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Periphyton-based tilapia-prawn polyculture

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New dimension in aquaculture may support organic status

Bamboo poles from local sources provided plenty of substrate material for the experiments.

The term periphyton refers to the entire complex of aquatic biota attached to and associated with submerged substrates. The principle of periphyton-based aquaculture, derived from traditional brush-park fisheries, is to provide substrates on which bacteria, protozoa, fungi, phytoplankton, zooplankton, benthic organisms, and a range of other invertebrates colonize.

These organisms supplement artificial feed. The hard substrates also act as shelter and minimize the territorial effects of cultured animals. Nitrifying bacteria can colonize the substrates in a well-oxygenated water column and improve water quality through higher rates of nitrification.

In recent years, the concept of periphyton-based aquaculture has been tested and applied with varied degrees of dependence on periphyton as food or substrates as shelter for cultured animals. For finfish, the reported increases in production due to substrates have ranged 30-115 percent in Indian major carp monoculture and 30-210 percent in carp polyculture, depending on the amounts and types of substrates used, cultured species, nature of ponds, feeding and fertilization practices, and other management aspects.

Tilapia, prawns in periphyton polyculture

Recently, there has been significant interest in the polyculture of freshwater prawns (*Macrobrachium rosenbergii)* with finfish, especially Nile tilapia (*Oreochromis niloticus)*. Interest in freshwater prawn culture has increased because of environmental controversy and disease outbreaks related to penaeid shrimp farming.

Tilapias are important aquaculture species due to their ease of farming, favorable product characteristics, and wide acceptance by both rich and poor consumers. Tilapia can be raised in systems that range from back-yard ditches relying on natural foods to intensive recirculation systems depending on complete formulated diets. The fish are highly opportunistic eaters, and this is one of the reasons for their success both in the wild and in culture. They are known to graze on periphyton, as well.

The authors' preliminary research findings indicated that production of these two species in substrate-based ponds is higher than in ponds without substrates in monoculture systems, but there was a need to further fine-tune their polyculture in periphyton-based systems. The authors therefore carried out studies in small farmers' ponds. The research was done as a doctorate project funded by the United Kingdom Department for International Development (Fisheries Training and Extension Project, Phase 2), the Bangladesh Department of Fisheries, European Community, and the Wageningen University and Research Centre in the Netherlands.

Research trials

Experimental ponds provided harvests of both tilapia and freshwater prawns.

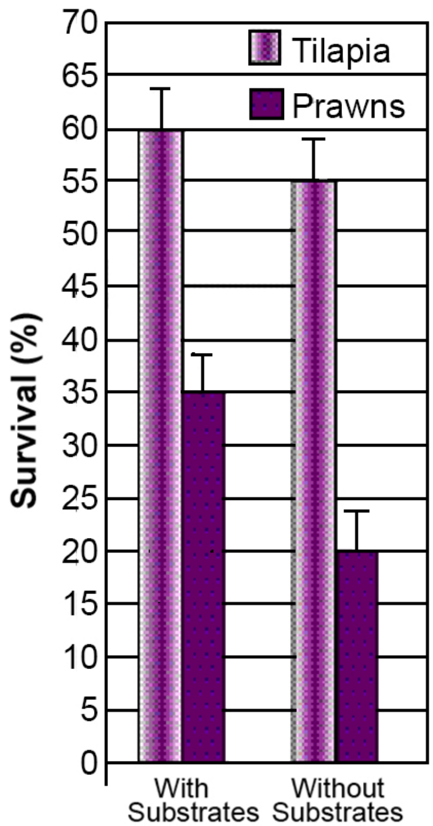
Four experiments were completed at the Bangladesh Agricultural University in Mymensingh, Bangladesh, or in nearby villages. Bamboo poles were used as substrate for periphyton development based on their performance and availability in this region. The poles were inserted vertically into pond bottoms, providing a submerged surface area of approximately 60 percent of the pond's water surface area.

The experiments were carried out in ponds with or without substrates. Both monoculture of tilapia stocked at 20,000 juveniles/ha and polyculture with 20,000 tilapia plus 20,000 prawn postlarvae/ha were studied. The tilapia and prawns were fed a 25 percent-protein feed at 2 percent body weight/day. The ponds were fertilized with urea and triple phosphate.

The effects of substrates on both tilapia and prawn production, as well as prawn addition on tilapia production were investigated. Also, the optimum stocking ratio and density of these two species were determined. Finally, using the best stocking ratio and density, the effects of periphyton substrate and supplemental feed were compared.

Effects of substrates, culture strategy

Substrate addition resulted in 5 percent higher tilapia survival and 45 percent higher tilapia production, while prawn survival increased from 20 percent to 35 percent, and production rose 127 percent (Figs. 1 and 2). However, neither survival nor production of tilapia was affected due to the addition of prawns to tilapia ponds, indicating the feasibility of mixed culture of these two species. The highest total yield of 2,445 kg/ha tilapia and 141 kg/ha prawns over a 145-day culture period was recorded in substrate-based polyculture ponds.



