Oysters improve growth of fish in an integrated aquaculture system in a tropical estuary

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Aquaculture generates large amounts of wastes in the form of uneaten food, faeces, and excretory metabohts. Increased environmental concern about the rapid expansion of aquaculture systems has resulted in integrated techniques where more than one species are cultured simultaneously, as a means of using the waste. The main concept of integrated systems such as Integrated Multi- trophic Aquaculture (IMTA) is to convert the soluble and solid waste products of the main culture organism (fish or shrimp) into additional valuable products thereby reducing environmental impacts and increasing the sustainability of the farming operation.

If waste material from fish culture is being broken down into finer particles, suspension feeding molluscs may be suitable for absorbing the organic particulate wastes. A bioremediative approach, utilizing lower trophic levels as nutrient recyclers, could reduce waste products and sedimentation, diversify products, and provide economic gains for growers.

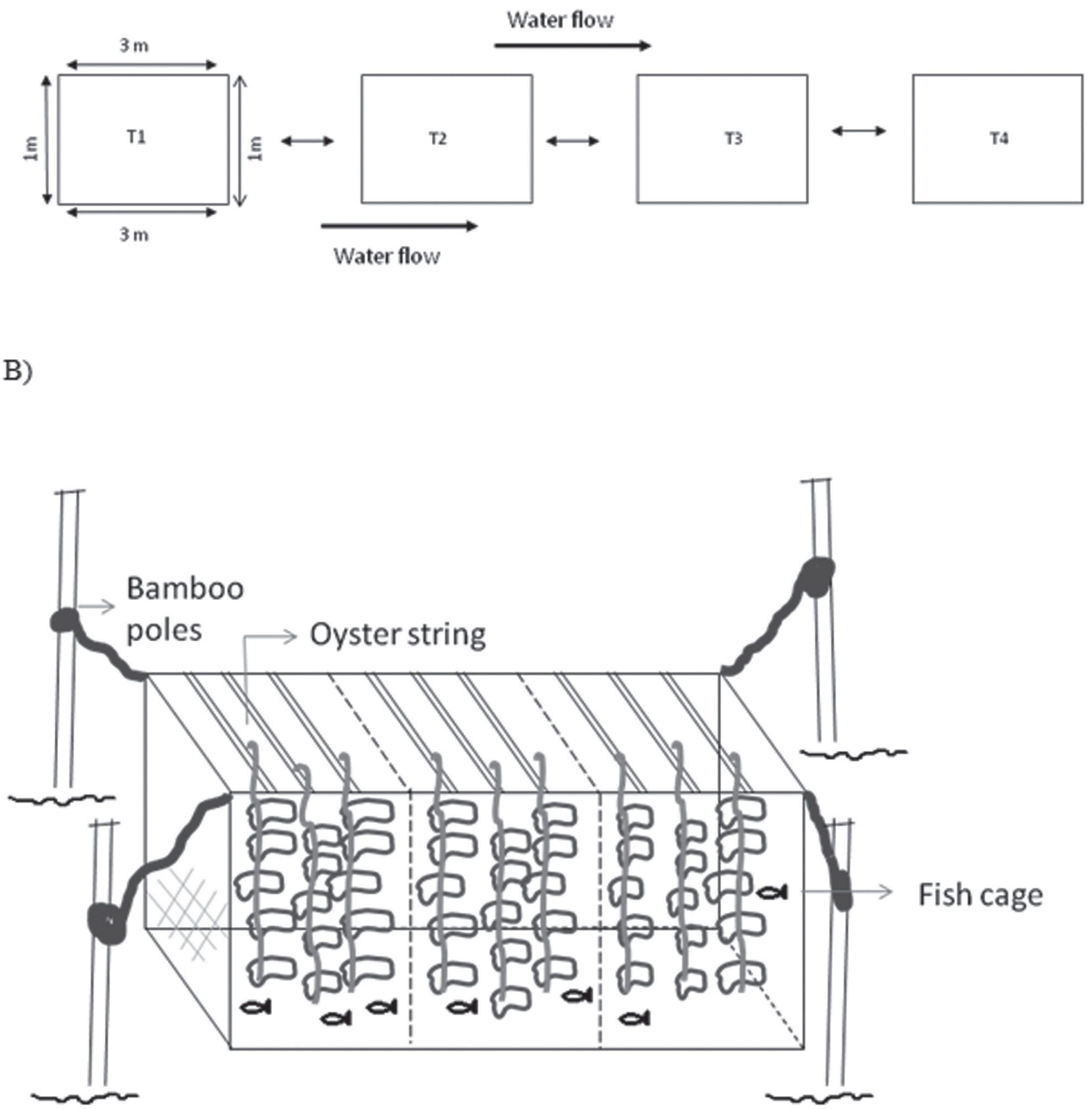

Fig. 1. Experimental setup. A) Schematic lay-out of the system B) Schematic layout of a single cage

