TECHNICAL REPORT
Polyculture of giant freshwater prawn *Macrobrachium rosenbergii* and cascadura *Hoplosternum lottorale* in earthen ponds in Trinidad

By

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February 1995
(Revised, 2008)

ABSTRACT

The feasibility of polyculture of the freshwater prawn *Macrobrachium rosenbergii* and the armoured catfish or cascadura *Hoplosternum littorale* was tested at the Institute of Marine Affairs, Trinidad.

Three grow out trials were conducted in triplicate in 0.02 ha earthen ponds. Cascadura fry and nursery reared post larval prawns were each stocked at 50,000 ha^{-1} in Trial I, 30,000 ha^{-1} and 100,000 ha^{-1} respectively in Trial II; and 25,000 ha^{-1} and 75,000 ha^{-1} respectively in Trial III. Results of Trial III were disregarded because of problems with the feed.

Survival rates averaged 89.3% and 72.1% for cascadura and prawn respectively in Trial I, and 85.3% and 78.6% in Trial II. Overall food conversions for Trials I and II averaged 2.9 and 3.3 respectively.

Average annual yields from Trial I were 9,306 kg $ha^{-1}yr^{-1}$ and 3,316 kg $ha^{-1}yr^{-1}$ for cascadura and prawn respectively, and 5,118 kg $ha^{-1}yr^{-1}$ and 4,241 kg $ha^{-1}yr^{-1}$ in Trial II, showing an overall enhanced production over monoculture systems.

An examination of the prawn morphotype biomass distribution showed that the larger prawns, blue claw and orange claw males, averaged 54.8% and 44.2% of the total prawn biomass for Trials I and II respectively which compares favourably with monoculture systems.

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1.0 INTRODUCTION

Polyculture, or the culture of more than one aquatic species at the same time in the same system, was first documented by the Chinese in efforts to increase production in carp culture ponds. It has been practiced to effectively control overbreeding in mixed-sex culture ponds by introducing predatory species, to improve pond environment by the use of algal and macrophytic grazers and to limit the extent of anaerobic conditions at the pond bottom (Little and Muir 1987). For various reasons, however, polyculture remains an inexact science.

Inter-specific interactions, including predation, competition for available oxygen, space and food and problems with increased biomass as it relates to water quality, are some of the major constraints. Other considerations include synchronization of attainment of market size of product at harvest (McGinty and Alston 1987) and selective feeding of different species (Cohen and Ra'anan 1983).

In Trinidad and Tobago, where land resources are limited, more intensive systems of aquaculture are to be encouraged. Although some polyculture has been practiced in the past, this was done generally on a poorly managed extensive scale (Manwarring and Romano 1990), resulting in relatively low and unpredictable yields.

The Institute of Marine Affairs (IMA), as a part of its aquaculture research programme, conducted polyculture trials utilizing the exotic giant freshwater prawn *Macrobrachium rosengergii* (Palaemonidae) and the indigenious armoured catfish or cascadura *Hoplosternum littorale* (Callichthydae). This fits in with the overall objectives of the research programme which include maximizing the potential of the target species. Based on observations in indoor glass tanks, both species appear to be compatible. Experiments were designed for pond polyculture trials utilizing the IMA's outdoor pond facility.

2.0 MATERIALS AND METHODS

Cascadura fry and nursery reared prawn post-larvae produced at the Institute were stocked at varying densities into freshly filled earthen ponds of approximately 0.2 hectares (20 x 10m) area. All trials were conducted in triplicate at densities based on previous monoculture trials. Stocking densities were 50,000 ha^{-1} for each species in Trial I; 100,000 ha^{-1} for prawn and 30,000ha^{-1} for cascadura in Trial II; and 75,000 ha^{-1} for prawn and 25,000 ha^{-1} for cascadura in Trial III. The stocking sizes of the post-larval prawns and cascadura fry averaged 0.7g and 0.8g respectively.

Water was supplied from an underground well and pumped directly to the ponds. All ponds used in these trials were aerated by the use of a 0.5hp air blower situated indoors. Water was added daily to replace evaporation and seepage losses. Water quality was monitored daily to ensure that dissolved oxygen levels above 3.0 ppm and pH values between 7.0 and 8.5 were maintained. Algal concentration was monitored daily using a secchi disc and visibility was maintained at levels greater than 40 cm. Adjustments to pH and algal concentrations were effected by a gradual exchange of pond water with well water of pH 6.7.

