

BOBP/WP/92



Cage nursery rearing of shrimp and prawn fry in Bangladesh



BAY OF BENGAL PROGRAMME
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Cage nursery rearing of shrimp and prawn fry in Bangladesh

by

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The shrimp culture industry of Bangladesh depends on catches of the wild fry of tiger shrimp. Employment as fry-catchers has been generated for thousands of rural poor. But the marketing system is not well developed and high fry mortality occurs due to poor handling. The growing freshwater prawn farming sector, however, continues to demand increasing quantities of large juveniles.

This report, based on field trials from 1990 to 1993, describes the results of cage nursery culture trials with both tiger shrimp (*Penaeus monodon*) and giant freshwater prawn (*Macrobrachium rosenbergii*) fry. It was thought that fry-catchers would be able to increase their earnings through sales of nursed post-larvae and juveniles. The survival of nursed post-larvae in the distribution system would also be increased. However, it is unlikely that tiger shrimp fry nursing can be made profitable. On the other hand, cage culture of a combination of hatchery-reared post-larvae and wild-caught fry of the freshwater prawn would be profitable.

An NGO played an important role in the subproject by implementing technical trials and organizing and supporting participating fisherfolk groups.

The Bay of Bengal Programme (BOBP) is a multiagency regional fisheries programme which covers seven countries around the Bay of Bengal – Bangladesh, India, Indonesia, Malaysia, Maldives, Sri Lanka and Thailand. The programme plays a catalytic and consultative role: it develops, demonstrates and promotes new technologies, methodologies and ideas to help improve the conditions of small-scale fisherfolk communities in member countries. The BOBP is sponsored by the governments of Denmark, Sweden and the United Kingdom, and also by UNDP (United Nations Development Programme). The main executing agency is the FAO (Food and Agriculture Organization of the United Nations).

This document is a technical working paper and has not been cleared by the Government concerned or the FAO.

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1. INTRODUCTION

Asia is the principal producer of cultured penaeid shrimp, accounting for 81 per cent of the total world production of about 600,000 t. Thailand is the largest exporter, at 150,000 tin 1992, followed by China, Indonesia, India, Viet Nam, Taiwan, the Philippines and Bangladesh (see table below).

Asian penaeid shrimp culture production, 1992

	Heads-on production		Area in production (ha)	Productivity (kg/ha)	No. offarms
	(%)	(t)			
Thailand	25.4	150000	60,000	2,500	14,000
China	23.7	140,000	150,000	933	3,000
Indonesia	22.0	130,000	200,000	650	15,000
India	7.6	45,000	70,000	643	1,500
Viet Nam	5.9	35,000	200,000	175	1,000
Taiwan	5.1	30,000	5,000	6,000	2,500
Philippines	4.2	25,000	40,000	625	3,000
Bangladesh	4.2	25,000	120,000	208	6,000
Malaysia	0.6	3,500	2,500	1,400	350
Japan	0.5	3,000	400	7,500	150
Others	0.8	5,000	8,300	602	440
	100.0	591,500	856,200		46,940

Source: Rosenberty, 1992

The tiger shrimp (*Penaeus monodon*) dominates Asian shrimp culture production because of its fast growth and adaptability to the pond environment and artificial feed. Culture technology has developed rapidly over the past decade-and-a-half and, in those countries with open economies, shrimp culture production has expanded at a tremendous rate. For example, Thailand's output of tiger shrimp went from 110 tin 1985 to 150,000 tin 1992. Indonesian production has grown similarly, from 12,000 t in 1985 to 130,000 t in 1992 (Rosenberry, 1992).

Although about 108,000 ha are devoted to shrimp culture in Bangladesh, the yield is only of the order 200 kg/ha (Anon 1993). The culture is mainly 'extensive', which accounts for the low productivity. There are many reasons for this situation:

- Government land policy;
- Shortage of investment funds;
- Antiquated investment policies; and
- Poor access to modern technology.

Intensification of culture in existing farms and construction of many new farms are increasing the demand for post-larvae (PL). But the hatchery industry is still in its infancy in Bangladesh. This means the pressure on natural sources will grow dramatically in the next few years. Shortages are already occurring, as evidenced by rising prices. A significant amount of seed is imported into Bangladesh from West Bengal, India.

