Intensive Tilapia Farming in Jamaica: A Comparison of Two Systems with Recommendations for Future Development

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ABSTRACT

Commercial tilapia farming developed in the early 1980's as a result of the successful introduction of aquaculture in Jamaica through a United States Agency for International Development/Government of Jamaica Fish Development Project.

In 1983, World Wide Promoters Inc., an Israeli company in a joint venture project with the National Investment Bank of Jamaica, constructed a 22 hectare farm for freshwater prawn, *Macrobrachium rosenbergii*, and tilapia culture utilizing a combination of water exchange and aeration.

In 1984, Jamaica Broilers Limited, with the National Investment Bank of Jamaica (NIBJ) started another company as a pilot project to assess the viability of *Macrobrachium* culture along with commercial production of male tilapia fingerlings through selective breeding. Aeration was the original method of oxygenation but was replaced with high volume water exchange in 1987.

The culture systems have undergone modification with prawn culture being discontinued by both farms and emphasis placed on tilapia. High stocking densities ranging from 5.43 to 2.47 fish/m^3 are being used in the final production phase on both farms. Complete production systems along with processing and export capabilities have been developed by both companies in response to a need for more efficient means of disposal of production which is approximately 1, 000 t/yr.

Increasing costs of major inputs, namely water, electricity and feed have forced ongoing reassessment of culture methods. It appears that a system that is less dependent on electricity with access to large volumes of low cost water is the preferred mode of operation. There are not many such sites available in Jamaica.

KEYWORDS: Aquaculture, Aqualapia, Jamaica, Tilapia.

INTRODUCTION

Aquaculture began on a small scale in Jamaica in the 1950's with a research and breeding program for *Tilapia mossambica*. In 1976, the Government of Jamaica in collaboration with the United States Agency for International Development initiated the Inland Fisheries Development Project. The economic feasibility of commercial tilapia production was demonstrated with more than 55, 000 t of fish being produced by the government between 1976 and 1979.

In 1982, production had reached 32.6 t/yr with 63 commercial farmers utilizing 58 ha of ponds. All farms utilized the semi-intensive method of

production which involved hand-sexing of fingerlings and stocking at densities of 1.5 to 1.7 fish/m^3. Supplemental feeding with a modified chicken ration and water fertilization were the norm. Fish utilized were *Oreochromis niloticus* (silver perch), *Ctenopharyngodon idella* (grass carp) and *Cyprinus carpio* (mirror carp). Fish were sold at the pond bank or at the Twickenham Park market located at the Inland Fisheries Project facility. All fish were sold whole.

In 1983, the Government of Jamaica, through its investment company, the National Investment Bank of Jamaica, embarked on a joint venture project with World Wide Promoters consisting of a number of agricultural companies, including an intensive freshwater fish farm. The technology to be employed was a mixture of Taiwanese and Israeli culture methods and was considered state of the art. A tract of 157 ha of land was leased from the Commissioner of Lands in the Parish of Clarendon for this purpose under a 49-year lease through their company, Jamaican Aqualapia Limited (JAL), which had a share structure of 60% for NIBJ and 40% for WWP.

While this project was being developed, the Jamaica Broilers Group of Companies saw a niche for freshwater prawn farming and commenced investigations into suitable sites and technology to be employed. A site consisting of 202 ha in close proximity to the Black River in the parish of St. Elizabeth was identified. This was acquired under a similar lease by a new company, Aquaculture Jamaica Limited (AJL), having as partners NIBJ with 25% of the share and JBL with 75%. Both tracts of land belong to the Government of Jamaica and can only be leased. These leases, however, allow the lessees the capability of obtaining financial assistance from lending institutions.

WATER SOURCES

AJL receives water from the Black River which has an average daily flow of 12, 670 liters per second. They do not pay a rate for abstraction as the area does not fall under the ambit of any irrigation system. Water is shunted via canal by gravity to the ponds.

Water for processing and office use is taken from the canal system, filtered, chlorinated, and pumped into storage tanks. A potential source of pollution is from nearby sugar factory and distillery.

AJL, even though situated beside a river, does not get its main supply from it, but depends on water provided by the Irrigation Authority in that area. The company has a contract for 1, 077 m^3 hr^{-1} d^{-1}, but only receives 562 m^3. This water comes from a deep well which uses electrically driven pumps and is expensive. The current rate is $US 27.70/$m^3$. Additional water is received from a small well located on the property and is used for hatchery, processing and office operations. Water is taken from the river when available and required,

then pumped into the pipeline servicing the lower half of the farm. This is available for approximately four to six months of the year.