Both species were fed a 35% crude protein pelleted sinking ration supplied by a local feed mill. Ponds were fed twice daily with equal quantities at early morning and late afternoon, except on weekends when they were fed once daily at midmorning. Quanity of feed was calculated from stocking to harvest as a decreasing percentage (15% to 3%) of the estimated total standing biomass in the pond. This was based on biweekly sampling. The ponds were sampled using a 2.5mm square mesh knotless seine to obtain estimates of the average weights of fish and prawns in the pond.

Ponds were harvested after a growout period of approximately 133 days by lowering the pond water level to a depth of 0.5m and removing most of the animals in two seine hauls. Ponds were then totally drained and the remaining animals were collected by hand and dipnet.

Individuals of each species were counted and weighed to determine survival rates and average individual weights. Prawns were categorized as small males, orange claw males, blue claw males, berried females and non-berried females. Food conversions were determined from total weight of food put into the pond and total biomass at harvest. Extrapolated yields of kg ha^{-1} and annual yields of kg ha^{-1} yr^{-1} were determined from the harvested biomass and growout period.

3.0 RESULTS

3.1 Trial I

Summaries of survival rates, average harvest weights, biomass, food conversions and extrapolated yields for Trial I are presented in Table 1.

Prawn survival for the stocking density of 50,000 ha^{-1} in this trail ranged from 44.2% to 87.0% and averaged 72.1%. Average individual harvest weight ranged from 29.0g to 36.7g with a mean value of 33.9g. Prawn biomass at harvest ranged from 15.53kg to 29.79kg, averaging 23.3kg.

Table 1: Summary of results of polyculture Trial I using stocking densities of 50,000 ha^{-1} for *Macrobrachium rosenbergii* and 50,000 ha^{-1} for *Hoplosternum littorale*

Pond No.	Average Harvest Weight g	Survival	Biomass at Harvest kg	Food Conversion	Yield kg ha^{-1}	Annual Yield kg ha^{-1}yr^{-1}
1	* 74.60	89.0	63.43	2.80	3,321	9,183
	+ 36.70	85.0	29.79		1,560	4,313
2	* 83.20	83.4	67.62	3.20	3,468	9,589
	+ 36.00	44.2	15.53		796	2,202
3	* 69.20	95.6	64.50	2.70	3,308	9,147
	+ 29.00	87.0	24.58		1,261	3,434
Mean ± sd	* 75.67±7.06	89.30±6.11	65.18±2.18	2.90±0.26	3,366±88.80	9,306±245.46
	+ 33.90±4.26	72.10±24.15	23.30±7.22		1,206±384.61	3,316±1,060.41

* *Hoplosternum littorale* + *Macrobrachium rosenbergii*

3.2 Trial II

Summaries of survival rates, average harvest weight, biomass, food conversions and extrapolated yields for Trial II are presented in Table 2.

Prawn survival from the stocking density of 100,000 ha^{-1} used in this trial ranged from 67.7% to 94.6% and averaged 78.6%. Average individual harvest weight ranged from 18.2g to 20.6g with a mean value of 19.8g. Total prawn biomass at harvest ranged from 27.23kg to 32.84kg, averaging 29.83kg.

Cascadura survival for the stocking density of 30,000 ha^{-1} used in this trial ranged from 71.9% to 93.1% and averaged 85.3%. Average individual harvest weight ranged from 67.6g to 82.8g with a mean value of 73.5g. Fish biomass at harvest ranged from 34.1kg to 37.1kg, averaging 36.0kg.

Overall food conversion for this polyculture trial ranged from 2.9 to 3.1, averaging 3.0.

3.3 Trial III

Results of this trial were disregarded because of problems with the palletized ration. Because of a shortage in the country at the time of the trial, the fish meal constituent of the feed was wholly substituted with soya bean meal to build up the protein content in the feed and this was found after the trial by research personnel. This had an adverse effect on the survival and growth rates of the animals.

3.4 Prawn Morphotype Yields

Tables 3 and 4 show breakdown yields of prawn morphotypes for polyculture trials at stocking densities of 50,000 ha^{-1} for each species in Trial I and respective stocking densities of 100,000ha $^{-1}$ and 30,000 ha^{-1} for prawn and cascadura in Trial II.

In Trial I, blue claw males ranged from 22 to 35 individuals per pond. Orange claw males at this density ranged from 188 to 272. The combined weight of the blue claw and orange claw males produced constituted an average of 54.8% of the prawn biomass, whereas females, both berried and spent, made up an average of 33.7% and small males an average of 11.4%. In Pond 2, where prawn survival was lowest (44.2%) average individual weights were highest for all morphotypes except the small males.

