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Modadugu V. Gupta
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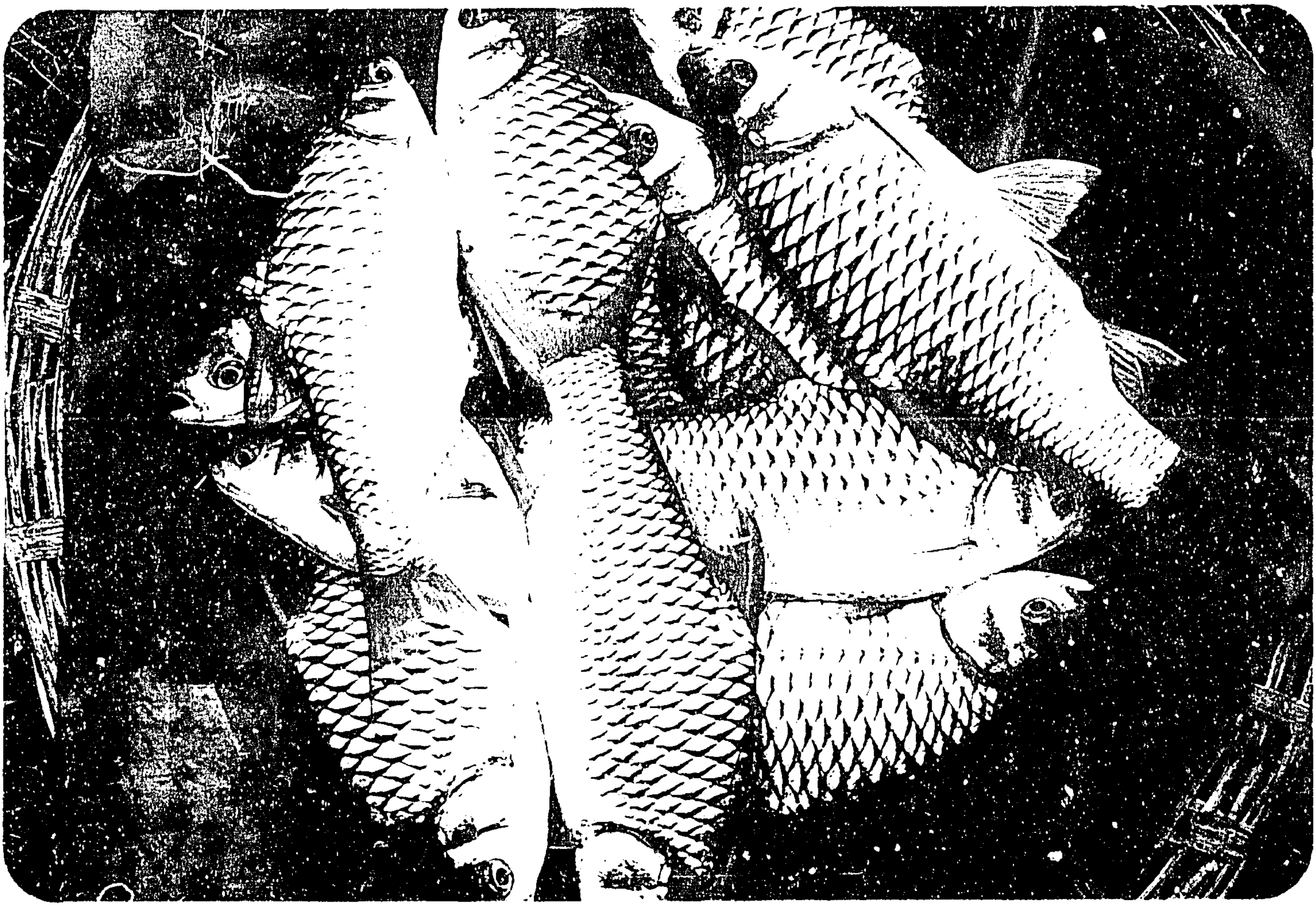

International Center for Living Aquatic Resources Management
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Cover: Silver barb (*Puntius gonionotus*) harvested from a seasonal pond in Trishal, Bangladesh. Photo by M.V. Gupta.