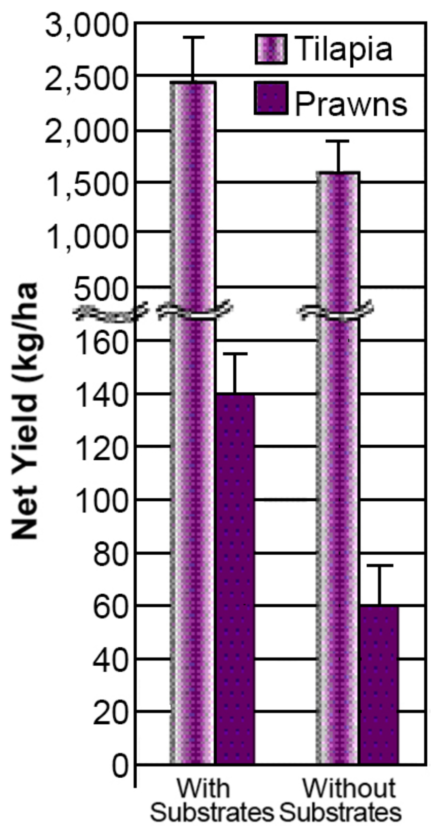


Fig. 1: Survival of tilapia and prawns in ponds with and without periphyton substrates. Fig. 2: Net production of tilapia and prawns after 145 days in ponds with and without periphyton substrates.

The authors also checked whether there were significant dietary competitions for natural food between tilapia and prawns by gut content analysis. Since both species were found to strongly prefer phytoplankton above zooplankton, there was considerable overlap in their food preferences.

Stocking ratio, density

With a total stocking density fixed at 20,000 animals/ha, five stocking ratios were tried in fed and fertilized ponds with substrates: 100 percent tilapia, 75 percent tilapia with 25 percent prawns, 50 percent tilapia with 50 percent prawns, 25 percent tilapia with 75 percent prawns, and 100 percent prawns. The highest production – 1,623 kg tilapia/ha and 30 kg prawns/ha in four months – and net return of 53,000 Bangladesh taka ($765)/ha were recorded at a stocking ratio of 75 percent tilapia and 25 percent prawns (Fig. 3), indicating that polyculture of these species is possible only when tilapia are considered the main species. However, since the market price of prawns is many times higher than that of tilapia, even a small production of prawns contributes significantly to the overall economics.

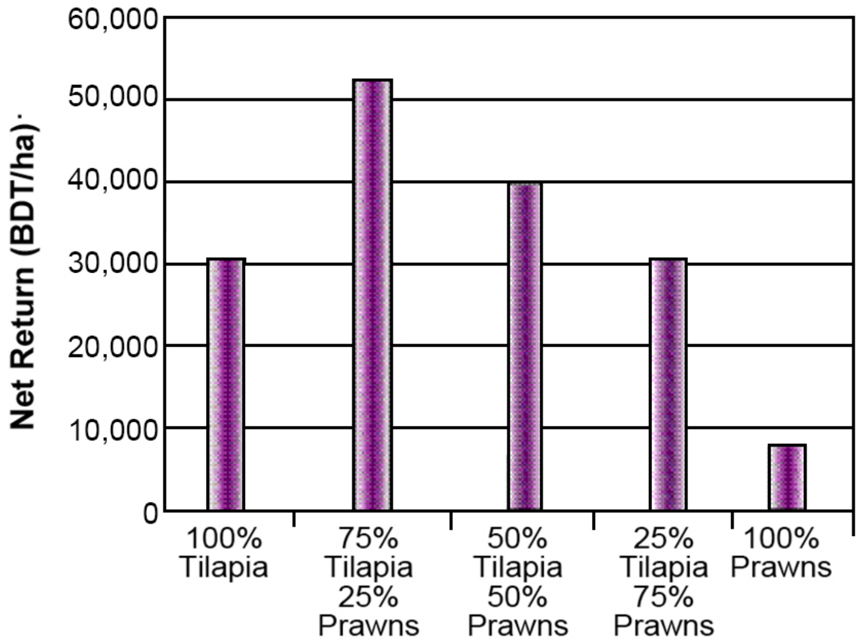


Figure 3. Net returns after 120 days from different stocking ratios of tilapia and prawns in periphyton-based systems. BDT = Bangladeshi taka.

A further experiment was carried out to optimize the total stocking density using the 75 percent tilapia:25 percent prawn stocking ratio. When stocking densities of 20,000; 30,000; and 40,000 animals/ha were compared, the authors concluded that a density of 30,000/ha was the best for periphyton-based systems, although the higher density provided rather similar results. With a 3:1 ratio of tilapia and prawns, this density of 30,000/ha resulted in net production of 2,209 kg tilapia and 163 kg prawns/ha during a 105-day culture period (Fig. 4). The net return was 78,000 taka ($1,126) in this combination.

