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Effects of periphyton grown on bamboo substrates on growth and production of Indian major carp, rohu (*Labeo rohita* Ham.)

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Abstract
The effects of periphyton, grown on bamboo substrates, on growth and production of Indian major carp, rohu, *Labeo rohita* (Hamilton), were studied in 10 ponds during July to October'95 at the Bangladesh Agricultural University, Mymensingh. Five ponds were provided with bamboo substrates (treatment I) and the rests without bamboo substrates (treatment II). It was revealed that there had been no discernible difference in the water quality parameters between treatments. A large number of plankton (30 genera) showed periphytic nature and colonized on the bamboo substrates. The growth and production of fish was significantly ($p<0.05$) higher in the ponds with bamboo substrates as compared to the ponds without substrates. The net production of rohu in treatment I was about 1.7 times higher than that of treatment II. Fish production was as much as 1899 kg/ha over a culture period of 4 months in the periphyton-based production system.

Key words : Periphyton, Bamboo Substrate, *Labeo rohita*

Introduction

Pond production systems in Bangladesh or elsewhere in the region are becoming increasingly reliant on external resources (feed, fertilizers) to supplement or stimulate autochthonous food production for pond fish. Moreover, most production systems, especially the more intensive types, are inefficient, only about 30% of nutrient inputs being converted into harvestable products, the remainder being lost to the sediments, effluent water and the atmosphere (Acosta-Nassar *et al.* 1994, Beverdge *et al.* 1994, Olah *et al.* 1994). Intensive pond production systems are also reliant on the environment at large to disperse and assimilate wastes (Beveridge & Phillips 1993).

An improved technique of fish culture based on the natural production could be a solution for the poorer country like Bangladesh. Periphyton-based fish culture may offer a new direction in this regards which deserves attention of the fisheries scientists. Periphyton is a preferable food materials for many fishes, especially Indian major carps, tilapia etc. If periphyton is grown on artificial substrates like bamboo poles, then these will be major food sources for fishes cultured in a pond. Fishes, whose feeding habit is sucking algae, diatom and other plankton, may easily graze on periphyton. Hem and Avit (1994) explored the possibility of increasing fish production through periphyton production enhancement in the Ivory Coast, Africa, and reported tilapia (*Sarotherodan melanotheron*) production of 8 metric tones/ha/ year when bamboo poles were "planted" vertically in the bottom of grow-out systems. This increased fish production was attributed to the bamboo providing a substrate for the growth of periphyton on which tilapia was observed to graze.

This technique has been tried to adapt in Bangladesh in collaboration with Northwest Fisheries Extension Project (NFEP) where bamboo mats called "chatai" were used for tilapia production. Tilapia (*Oreochromis niloticus*) production were 0.64 and 0.60 metric tones/ha in four months for ponds with and without bamboo mats, respectively, which were not statistically different (Faruk-ul-Islam 1996). Through an initial screening of the local species, rohu *Labeo rohita* (Ham.), has been considered as a suitable species for periphyton-based culture system. The importance of carp culture in Bangladesh and in the region and lack of easy and profitable means of culture system have driven the researchers to explore the potential of periphyton-based aquaculture with the indigenous fish species. With this idea in view, the present study has been designed to observe if increased production of rohu could be achieved using periphyton grown on bamboo substrates.

Materials and methods

Experimental design and pond preparation

This trial was conducted for a period of 4 months from July to October, 1995 at the Field Laboratory of the Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh. Ten earthen ponds with an area of 75 m^2 and an average depth of 1.5 m were used for this study. Ponds were rain-fed, well exposed to sunlight, and without any inlet or outlet. Two treatments were considered in this trial each with five replications. Among ten ponds, 5 were regarded as treatment I which were provided with bamboo poles as substrates and the rest 5 were treated as treatment II without substrates (control). Before starting the experiment, ponds were prepared following Dewan *et al.* (1991). Ponds were initially cleaned and treated with rotenone at the rate of 50 g/dec/feet water. After 5 days, lime was applied at the rate of 250 kg/ha and left for 5 days. About 1.5 meter long bamboo poles were inserted into the pond bottom vertically at a density of 9 poles per m^2. Then inorganic fertilizers (urea and TSP) were used at the rate of 200 and 100 g/dec, respectively. The ponds were left for 15 days to allow sufficient production of periphyton on the substrates.

Fish stocking and pond management

After sufficient growth of periphyton on the substrates, all ponds were stocked with same sized (average weight 9.96 g each) fingerlings of rohu, *Labeo rohita* (Ham.) at a density of $1/m^2$. During the entire experimental period, dilute urea and TSP were sprayed fortnightly at the rate of 400 and 500 g/dec, respectively.

