made with nylon net fasten with bamboo frame. After 3 weeks of rearing in nursery, all fries were released in the whole pond by opening the nursery enclosure.

Feeding

In the nursery, the stocked PL and fries were fed with CP nursery feed. Feed was supplied by spreading @ 100%, 80% and 60% of the estimated biomass at 6h intervals daily in the 1st, 2nd and 3rd week respectively. Shrimp and prawn were fed with commercial CP shrimp feed and mullet and catfish were fed with CP carp feed at the rate of 10-3% of estimated body weight from the 4th week to the end of culture period.

Growth measurement

The growth of experimental fishes were observed weekly basis for each pond random sampling method. At least 30 fishes were sampled with the help of a cast net to measure the growth to assess the health status and for feed adjustment.

Physico-chemicals properties

Water quality parameters like temperature, water depth, transparency, dissolved oxygen (DO), salinity, pH were determined weekly basis using a Celsius thermometer, a graduated pole, a Secchi-disk, a portable dissolved oxygen meter (HI 9142, Hanna Instruments, Portugal), refractometer and a portable pH meter (HI 8424, Hanna Instruments, Portugal), respectively. Water quality parameters were determined following standard methods [9]. Total alkalinity was determined following the titrimetric method according to the standard procedure and methods [10].

Harvesting

After 90 days of culture, harvest was done for shrimp by selective cast net. Remaining fishes (brackish water catfish, green back mullet and prawn) those were reared in the same pond for 150 days. The final harvest of the rest of shrimp and other species was done by completely drain out the treatment ponds. After harvesting of all fish species their growth and production were estimated and compared.

Calculation of growth parameters, survivals and production

Mean weight gain (g) = Mean final body weight (g) - Mean initial body weight (g).

Average Daily Weight Gain = Mean final body weight (g) - Mean initial body weight (g)/ culture period (days)

Specific growth rate SGR (% bw/d) = [In (final weight)-In (initial weight]/culture period (days) x 100.

Survival rate (%) = (Final fish number / Initial fish number) × 100.

Production (kg ha-1) = [{Final number of all harvested fish x individual weight of fish (g)} / 1000] x 247.1]

Data Analysis

The mean values for growth, survival and production were tested using one-way analysis of variance (ANOVA), followed by testing of pair-wise differences using Duncan's Multiple Range Test. Significance was assigned at the 5% level. All statistical analysis was done by using the SPSS (Statistical Package for Social Science) version-21.5. The graphs of water quality parameters were performed using Microsoft Excel.

Results and Discussion

Hydrological Properties

Water temperature of different ponds varied from 30-35ºC. Salinity of water was almost same in all ponds which varied from 04-15 ppt (Table 2).

Table 1: Water quality parameters of different treatments during rearing period.

Parameters	T1	T2	T3
Temperature (ºC)	30-35	30-35	30-35
Salinity (ppt)	4-15	4-15	4-15
Depth (cm)	80-96	85-104	85-105
Transparency (cm)	28-37	27-36	29-38
pH	8.2-9.1	8.1-9.2	8.1-9.1
Alkalinity (mg/l)	98-168	100-170	96-156
Dissolved oxygen (mg/l)	5.62-8.62	5.61-9.34	5.36-9.84
Free CO_2(mg/l)	0.0-0.0	0.0-0.0	0.0-0.0

Salinity steadily increased from May until reached its peak at June (15 ppt) then it showed sharp fall till October due to the onset of monsoon. Depth of water was recorded 80-96 cm in T1, 85-104 cm in T2 and 85-105 cm in T3. Water transparency was found to vary from one pond to another. Transparency of water was recorded 28-37 cm in T1, 27-36 cm in T2 and 29-38 cm in T3 which indicate the prevalence of sufficient plankton. Dissolved oxygen was congenial throughout the culture period and varied from 5.62-8.62 mg/l, 5.61-9.34 mg/l and 5.36-9.84 mg/l in T1, T2 and T3 respectively.

