Fish Farm Technology. 1- Brackishwater Fish Culture Based on 'Aquafeed'

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A method has been evolved to enhance the production of natural feed in brackishwater fish farms by providing substrates for biogrowth ('aquafeed' production) which is a biomass complex consisting of sedentary and associated organisms of plant and animal species. The seasonal fluctuations of the aquafeed production over different substrates ranged as: 787-1830 g/coconut leaf (6 m^2)/45 days, 16.0–072.9 g/glass panel (2 x 10 x 10 cm^2)/30 days, 52–230 g/nylon mat (2 x 25 x 25 cm^2)/30 days and 18.6–123.1 g/wooden block (6 x 10 x 10 cm^2)/30 days. The average dry weight composition of the major components of aquafeed obtained in the present study was sand-silt-clay 40%, protein 22%, carbohydrate (water soluble) 1.8% and fat 3.35% (water content 85%). *Mugil cephalus* of 1.85 cm reared in a 0.01 ha. pond and fed on aquafeed attained a size of 23 cm length and 146.73 g weight during one year. Survival rate was 54% at a density of 10000/ha. Salinity and temperature of the pond during the culture period ranged between 1.4 and 32.8‰ and 28.1 and 36.5 °C respectively.

In intensive fish culture, effective and economical feeding of culture organisms is a major problem; aquaculturists and fish farmers are still depending on the traditional method of adding fertilizers and supplementary feed to the habitats (Ball, 1949; Tang & Chen, 1957; Prowse, 1962; Bhimachar & Tripathi, 1966; Lin, 1968; Dajajadiredja & Poernomo, 1972; Hickling, 1971 and Banerjee *et al.*, 1973).

However, in the case of estuarine and brackishwater habitats where tidal range is high and frequent replenishment of pond water takes place, adding of fertilizers is largely a waste. Further, use of supplementary feed is not economical. Under these circumstances the present work aims to develop a cheap and viable method for the large scale commercial culture of fishes and prawns. Through different sets of experiments, efforts were made to develop a devise to promote a luxurient growth of both plants and animals in the water by providing submerged substrates. These artificial substrates promoted the settlement, growth and multiplication of primary as well as secondary produces which served as the basic links in the trophic pyramid converting the nutrients into organic matter which in turn formed an excellent source of food for fish and prawn. The organic mass thus produced, which is a combination of microscopic and truly sedentary to simple associate organisms of plant and animal species, is designated here as 'aquafeed' since it is voraciously nibbled and consumed by several species of fishes and prawns.

Material and Methods

In order to study the quantity of aquafeed production over submerged substrates and its utilization as fishfeed, the following experiments were conducted. Two ponds, each of 0.01 hectare were prepared adjacent to the Kayamkulam Lake with direct connection with the main lake so as to effect the maximum exchange of pondwater through tidal action. The Kayamkulam Lake is situated in Central Kerala at 9°8′ lat. and 76°31′ long on the south-west coast of India and is connected to the Arabian Sea on the west by a narrow gut. The depth of these ponds ranged from 0.8 to 1.5 m during different seasons. The water passages to these ponds were guarded by asbestos pipes of 15 cm diameter fitted with copper plates

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having holes of 4 mm diameter. Pests and predators were then eliminated by applying 0.5 kg of finely homogenised seeds of *Croton tiglium* Linn. to each of these ponds. Since this seed was found not toxic to crustaceans such as crabs and prawns they were eliminated as far as possible by nets. The ponds were cleaned on April 4, 1981.

One of the ponds (pond–A) was used to assess the quantity of organic production (aquafeed) over the submerged palm leaves. After guarding the water passage and eliminating pests and predators, fresh leaves of coconut marked with nylon tags were introduced into the pond at the rate of one leaf a month for one year and kept just submerged in water on wooden stakes. The leaves were introduced during the middle of every month and the organic growth over them was assessed at the end of the succeeding month by taking representative leaf blades with maximum and minimum growth of organisms. The average biomass from the leaf blades was later calculated for the entire leaf. The food value of the aquafeed was assessed by estimating its constituents such as protein, carbohydrate and fat.

In the other pond (pond B) 4 fresh leaves of coconut palm were kept just submerged as in the other pond. Later, palm leaves were introduced at an interval of 10 days at the rate of 2 each during the culture period till one month prior to the termination of the experiment. These leaves served as substrates for the growth of the sedentary organisms and their associates which in turn formed part of the food for the culture species. Juveniles of *Mugil cephalus* were introduced on May 4, 1981 and growth rate was assessed on May 2, 1982. The details regarding number, length and weight of the specimens cultured in the pond are furnished in Table 3. In another test, the authors studied the biogrowth over submerged glass panels, nylon mats and wooden blocks in the two neighbouring aquatic habitats, the Ashtamudi Lake (an estuary) and the Vizhinjam Bay (an inlet of the Arabian Sea). The seasonal fluctuations of biogrowth in these two habitats were studied by the monthly immersion and collection of glass panels of 10 x 10 cm with one side smooth and the other side rough, nylon mats of 25 x 25 cm made of 1 mm threads with sieves of 1 mm size and cubic wooden blocks of 6 x 10 x 10 cm. Though the study envisaged to collect monthly data for one year, owing to loss of exposed materials during rough whether only the seasonal range of biomass growth is given in this study.