Cycling of nutrients in estuaries may be controlled in large part by filter feeding bivalves. Bivalves feed selectively, so that certain particles are ingested and digested while others are rejected as pseudofaeces. Such selective feeding could affect the nutrient (nitrogen and phosphorous) removal, enhance water clarity and thereby increase the growth of the fishes cultured in the system. Here we report, in brief, the results of a study which focuses on the role of oysters in improving the growth of fishes in an integrated aquaculture system in a tropical estuary of Kerala.

The field work was carried out in Azhikode estuary at Moothakunnam ($10^{0}11'$ N and $76^{0}11'$ E), Ernakulam District. The experimental setup consisted of four cages (T1, T2, T3 and T4) which were laid in the direction of the current and the distance between cages being 50 m (Fig.1). Each treatment was made in triplicate. The area of the cage was 1 m^2 and the depth was 1 m. The organisms chosen for culture were the pearl spot, *Etroplus suratensis* and the Indian backwater oyster, *Crassostrea madrasensis*. The four cages differed in the stocking density of the organisms cultured. Keeping the quantity of the fish steady (100 per cage of 3-5 g fish), the oyster stocking biomass was 1:0.3 (T1), 1:0.5 (T2) and 1:0.7 (T3). The control (1:0; T4) did not have any oyster. Fish were fed daily with pelleted feed at the rate of 80-100% of the body weight initially and 5-8% during the last phase of culture. The culture period lasted for 270 days.

Samples were taken on a monthly basis from February to November 2012. During the study period temperature, pH, salinity and DO were measured. The nutrient parameters measured in the samples included ammonia, nitrite, nitrate (dissolved inorganic nitrogen, DIN) and orthophosphate (dissolved inorganic phosphorus, DIP). Samples of fish and oysters were collected monthly to obtain the length-weight data.

Water Quality

Temperature, pH and salinity did not show any variation between the four treatments. The temperature at the culture site during the study period ranged from 27.7^{0}C in August to 32^{0}C in November The pH ranged from 7.5-7.8 during the study period and the salinity ranged from 0.15 ppt in August to 30 ppt in May.

The DO measured during the culture period varied between the four treatments. Among the four treatments, higher value for DO was observed in T2 (9.36 ± 0.41ppm) and lower value in T4 (5.39 ± 0.7 ppm). Higher value in T2 could be attributed to the optimum stocking density of oysters whose filtration capacity reduces the turbidity thereby increasing the light penetration and thus the levels of DO. The absence of oysters in T4 causes excess heat adsorption due to the presence of concentrated sediments and thus reduce oxygen levels.

Nutrients

Nutrients are important parameters in the estuaries influencing growth, reproduction and metabolic activities of biotic components. Phytoplankton are filtered from the water column by the oysters and after ingestion and digestion these nutrients are available to support the oyster's metabolism and growth. Nutrients like nitrogen, and to a lesser amount phosphorus, in the form of dissolved inorganic nitrogen and phosphorus (DIN and DIP) are required to synthesize proteins used to build tissue as the oyster grows. The nutrients, ammonia [NH_3], nitrite [NO_2^-] and nitrate [NO_3^-] constitute the dissolved inorganic nitrogen (DIN) while dissolved inorganic phosphorus is constituted by orthophosphate [PO_4^{3-}].

