POLYCULTURE TRIALS INVOLVING RED TILAPIA, ARMOURED CATFISH (*Hoplosternum littorale*) AND FRESHWATER PRAWN (*Macrobrachium rosenbergii*) IN EARTHEN PONDS IN TRINIDAD.

GREGORY DE SOUZA, PAUL W. GABBADON AND ADDISON S. TITUS
Institute of Marine Affairs
P.O. Box 3160, Carenage Post Office
Trinidad and Tobago, West Indies

ABSTRACT

Polyculture trials were conducted under semi-intensive conditions in earthen ponds in Trinidad using the following combinations of species: (i) red hybrid tilapia and armoured catfish (*Hoplosternum littorale*); (ii) freshwater prawn (*Macrobrachium rosenbergii*) and armoured catfish; and (iii) tilapia and prawn.

Stocking densities were: tilapia 25 000 ha-1; catfish 30 000 - 50 000 ha-1; and prawn 10 000 - 100 000 h-1. A 35% protein diet of pelleted ration in floating (for tilapia) and sinking (for catfish and prawn) forms were fed as a percentage of estimated biomass. Growout times approximated 5.5 months.

Average maximum yields were as follows: tilapia and catfish 27 614 kg ha-1 yr-1; prawn and catfish 12 622 kg ha-1 yr-1; and tilapia and prawn 24 176 kg ha-1 yr-1.

INTRODUCTION

Aquaculture in Trinidad and Tobago started in the 1950's with the introduction of *Sarotheradon mossambicus*. Up to the 1980's, however, commercial aquaculture had not been successful and this was largely due to low management levels and backyard systems of culture. Generally, mixed-sex tilapia and some indigenous species were cultured in poorly designed ponds (Manwaring and Romano 1990), resulting in low and unpredictable yields.

With the introduction of the red hybrid tilapia and giant freshwater prawn *Macrobrachium rosenbergii* from Jamaica, coupled with a more structured approach to extension services to farmers and inputs from research institutions, management levels have improved and fish farming is presently generating more interest. These species are also cultured in most of the other Caribbean territories (O.A.S. 1992).

The armoured catfish *Hoplosternum littorale* (Callichthydae) ranges from Trinidad to Brazil. It has been identified as a potential commercial aquaculture species (Bruce 1981, Singh 1981, Boujard et al.. 1988) and is experimentally cultured in Suriname (P. Bakuwel, Comfish, Suriname, pers. comm.) and French Guiana (Houstache et al 1992). *Hoplosternum littorale* or "cascadura" is a popular foodfish in Trinidad and has been experimentally cultured at the Institute of Marine Affairs since 1985. The need for culture is justified by its high local demand, potential foreign markets and dwindling wild stocks which have been adversely affected by overfishing and habitat destruction through large-scale commercial agriculture.

For small developing island nations like Trinidad and Tobago, and many of the other Caribbean islands, land availability is limited by competing interests, and more intensive and productive aquaculture systems are to be encouraged. Polyculture is seen as one possibility. It is practised to enhance pond production, control overbreeding in mixed-sex culture ponds by introducing predatory species, to improve pond environment by algal and macrophytic grazers and to limit the extent of anaerobic conditions at the pond bottom (Little and Muir 1987).

Constraints to polyculture include interspecific interactions, including predation, competition for available oxygen, space and food, and problems of increased biomass as it relates to water quality. Other considerations include synchronization of attainment of market size of product of harvest (McGinty and Alston 1987) and selective feeding of different species (Cohen and Ra?anan 1983).

This study was conducted to test the technical feasibility of the polyculture of the three species in different combinations and to compare overall production with that obtained from monoculture systems under similar conditions.

METHODOLOGY

Preliminary observations in indoor glass aquaria were made to determine the nature of interspecific reactions between the species. Based on these, research trials were conducted in triplicate in outdoor earthen ponds each approximating 0.2 hectares (20x10m) of water surface area. Ponds were aerated by air diffusers from airblowers situated indoors. Water was supplied from an underground well and average daily water temperature was 27.1C with no apparent thermal stratification. Losses from evaporation and seepage were replaced daily.