Fortnightly data were collected on parameters such as temperature, light penetration, salinity, dissolved oxygen, pH, nutrients such as phosphate, silicate, nitrite and nitrate and primary productivity from the culture ponds and the open lake by adopting standard methods (Strickland & Parsons, 1965). The texture of the bottom soil was studied by employing the method of Piper (1950). Data on meterological features were obtained from CPCRI, ICAR Regional Station, Kayamkulam.

Results

The result of the tests are presented in Figs. 1–5 and Tables 1–3. Since the hydrographic features of the two ponds were almost identical, only those of Pond-B are presented in this paper. Humidity and rainfall of the area ranged from 85 to 96% and 0 to 731.4 mm respectively (Fig. 1). The hydrographic features show varying degree of seasonal fluctuations. Salinity was the most fluctuating factor and it ranged from 1.4 to 32.8‰. Highest salinity was recorded during the pre-monsoon and lowest during the monsoon (Fig. 1). The fluctuations of temperature minima and maxima of the surface water ranged from 26.7 to 31.3°C and 28.1 to 36.5°C respectively with the lowest during the monsoon (Fig. 2). Similarly the dissolved oxygen concentration minima and maxima ranged from 3.84 to 4.68 and 5.59 to 7.76 ml/l respectively (Fig. 3). Fluctuations

Table 1. *Percentage composition of the bottom soil near the bank and middle of the culture pond*

Source	% dry weight Near the bank	Middle
Coarse sand	34.75	7.50
Fine sand	49.10	57.15
Silt	7.50	18.10
Clay	5.00	10.35

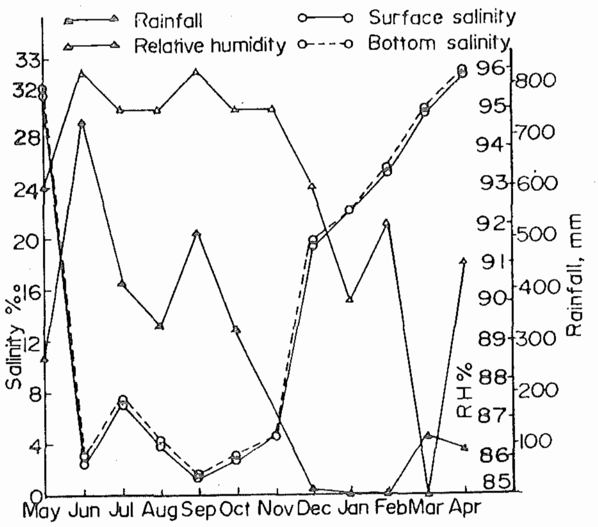

Fig. 1. Seasonal variations in the surface and bottom water salinities of the culture pond and the rainfall and relative humidity of the area

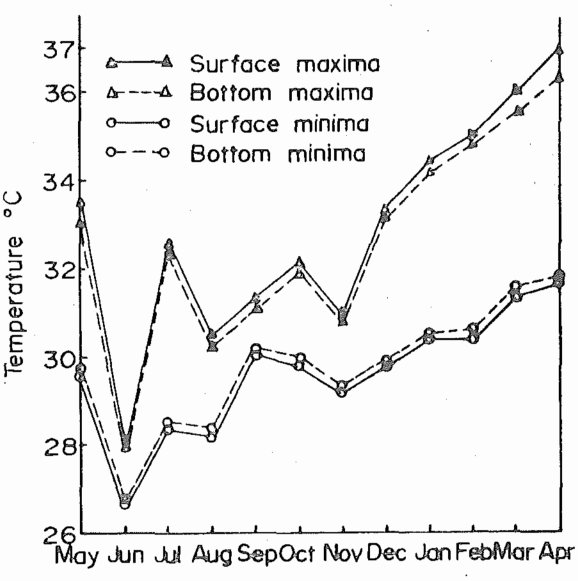

Fig. 2. Diurnal and seasonal variations in the temperature of the surface and bottom waters of thc culture pond

of pH value ranged from 6.9 to 8.1. Seasonal fluctuations of major nutrients such as phosphate, silicate, nitrate and nitrite of the surface water ranged from 0.74 to 1.75 μg at P/1; from 4.0 to 7.8 μg at Si/1; from 3.4 to 6.8 μg. at N/1 and from 0.64 to 1.15 μg at N/1 respectively (Fig. 4) The rate of light penetration was comparatively high during