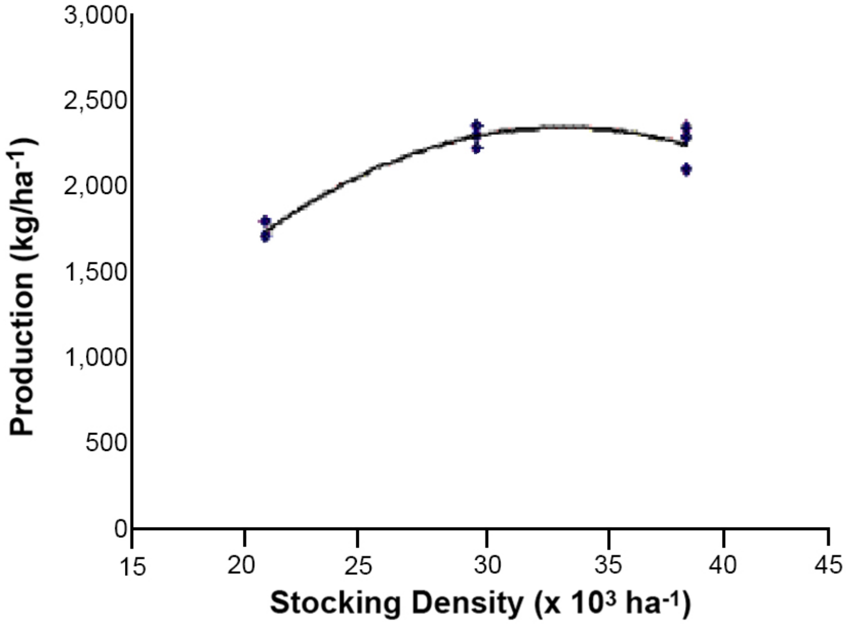


Fig. 4: Net total production of tilapia and prawns at different stocking densities in periphyton-based systems.

Feed complement or replacement?

Experimental ponds were clearly identified at Bangladesh Agricultural University.

Using the best stocking ratio and density values, several combinations of periphyton substrates and supplemental feed addition were tested in farmers' ponds: substrate plus feed (treatment SF), substrate plus no feed (SF_O), feed plus no substrate (S_OF), and no feed and no substrate (control).

There were no significant differences for survival, harvest weight, and net yield of both tilapia and prawns between the periphyton- and feed-driven systems (Table 1), indicating that periphyton can replace supplemental feeding. However, supplemental feed further increased tilapia production by 28 percent and prawn production by 61 percent in ponds with substrates, indicating the complementary nature of periphyton and supplemental feed in earthen ponds.

Uddin, Yield parameters of tilapia and prawns, Table 1No Substrate

Yield Parameters	Treatment Substrate Plus Feed	Treatment Feed Only	Treatment Substrate Only	Treatment No Feed, No Substrate
Tilapia				
Survival (%)	76.00 ± 2.00	68.00 ± 3.00	66.00 ± 4.00	54.00 ± 4.00
Feed-conversion ratio	1.23 ± 0.02	1.39 ± 0.06	–	–
Harvest weight (g)	120.00 ± 6.02	109.00 ± 7.00	108.00 ± 5.00	74.00 ± 10.00
Net yield (kg/ha)	1,940.00 ± 95.00	1,594.00 ± 171.00	1,517.00 ± 109.00	829.00 ± 62.00
Prawns				
Survival (%)	58.00 ± 7.00	43.00 ± 2.00	52.00 ± 8.00	32.00 ± 4.00
Harvest weight (g)	38.00 ± 5.00	26.00 ± 5.00	28.00 ± 6.00	16.00 ± 2.00
Net yield (kg/ha)	153.00 ± 28.00	73.00 ± 12.00	95.00 ± 23.00	32.00 ± 8.00

Table 1. Yield parameters of tilapia and prawns among treatments.

As the experiment was conducted in rain-fed seasonal ponds, farmers had to sell before the ponds dried out when prices were low. Nevertheless, net margins were 55,700 taka ($804)/ha in SF ponds; 41,500 taka ($599)/ha in S_OF ponds; and 51,000 taka ($736)/ha in SF_O.

Interestingly, although the contribution of prawns to the total production volume was only 4-7 percent, they contributed 22-32 percent of the total sales value. Therefore, even at low density, freshwater prawns contribute an important fraction of farming revenue in tilapia-prawn periphyton-based ponds.

Organic options

There are growing consumer perceptions, especially in the developed world, that organically produced food products are safer and healthier for people and the environment. However, one of the main difficulties with organic aquaculture is that fish feeds must be organic in origin. This strongly limits the use of the main sources of protein used in conventional aquaculture feeds and increases the cost of feeds produced organically.

On the other hand, organic standards encourage the use of food sources of biological origin not suitable for human consumption. Periphytic communities are one such food source that fits the criteria for responsible and organic aquaculture. Periphyton-based production may open opportunities to produce and promote organic products in export and domestic markets, while also providing opportunities for small-scale farmers.

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