There is, at the same time, substantial waste in the seed-collecting and distribution system. High mortality occurs from the time the tiger shrimp seed is landed till it reaches the farmer. Raj and Hall (1993) estimated that mortality all the way up the market chain is 20-30 per cent in West Bengal. On top of this, there is the mortality due to the primitive pond and water management practices of the farmers. Although definitive studies are yet to be made, it is likely that mortality from landing to harvest is 65 per cent or more.

Management practices vary widely. Most operations are 'extensive' and have a stocking rate of 5000-15,000 PL/ha. If the higher rate is taken as maximum, the total demand would be 1.8 billion PL. As farming intensifies, severe pressure will be put on natural sources. Stocking densities in semi-intensive farms range from 50,000 to 100,000 PL/ha. Intensive operations may require 300,000/ha. Very few intensive farms are likely to be established in Bangladesh because high investment is needed, operating costs are substantial and risks due to diseases are considerable. But even the present demand has not led to hatchery development on a large scale in Bangladesh. Such development as there has been, has been very slow and is likely to remain so. Suitable sites are largely restricted to the southeast coast, where infrastructure is poorly developed. One commercial hatchery has been established at Kalitali, Cox's Bazar, but is not yet in full production. Shrimp farming will, therefore, continue to depend on wild fry for the foreseeable future. And the shrimp seed collectors will remain the first and crucial step in the wild fry supply chain.

2. SHRIMP SEED-COLLECTORS

The concentration of shrimp farming in the country reflects the areawise distribution of shrimp fry-collection (see table alongside). Chittagong and Khulna are the main districts. The fry-collectors working the sea beach of Cox's Bazar have become major suppliers to the industry. The shrimp fry-collectors are predominantly landless peasants, illiterate and with few employment alternatives. Women and children are much involved in seed-collection and, in some areas, are numerically dominant.

Penaeid shrimp culture production by district in Bangladesh (1990-91)

District	Area under culture (ha)	Estimated promotion (t)
Khulna	79,728	15,951
Chittagong	27,453	3,323
Jessore	690	138
Patuakhali	326	65
Noakhali	61	7
Barisal	22	5
Total	1,08280	19,489

Source: Anon., 1993



Catching tiger shrimp fry Cox's Bazar beach

The Bay of Bengal Programme (BOBP) initiated the first study of shrimp fry-catchers in Satkhira (Larsson, 1986). This study estimated that there were 25,000 fry-catchers in the Satkhira District alone! A follow-up study was conducted by UBINIG, an NGO (Anon, 1987). Sites in the southwestern (Satkhira/Khulna) and southeastern (Cox's Bazar/Chakaria) regions of the country

were included. In the UBINIG study, seven villages were surveyed; three in Cox's Bazar and four in the Satkhira/Khulna area. In the Cox's Bazar villages, 75 families were interviewed. Seventyone per cent of them depended on fry-catching, but social conventions restricted the activities of the women. Although some women were catching fry, most of them sorted the fry. Such work is very laborious, but is an essential part of fry-catching.

Only 30 families could be interviewed in Satkhira/Khulna. The study revealed that shrimp fry-collection was the major occupation in the area. Women were much more involved in actual fry-collection here, than in Cox's Bazar, because of differences in social convention. Female-headed households were common in the area. Polygamy is widespread and, usually, the first wife is abandoned. These women depend solely on fry-catching as their source of income.

Other aspects of the study revealed the high rate of illiteracy, especially among women. As would be expected, basic sanitary, educational and service amenities are also lacking.

3. TECHNOLOGICAL ALTERNATIVES

Coastal aquaculture in Bangladesh has become synonymous with shrimp culture. Unlike in some of the Southeast Asian countries, the commercial development of species other than tiger shrimp is nonexistent. Domestic markets for molluscs are extremely limited and are insufficient stimuli for investor interest.

What, then, were the alternatives available to BOBP's target group, the fisherfolk? As previous studies indicated, fry-catchers are an important link in the shrimp culture industry. Yet they are, landless, have very low incomes and extremely limited access to land resources. This economic and social condition effectively eliminates them from involvement in the grow-out side of shrimp farming.

Technical and market factors led to the selection of shrimp fry nursing as a suitable economic activity for fry-collectors. Such nurseries are widespread in the Philippines and Indonesia. Considerable experience has been amassed in their operation. Nurseries offer several benefits when incorporated into farming systems:

Sufficient quantities of fry can be accumulated at one site to reduce marketing costs.