In Trial II, the number of blue claw males ranged from 79 to 108 per pond. Orange claw males were again more abundant and ranged from 230 to 378 per pond. The combined weight of larger males (blue claw and orange claw) produced constituted an average of 44.2% of the total prawn biomass with females making up an average of 45.7% and small males 10.1%.

4.0 DISCUSSION

From results of the growout trials conducted, it is shown that polyculture of the giant freshwater prawn *M. rosenbergii* and the cascadura *H. littorale* is technically feasible under local conditions, using a semi-intensive system.

Table 2: Summary of results of polyculture Trial II using stocking densities of 100,000 ha^{-1} for *Macrobrachium rosenbergii* and 30,000 ha^{-1} for *Hoplosternum littorale*

Pond No.	Average Harvest Weight g	Survival	Biomass at Harvest kg	Food Conversion	Yield kg ha^{-1}	Annual Yield kg $ha^{-1}yr^{-1}$
1	* 82.80	71.9	34.12	3.10	1,787	4,867
	+ 18.20	94.6	32.84		1,719	4,683
2	* 70.00	90.8	37.16	2.90	1,906	5,230
	+ 20.60	67.7	27.23		1,397	3,833
3	* 67.60	93.1	36.80	3.10	1,887	5,258
	+ 20.50	73.6	29.44		1,510	4,207
Mean	* 73.47±8.17	85.30±11.63	36.03±1.66	3.00±0.12	1,860±64.02	5,118±218.11
± sd	+ 19.77±1.36	78.60±14.14	29.84±2.83		1,541±163.75	4,241±426.02

* *Hoplosternum littorale* + *Macrobrachium rosenbergii*

Table 3: Yields obtained for *Macrobrachium rosenbergii* morphotypes at harvest for a stocking density of 50,000 ha^{-1} in polyculture with *Hoplosternum littorale* at 50,000 ha^{-1}

Pond No.	Morphotype	No. of Individuals	Biomass kg	No. of Individuals	% Biomass	Average Individual wt.
1	Blue claw males	35	1.92	4.3	6.2	54.9
	Orange claw males	240	10.01	29.7	33.8	41.7
	Berried females	281	6.69	34.8	22.6	23.8
	Spent females	139	3.25	17.2	11.0	23.4
	Small males	112	7.75	13.9	26.2	9.6
	Total Weighted mean	**807**	**29.62**	**100.0**	**100.0**	**36.7**
2	Blue claw males	22	1040	5.1	9.0	63.6
	Orange claw males	188	9.06	43.6	58.3	48.2
	Berried females	88	2.47	20.4	15.9	28.1
	Spent females	81	2.15	18.8	13.8	26.5
	Small males	52	0.45	12.1	2.9	8.7
	Total Weighted mean	**431**	**15.53**	**100.0**	**100.0**	**36.0**
3	Blue claw males	25	1.21	3.0	4.9	48.3
	Orange claw males	272	12.76	32.2	52.0	46.9
	Berried females	219	5.23	25.9	21.4	23.9
	Spent females	190	4.03	22.5	16.4	21.2
	Small males	140	1.29	16.5	5.3	9.2
	Total Weighted mean	**846**	**24.51**	**100.0**	**100.0**	**29.0**

Table 4: Yields obtained for *Macrobrachium rosenbergii* morphotypes at harvest for a stocking density of 100,000 ha^{-1} in polyculture with *Hoplosternum littorale* at 30,000 ha^{-1}

Pond No.	Morphotype	No. of Individuals	Biomass kg	No. of Individuals	% Biomass	Average Individual wt.
1	Blue claw males	35	1.92	4.3	6.2	54.9
	Orange claw males	240	10.01	29.7	33.8	41.7
	Berried females	281	6.69	34.8	22.6	23.8
	Spent females	139	3.25	17.2	11.0	23.4
	Small males	112	7.75	13.9	26.2	9.6
	Total Weighted mean	**807**	**29.62**	**100.0**	**100.0**	**36.7**
2	Blue claw males	22	1040	5.1	9.0	63.6
	Orange claw males	188	9.06	43.6	58.3	48.2
	Berried females	88	2.47	20.4	15.9	28.1
	Spent females	81	2.15	18.8	13.8	26.5
	Small males	52	0.45	12.1	2.9	8.7
	Total Weighted mean	**431**	**15.53**	**100.0**	**100.0**	**36.0**
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	Berried females	219	5.23	25.9	21.4	23.9
	Spent females	190	4.03	22.5	16.4	21.2
	Small males	140	1.29	16.5	5.3	9.2
	Total Weighted mean	**846**	**24.51**	**100.0**	**100.0**	**29.0**

Although the approach to polyculture is normally one in which there is a major target species for which food is put into the pond, and a minor one which is considered extra (D'Abramo 1986), the approach taken in these trials was to calculate feed quantities for the total estimated biomass. Both animals used are bottom-feeding foragers by habit and 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, especially in the case of Trial I, in which the different species were stocked in equal numbers. Proper feeding also reduces the incidence of intra-specific killing or cannibalism following molting in prawns (Peebles 1978).