PRODUCTION SYSTEMS

JAL introduced the red tilapia into Jamaica by bringing stock from Israel and the United States. Broodstock, *Macrobrachium rosenbergii* and mirror carp were also introduced. Red tilapia hybrids from Panama, along with *Colossoma macropomum*, were imported a few years later. AJL purchased *Macrobrachium rosenbergii* stock and certified purebred *Tilapia aurea* and *Tilapia nilotica* broodstock from Israel. When the tilapia species were crossbred, mainly male offspring resulted. Tilapia production, however, was to be a minor part of operations. Red tilapia hybrids were bought afterwards as farmers and consumers demanded it over silver colored tilapia.

JAL commenced operations with a hatchery and two phases of ponds totalling 22.7 ha producing both tilapia and *Machrobrachium*. Aeration with electrically powered paddlewheel aerators in heavily stocked ponds ensured adequate oxygenation. Electrical lines were run along pond dykes in the first three phases of ponds at JAL to accommodate aerators. This proved to be both expensive to install and maintain as wires would get damaged due to frequent voltage fluctuations. A standby generating system was also installed with a capacity of 450 kva as power outages are an everyday occurrence. Not only would fish in the intensive ponds be affected, but fry in the hatchery. Only the ponds in the pilot project at AJL were wired similarly, with the rest of the farm having only security lighting.

The hatchery was constructed with a capacity for holding one million fry per cycle for sex reversal. Brood and nursery ponds were established along with a number of small ponds for holding carp and other species. All ponds received water through a pipeline directly connected to a well. Prawns were hatched on the farm and polycultured system with tilapia and carp. This practice was discontinued in 1985 as it was found that there were problems at harvest with prawns being difficult to predict. Stocking densities varied as the farm experimented with finding optimal densities for each stage of growth.

AJL started with 18 ha of ponds, all of which were designed for prawn culture with shallower basins and gentler slopes than typical tilapia ponds. Aspirator type aerators, and daily flushing of the bottom water were utilized to increase oxygenation and circulation. The lower strata of the water column was flushed from the pond daily.

Fish were not stocked with prawns at the beginning. In this system, postlarvae prawns were stocked at 9.88/m^2 and grown for six months to an average size of 30 to 47 g. Average survival ranged from 55 to 60% with yields of approximately 1,572 kg/ha for each crop. Stocking rates were not adjusted

with the introduction of tilapia into the system. Prawns were stocked at the same density, but 0.494 tilapia/m^2 were added for plankton control.

In 1988, AJL decided to concentrate on red tilapia production as the returns on investment were far below expectations, and tilapia provides steady cash flow. JAL continued with both types of tilapia along with the carp and *Colossoma* as a localized market existed, and the silver tilapia could also be used for processing into skin-off filets.

The stocking regimes which evolved for tilapia on both farms after prawn culture was discontinued is summarized in Table 1. Brood fish are stocked at a ratio of three females to one male on both farms. After continuous cropping of fry for approximately 25 to 30 days, the fish are harvested and restocked or rested. There are always resting, current and young broodstock on each farm.

Table 1. Stocking densities, duration, and percent survival for tilapia for each farm.

	AJL			JAL		
	Density per m^2	Days per m^2	Survival (%)	Density (%)	Days	Survival
Brood	9.88	30	100	9.88	30	100
Hatchery	3.75*	30	60-70	4.00*	30	70
Nursery 1	44.46	60	70	19.76	60	70
Nursery 2	22.23	60	80	5.928	60	75
Nursery 3	ND	ND	ND	4.94	60	80
Production 1	13.1	150	85	19.76	80	90
Production 2	5.56	150	95	14.82	80	90

ND - not done
* - per liter

AJL employs sex reversal in cages in ponds to supplement hatchery output and JAL in raceway type tanks when there is an oversupply of fry. The nursery systems differ in density and crop duration as a third nursery stage is used by JAL (Table 1).

In the production phases, fish are harvested according to end use. Fish from production first phase average 170 g for AJL and 220 g for JAL.

AJL stocks these directly into second phase ponds, but JAL sells the larger fish live at the pond bank and restocks those below 200 g. Fish to be sold whole by AJL are culled from second phase harvests at 280 to 350 g. The largest fish are used for fileting and average 400 to 450 g. JAL uses fish of 350 to 400 g for this purpose.

The production ponds differ in size with the intensive ponds at JAL being 0.10 to 0.20 ha and 0.40 to 0.80 ha at AJL. Each intensive pond at JAL is equipped with two to three aerators and water for flushing up to ten percent of volume per day. The AJL system has water flowing directly from the canal providing up to 30 percent exchange per day, thereby negating the need for artificial aeration.

Production increased rapidly at JAL as succeeding phases of ponds were put into operation and by 1987, all four phases were in production, increasing farm size to 46 ha of ponds. Each year saw an increase in production up to 1987 and then decline up to 1990 for JAL. AJL however, has experienced a continuous increase up to the same period, except for 1989, when operations were disrupted

Table 2. Annual production (kg) for prawns and tilapia for each farm.

