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Impact of freshwater prawn and tilapia culture on benthos in periphyton facilitated ponds

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Abstract: An experiment was carried out to evaluate the effect of addition of tilapia on abundance of benthos in freshwater prawn (*Macrobrachium rosenbergii*) (de Man) culture system for a period of 120 days at Fisheries Field Laboratory Complex, Bangladesh Agricultural University, Mymensingh. A long pond (83×8.9 m) was drained completely and partitioned by galvanized iron sheet into 18 small ponds of 40 m^2 each, of which 6 ponds were used for this experiment. The experimental ponds were divided into 2 treatments each with 3 randomly selected ponds. The absence and presence (0 and 0.5 individual m^2) of tilapia were investigated in 40 m^2 ponds stocked with 3 prawn Juveniles (5±0.04 g) m-2 with added substrates for periphyton development. A locally formulated and prepared feed containing 30% protein was supplied considering the body weight of prawn only. Feeds were supplied twice daily and feeding rates were at a rate of 10% of body weight for 1^{st} month, 7% of the body weight for 2^{nd} month and 3% of the body weight for the rest of the culture period.. Benthic organisms had no significant difference (p>0.05) between the treatments.
Key words: Benthos, Freshwater prawn, Tilapia

Introduction

Freshwater prawn (*Macrobrachium rosenbergii*) play a vital role in the development of socio economic conditions of the country through increasing export trade, food production, creation of rural employment and proper utilization of natural resources (Rahman, 1994). These have created large scope of prawn farming in this country. In Bangladesh, freshwater prawn culture started as a commercial venture in the later part of 1980's (Karim, 1989). Freshwater prawn farming areas increased just from 2,200 hectare in 1991 to current estimated areas under culture of about 35,000-40,000 hectare (DoF, 2003). Currently, 0.04 million people are directly or indirectly involved in the freshwater prawn sub-sector, in which 75 thousand farmers are involved in gher system and around 30 thousand in pond system of freshwater prawn culture sector in Bangladesh (CARE, 2000).

The use of benthic organism and periphyton substrates in freshwater finfish and prawn production has been found promising (Van Dam et al., 2002). Substrates based system can increase freshwater prawn production to a significantly higher level when compared to traditional production system (Tidwell and Bratvold, 2005).Cohen et al. (1983) reported that added substrate in ponds increased prawn production by 14% and average size by 13%.

A lot of pieces of research have been conducted concerning the macrobenthic fauna in mangrove ecosystems (Chong *et al*., 2001). However, research concerning the benthic fauna inhabiting aquaculture ponds has rarely attracted attention except for commercial species; nevertheless benthic organisms play important roles in the maintenance of conditions for aquaculture and adjacent coastal ecosystems (Yoshimi *et al*., 2007). Adequate knowledge of trophic interactions among food webs within the aquaculture ponds, rates of detrital decomposition by benthos, estimates of secondary production including commercial species such as prawns and fishes is still lacking, despite the fact that such knowledge is necessary to properly assess the energetic role of benthos in aquaculture ecosystems. Considering the environment of artificial and/or semi-artificial aquaculture ecosystems to maintain sustainable production, it is of principal importance to understand and describe the species richness, abundance of each species and community structure of macrobenthic fauna inhabiting aquaculture ponds. As the first step for this study, we detail here the initial results on the biodiversity and community structure of macrobenthic fauna inhabiting aquaculture ponds by quantitative sampling in the Fisheries Field Laboratory Complex of the Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh. Therefore, freshwater prawn productivity can be enhanced through stimulation of suspended and attached bacteria and algae development, and by using them to improve water quality, provide additional food and improve nutrient efficiency. The aim of this study, therefore, was to estimate the abundance of benthic population of the experimental ponds both qualitatively and quantitatively and to determine the suitability of benthic organism as feed to popularize prawn and tilapia culture as homestead enterprises for rural people.