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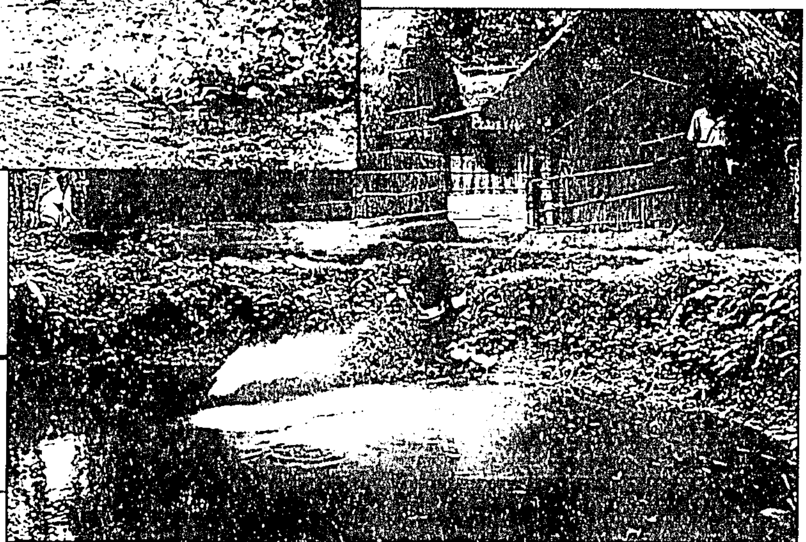
Aspects of Silver Barb Culture in Bangladesh

Photos by M.V. Gupta

A derelict seasonal pond.



A rural woman feeding rice bran to fish in her homestead pond.

A rural family catching silver barb (*Puntius gonionotus*) for home consumption from their homestead pond.

A rural farmer with silver barb (*Puntius gonionotus*) harvested from her seasonal homestead pond in the background.

ABSTRACT

Hundreds of thousands of seasonal ponds and ditches in rural Bangladesh are mostly derelict or underutilized, due to lack of appropriate aquaculture technologies. On-station and on-farm research undertaken by the Fisheries Research Institute resulted in development of management practices for culture of silver barb (*Puntius gonionotus*) which can be grown to market size in short periods in such waters. These research results were disseminated to a large number of farmers throughout the country by various extension agencies during 1991. Two hundred fifty-three farmers in different parts of the country, to whom the technology was extended by a nongovernmental organization, the Bangladesh Rural Advancement Committee (BRAC), were surveyed before and after adoption of the technology, to evaluate the socioeconomic viability and farmers' assessment of the technology in different agro-climatic zones.

The ponds used for culture ranged in area from 40 to 300 m², with an average of 378 m². Some 67% of the ponds surveyed were under single ownership and 28% under multiple ownership. Only 23.8% of these ponds were originally excavated for fish culture. The rest were borrow pits from house or road building. None of the farmers had fish culture as a primary occupation. Thirty-six per cent of the ponds were managed by women. Before the introduction of silver barb culture technology, 91.6% of the farmers were practising traditional fish culture, with average productions of 771 $kg{\cdot}ha^{-1}$. They lacked the knowledge and the capital for purchase of inputs.

Monoculture of *P. gonionotus* was suggested by the extension workers, but 80% of the farmers also stocked carps. The rearing period varied from 3 to 8 months, depending on water retention in the ponds. Input use by farmers was much less than the quantities suggested. Cattle manure was the main fertilizer used by farmers; at 38.8-67.5% of the suggested quantity. Rice bran was used as a supplementary feed at only 7.5-46.6% of the suggested quantity. Farmers used nearly 94% of cattle manure from their own sources, while they had to buy 49% of rice bran used. This is probably because farmers surveyed were resource-poor, with landholdings of less than 0.2 ha (including household area) and spend part of the year as daily wage laborers.

Fish production varied from 772 $kg{\cdot}ha^{-1}$ after three months rearing to 1,568 $kg{\cdot}ha^{-1}$ after eight months. Significant differences in fish yields were observed between mono- and polyculture. Monoculture of *P. gonionotus* gave an average gross production of 815 $kg{\cdot}ha^{-1}$ after five months, whereas from polyculture, gross production amounted to 1,373 $kg{\cdot}ha^{-1}$ during the same rearing period. Cost of production on an average amounted to Tk.13,158$\cdot ha^{-1}$ including noncash costs, with a net benefit of Tk.31,431$\cdot ha^{-1}$. Adoption of the technology by farmers resulted in increasing fish production by 74%.