Water quality was monitored daily and dissolved oxygen levels were maintained above 3.0ppm. The pH and algal concentration were adjusted by addition of well-water of pH 6.7 to maintain values of between 7.0 and 8.5, and a secchi-disc reading of at least 40cm respectively.

Food was given twice daily, except on weekends when there was one feeding at mid- morning, using 35% crude protein pelleted rations. Feed rates were based on estimated biomass from biweekly sampling using a 2.5mm square knotless seine.

Following is a summary of the different species combinations, stocking densities, stocking sizes, growout periods and feeding regimes for the polyculture trials performed:

Prawn and *H. littorale*

Two trials were conducted using stocking densities of 50 000 ha-1 for each species in Trial 1, and 100 000 ha-1 for prawn and 30 000 ha-1 for armoured catfish in Trial 2. Nursery reared post-larval prawns and *H. littorale* fry of average weight of less than 1g each were stocked into freshly filled ponds for an average growout period of 133 days. Feeding rates were based on estimates of total pond biomass and ponds were fed with a sinking pelleted ration, as both species are bottom feeders.

Tilapia and prawn

Two trials were conducted using six to eight week old male fingerling tilapia and small male prawns which were retained after harvest of prawn monoculture growout trials. In both trials, fish were stocked at 25 000 ha-1, while prawns were stocked at 10 000 ha-1 in Trial 3 and 15 000 ha-1 in Trial 4. Stocking sizes of fish and prawn averaged 20.1g and 8.1g respectively. The growout period for these trials averaged 160 days. Feeding rates were based on estimated tilapia biomass and ponds were fed a floating pelleted ration.

Tilapia and H. littorale

Two trials were conducted using male fingerling tilapia and fingerling H.

littorale. Tilapia were stocked at 25 000 ha-1 in both trials, with catfish being stocked at 30 000 ha-1 in Trial 5 and 50 000 ha-1 in Trial 6. Stocking sizes of tilapia and *H. littorale* averaged 20.4g and 8.6g respectively. Growout period for these trials was 166 days. Feeding rates were based on estimated species biomass and ponds were fed both floating (for tilapia) and sinking (for *H. littorale*) pelleted rations.

After growout, ponds were harvested by seine haul and total draindown. Remaining animals were retrieved by hand. In all trials, individuals of each species were counted and weighed to determine survival rates and average individual harvest weights. In the prawn and H. littorale trials harvested prawns were categorized into blue claw males, orange claw males, berried females, spent females and small males.

Food conversion was determined from total weight of food put into the pond over the growout period and total biomass produced over the period. Extrapolated annual yields of kg ha-1 yr-1 were determined from biomass produced and the duration of the growout period.

RESULTS

A summary of averages of results of Trials 1 to 6 including species combinations, stocking densities, growout periods, harvest weights, survival, food conversions and annual yields is contained in Table 1. Trials 1 and 2 (*Macrobrachium rosenbergii* and *H. littorale*).

Prawn survival for the stocking density of 50 000 ha-1 (Trial 1) averaged 72.1% and mean individual weight at harvest was 33.9g. At the stocking density of 100 000 ha-1 (Trial 2), survival averaged 78.6% and mean individual weight at harvest was 19.8g. The average H. littorale survival for Trial 1 (50 000 ha-1) was 89.3% with an average individual harvest weight of 75.7g and in Trial 2 (30 000 ha-1) average survival was 85.3% with an average individual weight of 73.5g.

A breakdown of average yields of prawn morphotypes for Trials 1 and 2 are contained in Table 2. For the stocking density of 50 000 ha-1 in Trial 1 the combined weight of blue claw and orange claw males constituted an average of 54.8% of the prawn biomass, while the females made up an average of 33.7%.

For the stocking density of 100 000 ha-1 in Trial 2 the combined weight of the larger males (blue claw and orange claw) constituted an average of 44.2% of the total prawn biomass while females made up an average of 45.7% of the biomass.

Average combined annual yields of fish and prawn for Trials 1 and 2 were 12622 kgha-1 yr-1 and 9359 kgha-1 yr-1 respectively. Average overall food conversions for these trials were 2.90 and 3.00. Trials 3 and 4 (red tilapia and *M. rosenbergii*).