Materials and Methods

Study area and pond facilities: The experiment was conducted in 6 earthen ponds each of which was $40m^2$ in the Fisheries Field Laboratory Complex of the Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh, for a period of 120 days from 20 February to 20 June 2008. The ponds were rectangular in shape, well exposed to sun light, independent, and having water supply facilities. The water depth was maintained to a maximum of 1m over the study period. The surrounding of all ponds was covered by 1m height nylon net to prevent the entry of predators like snakes, frog and others.

Experimental design: The experimental design was CRD (completely randomised design). There were two treatments: treatments PT_0 and treatment $PT_{0.5}$, each treatment with three replications. The experimental design has been shown in Table below:

Properties of culture	Treatment (PT_O)	Treatment ($P\ T0_{.5}$)
Prawn	120 nos (3 juveniles m^{-2})	120 nos (3 juveniles m^{-2})
Tilapia	Nil	20 nos (0.5 fry m^{-2})
C/N ratio	20	20
Periphyton substrate Arrangement	Present	Present

Pond preparation: All undesirable fish were completely eradicated by applying rotenone at a rate of 2.5 gm^{-3}. Aquatic weeds were removed manually. The grasses of the pond dikes were also cut into small size by using scythe. Lime (CaO) was applied at a rate of 250 kg ha^{-1} after one week of rotenone application. Lime was dissolved in water in an earthen pot and then applied by spreading homogenously in the ponds. Ponds were fertilized with urea and triple super phosphate (TSP) each at a rate of 25 kg ha^{-1} and cow dung at a rate of 1000 kg ha^{-1} after three days of liming. TSP was applied after dissolving in plastic buckets for 10 to 12 hours before application. Fertilizers were applied by spreading methods.

The shelter was built by bamboo kanchi with date tree leaves. Shelter was installed in each pond before prawn juveniles stocking to provide shelter for prawn. About 436 bamboo (locally known as kanchi) with a mean diameter of 0.05 m were posted vertically into the bottom mud of each ponds, excluding a one meter wide perimeter water surface from the dike. This resulted in an additional area for periphyton development equaling about 60% (i.e.24 m^2) of the pond surface area. Ponds were not fertilized during the grow-out period. After the first fertilization before prawn stocking, the ponds were left 10 days to allow plankton development in water column and periphyton growth on bamboo kanchi.

Collection of prawn juveniles: The juvenilies of *Macrobrachium rosenbergii* (5±0.04g) were purchased from a nearby commercial hatchery.The fingerlings of tilapia *Oreochromis niloticus* (24.3±0.24g) were collected from Bangladesh Fisheries Research Institute (BFRI).

Stocking: Juveniles of *Macrobrachium rosenbergii* (5± 0.049) procured from a nearby commercial hatchery were stocked at 3 juveniles m^{-2}in the ponds and nursed juveniles of *Oreochromis niloticus* (24.3± 0.24g) were stocked according to the experimental design.

Feeding: Juvenile of freshwater prawn fed with processed palleted feed containing 30.03% crude protein daily at a rate of 10% of the body weight for 1st month 7% of the body weight for 2nd month and 3% of the body weight for rest of the cultured period. Half of the required feed for a day was supplied in the evening and rest half in the morning. Feed requirement were calculated and adjusted after sampling of prawn in a month. Locally purchased tapioca starch was used as carbohydrate source for manipulating the C/N ratio. In order to raise the C/N ratio to 20 in all the ponds, 0.9kg tapioca starch was applied for each kg of formulated feed.

The pre-weighed tapioca starch was mixed in a beaker with pond water and uniformly distributed over the pond's surface directly after the feed application at 7.00 am.

Collection of benthos: The benthic macroinvertebrate samples were collected monthly with an Ekman dredge (covering an area of lower month 225 cm^2). In each pond, bottom mud samples were collected from 3 different locations and washed through a 250μm mesh size sieve. Benthic macroinvertebrate remaining on the sieve was preserved in a plastic vial containing a 10% buffered formalin solution. Identification keys used for benthic macroinvertebrate were Brinhurst (1971) and Pinder and Reiss (1983). Benthic macroinvertebrate density was calculated using the formula: $N = Y \times 10000/3A$

Where, N=the number of benthic organisms (number m^{-2}); Y=total number of benthic organisms counted in 3 samples; A = area of Ekman dredge (cm^2).