The four treatments showed variation in the ammonia content (Fig. 2). Among the four treatments, T2 was characterized by lower values of ammonia (0.04± 0.01 ppm) and higher values (0.13 ± 0.03 ppm) by T4. The presence of filter-feeding oysters in T2 stimulates the bacterial process of nitrification and denitrification, helping the escape of nitrogen gas, thus lowering the ammonia content in water. The nitrite and nitrate values did not show any variation between the treatments. Nitrite and nitrate values ranged from 0.002 to 0.009 ppm and 0.003 to 0.10 ppm

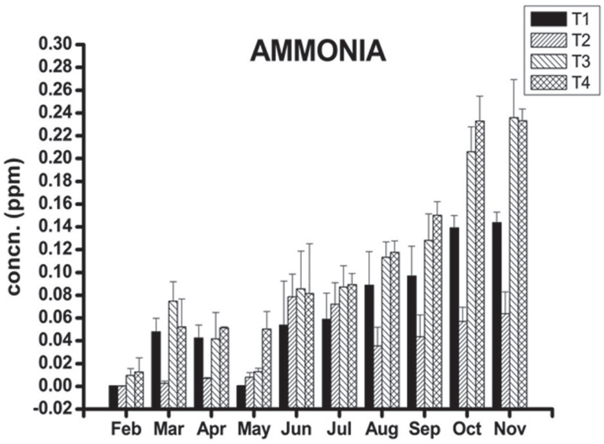

Fig. 2. Monthly variation in ammonia during 2012 for the treatments 1,2,3,4

respectively. Treatments 1, 2 and 3 were found to be similar in orthophosphate content (Fig. 3) with T2 exhibiting higher levels (0.05 ± 0.01ppm) and T4 showing lower levels (0.03 ± 0.01ppm). The removal of phytoplankton by oyster filtration in treatments 1, 2 and 3 prevents the assimilation of orthophosphate by the phytoplankton and thus increased level of the nutrient.

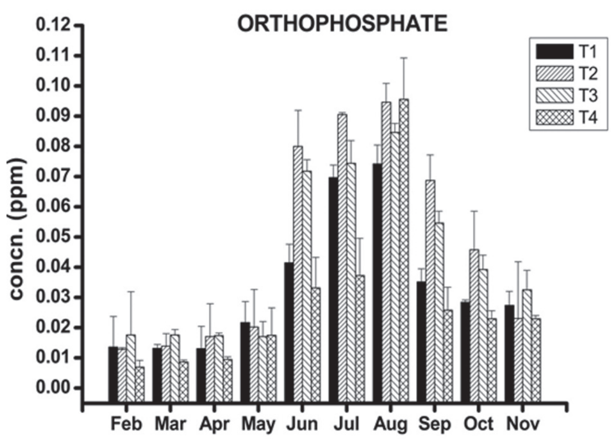

Fig. 3. Monthly variation in orthophosphate during 2012 for the treatments 1,2,3,4

Growth of fish and oysters

The organisms were harvested at the end of the culture period (Fig. 4, 5, 6). Highest mean length (12.95 ± 0.36 cm) and mean weight (69.62 ± 6.70 gm) of fish were obtained from T2. The specific growth rate in terms of fish weight in T2 was 1.38% which was higher than the other treatments. Data collected on shell length and width of oysters showed that T2 recorded the highest value of 92.11 ± 2.94 mm and 51.39 ± 1.61mm respectively (Table 1).

Fig. 4. Harvest of fish and oysters at the end of the culture period

Fig. 5. Harvested fish

Fig. 6. Harvest of oysters at the end of the culture period

Summary and conclusions

The results shows that the treatments 1, 2 and 3 outperformed T4 regarding the various water quality parameters and growth of fish and oysters. The

Table 1. Biological parameters of fish and oysters at the end of the culture period

Treatments	Fish			Oyster		
	Length (cm)	Weight (gm)	SGR_w (%)	Length (mm)	Width(mm)	SGR_l(%)
T1	12.19 ± 0.34	59.14 ± 4.57	1.32	72.73 ± 2.72	49.68 ± 1.72	0.25
T2	12.95 ± 0.36	69.62 ± 6.70	1.38	92.11 ± 2.94	51.39 ± 1.61	0.29
T3	11.75 ± 0.32	54.14 ±5.21	1.24	68.14 ± 1.50	48.91 ± 1.37	0.24
T4	11.74 ± 0.30	50.77 ± 6.21	1.20	_	_	_

*SGR_w- specific growth rate of fish in terms of weight

*SGR_l - specific growth rate of oysters in terms of shell length

better results in T2 could be attributed to the reason that fish and oysters in the ratio of 1:0.5 by weight is the optimum stocking rate in an integrated aquaculture using fish and oysters in a tropical estuarine system.

In summary, the present study has shown that oyster culture has a significant impact in connecting water column processes where nutrients are central to the production of single cell plankton upon which oysters feed. The filter-feeding oysters process the DIN and DIP pool, to help attain water quality improvements and thereby improve the growth of fish.