Prawn survival for the stocking density of10 000 ha-1 in Trial 3 averaged 90.6%. Mean individual harvest weight was 100.9g. At the stocking density of 15 000 ha-1 in Trial 4, survival averaged 93.2% with a mean individual harvest weight of 76.9g. Projected annual yields for prawn in Trials 3 and 4 were 1888 kgha-1 yr-1 and 2159 kgha-1 yr-1 respectively. From a stocking density of 25 000 ha-1 average survival of tilapia for Trials 3 and 4 were 93.9% and 95.4% respectively with mean individual harvest weights of 434g and 426g respectively. Projected annual yields of tilapia for Trials 3 and 4 were 22117 kgha-1 yr-1 and 22016 kgha-1 y-1. Overall food conversions for both trials averaged 1.54. Trials 5 and 6 (red tilapia and H. littorale).

Average survival rates for tilapia in Trials 5 and 6 (stocking density 25,000kg ha-1 were 91.2% and 91.1% respectively. Mean individual weights at harvest were 456g for both trials with project annual yields of 21852 kgha-1 yr-1 and 21844 kgha-1 yr-1 respectively. *Hoplosternum littorale* average survival for Trials 5 and 6 at stocking densities of 30 000 ha-1 and 50 000 ha-1 were 91.6% and 85.2% respectively. Mean individual weights at harvest were 79.3g and 72.3g respectively, while projected annual yields were 4267 kg/ha-1 yr-1 and 5984 kg/ha-1 yr-1 respectively. Overall average food conversions were 1.67 and 1.72 respectively.

DISCUSSION

From the results of the growout trials conducted, it is shown that polyculture of the three species used in the various combinations is technically feasible.

Although the approach to polyculture is one in which there is a major target species, the biomass of which is used to determine feed rates, and a minor one which is considered extra (D'Abramo 1986), this method was used only in the combination of tilapia and prawns (Trials 3 and 4).

The tilapia hybrids, making up the bulk of the pond biomass, feed on the surface and midwater while the prawns are bottom feeders and scavenge any unused food particles which fall to the bottom of the pond.

In the case of prawn and *H. littorale* polyculture, both animals are bottom foragers. It was assumed that there would be some level of competition for sinking pellets at the bottom of the pond if feed quantities were calculated for only one species. This is especially so in the case of Trial 1 where the different species were stocked in equal numbers. Proper feeding also reduces the incidence of intraspecific killing or cannibalism in prawns (Peebles 1978).

For the tilapia and *H. littorale* polyculture, although tilapia constituted the bulk of the pond biomass, the stocking density of the catfish was higher in both trials (Trials 5 and 6). Based on observations, the tilapia fed voraciously and it was assumed that any excess food falling to the pondbottom would not be enough to sustain the H. littorale biomass.

Tilapia production figures obtained from Trials 3, 4, 5 and 6 are comparable with those of monoculture trials using the same stocking density (Gabbadon et al, in prep.) while the prawn and *H. littorale* figures are predictably lower than those of monoculture trials (Gabbadon and de Souza 1989, de Souza and Gabbadon 1990) because of the lower stocking densities. Overall, pond production was enhanced, in agreement with Rouse and Stickney (1982).

Prawn survival in Trials 1 and 2 was comparable with that of prawn monoculture trials (Gabbadon and de Souza 1989) and was better for Trials 3 and 4. This is expected, as survival rates improve with larger stocking size for prawns (Ling 1969). It was in direct contrast to relatively poor prawn survival results for polyculture of channel catfish *Ictalurus punctatus* and *M. rosenbergii* (Pavel 1985) which was attributed to low dissolved oxygen levels which the catfish were better able to tolerate.