- Survival in the grow-out system is increased, because nursed PL are larger and stronger.
- Mortality of weak PL is also absorbed in the nursery.
- Where hatcheries exist, early PL can be held in nurseries, resulting in faster turnover for both the hatchery and nursery operators.

Nurseries may be land-based, in ponds, or floating cages may be used. The latter is more applicable to BOBP's target group.

The basic cage design has been described by Nielsen and Hall (1993) as follows: it consists of a frame of four narrow bamboo platforms. The sides are 0.45 x 6.00 m and the end pieces 0.45 x 3.00 m. These are tied together by rope to form a rectangular frame with inside dimensions of 2 x 5 m. Four to six 100-litre plastic barrels are attached under the raft as floats (see picture alongside). Two nylon *happas* (net cages) of 1 mm mesh size measuring 2 x 1 x 1 m and one *happa* of 2 mm mesh size with dimensions 3 x 2 x 1 m are hung from inside the frame. Galvanized wire frames are used to maintain their shape during flood and ebb tides. The design is based on that of De La Pesa *et al.* (1985).



Assembling nursery cage frames, Mognamapara.

Feed consists of a paste made of low-value shrimp and fish caught by the fry-catchers. The paste is spread on a feeding tray made of plastic mosquito screen sewn to a wire frame (see picture alongside). The paste is allowed to sun dry for a few hours, after which it is suspended in the cage. A small tin, holding 200 g, is used to measure and control the amount of feed.

Stocking rates, being dependent on the availability of post-larvae, varied widely during the BOBP field trials. The target was 10,000 PL/cage, but ranged from less than 200 to somewhat more than the target.



Feeding frame

4. PARTICIPATORY FIELD TRIALS

The Chokaria region is one of the major shrimp culture regions in Bangladesh. There are about 3400 ha of brackishwater farms and 5600 ha of salt beds which may be alternated with shrimp culture during the rainy season (Pramanik *et al.*, 1990).

The village of Mognamapara, on the banks of the Matamuhari River, is centrally located in the Chokaria shrimp culture area (see Figure 1). Fry-catching is an important occupation in the village (Anon., 1987) and fry-catchers have easy access to buyers.

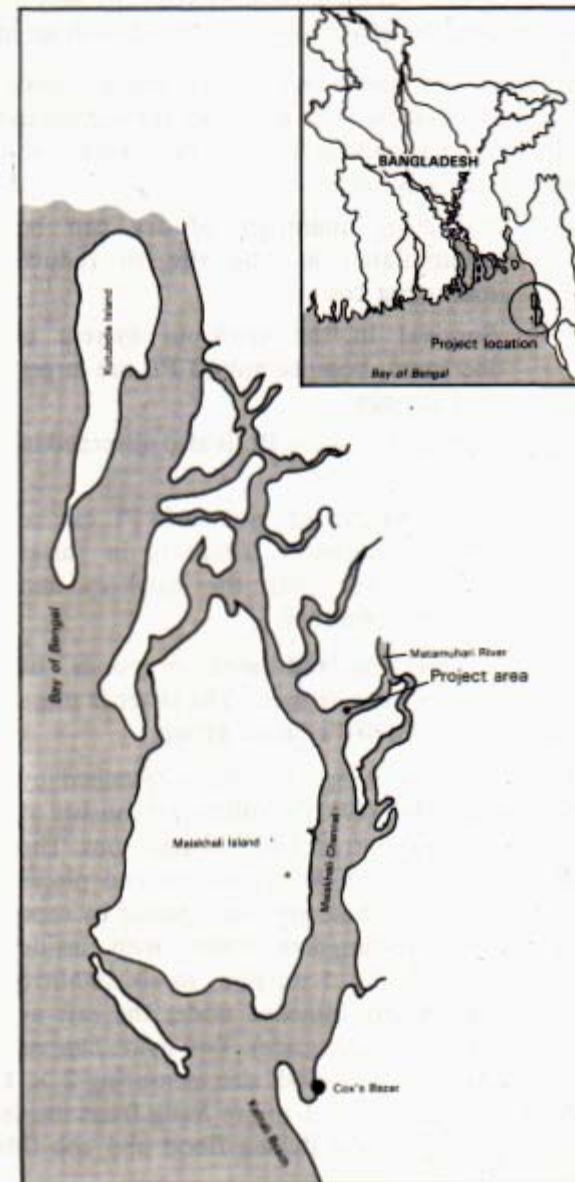
Fig. 1. Mognamapara, Matamuhari River, Cox's Bazar

The tidal channel of the Matamuhari River is sheltered, with moderate currents. The area fronting the village appeared to be a suitable site for anchoring nursery cages for the field trials.