Fish production (pre and post-technology introduction) from ponds in gangetic plain and brackishwater areas was higher, as compared to those in low-lying floodprone areas and floodlands. This is probably due to the stable environment in these areas, with low risk, which encouraged farmers to use higher inputs, as compared to those in risk-prone areas.

Of the total fish production, 54% was consumed by households and given away, whereas the rest was sold. Revenue from 30% of the fish produced was enough to meet the cost of production, indicating economic viability and sustainability of the operation.

Ninety-one per cent of the farmers expressed satisfaction with the technology, and 33% were in favor of expanding operations. Rapid growth of *P. gonionotus*, low-investment and simple technology were perceived as the most important encouraging factors for the adoption of the technology, whereas nonavailability of credit for inputs, inadequate supply of *P. gonionotus* fingerlings and small size of ponds, were conceived as constraints to expansion.

The study showed that even a seasonal pond or ditch as small as 378 m^2, with low-cost, low-input can produce as much as 50 kg of fish after 5-6 months rearing. This can provide 8.3 $kg \cdot year^{-1}$ for each member of a family of six, which is higher than the national per caput fish consumption of 7.9 $kg \cdot year^{-1}$.

INTRODUCTION

Fish is the main source of animal protein to resource-poor rural farmers, who constitute 69% of the total population of Bangladesh, and contributes some 71% of the total animal protein intake. These rural households fish in openwaters for their requirements, through which they are able to meet only a meager part of their nutritional requirements. The recent decline in fish production from open waters due to increasing fishing pressure and environmental degradation, combined with the lack of purchasing power, is resulting in declining animal protein intake in rural areas, resulting in malnutrition (World Bank 1991). In Bangladesh, which is endowed with vast water resources, aquaculture can play a role in increasing fish production, rural household nutrition and income. In addition to an estimated 1.3 million perennial ponds, there are hundreds of thousands of shallow seasonal ponds and ditches, roadside canals, borrow pits, etc. in rural areas. These retain water for only a part of the year (mostly 4-7 months). They are mostly in derelict condition and underutilized: typically covered with aquatic weeds and posing health hazards. There is a lack of knowledge about fish species which are suitable for culture in such waters. Studies have indicated that species such as Nile tilapia (*Oreochromis niloticus*) and silver barb (*Puntius gonionotus*) are suitable and can be grown to market size in short periods (Gupta 1990; Gupta et al. 1992).

The silver barb (*Puntius gonionotus*) is native to Southeast Asia (Annex 1) and was introduced to Bangladesh in 1977 (Rahman 1989). It is known locally as *Thai sharputi* or *Rajputi*. This species can survive in shallow, turbid waters and grows to table size in as little as three to four months. It is very well suited for culture in seasonal waters. The species is akin to the indigenous species *P. sarana*, which is very much liked by the population and is in high demand. Unfortunately, catches of *P. sarana* and other *Puntius* spp. from open waters have declined drastically in recent years, due to environmental degradation. *P. gonionotus* was not established as a cultured species in Bangladesh until 1989, as previously there were no management practices for its culture.

In view of the potential of *P. gonionotus* for culture in seasonal, turbid waters and the liking of the population for the fish, the Fisheries Research Institute (FRI) undertook on-station research to develop management practices for its culture. This showed that the species has high production potential compared to *P. sarana*: 2,075 $kg \cdot ha^{-1}$ in six months compared to 1,304 $kg \cdot ha^{-1}$ for *P. sarana* (Kohinoor et al., in press, a). Other studies undertaken by FRI have indicated that production as high as 1,953 $kg \cdot ha^{-1}$ could be obtained in five months rearing through monoculture of *P. gonionotus*, using rice bran as supplementary feed (Hussain et al., in press). Higher production (up to 2,384 $kg \cdot ha^{-1}$ in six months) was achieved with incorporation of mustard oil cake in the supplementary feed (Kohinoor et al., in press, b). Subsequently, on-farm farmer participatory research was undertaken by FRI in collaboration with an NGO, the Bangladesh Rural Advancement Committee (BRAC), to evaluate the viability of the technology under farmers' conditions. These studies revealed that with very low-cost inputs, farmers are able to obtain production of 1,205 to 2,156 $kg \cdot ha^{-1}$ in three to six months, from seasonal ponds which were hitherto lying fallow (Gupta 1992; Gupta and Shah 1992).