	JAL		AJL	
Year	**Tilapia (t)**	**Prawns (t)**	**Tilapia (t)**	**Prawns (t)**
1984	109,177	1,413	ND	ND
1985	214,025	541	ND	15,355
1986	456,057	ND	16,426	15,500
1987	643,927	ND	150,000	8,471
1988	462,657	ND	386,622	13,636
1989	440,454	ND	330,189	ND
1990	413,980	ND	653,387	ND

ND - not done

due to construction activities. A significant jump in yields resulted in 1990 when 21.5 ha of new ponds with the full-flow through system were put in operation bringing the total to 46 ha. Table 2 summarizes annual production of both companies.

FEED

The high fish densities in JAL ponds necessitated improvements of the local feed. After agreeing on possible formulations, Master Blend Feeds Limited, the largest feed manufacturer, commenced making a ration containing 30 to 32 percent protein. The regular supplementary feed with 26 to 28% protein was still available to other farmers. Requirements for JAL at peak production was 30 t/wk.

When AJL instituted their tilapia system in 1987, they also requested modifications to be made. These included lowering the corn content, increasing water stability, and inclusion of a vitamin premix. By 1988, both companies

agreed that the inclusion of fishmeal was necessary to improve growth rate, but as this was an expensive item, the amount included would have to be enough to show some improvement without significantly increasing the unit price. Since 1983, the price of these special feeds has moved from J$ 1, 240/t in 1983 to J$ 4, 680/t in 1991 (US$ 1.00=J$ 18.30). Between the two companies in 1990, feed purchases were averaging 75 t/wk., which was approximately 60% of the total fish feed manufactured by the company.

PROCESSING AND MARKETING

Both companies recognized the need to have processing and freezing capabilities if the marketplace was to fully exploited. In 1885, JAL started providing processed fish locally before a proper plant was constructed. They installed a cold room and a carbon dioxide tunnel blast freezer capable of freezing 1,820 kg or chilling 21,800 kg of product.

Fish was processed manually, chilled to 0•C, packed in either bulk 18 or 22.7 kg boxes or, in the case of fillets, in one kg plastic bags packed in 11 kg boxes. The processing remains were all burned in the beginning. With the development of the overseas market, stricter controls had to be put in place, especially in the area of sanitation.

The plant consisted of eight tables capable of holding ten workers each. These included sorters, washers and packers. At peak, 900 kg *filet* and 2500 kg of fish could be gutted and scaled each day. For the years 1987 and 1990, 50 and 69% of the production were processed, respectively. The plant was not air conditioned, but an had an exhaust fan. Water was supplied directly to the plant from the well on the farm.

A small plant was built at AJL, but has been upgraded several times. It started out as a grading and packing plant for prawns, which were sold in 2.27-kg boxes. With the introduction of tilapia, the plant had to be remodelled for increased cold storage. With increased production and foreign sales, the need for further expansion arose, and in 1990, a new plant was commissioned with automated equipment modified to deal with the demands of tilapia processing. The plant is currently only 50% utilized. At full production, 6,800 kg of *filet* and 7,500 kg of fish can be gutted and scaled per week. AJL plans to utilize the plant fully by developing a contract farmer program similar to one currently used by their parent company, JBL.

AJL tried unsuccessfully to export prawns due mainly to the uncertainty of predicting yields and with problems with freezing to maintain high quality.

Unfamiliarity of the target markets with the head-on product also proved to be a deterrent. Much promotional work had to be done to gain local acceptance as marine shrimp was the preferred item in the target upscale market.

The pattern of tilapia sales differed from JAL's with emphasis being placed on local sales at first. With interest being expressed by overseas buyers, small

shipments were made to Canada and the United Kingdom. JBL decided to utilize its overseas company to assist with the logistics of delivering quality product and collecting payments. This has assisted the company in maintaining close contact with consumers and changing trends in the marketplace. By the end of 1990, AJL was exporting 40% of its production. Plans are to export 60%/yr. The European market has been targeted; fish *filet* is currently being supplied to Switzerland and France and gutted fish to England.

Additionally, the local market gets product on a consistent basis through a delivery service and outlets at the farm and at the corporate offices in Kingston. No fish is sold unprocessed. Otherwise, JAL encouraged live sales at the farm and has storage areas (live tanks) constructed for this. Live sales at JAL averaged 3, 640 kg/wk during 1988 and 1989, but in 1990 dropped to 2, 270 kg. In an effort to better utilize product, fish heads were offered at a low price to encourage sales. Demand rapidly increased, as it was seen as a substitute for other low cost protein sources, such as chicken necks and backs. This reduced the quantity of burned waste and provided employment for vendors. AJL has gone further by processing the offal into dog food.