Field trials may be implemented either through existing institutions or by the ultimate beneficiaries; departments of fisheries and research institutions are included in the former. But there are several advantages to the latter approach:

- The fisherfolk are exposed to new ideas;
- They learn the techniques of organizing and working together;
- They are able to evaluate the appropriateness of the technology to their situation;
- Feedback from them often leads to improvements in the technology.

An organizational framework, through which the trials are implemented, must be established at the village level. Government extension staff is usually limited in availability, training and commitment at the village level. Nongovernmental organizations (NGO's) often possess the skills and motivation necessary to be effective in rural communities.



UBINIG became interested in assisting the fry-catcher communities it had studied during the baseline survey. The organization had hitherto been primarily involved in policy studies, but it was anxious to become active in community development. UBINIG is an incorporated body, not a traditionally organized NGO. It has staff and financial resources enabling them to successfully implement field trials.

UBINIG undertook two functions within the framework of the BOBP-sponsored cage nursery culture subproject:

- Identifying and organizing the participants; and
- Training them in cage culture technology.

Because of the strong commitment of the organization to people's welfare, it undertook a wide variety of additional developmental activities using its own resources. It placed a four-person team in Mognamapara and initiated mangrove replanting, primary education, a women's literacy programme, savings schemes, fruit tree planting and other supporting activities. While not directly related to cage nursery culture, these activities helped to consolidate the participants' groups, as well as bring direct, tangible benefits to the fry-catchers' communities.

5. CAGE NURSERY CULTURE

The cage nursery culture trials were undertaken over a period of three years. Outcomes of these were considered from both technical and community participation aspects. Culture trials for both tiger shrimp fry and freshwater prawn fry were undertaken during the 1990/91 and 1991/92 seasons, while only tiger shrimp fry nursing was attempted during the 1992/93 season. Tiger shrimp fry nursing was implemented at Mognamapara, Cox's Bazar, and the freshwater prawn fry nursery trials were sited in Potiya, by the Chandkhali River, near Chittagong.

5.1 Tiger shrimp fry nursing

Trials were conducted very early in the 1990/91 season (see table below). A total of 35,600 fry were stocked, of which only 948 survived. The results for 1991 were equally discouraging. Fry were very scarce in the Matamuhari River and cages could be stocked only in February and April. A severe cyclone destroyed the rafts and cages at the end of April.

Tiger shrimp fry nursing, 1990-1993

Month	Fry stocked (no.)	Cost/100 (Tk)	Total fry cost (Tk)	Feed cost (Tk)	Rearing time (days)	Survival (%)	Fry sold (no.)	Price/100 (Tk)	Gross revenue (Tk)	Net revenue (Tk)
1990										
August	13,700	10	1,370		1	0				
September	13,300	10	1,330	80	18	7.1	948	30	284	-1126
October	8,600	10	860	40	4	0				
1991										
February	3,959	19	752	75	15	6.6	260	40	104	.723
April	21,000	10	2,100	210		Destroyed by cyclone				
1992										
February	367	20	73	31	15	59.4	.218	50	109	5
March	12,031	18	2,166	105	21	61.0	7,339	50	3,669	1399
April	5,490	18	988	84	21	63.0	3,459	50	1,729	657
1993										
March	14,621	20	2,924	50	5	72.7	10,629	30	3,189	215
April	52,210	21.5	11,225	200	20	51.6	26,940	30	8,082	.3343
May	56,464	20	11,293	210	21	19.4	10,954	26.5	2,903	-8600

US \$ = Taka 35 appx.

Fry availability improved somewhat during the latter part of the 1991/92 season, allowing trials to be undertaken in February, March and April of 1992. The results were much better than in the earlier trials. Of a total of 17,888 fry stocked, 11,016 were harvested and sold. The overall survival was 61 per cent. All the trials realized a positive, net revenue, albeit very small. The selling price rose to unprecedented heights due to high demand and poor catches.