Analysis of experimental growth data: Experimental data collected during the growth trial were used to determine the growth parameters as follows:

Weight gain (g): Weigh gain = Mean final prawn weight –Mean initial prawn weight

Percent weight gain (%): % weight gain =

$$\frac{\text{Mean final prawn weight} - \text{Mean initial prawn weight}}{\text{Mean initial weight}} \times 100$$

Average daily gain (g): ADG (g) =

$$\frac{\text{Mean final prawn weight} - \text{Mean initial prawn weight}}{T_2 - T_1}$$

Specific growth rate (% per day): SGR (% per day) =

$$\frac{\log_e W_2 - \log_e W_1}{T_2 - T_1} \times 100$$

Where, W_1 = Initial live prawn body weight (g) at time T_1(day), W_2 = Final live prawn body weight (g) at time T_2 (day).

Results and Discussion

Mean abundance of benthos with their different groups are shown in Table 1. Benthos population of the prawn ponds was composed of four major groups: Chironomidae, Oligochaeta, Mollusca and unidentified groups.

Table 1. Mean abundance ± SE ($\times 10^2$) of different groups of benthos of the ponds under two treatments each having three replicates. Values are means of 3 replicates and 5 sampling dates (N=15)

Benthos groups	Abundance, ($\times 10^2$, individuals m^{-2})	
	Treatment $PT_{0.5}$ (with Tilapia)	Treatment PT_0 (without Tilapia)
Chironomidae	8.35±1.19	9.80±1.80
Oligochaeta	0.69±0.12	0.90±0.17
Mollusca	1.66±0.33^b	3.16±0.43^a
Unidentified	0.87±0.29	0.82±0.15
Total	11.59±1.40	14.70±2.12

* Mean values with the different superscripts in rows are significantly different (P<0.05)

Chironomidae: Chironomidae was the most dominant benthic group. The mean abundance (X10^2 nos m^{-2}) was found to range from 3.11 to19.55 and 2.51 to 23.11 with the mean values of 8.35±1.19 and 9.80±1.80 for treatments $PT_{0.5}$ and PT_0 respectively. Danial (1972) found that Chironomidae was the most dominant groups of benthos in lake. There was no significant difference (*P> 0.05*) between treatments $PT_{0.5}$ and PT_0 when ANOVA was performed. Monthly variations in the abundance of Chironomidae among the treatments have been shown in Fig. 1.

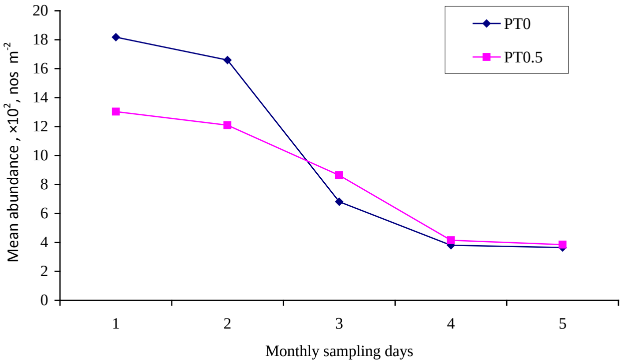

Fig 1. Monthly variation of abundance of chironomidae (benthos) in sediment of the ponds under different treatments