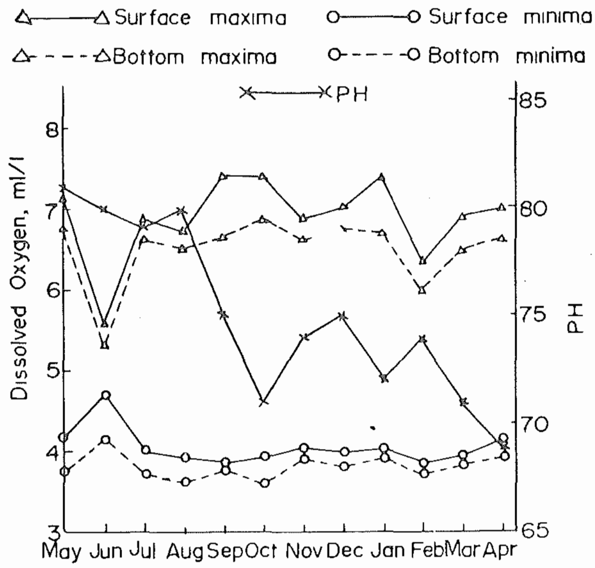

Fig. 3. Diurnal and seasonal variations in the dissolved oxygen of the surface and bottom waters of the culture pond

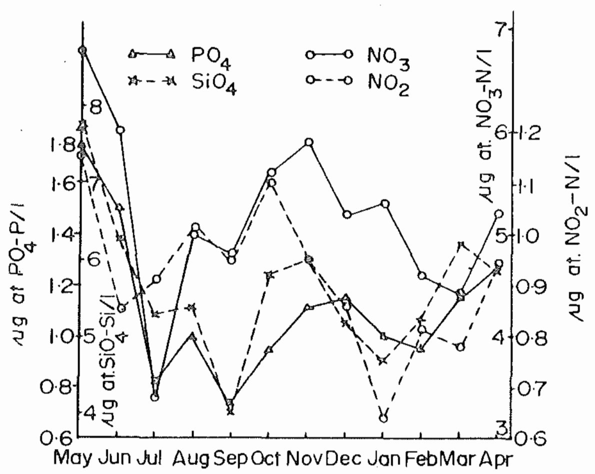

Fig. 4. Seasonal variations in the phosphate, silicate, nitrate and nitrite content in the surface water of the culture pond

the monsoon and it ranged from 24 to 53 cm. The gross and net productivity ranged from 0.682 to 1.638 and from 0.409 to 1.517 gc/m³/12 h respectively (Fig. 5). Analysis of the bottom soil indicated that it is a combination of sand, silt and clay (Table 1). Composition of the samples taken from the middle of the pond showed the real texture of the pond bottom, which is soft and clayey in

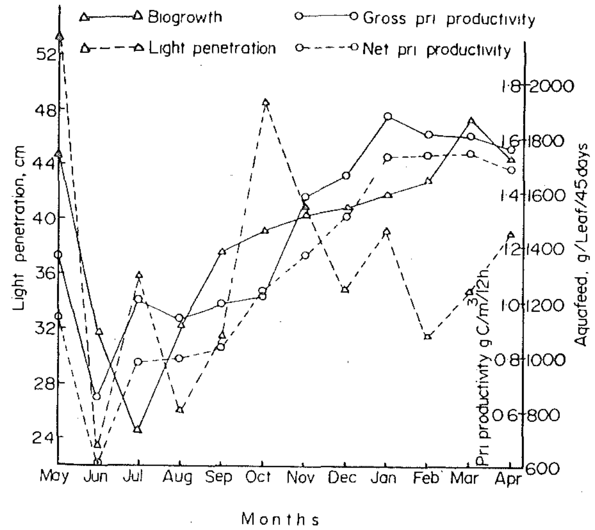

Fig. 5. Seasonal variations in the primary productivity and light penetration in the culture pond and the aquafeed production in the adjacent pond

nature. The comparatively high percentage of coarse sand near the bank is due to the sandy soil used for the construction of the dykes. Figure 5 illustrates the quantity of aquafeed developed over the submerged palm leaves. It ranged from 787 to 1830 g/leaf/45 days. Each leaf provides a surface area of approximately three square metres each on the upper and lower surfaces. The intensity of biogrowth was higher on the upper side. The biochemical composition of the aquafeed is presented in Table 2. The data

Table 2. *Biochemical composition of the 'aquafeed' separated from coconut palm leaves submerged in the pond for* 45 *days*

Source	Wet weight %	Dry weight %
Water	85.00	—
Sand-silt-clay	6.00	40.00
Protein	3.300	22.00
Carbohydrate (water soluble)	0.270	1.80
Fat	0.517	3.45
Total	95.087	67.25

on the growth during the first year of *M. cephalus* are presented in Table 3. The rate of survival was 54%. Juveniles of average length 1.85 cm and weight of 0.095 g attained

Table 3. *Details regarding Mugil cephalus cultured in a* 0.01 *hectare pond between May,* 1981 *and April,* 1982

Source	Initial	Final
Total	100	54
Av. length, cm	1.85 ± 0.0063	23.00 ± 0.447
Av. wt, g	0.095 ± 0.0071	146.73 ± 7.845
Total wt, g	9.5	8265
No./ha.	10000	5400
Wt./ha, kg.	0.950	826.500

a length of 23 cm and weight of 146.73 g during the course of one year.