Eight trials were made during the 1993 season. Fry were extremely scarce in the Matamuhari River and had to be purchased from dealers on the Bay of Bengal shore to allow completion of the technical trials.

Rearing protocols were modified with the incorporation of a transitional nursery pond in the intertidal zone. The participants suggested that such a pond would improve survival by allowing the fry to gain strength before being exposed to the strong tidal currents of the river.

The pond was excavated to a depth of 2 m at low tide and made large enough to accommodate two nursery cage rafts. The nursery cages were floated inside the pond and water exchanged on each tidal cycle (see picture below).



Installing nursery cages in transition pond, Mognamapara

Fry were maintained in the transition pond for 3 to 5 days. On two occasions, fry were sold directly from the pond, but normally fry were transferred to open water cages for a further 4 to 9 days.

The feeding method was identical to that used in West Bengal, as described by Nielsen and Hall (1993). The results indicate the effectiveness of the transition pond (see table below).

Results of cage nursery culture trials at Mognamapara, 1993

Trial No.	Week	Fry stocked (no.)	Cost/100 (Tk)	Total cost (Tk)	Rearing time (days)	Yield (Tk)	Survival (%)	Fry stocked (no.)	Rearing time (days)	Yield (Tk)	Cost/1000 (Tk)	Selling price/1000 (Tk)	Gross price/1000 (Tk)	Gross income (Tk)	Survival (%)	
1	12	14,621	200	2,925	5	10,650	72.8	Sold directly from transition pond			300	3195	271			
2	14	6,482	230	1,491	5	5,993	92.5									
3	14	5,625	230	1,294	5	3,625	64.4	19,770	9	11,373	—	270	3071	-2049	57.5	
4	16	75,29	230	1,732	4	6,205	82.4	6,205	4	3,863	—	300	1159	-573	62.3	
5	16	11,073	230	2,547	3	9,809	88.6	9,809	4	6,821	—	300	2046	.500	69.5	
6	16	Stocked directly in open water cages							11,349	5	4,856	230	300	1457	-1153	42.8
7	18	35,810	200	7,162	12	5,389	15.0	Sold directly from transition pond			300	1617	-5545			
8	20	20,654	200	4131	4	14,334	69.4	14,334	4	5,591		300	4300	169	39.0	

The low survival in trial no. 7 was due to sudden heavy rain which lowered the salinity too rapidly for the fry to adjust.

5.2 Freshwater prawn fry nursing

Juveniles of freshwater prawns are supplied to farmers during September and October as they become available in the wild. Hatchery production starts in early May, which enables nursery cage culturists to supply juveniles to farmers from June through October.

The first trials were implemented in 1990 (see table below).

Freshwater prawn fry nursing, 1990-92

Month	Fry stocked (no.)	cost/100 (Tk)	Total fry cost (Tk)	Feed cost (Tk)	Rearing time (days)	Survival (%)	Fry sold (no.)	Price/100 (Tk)	Gross revenue (Tk)	Net revenue (Tk)
1990										
October*	3,200	40	1,280	189	63	27.8	890	40	356	-1113
November**	2,400	40	960	210	42	83.3	1,999	50	1,000	.170
1991										
June*	2,207	40	882.8	200	56	37.2	821	100	821	-262
July*	5,000	40	2,000	280	35	44.0	2,200	105	2,310	30
August*	6,000	40	2,400	224	28	43.7	2,622	80	2,098	-526
September**	3,620	50	1810	350	35	66.5	2,407	20	2,889	729
1992										
September*	8,000	40	3,200	175	35	53.5	4,280	75	3,210	-165
September**	5,030	50	2,515	84	14	86.5	4,351	170	7,397	4798
October**	21,560	50	10,780	315	21	83.5	8,003	160	28,804	17,709

*Hatchery

** Wild

Survival of wild fry (picture below left) was much higher than hatchery fry (picture below right), but a loss was sustained in November due to the low price obtained for juveniles. Hatchery fry had poor survival in 1991, while the cages stocked with wild fry in September showed a slight positive net revenue. Prices were much higher due to the larger size of the product.



Brush pile fishery for wild freshwater prawn fry, Chandkhali River



Hatchery produced freshwater prawn fry, Potiya

The last trials were undertaken in 1992. The results from nursing wild fry were very encouraging, showing substantial increases in net revenue. Hatchery fry continued their poor performance, while survival of wild fry was over 80 per cent. The probable cause of high hatchery fry mortality was overstocking and inadequate sorting.