Survival rates for *H. littorale* in Trials 1 and 2 were comparable with those for Trials 5 and 6 although the stocking size was much smaller. This was expected as fry were stocked into freshly filled ponds in Trials 1 and 2 to prevent predation from odonatan larvae (de Souza and Gabbadon 1990). Although *H. littorale* production for stocking densities of 30 000 ha-1 and 50 000 ha-1 was less than that for monoculture (de Souza and Gabbadon 1990), this may be attributed in Trials 1 and 2 to the relatively lower stocking densities than those recommended for monoculture. In the case of Trials 5 and 6, *H. littorale* production may have been affected by the overall biomass in the system which was possibly approaching the carrying capacity. Another possible explanation is that the tilapia consumed some of the sinking pellets earmarked for the bottom-feeding catfish, thereby affecting their production.

The suitability of the *H. littorale* as the second species in polyculture must be noted. This fish gulps air at the surface and utilizes its highly vascularized gut as an accessory respiratory organ (Carter and Beadle 1931). It does not make significant demands for available dissolved oxygen in the water column. This peculiar breathing habit of *H. littorale* also renders it tolerant to crowding in more intensive systems (Singh 1981). It also serves to control the successful breeding of mosquitoes in prawn culture ponds. This fish is not a prolific breeder and there is no need for monosex culture. The seasonally produced floating nest, though camouflaged, is easily detected in well managed ponds, and may be collected for fry production. It must be mentioned, however that the seasonality of fry availability may be an adverse factor to the successful year-round culture of this species.

Product quality is ensured by the absence of physical injury among species at harvest. The hard bony plates of H. littorale protect it from snapping prawn chelae or damage from the weight of tilapia. The catfish's mouth, which is small and situated subterminally, does not allow it to inflict any damage by biting. The prawns grown with tilapia are of a relativley large size and may be easily separated from fish at harvest.

The population structure of prawns at harvest dictate to a large degree, the marketability and price of the product (Karplus et al 1986). The average percentage biomass accounted for by large males in Trial 1 (54.8%) compare favourably with that for monoculture (Gabbadon and de Souza 1989). In Trial 2, this percentage (44.2%) in slightly less than that for prawn monoculture at the same stocking density.

Average individual weight of harvested prawn for the stocking density of 50 000 ha-1 in Trial 1 is higher than that from monculture trials of the same density and may be related to a lower mean prawn survival. Mean survival for monoculture (Gabbadon and de Souza 1989) at 100 000 ha-1 is almost identical with that of Trial 2, but average individual weight is appreciably less than for the monoculture trial. Although overall stocking density is increased in polyculture, thereby maximising the use of pond space, at this stocking density the biomass of fish and prawn may be approaching the carrying capacity of the system which would be a limiting factor to increase in prawn size. Small males produced from Trials 1 and 2 are capable of compensatory growth (Malecha 1977) and when separated from larger males and restocked for growout, show increased growth rates. Small males are more suitable than post-larvae for polyculture with larger fish, as with tilapia fingerlings in Trials 5 and 6.

Alternatively, it may be possible to stock smaller prawns with all-male sex-reversed tilapia fry, which are not large enough to prey on the young prawns, but more research is needed to explore this possibility. This will facilitate trials using different stocking density combinations, particularly of the prawns, which was limited in Trials 5 and 6 by the availability of small males from harvested prawn populations.

Prawns harvested from Trials 5 and 6 were all similarly sized and no sorting was necessary for marketing purposes. Tilapia produced in these trials and Trials

3 and 4 were also of a marketable size, as determined by Manwaring et al (1993) in a tilapia marketing survey of local retail markets. Thus, the potential problem of synchronization of attainment of market size in polyculture (McGinty and Alston 1987) is overcome.

In summary, polyculture is proven to be technically feasible under the conditions stated, despite potential problems of interspecific interactions including predation and competition for available oxygen, space and food. It can be particularly useful for Trinidad and Tobago and many of the smaller Caribbean territories where land space is limited. It must be noted however that in more intensive systems, with increased stocking densities and more inputs of food, stricter management is necessary to ensure success.

LITERATURE CITED

Boujard T., P.Y. Le Bail, P. Planquette 1988. Presentation of a few freshwater fishes from French Guiana with fish farming potential. Aquatic Living Resources 1(2): 107-113.

Bruce R. W. 1981. Local species with potential for aquaculture in Trinidad and Tobago. Pages 43-49 in The Potential for an Aquaculture Industry in Trinidad and Tobago. Institute of Marine Affairs, Trinidad and Tobago.