Assessment of water quality, plankton and periphyton

Water quality measurements were made between 0900-1000 h on each sampling day. Water temperature (^{0}C), dissolved oxygen (mg/l) and pH were measured at the pond site. Chlorophyll-a (µg/l) were measured in the Water Quality and Pond Dynamics Laboratory, Faculty of Fisheries.

Water temperature was recorded using a Celsius thermometer. Dissolved oxygen was determined by a portable DO meter (YSI model 58), pH of water were determined with a pH meter (Jenway, model 3020). Chlorophyll-a was determined after filtering water sample through Whatman filter paper (46 cm) using a spectrophotometer (Milton Roy Spectronic, model 1001 plus).

To enumerate plankton population, 10 samples (5 liters of water in each sample) of water were collected from different areas and depths from each pond fortnightly and were filtered through a fine mesh (25 µ) phytoplankton net. Then the filtered samples were taken in a measuring cylinder carefully and made up to a standard volume of 100 ml with distilled water. Buffered formalin (5%) was added as a preservative and stored in small sealed plastic bottles until examination. Using a Sedgewick-Rafter cell, a 1 ml sub-sample was examined from each sample. All organisms present in 10 cells chosen at random were counted and identified following Bellinger (1992).

Periphyton samples from bamboo poles were taken by scraping with the help of blunt razor blades. Scrapings were kept in 1000 ml water and vigorously shaken. Then the samples were preserved in 5% formalin for future study. The periphyton concentrations were determined by a Sedgewick-Rafter cell (S-R cell) as done for phytoplankton. Identification of periphyton was also done according to Bellinger (1992).

Fish harvesting

Ponds were drained at the end of experiment and all fishes were harvested and measured in total length (cm) and weight (g). Total weight of fish per pond was also determined.

Statistical analysis

For statistical analyses of data, a one way ANOVA and *t*-test were applied using the statistical package, STATGRAPHICS Version 7 on a personal computer IPC.

Results

Water quality parameters

Water quality parameters of a large number of samples were analysed in this experiment to observe any appreciable changes that might have occurred in response to bamboo substrates. Physical parameters like temperature, transparency and chemical parameters such as pH and dissolved oxygen (DO) have been measured throughout the experiment. Water quality parameters are presented in Table 1.

Table 1. Mean (+ SD) of water quality parameters in two treatments

Water quality parameters	With substrates (T_1)	Without substrates (T_2)
Water temperature(^{0}C)	29.3 ± 0.18	29.7 ± 0.16
Transperancy (cm)	40.55 ± 3.10	35.96 ± 4.81
pH	6.0-9.0	6.9-9.2
Dissolved oxygen (mg/l)	7.11 ± 0.28	7.24 ± 0.74
Chlorophyll-a (mg/l)	76.0 ± 14.56	72.6 ± 11.30
Phytoplankton (units/l)	140,045± 3,235	140,825 ± 7,965
Zooplankton (units/l)	21,750 ±3,154	21,250 ± 1,455
Periphyton (units/cm^2)	27,754 ± 3,674	-

Water temperature varied a very little over the entire period. Mean values were 29.3 ± 0.18 and 29.7 ± 0.16^{0}C in treatment I and treatment II, respectively. Mean values of transparency of water in treatment I and treatment II were 40.55 ± 0.31 and 35.96 ± 4.81cm, respectively. pH of water was almost neutral. pH values varied from 6.0 to 9.0 in treatment I and from 6.9 to 9.2 in treatment II. Mean values of dissolved oxygen in treatment I and treatment II were 7.11 ± 0.28 and 7.24 ± 0.74, respectively. The mean values of chlorophyll-a of pond water under treatment I and treatment II were 76.00 ± 14.56 and 72.60 ± 11.30, respectively.

Plankton and periphyton

The mean (± SD) values of phytoplankton in treatments I and II were 140,045 ± 3,235 and 140,825 ± 7,965 units/l, respectively (Table 1). On the contrary, the mean (± SD) values of zooplankton were 21,750 ± 3,154 and 21,250 ± 1,455 in treatment I and treatment II, respectively. Planktonic organisms were mainly consisted of 5 groups of phytoplankton and 3 groups of zooplankton (Table 2). Some 32 genera of phytoplankton belonging to Bacillariophyceae (6), Chlorophyceae (17), Cyanophyceae (6), Euglenophyceae (2) and Rhodophyceae (1) were found. Eleven genera of zooplankton were also identified belonging to Cladocera (2), Copepoda (3) and Rotifera (6).