These results created interest among extension agents — both government and nongovernment. One of the NGOs, the BRAC, extended the technology to 1,725 farmers in 14 districts of the country during 1991. A survey was undertaken in 1992 to evaluate the adoption, economic viability and farmers' assessment of the technology under different aquaecosystems. The results of this survey are presented in this report.

METHODOLOGY

Area and Sample Selection

P. gonionotus culture technology was extended by the BRAC in 1991 to 1,725 new entrants to aquaculture in 29 thanas (administrative units) covering 14 districts (Fig.1). Based on their ecosystem typology, these districts were grouped into five categories: (i) gangetic plain (Rajshahi, Natore, Pabna, Jessore, Kushtia and Jhenaidah districts); (ii) low-lying, flood-prone (Faridpur, Rajbari, Manikganj and Narsingdi districts; (iii) floodland (Mymensingh district); (iv) low rainfall (Rangpur and Gaibandha districts) and (v) brackishwater (Satkhira district) (Table 1).

A three-stage sampling procedure was followed. First, districts were selected to represent different ecosystems, at the same time taking into consideration the numbers of ponds used for *P. gonionotus* culture. Second, the BRAC area offices in different thanas were selected

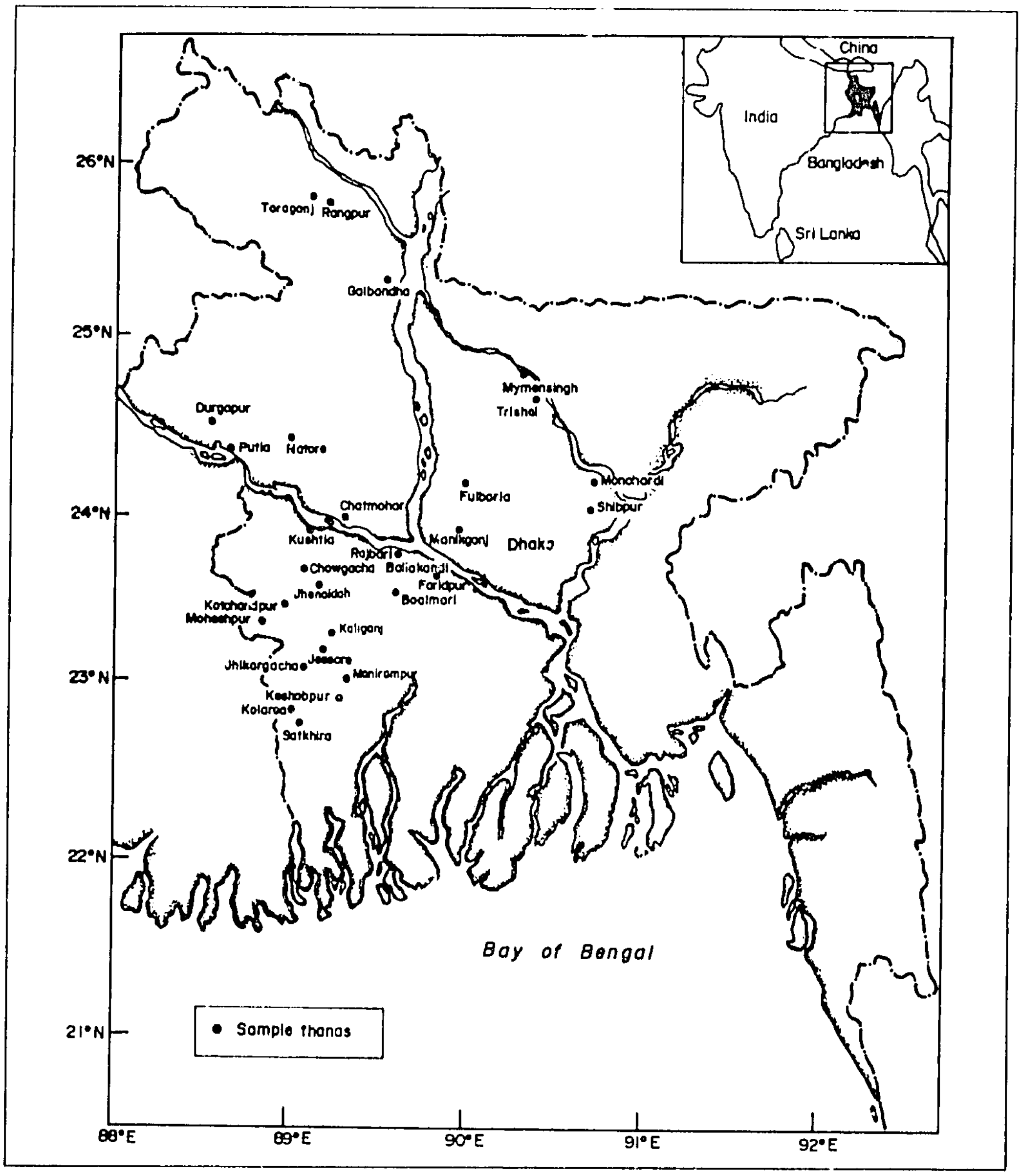


Fig. 1. Map of Bangladesh showing sample thanas for the study.

Table 1. Distribution of sample respondents by ecoregions.

Ecosystem	District	Thana	No. of ponds used for *Puntius gonionotus* culture	No.of ponds sampled
Gangetic plain	Rajshahi	Putia	46	20
		Durgapur	45	-
	Natore	Natore Sadar	64	21
	Pabna	Chatmohar	12	-
	Jessore	Jessore	70	-
		Monirampur	139	34
		Keshbpur	42	-
		Jhikargacha	40	-
	Kushtia	Kushtia	200	21
	Jhenaidah	Jhenaidah	165	40
		Kotchandpur	81	-
		Moheshpur	67	-
		Chowgacha	57	-
		Kaligonj	87	-
		Subtotal	1,115	136
Low-lying flood-prone	Faridpur	Faridpur Sadar	15	-
		Boalmari	30	14
	Rajbari	Rajbari Sadar	15	12
		Baliakandi	15	-
	Manikganj	Manikganj Sadar	2	-
	Narsingdi	Shibpur	16	-
		Monohardi	35	-
		Subtotal	128	26