Alkalinity level of water was found sufficient to support the primary production for all ponds, found to vary from 98-168 mg/l in T1, 100-170 mg/l in T2 and 96-156 mg/l in T3. Water pH of all ponds slightly decreased with the progress of culture period but it did not decrease below critical value and was always alkaline. The pH value varied from 7.9 to 9.04 in T1, 7.9 to 8.9 in T2 and 7.8 to 9.40 in T3. Changing trends of different water quality parameters are graphically shown in figure 1.

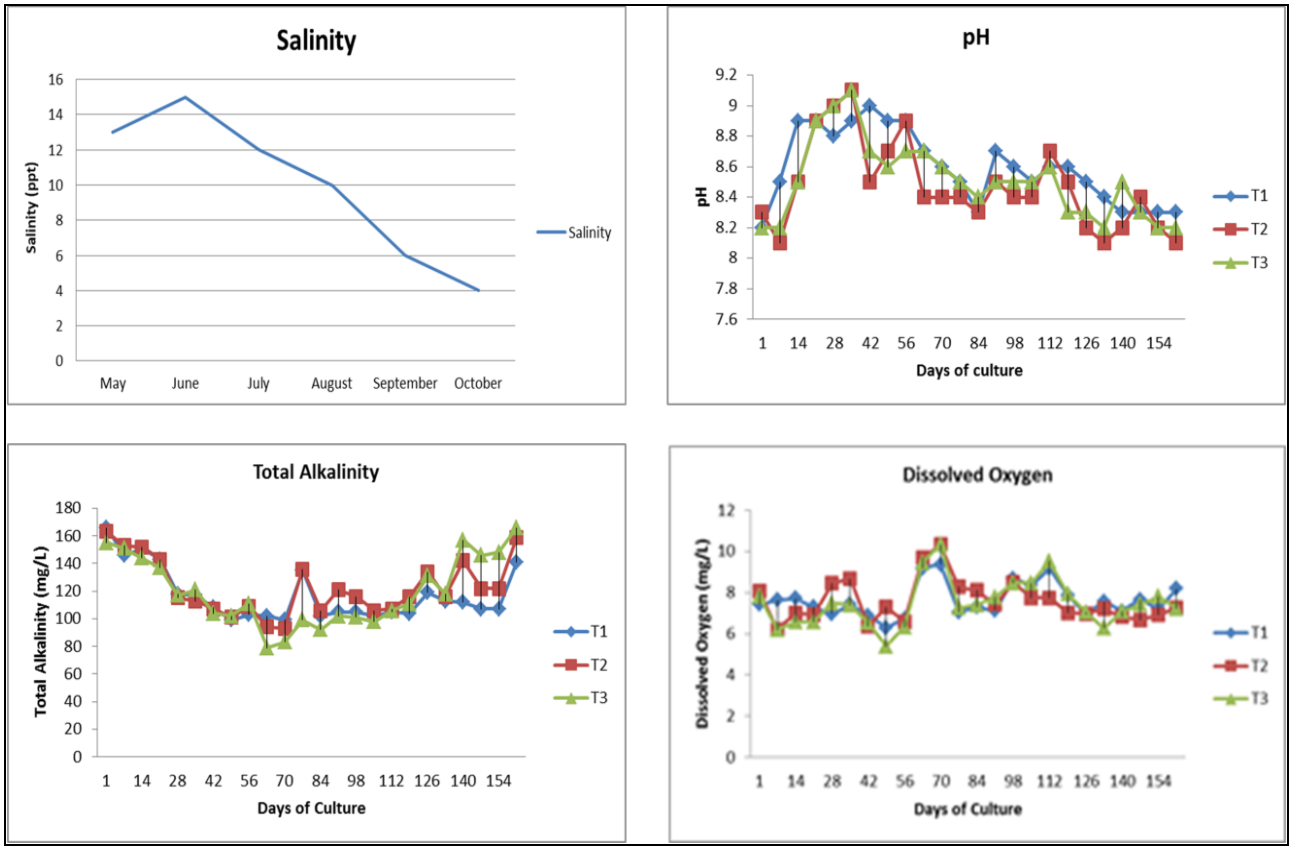

Fig 1: Changing trend of water quality variables of the rearing ponds during culture period