Carter G.S., L.S. Beadle 1931. Reports of an expedition to Brazil and Paraguay. The fauna of the swamps of the Paraguayan Chaco in relation to its environment II. Respiratory adaptation of the fishes. Linn Soc.(Zool.) 37: 327-368.

Cohen D., Z. Ra?anan 1983. The production of the freshwater prawn *Macrobrachium rosenbergii* in Israel. 3. Density effect of all-male Tilapia hybrids in prawn yield characters in polyculture. Aquaculture. 35(1): 57-71.

D'Abramo L.R. 1986. Polyculture of the freshwater prawn (Macrobrachium rosenbergii) with a mixed-sex population of channel catfish (*Ictalurus punctatus*). Aquaculture. 59(1): 71-80.

De Souza G., P. Gabbadon 1990. Cascadura farming: From hatchery to production. Institute of Marine Affairs. Aquaculture series. no. 2. 20pp.

Gabbadon P., G. de Souza 1989. Preliminary studies on freshwater prawn *Macrobrachium rosenbergii* monoculture in earthen ponds in Trinidad. Institute of marine Affairs research report.

Gabbadon P.W., G. de Souza, A. Titus. In preparation. Tilapia farming: A manual on commercial tilapia production. Institute of Marine Affairs Aquaculture series. no. 3.

Houstache G., M. Pascal, M. Kernen, C. Tessier 1992. Incubation and thermic conditions in *Hoplosternum littorale*. Aquat. Living Resour. 5(1): 31-39.

Karplus I., G. Hulata, G.W. Wohlfarth, A. Halevy 1986. The effect of density of *Macrobrachium rosenbergii* raised in earthen ponds on their population structure and weight distribution. Aquaculture. 52: 307-320.

Ling S.E. 1969. Methods of rearing and culturing *Macrobrachium rosenbergii* (de Man). FAO UN Fish. Rep. 57(3): 607-619.

Little D., J. Muir 1987. A guide to integrated warm water aquaculture. Institute of Aquaculture, Univ. of Stirling. 238pp.

Malecha S.R. 1977. Genetic and selected breeding. Pages 328-355 in J.A. Hanson and H.C. Goodwise, eds Shrimp and prawn farming in the western hemisphere. Dowden, Hutchinson and Ross Inc., Stroudsberg II. 439pp.

Manwaring G., H. Romano 1990. Aquaculture marketing - A survey of existing producers. Caribbean Marine Studies. 1(1): 2-10.

Manwaring, G., G. de Souza, P. Gabbadon, A. Titus 1993. Marketing the red hybrid tilapia: A pilot survey of retail fish markets in Trinidad. Institute of Marine Affairs research report.

McGinty A.S., D.E. Alston 1987. Polyculture of all-male tilapia hybrids with low densities of *Macrobrachium rosenbergii.* Contributions. Univ. of Puerto Rico. 25: 105-109.

Organization of American States 1992. Country profiles for aquaculture development in the Caribbean. Multinational Project on the Environment and Natural Resources. Department of Scientific and Technological Affairs. Washington, D.C., June 1992.

Pavel D.L. 1985. Polyculture of channel catfish, Ictalurus punctatus, with post larval and juvenile prawns, *Macrobrachium rosenbergii*. M.S. Thesis, Louisiana State University, Baton Rouge, 70 pp.

Peebles B. 1978. Moulting and mortality in *Macrobrachium rosenbergii*. Pages 39-46 in Proceedings World Mariculture Society, 9th Annual Meeting. Atlanta, Georgia, Jan 3-6, 1978.

Rouse D.B., R.R. Stickney 1982. Evaluation of the production potential of *Macrobrachium rosenbergii* in monoculture and polyculture with Tilapia aurea. World Mariculture Society 13: 73-85.

Singh T. 1981. The cascadura (*Hoplosternum littorale*): Its aquaculture potential in Guyana. Pages 27-29 in The Potential for an Aquaculture Industry in Trinidad and Tobago. Institute of Marine Affairs, Trinidad and Tobago.