REVENUE AND COST ANALYSIS

Both farms sell their product lines at similar prices. AJL, because of automation and freezing capacity, has more product lines, but JAL utilizes more species. With nearly all of AJL's production being processed, the value-added benefits can be seen in the revenue earned when compared with JAL, which processes a much lower percentage of production. For 1990, total revenue from fish sales was US$900,810 and US$ 1.68 million for JAL and AJL, respectively.

A number of cost centers will be examined to show how some costs varied because of the differences in the systems. The cost of water will be seen as a significant item in JAL's accounts, and improvement in the water supply from the irrigation authority would have resulted in significant increases in cost. For the full benefit of increased water supply to be realized, alteration of the intensive ponds would be required, as these had accumulated mounds of debris, including soil from erosion of the pond sides and uneaten feed.

Security was a major expense for both companies, as theft from ponds was a constant and significant problem. In JAL's case, it is difficult to separate between loss due to stealing and predation.

In Table 3, a summary of major costs is presented for a four month period which is considered to be representative of annual trends.

RECOMMENDATIONS FOR FUTURE DEVELOPMENT

Developing countries that spend large portions of their budgets importing fuel would be ill-advised to promote intensive aquaculture operations that depend on high energy inputs. In Jamaica's case, each successive devaluation of

Table 3. Comparitive costs for each farm for 1990.

ITEM	AJL US$, in thousands	JAL US$, in thousands
Feed	37.938	42.820
Water	0	4.707
Electricity	4.312	12.896
Security	11.048	12.916
Processing	158.394	23.112
Marketing	22.523	5.045
Salaries/Wages	8.500	10.334
Administration	34.514	27.247
TOTAL	296,940	139,077

its currency has increased electricity charges, and the cost of feed consisting of imported raw ingredients, chemicals and equipment. Recovery of these costs by increasing product prices is difficult as consumer purchasing power erodes.

Dependence on imported equipment also has its drawbacks. Maintaining aerators at JAL has proven to be time consuming and expensive. Spare parts have to be imported from the country of origin, which could be Israel, Taiwan or Italy, resulting in long delays. As a result, an inventory of approximately 33% more than the number in use was necessary for operations to run smoothly. This is a significant capital outlay when one considers that one aerator can cost from US$ 300 to US 1, 200.

The purpose of intensification is to maximize yield per unit area when certain resources are at a premium. Availability of land, water, electricity and feed are the major items which will determine the intensity of an operation. In countries where land is not expensive and large tracts with suitable terrain are available, it would be better to capitalize on this, especially if pond construction costs are reasonably inexpensive. Purchase of expensive land for aquaculture necessitates some degree of intensification if adequate returns on investment are realized. Demand for land is increasing, so pressure will be put on optimizing yield.

Regardless of the preferred culture method, water availability will determine to some extent what system will be employed. As countries develop, more of their untapped resources are brought under state control, and it will become increasingly difficult for prospective farmers to utilize them at no charge. New sources of water are continuously being harnessed for domestic, hydroelectric and agricultural uses leaving less unpolluted bodies available. Systems which depend on large volumes of water, such as AJL's, will be hard to

duplicate. If such a site is found, the savings in terms of water cost and non-dependence on electricity would significantly improve the profitability of an intensive operation. An additional benefit would be a gravity-fed water supply rather than pumping.

With intensification, feed quality becomes of utmost importance, and if an adequate ration cannot be manufactured economically, the project will have a difficult time operating at optimum feed conversion levels. This is perhaps the most important criterion which can be used to judge a company's production performance. In mid 1990, the fish vitamin premix and vitamin C was excluded from AJL's ration, resulting in mortalities occurring in the most densely stocked ponds within one week and resulted in a reduction in growth over a one month period of approximately 15%. Unfortunately, most farms are too small to manufacture their own feed economically, or the ingredients may not be available to them. If only substandard feed is available, it is best to operate on a semi-intensive level as natural foods will augment commercial feeds.

As a developing country, Jamaica's future is closely linked to changes in the industrialized countries, especially North America. Development in aquaculture, therefore, should be on a path of sustained production utilizing appropriate technology which takes into consideration the sensitive variables that determine success or failure. Dependence on imports to sustain a business is precarious, as its fate does not rest with the management, but on external forces. Aquaculture development is hampered by high interest rates and cannot afford the additional burden of a rapidly devaluing dollar.

Aquaculture development should therefore utilize local resources as much as possible and limit expensive technology only as required. Utilizing land, water, and local feed ingredients can improve chances of a sustained industry as farmers gain more control of the systems they develop.

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