Table 2. List of plankton and periphyton community recorded from the experimental ponds

Groups	Plankton	Periphyton
Bacillariophyceae	*Cymbella*	*Cymbella*
	Diatoma	*Navicula*
	Mepsira	*Nitzschia*
	Nitzschia	*Melosira*
	Navicula	
	Tabellaria	
Chlorophyceae	*Actinastrum*	*Ankistrodesmus*
	Ankistrodesmus	*Botryococcus*
	Arthrodesmus	*Ceratium*
	Botryococcus	*Chlamydomonas*
	Characium	*Cladophora*
	Chlorella	*Closterium*
	Closterium	*Draparnaldia*
	Cosmarium	*Gloeocystis*
	Gloeocystis	*Gonatozygon*
	Gonatozygon	*Oedogonium*
	Oocystis	*Rhizoclonium*
	Pediastrum	*Stigeoclonium*
	Scenedesmus	*Ulothrix*
	Spirogyra	*Volvox*
	Spirulina	
	Ulothrix	
	Volvox	

Cyanophyceae	*Anabaena* *Aphanocapsa* *Chrococcus* *Merismopedia* *Microcystis* *Oscilatoria*	*Anabaena* *Aphanizomenon* *Oscilatoria* *Nodularia*
Euglenophyceae	*Euglena* *Phacus*	*Euglena* *Phacus*
Rhodophyceae	*Audouinella*	*Audouinella*
Rotifera	*Asplanchna* *Brachionus* *Filina* *Hexarthra* *Keratella* *Polyarthra*	*Brachionus* *Filnia* *Keratella*
Copepoda	*Cyclops* *Diaptomus* Nauplius	*Cyclops*
Cladocera	*Daphnia* *Diaphanosoma*	*Diaptomus*

Periphyton organisms were mainly consisted of 5 groups of phytoplankton and 3 groups of zooplankton. Thirty genera of periphyton under 5 groups of phytoplankton belonging to Bacillariophyceae (4), Chlorophyceae (14), Cyanophyceae (4), Euglenophyceae (2) and Rhodophyceae (1). Five genera of zooplankton were also identified belonging to Cladocera (1), Copepoda (1) and Rotifera (3) (Table 2). The mean values of periphyton concentration under treatment I were 27,754 ± 3,674 cells/cm^2 (Table 1). The trends of periphyton grown on bamboo substrates on fortnightly basis are shown in Fig. 1.

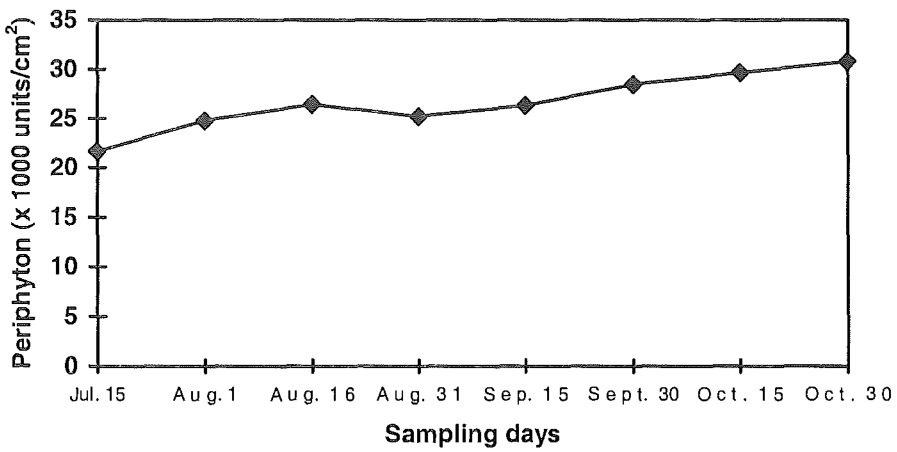

Fig. 1. Fortnightly concentration of periphyton in the ponds with bamboo substrates.

Survival and production of fish

Based on numbers harvested by the end of the experiment, fish survival rates were 85.60 and 76.26% in treatment I and treatment II, respectively (Table 3). The survivorship of rohu was significantly ($p<0.05$) higher in treatment I with bamboo substrates than treatment II. The average weight gain per fish was 222.53 g in treatment I and 143.27 g in treatment II. When compared using a *t*-test there was a significantly higher ($p<0.05$) average gain in weight per fish in treatment I. The net production of fish under treatment I and treatment II were 1,898.88 and 1,089.30 kg/ha, respectively. As much as 1.7 times higher production of fish was obtained from the ponds having bamboo substrates for growing of periphyton.