Oligochaeta: The mean abundance (X10^2, nos. m^{-2}) of Oligochaeta was found to range from 0.148 to 1.630 and 0 to 2.667 with the mean values of 0.69±0.12 and 0.90±0.17 for treatments $PT_{0.5}$ and PT_0, respectively. There was no significant difference (*P> 0.05*) between the treatments when ANOVA was performed. Monthly variations in the abundance of Oligochaeta among the treatments are shown in Fig. 2. Oligochaeta ranked the second dominant group of benthic fauna recorded during the study period. The mean abundance (× 10^2nos. m^{-2}) of Oligochaeta was found to range from 14.80 to 163 and 266.7 with the mean values of 0.69±0.12 and 0.90± 0.17 for treatments $PT_{0.5}$ and PT_0 respectively; Oligochaeta were abundantly recorded during the pre-monsoon months, but a decline was evident in colder months reported by Shamsi and Jafri (1994) which are similar to those of the present study.

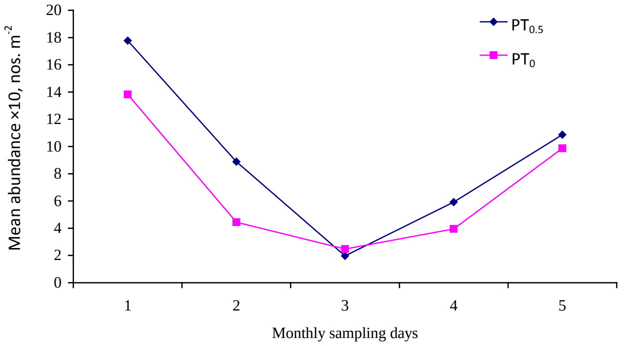

Fig 2. Monthly variation of abundance of Oligochaeta (benthos) in sediment of the ponds under different treatments

Mollusca: The mean abundance (×10^2, nos. m^{-2}) of Mollusca was found to range from 0.148 to 4.741 and 0.444 to 7.407 with the mean values of 1.66±0.33 and 3.16±0.43 for treatments of $PT_{0.5}$ and PT_0, respectively. There was significant difference (*P< 0.05*) between the treatments, when ANOVA was performed. Monthly variations in the abundance of Mollusca under the different treatments have been shown in Fig. 3. Mollusca and unidentified groups are the least abundant benthic groups recorded in the treatments $PT_{0.5}$ and PT_0. This is probably due to their inability to thrive in adverse environment conditions. These findings are more or less similar to the findings of Khan (1990) and Das and Islam (1983).

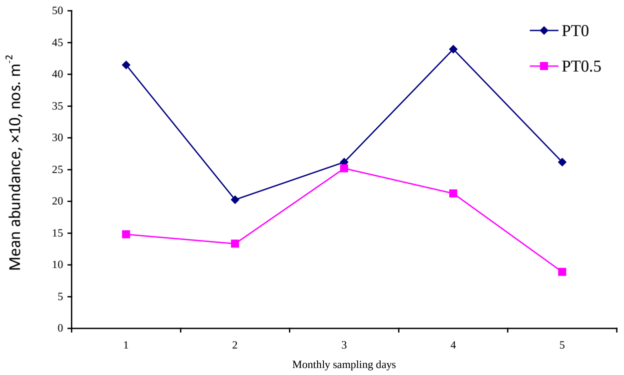

Fig 3. Monthly variation of abundance of mollusc (benthos) in sediment of the ponds under different treatments

Unidentified groups: The mean abundance (×10^2, nos. m^{-2}) of unidentified benthos was found to range from 0 to 3.852 and 0 to 192 with the mean values of 0.87±0.29 and 0.82±0.15 for treatments $PT_{0.5}$ and PT_0, respectively. There was no significant difference (*P> 0.05*) between the treatments when ANOVA was performed. Monthly variations in the abundance of unidentified groups under the different treatments have been shown in Fig. 4.