Temperature is one of the critical physical modifiers that influence on energy flow, growth and biological effects in marine organisms [11]. Temperature is one of the critical physical modifiers that influence on energy flow, growth and biological effects in marine organisms [11]. Defective production will be occurred when the water temperature falls out of optimum temperature range for significant epoch [12] suggested that temperature optima is >30 ºC for small shrimp (<5 g) while for large shrimp; the optimum temperature is about 27ºC, similarly shrimp yield was found increased in pond between 26 and 28 ºC temperature and yield was impaired when temperature was above 33^{0}C [13]. The optimum range of water pH for shrimp culture is 7-9 [14]. Besides, several authors have reported a wide variation in pH 7.5-9.2 [14] and 7.68-8.35 [15] in shrimp farms and found the ranges favorable for shrimp culture. Hence, pH values in all the shrimp ghers were observed within these ranges. The transparency is mainly depends on the presence of phytoplankton population. The secchi disc reading should be 30-40 cm [16] whereas, it was observed 30-50 cm for this study and the transparency of present study was between the ranges of 27-45 cm. The recorded alkalinity of the selected ghers was between the ranges of 140-240 mg/l which is closely similar with [17]. DO is considered as one of the crucial factor for shrimp culture [18, 19]. The DO level of the experimental ghers varied between 4.0-5.90 mg/l before interventions and 4.4-6.53 mg/l whereas [20] considered 4-8 ppm of DO as favorable range for shrimp culture and [21] reported that dissolved oxygen content of a shrimp farm should be >4.0 mg/I.

Growth and Production Performance

Stocking density, growth, survival, production of shrimp, prawn, green back mullet and brackish water catfish under different treatments are furnished in Table 3. Final weight of shrimp, prawn, catfish and mullet were highest in T1 than other treatments (Table 3). This may be due to the lower stocking density of catfish. Final weight (59.2g) and survival (73.7%) of catfish was found significantly (P<0.05) highest in T1 than other treatments.

Table 2: Details of Stocking density, growth, survival and production of shrimp, prawn, green back mullet and brackish water catfish under different treatments.

Treatment	Species	Stocking Density/h	Initial Weight (g)	Final weight (g)	Average Daily Weight gain (g)	SGR (%/day)	Survival (%)	Production Species wise (kg/ha)	Total production (kg/ha)
T_1	Shrimp	20000	0.008	20.5±3.5	0.25±0.01	8.71±0.2	45.5±4.6	186±8.2	955.2^c
	Prawn	10000	0.037	110±33.48	0.73±0.03	5.32±0.3	28±2.8	308±14.8	
	Catfish	5000	0.001	59.2±4.24^a	0.39±0.02 ^{a}	7.32±0.2^a	73.7±5.2^a	217±13.8 ^{c}	
	mullet	10000	0.14	43.6±3.63	0.28±0.01	3.82±0.08	56.0±4.3	244.2±12.9	

T_2	Shrimp	20000	0.008	15.6±1.71	0.19±0.07	8.41±0.2	64.9±4.8	202.5±10.5	1352.1[a]
	Prawn	10000	0.037	97.6±13.7	0.65±0.03	5.25±0.03	65.5±4.7	639.3±16.8	
	Catfish	10000	0.001	45.8±6.1[b]	0.30±0.01[b]	7.15±0.3[b]	68.5±3.9[b]	313.7±9.6[a]	
	mullet	10000	0.14	27.5±4.03	0.18±0.06	3.52±0.01	71.5±6.3	196.6±8.7	
T_3	Shrimp	20000	0.006	18.5±1.9	0.23±0.08	8.92±0.2	38±2.7	140.6±7.8	1078.5[b]
	Prawn	10000	0.05	62.5±14.6	0.41±0.02	4.75±0.07	45±3.6	562.5±14.1	
	Catfish	15000	0.001	29.8±4.37[c]	0.19±0.06[c]	6.86±0.1[c]	60.5±4.5[c]	270.4±12.5[b]	
	mullet	10000	0.14	15.0±3.20	0.09±0.03	3.11±0.01	53±4.1	105±8.9	