Discussion

A comparison of the hydrographic features of the culture pond with those of the open lake shows certain similarities as well as differences. The level of salinity and its seasonal fluctuations were more or less the same in all these habitats with minor variations. The minimum and the maximum temperatures of the culture pond were generally higher than those of the lake, which ranged from 26.3 to 32.0°C and 28.5 to 34.5°C respectively. The dissolved oxygen content minima and maxima of the lake ranged between 3.77 and 5.46 and 5.07 and 6.37 ml/1 respectively, which is within the range of those of the culture pond. The lower values of the dissolved oxygen of the culture pond were much lower and higher values much higher than those of the lake. This is probably due to the increased rate of primary productivity in the pond. The gross and net primary productivity of the lake ranged from 0.341 to 1.228 and from 0.300 to 0.955 gc/m³/12 h respectively, which is much lower than that of the pond. The nutrient content of the pond water was identical with that of the lake, which receives a rich supply of nutrients from the coconut husk retting industry on the one side and domestic and industrial wastes from the adjacent areas on the other.

The data on the productivity of the aquafeed presented in this study do not reflect the true picture of the actual production for only a portion of the flora and fauna is truly sedentary and the rest are either temporarily attached to the substrates or simply associates for food and shelter and these may leave the substrate when disturbed. Even among the sedentary forms, in some cases, as growth progresses parts of the body may get detached from the parent organisms and dropped off the substrate into the surrounding water as separate individuals or reproductive elements enriching the plankton population. This is very important as far as plankton feeding culture species are concerned. Another aspect is that though the pond was thoroughly cleaned removing all the pests and predators at the beginning of the experiment the eggs that survived the treatment and the larvae and the fry that entered the pond through the holes of the water passage in due course formed a supplementary group of primary and secondary consumers. A portion of the floral and faunal growth over the substrates was thus lost to these intruders.

The seasonal fluctuations of biogrowth in the Ashtamudi Lake ranged between 16.0 and 72.9 g/panel/30 days, 52-230 g/mat/30 days and 18.6 and 123.1 g/block/30 days and that of Vizhinjam Bay ranged between 15.9 and 76.1 g/block/30 days. Results of the present study approach within the range of the earlier observations. Wide range in the seasonal fluctuations are mostly dependent on the changes in the faunal characteristics which is partly a reflection of the breeding periods of the respective groups. High values were thus obtained during the peak breeding period of barnacles, bivalves, tube-dwelling polychaetes and amphipods.

The data on the biochemical composition of the aquafeed (Table 2) indicate that its value as fish feed is significantly high. If we substract the weight of the inorganic materials such as fine sand-silt-clay, the percentage composition of the major biochemical components such as protein, carbohydrate and fats comes within the range of those of the various planktonic elements (Madhupratap *et al.*, 1979; Marshall & Orr, 1960 and Rosamma *et al.*, 1979), though much lower than the average.

While considering the growth rate of *M. cephalus* it seems relevant to review the growth rate reported by the earlier workers. In a review of the growth of *M. cephalus* in India it is given as 14 cm in 1st, 24 cm in 2nd, 33 cm in 3rd and 39 cm in 4th year (Hora & Pillai, 1962). A much higher growth rate namely, 426.6 mm; 873.8 g per year, has been mentioned by Pillai (1980). Yashouv (1966) mentioned 200 to 300 g growth during the first year, 550 g the second year and under intensive conditions of cultivation attain 700 g and even over 1 kg during the first year.

The above review shows that the growth rate of *M. cephalus* in the present study stands somewhat in the middle of the range. Further, the hectarage production is almost similar to that of a moderately well managed culture pond.

In the present study no supplementary feed was given. The productivity of the pond was considerably enhanced by introducing substrates for the growth of the floral and faunal organisms which in turn formed the food of the culture organisms. This is very important because in the case of near-shore and brackish water habitats, where tidal range is high, adding of fertilizers is almost a waste. Further, use of supplementary feed is quite expensive. In the present instance a device has been introduced to trap the rich nutrients available in the water which is periodically replenished through tidal action thereby converting the abiotic elements to primary and secondary producers which represent the food of the culture species

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