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Giant freshwater shrimp (Macrobrachium rosenbergi) grown together with the grass carp from March (below) to August (above) 1975.

Aquaculture . . .

(Continued from page 20)

The Experiments

The experiments were carried out in a series of 11 x 4 x 0.6 meter (25,000 liter) PVC-lined earthen ponds, which were filled with fresh (well) water. One pond was stocked with the freshwater macroscopic alga *Chara* sp. through which undiluted effluent from the HBF treatment plant was passed at a rate of 500 liters/day, providing a turnover rate of two percent of the pond volume per day.

In the second and most successful experiment, a procedure was adopted in which a daily supply of sewage effluent was pumped into a reservoir each morning, its nitrogen content checked by analysis, and enough freshwater or nutrients (sodium nitrate and sodium phosphate) added to provide a constant concentration of 2000 μmoles of nitrogen and 200 μmoles of phosphorus per liter. For the remainder of the experimental period (5/3-8/29), except for a two-week period in late June when the treatment plant was inoperative, the nitrogen removal by the *Chara*-stocked pond averaged approximately 90%.

Extrapolation of the above performance to full-scale application is unrealistic at this early stage of the research, but based upon the results of this preliminary experiment, an area of 60 acres of *Chara* pond culture would be needed to perform tertiary sewage treatment (nitrogen removal) with 90% efficiency for 1 MGD effluent or a community of 10,000 people. However, it is expected that this areal requirement could be significantly reduced by a more efficient algal culture system.

In an adjacent pond, of the same size and construction as the *Chara* pond, 28 juvenile (20 gram) grass carp were stocked on April 8, 1975. These fish were fed the harvest (growth) of the *Chara* at a rate of 1-2 kg *Chara* per day.

During a period of 161 days (4/8-9/3), the grass carp were fed 170 kg of Chara and increased in size from 21 to 180 grams/fish, a total biomass increase of 4.5 kg, a conversion efficiency of only 2.6%. The latter is not impressive since efficiencies of 10-20% (wet wt food: wet wt fish) are not uncommon in fish culture, but it may not be unusual in a voracious herbivore such as grass carp that consumes vast quantities of vegetation, a large fraction of which is rejected as undigested organic wastes. This phenomenon is, in fact, the basis for the highly successful polyculture practice in mainland China, in which organic wastes from the grass carp serve, directly or indirectly, as food for several other fish species grown together in the same pond.

In cognizance of the potential food value of the wastes from the inefficient grass carp, approximately 75 juvenile freshwater shrimp *Macrobrachium rosenbergi)* were stocked in the grass carp pond on April 23, 1975. In the ensuing 146 days (4/23-9/15) these crustacea grew from 1.7 g to 19.7 g/shrimp, at the end of which period 66 individuals were recovered for a survival of 88% and a biomass increase of 1.2 kg. By that time, the shrimp had reached adult and marketable size and sexual maturity, gravid females being noted in the population.

The combined yield of 5.0 kg of grass carp and 1.3 kg of *Macrobrachium* per 33 m^2 pond is equivalent to a production of 1,700 pounds/acre for six months of 1.7 tons/acre/year (assuming year-around production at essentially the same rate), an extremely high yield for an aquaculture system based on natural food. More properly, however, the area required for the food production (the *Chara* pond) should also be included, making the production equivalent to 1,700 lbs/acre/year, which is still an impressive figure.