Prawn survival in these polyculture trials (72.1% and 78.6%) was comparable with that of monoculture trails (91.1% and 79.0% for stocking densities of 50,000 ha^{-1} and 100,000 ha^{-1} respectively) conducted at the IMA (Gabbadon and de Souza 1989). This was in contrast to the results obtained by Pavel (1985) in which there was relatively poor prawn survival from polyculture with channel catfish *Ictalurus punctatus*. This was attributed to low dissolved oxygen levels which the catfish were better able to tolerated. The cascadura gulps air at the surface and utilizes its gut as an accessory respiratory organ (Singh 1978) and does not make significant demands for dissolved oxygen in the water column. Most of the dissolved oxygen is therefore available to the prawns except at nights or on overcast days when algal respiration would also utilize dissolved oxygen.

Overall prawn production (1,206 kg ha^{-1} and 1,541 kg ha^{-1}) was less than that produced in prawn monoculture trials (1,352 kg ha^{-1} and 2,369 kg ha^{-1}) was less than that produced in prawn monoculture trials (1,352 kg ha^{-1} and 2,369 kg ha^{-1}) for stocking densities of 50,000 ha^{-1} and 100,000 ha^{-1} respectively) under similar conditions (Gabbadon and deSouza 1989), and more so at the stocking density of 100,000 ha^{-1}. Overall pond production was however enhanced with the culture of fish in the same pond, in agreement with Rouse and Stickney (1982).

Survival rates for cascadura were very good and this was expected since fry were stocked into freshly filled ponds (de Souza and Gabbadon 1990) to prevent predation by odonatan larvae. An additional benefit of the fish in prawn culture ponds is the control of the breeding of mosquitoes which is a serious problem in prawn monoculture ponds.

Cascadura production for stocking densities of 50,000 ha^{-1} and 30,000 ha^{-1} in polyculture with prawns (9,300 kg ha^{-1} yr^{-1} and 5,100 kg ha^{-1} yr^{-1}) were less than that (13,200 kg ha^{-1} yr^{-1}) for monoculture production (de Souza and Gabbadon 1990) and this may be attributed to the relatively lower stocking densities than those recommended for monoculture.

The average individual weights of fish produced in all replicates were in excess of 65g, the minimum weight of individual fish sold for TT3.00 each at the Sugar Cane Feed Centre (Floyd Neckles, personal communication).

The suitability of the cascadura as the second species in polyculture with prawns must be noted. Apart from the factors mentioned earlier (it does not compete for available dissolved oxygen and controls the successful breeding of mosquitoes), this fish is not a prolific breeder. There is therefore no need for monosex culture in growout ponds. The seasonally produced floating nest, though camouflaged, is easily noticeable in well managed ponds.

There are synchronization of attainment of market size of the products at harvest and neither of the products effects the other's quality. The hard bony body plates on the fish protect it from damage from snapping prawn chelae, ensuring product quality. The cascadura's small sub-terminal mouth does not allow it to inflict any damage to the prawns by biting, thus ensuring the product quality of the prawn.

The population structure of prawns at harvest dictates, 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 I compares favourably with that of 37.9% for monoculture results (Gabbadon and de Souza 1989), while in Trial II, this percentage (44.2%) is slightly less when compared with monoculture results (49.5%) for the same prawn stocking density. The mean average individual weight of prawns harvested for the stocking density of 50,000 ha^{-1} in the polyculture is higher than that from monoculture trials (Gabbadon and de Souza 1989) and may be related to a lower mean prawn survival.

At 100,000 ha^{-1}, mean survival rates for monoculture and polyculture trials for prawn are almost identical (79.0% and 78.6% respectively) but the mean average individual harvest weight (19.8g) for the polyculture trial is appreciably less than that for the monoculture trial (29.5g). Although overall stocking density in ponds is increased, thereby maximizing the use of pond space, at this stocking density the biomass of prawn and fish may be approaching the carrying capacity of the system which would be a limiting factor to increase in prawn size.