Floodland	Mymensingh	Mymensingh Sadar	70	26
		Trishal	79	-
		Fulbaria	20	-
		Subtotal	169	26
Brackishwater	Satkhira	Satkhira Sadar	122	-
		Kolaroa	86	39
		Subtotal	208	39
Low rainfall	Rangpur	Rangpur Sadar	75	11
		Taraganj	11	-
	Gaibandha	Gaibandha Sadar	19	15
		Subtotal	105	26
		Grand total	1,725	253

randomly from each district. Finally, the pond operators or owners from these places were selected at random. Of the total 1,725 farmers who adopted the *P. gonionotus* culture technology, 253 farmers (15%) were surveyed, taking proportional numbers of samples from each district. Data from Rangpur and Gaibandha districts which represent low rainfall areas were unreliable and were excluded from the analysis. Hence, the total number of samples considered for analysis stood at 227 (Table 1).

Data Collection

The approach used was pre- and post-testing of attributes that may contribute to the success or failure of aquaculture adoption. Before the start of the extension program by the

BRAC, a benchmark survey was conducted using a structured questionnaire (Annex 2) that comprised a short profile of the respondents, physical condition of the waterbodies, tenure status, gender, culture status, production and problems of fish culture and marketing. After introduction of the technology and harvesting of ponds, another survey was conducted among the same set of farmers to assess the impact of the new technology on the adopting households and farmers' assessment of the technology (Annex 3). Questionnaires for both the surveys were pretested in the field and necessary changes made before the full scale survey was undertaken.

Several training sessions were organized for the Program Organizers of the BRAC to give them a clear understanding of the questionnaires and data collection methods. These Program Organizers, in turn, trained the village extension workers attached to each BRAC area office, who undertook the survey. To help with data collection in the field, a full-time field investigator, who went around the different areas and supervised data collection, was employed for three months.