Values in the same column with dissimilar superscripts are significantly different (P<0.05)

Monthly weight increments of catfishes were shown on figure 2. Begum *et al*. (2018) [22] reported that the final weights of shrimp was 23.3g, 22.3g and 21.3g in T1, T2 and T3 respectively and final weight of prawn was 35.33g, 49.78g and 42.85g in T1, T2 and T3 respectively whereas, final weight of catfish was 18.44g, 16.62g and 15.13g in T1, T2 and T3 respectively. Islam *et al*. (2015) [23] described that shrimp attained an average body weight ranged 20.7-21.4g after rearing of 135 days and prawn attained 42-48g ABW after rearing of 225 days. However after 90 days of rearing the final weight of shrimp and 150 days of rearing the final weight of prawn of present experiment was higher than [23]. Final weight of catfish (18.44g) in T1 was significantly (P<0.05) higher than T3 but no significant difference (p>0.05) between T1 and T2 and T2 and T3 respectively.

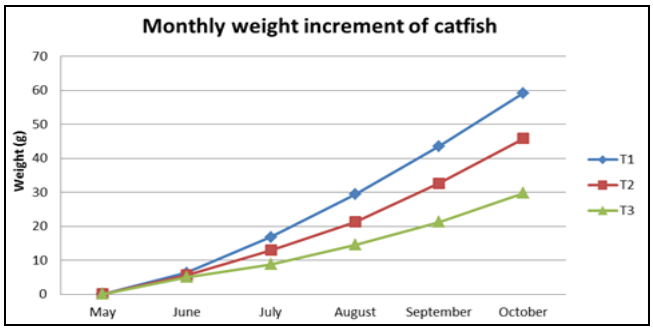

Fig 2: Monthly weight (g) increment of brackish water catfish (*M. gulio*)

Average daily weight gain of catfish was significantly (P<0.05) highest (0.39 g) in T1 than other treatments. Final weight of mullet was 43.6 g, 27.5 g and 15 g in T1, T2 and T3 respectively. This growth variation might be happened probably due to stocking density dependent interspecies interaction when fishes attained juvenile stages. Specific growth rate of catfish was significantly (P<0.05) highest (7.32 g) in T1 than other treatments in the current study which is similar with [22] and slightly higher than [24]. Survival of shrimp (64.9 %), prawn (65.5 %) and mullet (71.5 %) was highest in T2 whereas, survival of catfish (73.7%) was highest in T1 than other treatments. Survival of shrimp was lowest among all species due to bacterial disease. On the contrary, lower survival of prawn might be due to transportation stress. Survival (%) of catfish T1 and T2 was significantly highest than T3 (p>0.05) but no significant difference between T1 and T2. There are very few previous studies comparing the effects of *Mystus gulio* density on its growth and survival in polyculture system. In the present study, the total production of catfish was 955.2, 1352.1 and 1078.5 kg/ha in T1, T2 and T3 respectively. Begum *et al*. (2018) [22] reported that total production of catfish was 750.6, 895.8 and 756.42 kg/ha at T1, T2 and T3 respectively whereas, production of shrimp was 387.9, 357.9 and 334.8 kg/ha in T1, T2 and T3 respectively in polyculture of catfish with shrimp and prawn. Both production of catfish (313.7 kg/ha) and total production (1352.1 kg/ha) was significantly (P<0.05) highest in T2 than other treatments in the current study as well as in comparison with Begum *et al*. (2018) [22]. In this experiment, catfish showed higher survival with lower stocking density and production also showed density dependent augmentation.

Conclusion

From this experiment, it can be concluded that treatment T2 (1000 brackishwater catfish fries/ha) is the best stocking density for the polyculture of *M. gulio* with *P. monodon*, *M. rosenbergii* and *C. subviridis* due to higher total weight gain and better production. Findings of this study for polyculture of brackishwater catfish with shrimp, prawn and green back mullet might be the best recommendation for the coastal farmers of Bangladesh.

Acknowledgements

The authors would like to extend gratitude to Bangladesh Fisheries Research Institute (BFRI) for providing financial support for successfully completion of the research work.

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