Discussion

All water quality parameters were within the limits suitable for fish production. Variations of some parameters in different ponds in some occasions were apparent, but there was no discernible changes in any parameter. During the study, mean temperatures were 29.3 ± 0.18 and 29.7 ± 0.16^{O}C in treatment I and treatment II, respectively. The highest and lowest temperatures were recorded in July and October 1995, respectively. Dewan *et al.* (1991) recorded similar temperatures in the BAU fish ponds. The transparency of a water body normally indicates its productivity. It is usually affected by several factors such as silting, microscopic organisms, suspended organic matter, latitude, the season, and the intensity of sunlight (Reid 1964). In the present study, the highest and lowest transparencies were recorded in the month of July and October'95, respectively. pH values were in alkaline range in all the ponds which indicated good pH conditions for biological production. According to Boyd (1992), suitable pH range for fish pond should be 6.5 to 7.5. The mean values of dissolved oxygen were 7.11 ± 0.28 and 7.24 ± 0.74 mg/l in treatment I and treatment II, respectively. These ranges of DO are indicative of good ponds at the standard set out by Boyd (1992).

Table 3. Average yield parameters of rohu in different treatments

Treatment/	With substrate (T_1)					Without substrate (T_2)					Mean*	
Pond	3	5	6	8	9	1	2	4	7	10	T_1	T_2
Stocking density/pond	75	75	75	75	75	75	75	75	75	75	75^a	75^a
Average initial weight (g)	9.96	9.96	9.96	9.96	9.96	9.96	9.96	9.96	9.96	9.96	9.96^a	9.96^a
Density at harvest	62	65	66	64	63	58	55	56	59	57	64^a	57^a
% Survival	83	87	88	85	84	77	73	75	79	76	85	76

Average final weight (g)	244.5	244.2	167.3	213.7	192.5	142.4	155.1	136.4	113.7	209.3	232.45	153.23
Weight gain/fish (g)	234.6	234.2	257.4	203.8	182.5	132.5	145.2	126.4	103.7	199.4	222.53	143.27
Net yield (kg/ha)	1938.6	2030.0	2265.1	1739.2	1533.2	1024.5	1064.7	944.2	816.3	1515.5	1898.88	1089.30

** Figures in the same column having the different superscripts are significantly different (p<0.0.5) from each other.*

Plankton population indicates the productive status of a waterbody, because these are the direct and basic source of food for most of the animals in aquatic habitat. Phytoplankton belonging to 5 families, including Bacillariophyceae, Chlorophyceae, Cyanophyceae, Euglenophyceae and Rhodophyceae were found. Phytoplankton composition was represented by the usual nature of plankton in tropical fish ponds as reported by Mollah and Haque (1978), Dewan *et al.* (1991), and Wahab and Ahmed (1992). Both Bacillariophyceae and Chlorophyceae were represented by the higher number and this might have a positive bearing on the higher survival of fish in general.

Thirty genera of periphyton community were identified from which 25 genera were phytoplankton and 5 genera were zooplankton. Most dominant genera were *Stigeoclonium, Gonatozygon, Cladophora, Rhizoclonium, Botryococcus, Closterium, Nitzschia* and *Volvox*. These large number of periphyton have colonized on the bamboo substrates. Eminson and Phillips (1978) and Cattaneo (1987) stated that the hard substrates such as bamboo poles were the most suitable substrates for periphyton growth.

In this trial, fish were regularly observed grazing on the periphyton grown on the surface of the bamboo substrates in the treatment ponds. It is hypothesized that the periphyton grown on the bamboo surface was a readily available feed which might have enhanced the growth and production rate of *Labeo rohita* in the treatment ponds compared to that of the control ponds. This has been reflected in the higher gain in weight of fish in the ponds having bamboo substrates.

The survival rate of rohu was higher in treatment I than that of treatment II. Possibly this was due to the fact that periphyton grown on bamboo substrates have influenced the better survival of stocked fishes by providing protection from fish eating birds. The average weight gain of rohu was found to be significantly higher (P<0.05) in the ponds where bamboo substrates were introduced. This may be due to the availability of rich food, periphyton grown on substrates for which fish require less energy to graze on. It is a fact that in normal grow out system, fish spend lot of energy in search of - and filtering of food organisms.

The average net production in treatment I (with bamboo poles) was 18,998.88 kg/ha/120 days and in treatment II (without bamboo poles) was 1,089.30 kg/ha/120 days. It was found that fish production of treatment I was 1.7 times higher than that of treatment II. Enclosed acadja systems, with no external feed inputs, only capitalize on periphyton were reported to yield 8 MT per ha per year (Hem and Avit 1994).

This production of fish from the periphyton-based aquaculture is higher than that of country's average production from the polyculture system which is 10,000 kg/ha (Gupta, pers.com.). Therefore, periphyton based fish production technology offers a tremendous potential for a resource constraint country like Bangladesh.

Finally, it may be concluded that a locally available substrates found all over the country and in this region like bamboos can increase production of rohu (*Labeo rohita* Ham.) in the fish ponds. There may be other sources of cheap and locally available substrates which may be of worth looking in future. However, an economic evaluation of this new culture system is pre-requisite to develop a sustainable periphyton-based aquaculture technology for the rural people.

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