6. *MARKETING*

Mognamapara is located in the midst of one of the major shrimp farming areas of the country. Sales of tiger shrimp fry were made to local subagents or directly to farmers. The main marketing constraint was low fry availability.

The marketing chain for freshwater prawn fry in the Chittagong District is straightforward: from the catcher, through brokers, middlemen or fish vendors to the farmer, and sometimes directly from catchers to farmers in the vicinity of the cages. Middlemen advance subsistence loans, *dadan*, to fry-catchers.

Nursery cage stocking and marketing were affected by the participants' indebtedness. Fry-catchers are indebted to middlemen by accepting *dadan*; they are, as a consequence, obligated to sell any marketable prawn fry they catch to their creditors. However, a significant proportion of their catch,

which has to be sold immediately, could be nursed to a larger, more valuable size. Nursery cage culture expands marketing opportunities in two ways:

- Undersized fry caught in August and September can be held until marketable size is reached.
- Hatchery PLs can be stocked and reared to marketable size. In fact, they can be nursed until the optimum size is reached.

Excepting in 1990, prices for nursed juveniles ranged from Tk 800 to 1600, as demand increased markedly due to the growing popularity of prawn farming. Prices did not differ between direct sales to farmers and to sales to *aratdars* (Angell 1990).

7. FINANCIAL ANALYSIS

7.1 Tiger shrimp nursing

The 1990 and 1991 trials at Mognamapara were very preliminary. Rearing protocols still had to be worked out. Consequently, survival was very low. Furthermore, the cyclone of April 1991, completely destroyed the cages. The last two years were more representative of the results to be expected.

A production unit is considered to be one raft and its cages and the investment cost are summarized in the table alongside. The transition pond cost TK 9000 to construct, but can be shared among 15 participants; the transition pond holds five rafts, each carrying three cages. The cages can be stocked at high density during the brief transition period.

Investment costs of a cage nursery unit

Material	Cost (Tk)	Depreciation (yrs)	Annual depreciation (Tk)
Bamboo	1500	2	750
Floats, 100 l	2400	25	480
Rope, 10mm	180	2	90
Rope, 5mm	85	2	42.5
GI wire	20	2	10
Iron rod	50	2	25
Iron rod frame	800	2	400
Bamboo transport cost	125	2	62.5
Drum & iron frame transport cost	400	2	200
Labour	240	2	120
Nursery pond construction*	600	10	60
Miscellaneous (road taxes etc.)	200	2	100
Plastic net for cages	2200	3	733
	8800		3073

* Nursery pond not required for freshwater prawn nursery.

Experience indicates that a family could collect enough fry to stock 30,000 during the course of a season. The base case, therefore, assumes an annual stocking rate of 30,000 fry, 60 per cent survival and a selling price of 400 Tk/1000. The revenue is thus Tk 7,200. The stocking cost of fry was 200 Tk/1000, *i.e.* Tk 6000 in total. The feed cost was estimated at 4.8 Tk/1000 fry, totalling Tk 145. The margin between revenue and the operating costs is too low to cover the investment costs, resulting in a continuous negative cash flow and heavy losses (see table below).

Cash flow analysis for one production unit of tiger shrimp fry

	0	1	2	3	4	5	6	7	8	9	10
1. Investment	8800			3600	2200	3600	2400	5800		3600	2200
2. Operating costs		6145	6145	6145	6145	6145	6145	6145	6145	6145	6145
3. Outflow		6145	6145	9745	8345	9745	8545	13945	6145	9745	8345
4. Income		7200	7200	7200	7200	7200	7200	7200	7200	7200	7200
5. Net flow	-8800	1055	1055	-2545	-1145	-2545	-1345	-6745	-1055	-2545	-1145

7.2 Freshwater prawn nursing

The production unit is identical to the one used for tiger shrimp fry nursing. Although it has been depreciated at the same rate, the freshwater prawn fry cages would probably last longer due to slower corrosion. There is no transition pond in the freshwater system.



Freshwater prawn fry nursery cages, Chandkhali River.