The small males produced in the trials, though averaging 11.4% of the prawn biomass in Trial I and 10.1% in Trial II, accounted for an average of 14.2% of the total number of prawns harvested in Trial I and 29.9% in Trial II. These small males are capable of compensatory growth (Malecha 1977) and when separated from larger males and restocked for growout, shows increased grow rates.

In summary, polyculture is proven to be technically feasible under the conditions described. It can be particularly useful for Trinidad and Tobago where land availability is limited and where the infrastructure for energy inputs, as they apply to more intensive systems is already in place (O.A.S. Sub-regional Project for Aquaculture Development in the Caribbean 1992). It must be noted however that in more intensive systems with increased stocking densities and more inputs of food, more wastes are produced by the animals in the system and stricter management is necessary to ensure success.

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APPENDIX

PRAWN RECIPES

Benefits:

1. Good source of protein
2. Low in saturated fat and calories
3. Excellent source of iron, selenium and vitamins B12, D, and B3
4. Quick and easy to prepare
5. Can be used in a main dish or as an appetizer

Teriyaki Prawn Skewers

Marinade:
1/4 cup soy sauce
1/4 cup sesame oil
1/4 cup rice wine vinegar
1.4 cup peanut oil
1 tablespoon minced garlic
1/2 tablespoon minced fresh red jalapeno chili
2 tablespoons sugar
1 pound (16 to 20 size) gulf prawns, peeled and de-veined
Bamboo skewers
1 bunch scallions, cleaned and cut in 2-inch pieces
2 red bell peppers, medium cut

Whisk marinade ingredients together in a bowl. Place shrimp in a plastic bag with marinade for 1 to 2 hours and refrigerator. Soak bamboo skewers in water for the same amount of time to prevent burning. Using 2 bamboo skewers skewer the prawns alternating with a scallion pieces and pepper pieces so the brochettes will lay flat and be easy to flip over. Grill on each side for 2 to 3 minutes. Serve.

Tandoori Prawns

1/2 cup lemon juice
1 tablespoon finely chopped garlic
2 teaspoons finely chopped ginger
16 jumbo prawns, shelled and de-veined

Whisk together the lemon juice, garlic and ginger. Place prawns in a shallow baking dish and cover with the marinade. Let sit 15 minutes. Drain and pat the prawns dry.

1/2 cup plain yogurt
1/4 cup heavy cream
1/4 cup finely chopped red onion
1 tablespoon crushed garlic
1 teaspoon finely chopped ginger
1 tablespoon lemon juice
1/4 teaspoon ground turmeric
1 teaspoon ancho chili powder
1/2 teaspoon garam masala
1/2 teaspoon white pepper
4 metal or wooden skewers that have been soaked

Mix together all ingredients. Place prawns back in the baking dish and cover with the marinade. Cover with plastic wrap and refrigerate for 1 hour. Thread 4 shrimp on a skewer and grill for 3 to 4 minutes on each side.

Hot Spiced Prawns

3 tablespoons olive oil
3 scallions, cut into 3 pieces each and sliced into strips
2 fat cloves of garlic, peeled and sliced thinly
1 (1/2-inch) piece of ginger, peeled, sliced thinly, and cut into strips
2 1/4 pounds shelled raw shrimp
1/3 cup dry sherry
salt

Warm the oil in a large wide saucepan, and throw in the scallions, garlic and ginger.

Stir everything around vigorously until the onions begin to wilt, and then toss in the prawns, stirring again. Cover the pan and let everything cook for about 5 minutes; then, remove the lid and pour in the sherry. Stir again, and then cover the pan until the prawns are cooked through and no longer glassy in the middle. Taste; add a sprinkling of salt if you need it. Pour into a large shallow bowl, making sure you don't lose all the bits of onion, garlic and ginger, and take immediately to the table.

Broiled Prawns

1/4 cup olive oil
1 teaspoon salt and pepper
2 tablespoons fresh lime juice
1/4 cup fresh orange juice
1 teaspoon fresh chopped garlic
1 pound wild Prawns (16 to 20 or 21 to 25 count works best), peeled and de-veined
Wood or metal skewers

Mix all the ingredients together (except prawns) in a large bowl. Add the prawns and cover. Allow to marinate about 1/2 hour in the refrigerator.

Preheat grill to high and put about 5 to 6 prawns on each skewer. Place the prawn skewers on the grill (using metal tongs works well for this). Let cook about 3 to 4 minutes on each side. Carefully remove the prawns from the skewers and serve as an appetizer or with side dishes for an entree.

NOTES