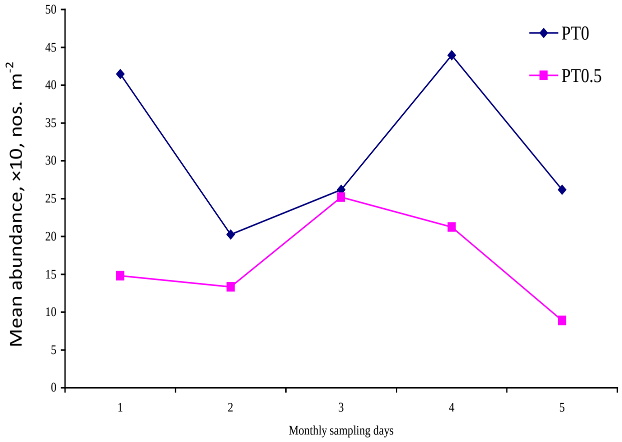

Fig 4. Monthly variation of abundance of unidentified benthos in sediment of the ponds under different treatments

Total Benthos: The mean abundance (×10^2, nos. m^{-2}) of total benthos was found to range from 4.444 to 24.00 and 0.681 to 34.815 with the mean values of 11.59±1.40 and

14.70±2.12 for treatments $PT_{0.5}$ and PT_0, respectively. There was no significant difference (*P> 0.05*) between the treatments when ANOVA was performed. Monthly variations in the abundance of total benthos under the different treatments have been shown in Fig. 5.

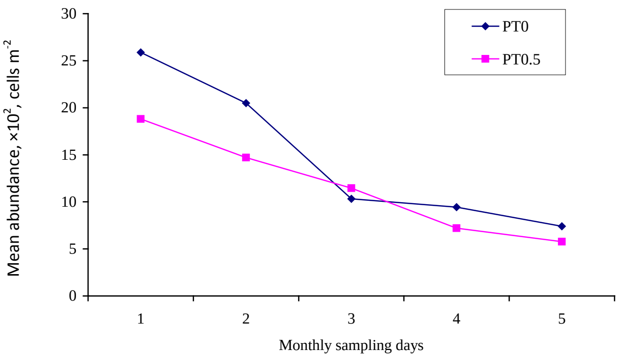

Fig 5. Monthly variation of abundance of total benthos in sediment of the ponds under different treatments

Growth and yield performance of freshwater prawn: The growth of freshwater prawn in different treatments was different. The different growth performance namely length (cm) and weight (g) gain, survival rate (%), percent weight gain and specific growth rate (% per day) and survival rate are shown in Table 2.

The mean initial weights (g) were 5.0 and 4.9 in treatments $PT_{0.5}$ and PT_0. There was no significant difference (P>0.05) in initial weights of prawn juveniles at stocking between different treatments. Final weight and weight gain was significantly higher (P<0.05) in treatment PT_0 than those in treatment $PT_{0.5}$. Specific growth rate was significantly higher in PT_0 than in $PT_{0.5}$. The addition of tilapia decreased the gross and net yield of prawn. Tilapia had significant effects on FCR of fresh water prawn, substrates decreased FCR by 13.5% whereas addition of tilapia increased 16% gross yield.

Table 2. Effects of addition of tilapia on growth and yield parameters of freshwater prawn

Variables	Treatments P $T_{0.5}$	Treatments P T_0	Significance (*P* Value)		
	(with tilapia)	(without tilapia)	P	T	P×T
Initial Stocking weight (g)	5.0	4.9	NS	NS	NS
Final harvesting weight (g)	35.2	37.2	NS	NS	NS
Final weight gain (g)	30.2	32.3	NS	NS	NS
SGR (% bw d^{-1})	1.63	1.68	*	NS	NS
Food conversion ratio	2.38[a]	2.05[b]	**	**	NS
Survival (%)	63.6	67.8	***	NS	NS
Gross yield (kg ha^{-1} 120 d^{-1})	668[b]	751[a]	***	**	*
Net yield (kg ha^{-1} 120 d^{-1})	519[b]	604[a]	***	**	*

P = periphyton substrates; T = tilapia addition; P×T = interaction of addition of periphyton substrates and tilapia. The mean values with different superscript letters indicate significant difference at * *P*<0.05; ** *P*<0.01; *** *P*<0.001; NS, not significant.

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