Both hatchery-produced and wild fry can be used to stock the cages. Hatchery fry enables the operator to extend the culture season by three months, because fry will be available from early May or June. A five-month season is used in the base case. Wild fry appear in the rivers in August, September and October. If caught in August and early September, they are generally too small to be sold, but are ideal for stocking nursery cages. Based on experience, as illustrated in the second table on page 7, survival of hatchery fry was put at 54 per cent and wild fry at 80 per cent for the base case. The selling price was put at 1000 Tk/1000, although it ranged from 800 to 1700 Tk during the 1991 and 1992 seasons. Annual operating costs and revenues used to estimate cash flow over a ten-year project period are presented in the tables alongside and below.

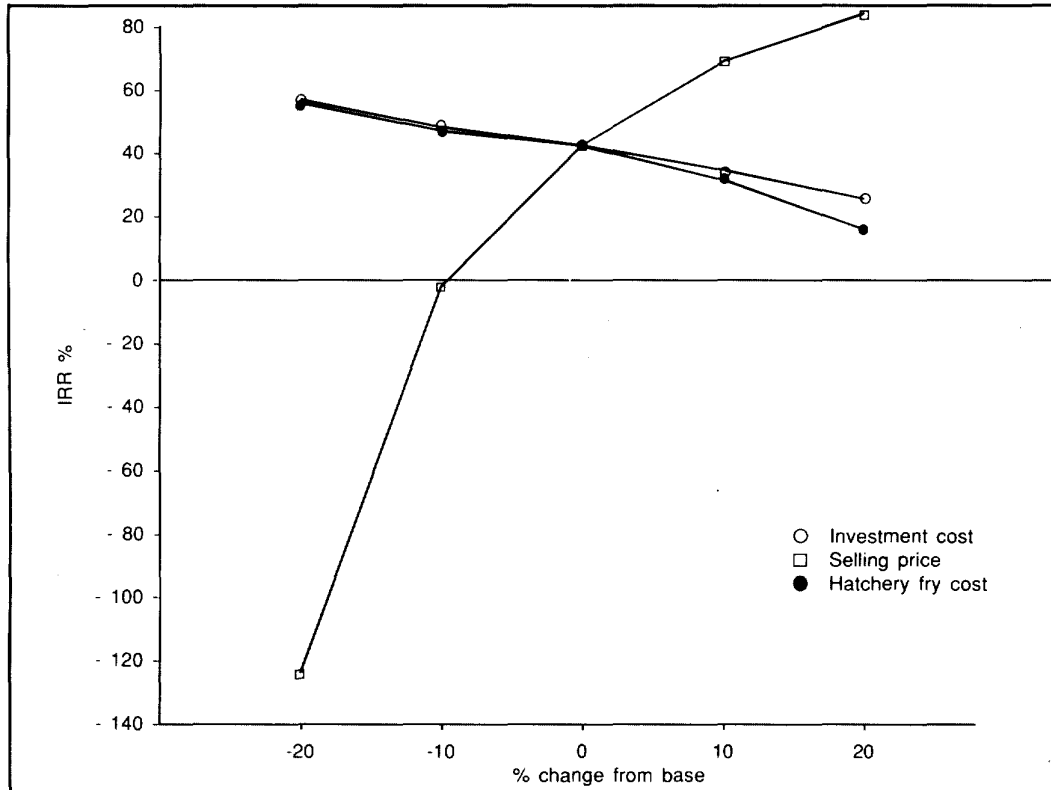
Annual operating costs and revenue for freshwater prawn fry nursing (one cage unit)

	<i>Fry stocked (no./mth)</i>	<i>Months</i>	<i>Cost (Tk/1000)</i>	<i>Cost (Tk)</i>
Cost of fry				
Hatchery fry	5,000	3	400	6,000
Wild fry	5,000	2	500	5,000
Total fry cost				11,000
Feed cost				415
				11,415
ANNUAL REVENUE	<i>Stocked (no.)</i>	<i>Survival %</i>	<i>Selling price (Tk/1000)</i>	<i>Revenue</i>
Hatchery fry	15,000	54	1,000	8,100
Wild fry	10,000	80	1,000	8,000
Annual revenue				16,100

	0	1	2	3	4	5	6	7	8	9	10
1. Investment	8200			3600	2200	3600	2400	5800		3600	2200
2. Operating costs		11415	11415	11415	11415	11415	11415	11415	11415	11415	11415
3. Outflow	8200	11415	11415	15015	13615	15015	13815	17215	11415	15015	13615
4. Inflow		16100	16100	16100	16100	16100	16100	16100	16100	16100	16100
5. Net flow	-8200	4685	4685	1085	2485	1085	2285	-1115	4685	1085	2485
6. IRR		0.36									

A sensitivity analysis (see Figure 2), by changing the variables involved, viz, investment cost, selling price, mortality and purchase cost of hatchery fry, shows that for departures of 10 and 20 per cent above and below the base values, the internal rate of return (IRR) is very sensitive to variations in selling price or mortality. Increases in investment costs and cost of fry obviously reduce profitability, with the latter having a more significant effect. Breakeven is possible even if investment costs increased by 40 per cent or cost of fry by 25 per cent.

Fig. 2. Sensitivity analysis of freshwater prawn fry nursing



8. CONCLUSIONS

The subproject involved technical, social and economic aspects. The major conclusions gleaned from the experience over the four years of activities are given below.

8.1 Technical aspects

Nielsen and Hall (1993) summarized their conclusions for cage nursery culture in West Bengal, most of which holds true for Bangladesh. The strong tidal and river currents in Bangladeshi channels and rivers require the use of sturdy bamboo frames. Materials are locally available to fabricate the cages.

The dominant technical issue remains stocking rates and sorting, particularly in freshwater prawn fry nursing.

The inclusion of a transition pond in Mognamapara improved survival rates significantly. However, the unique cooperative land ownership prevailing in the village is not common in coastal areas. Government, or *khas*, lands are nominally available to fisherfolk, but many practical problems obstruct their access to *khas* lands.

The availability of feed was not a constraint, but further trials are necessary to determine the best formulation using locally available ingredients.

8.2 *Social aspects*

Cage nursery culture, whether of tiger shrimp or freshwater prawn, requires strong organizational support. There is no 'standard' protocol, as each village is different. While it is best to build on existing groups, many fishing villages have no such organizations. An extended period of trial and error may be required before the right approach is found. UBINIG had to organize participants from the ground up, in the absence of existing community organizations.

The development issues confronting fry-catcher communities are diverse, ranging from basic sanitation and literacy to environmental conservation. NGO involvement was crucial to addressing these needs and, by doing so, consolidated the nursery culture groups. The most effective activities included nonformal education for women and girls, mangrove afforestation, savings and revolving credit.

The degree to which women can become involved in nursery culture depends on local social customs. Sustained involvement in the target community is necessary to break down the inhibitions which prevent women from fully participating in development. To accomplish the task, the NGO requires committed long-term financial resources.

Women were marginally involved in cage nursery culture in Mognamapara. They prepared feed and mended *happas*. Women were not involved in any formal way in decision-making and did not directly participate in meetings of fry-catchers. UBINIG field staff made a sustained effort to include women in cage nursery activities, but found it difficult to overcome the social pressures to which the women are subjected.

8.3 *Financial viability*

Tiger shrimp cage nursery culture in Bangladesh is unlikely to be profitable under prevailing market conditions. Other serious constraints are low survival rates and fry availability. It may be possible to use hatchery produced post-larvae, but this option does not yet exist in Bangladesh. There is one private hatchery in Cox's Bazar, but it still has not reached full production. Government hatcheries in the area are unable to produce fry on a sustained basis.

On the other hand, freshwater prawn fry nursing has good potential for further development, but proper site selection is crucial. Low survival of hatchery fry is the main constraint. Further trials to determine the proper stocking density and sorting protocols for hatchery fry should significantly increase the survival. The number of private freshwater prawn hatcheries is slowly increasing in Bangladesh, so fry should become increasingly available.

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The BOBP brings out the following types of publications;

Reports (BOBP/REP/...) which describe and analyze completed activities such as seminars, annual meetings of BOBP's Advisory Committee, and subprojects in member-countries for which BOBP inputs have ended.

Working Papers (BOBP/WP/...) which are progress reports that discuss the findings of ongoing work.

Manuals and Guides (BOBP/MAG/...) which are instructional documents for specific audiences,

Information Documents (BOBP/INF/...) which are bibliographies and descriptive documents on the fisheries of member-countries in the region.

Newsletters (*Bay of Bengal News*) which are issued quarterly and which contain illustrated articles and features in nontechnical style on BOBP work and related subjects.

Other publications which include books and other miscellaneous reports.

Those marked with an asterisk (*) are out of stock but photocopies can be supplied.

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