Concepts and Analytical Tools

On-farm resources used as production inputs were valued at prevailing market prices. Similarly, the values of fish consumed on-farm and given away were calculated at prevailing farmgate prices. Data were analyzed using the SPSS/PC+ program. Both descriptive and econometric analytical tools were used to analyze adoption of *P. gonionotus.* Data were grouped and compared with respect to region and gender, where deemed necessary.

Fish production is a process in which inputs are converted to fish output within a specific period of time. Hence, fish production from a unit area and time depends on all inputs put together. There are two ways to determine the effect of inputs on fish production: by partial and total factor productivity measures. The ratio of fish output to a single input measures the partial productivity, while the ratio of output to all inputs combined together is the total productivity (Ehul and Spencer 1990).

Partial productivity measures are simple to compute and provide insights into the efficiency of an input in the production process. However, they mask many of the factors responsible for the observed production and are sensitive to both composition of outputs and the relative intensity of various inputs. Total factor productivity (TFP) is a clear improvement over single-factor measures, because it is based on comprehensive aggregate of outputs and inputs. Thus, changes in the quantity and quality of all inputs can be accounted for (Antle and Capalbo 1988; Capalbo and Vo 1988). The parametric approach, which is based on econometric estimation of the production function, is one of the TFP measures. To measure fish productivity and efficiency of factors, a parametric approach was used, by estimating a production function. The functional form of the fish production model chosen is the unconstrained Cobb-Douglas production function model. The Cobb-Douglas production function is nonlinear in its parameters and the inputs are continuously variable and continuously substitutable at all times. It is useful for analyzing fisheries data (Ahmed and Rahman 1992; Chong and Lizarondo 1981).

P. gonionotus production is a result of various fixed and variable inputs in a body of water in the form of fingerlings, feed, fertilizers, etc. To study the influence of various fixed and variable inputs on fish production and to find the significant factors affecting total output, production function of the following form was estimated:

$$Q = A\,X_1^{B1}\,X_2^{B2}\,X_3^{B3}\,X_4^{B4}\,X_5^{B5}\,X_6^{B6}\,X_7^{B7}\,e_i^{Di\,ui} \quad \text{...(i)}$$

Log (natural) linear form of the equation can be expressed as:

$$\text{Ln } Q = \text{Ln } A + B_1 \text{ Ln } X_1 + B_2 \text{ Ln } X_2 + B_3 \text{ Ln } X_3 + B_4 \text{ Ln } X_4 + B_5 \text{ Ln } X_5 + B_6 \text{ Ln } X_6 + B_7 \text{ Ln } X_7 + D_1 + D_2 + D_3 + D_4 + u \quad \text{...(ii)}$$

where Q = Output of *P. gonionotus* (kg)
X_1 = Fingerlings (number)
X_2 = Rice bran (kg)
X_2 = Cattle dung (kg)
X_4 = Lime (kg)
X_5 = Inorganic fertilizers (kg)
X_6 = Culture period (months)
X_7 = Area of the waterbody (m^2)
D_1 = Gender dummy, 1 for male and 0 for female
D_2 = Flood. 1 for flood affected ponds and 0 for otherwise
D_3 = Operator type, 1 for single operator and 0 for otherwise
D_4 = Technology type, 1 for monoculture and 0 for mixed culture
u = Stochastic error term.

Fingerlings (X_1), rice bran (X_2), cattle manure (X_3), lime (X_4), inorganic fertilizers (X_5), culture period (X_6) and area of the waterbodies (X_7) were included in the model as continuous variables. Besides, there were other inputs which are considered potential for increasing fish yield such as kitchen waste, oil cake, duckweed, compost, etc. Since the use of these inputs was minimal and by only a few farmers, these variables were dropped from the model.

In addition to these economic variables, it was hypothesized that some sociodemographic and risk factors like mono- *vs.* polyculture, gender, operator type and risk of flooding may be important in determining yield of fish. These were included as dummy variables.

TYPOLOGY

Profile of the Respondents

The target groups who benefit from BRAC activities are those rural households which own less than 0.2 ha of land (including the homestead area) and for which the head of the family works as a wage laborer for at least 100 days in a year. These are the very poor rural households who adopted *P. gonionotus* culture technology and were covered by the survey.

GENDER

Of the total 227 fish farmer respondents surveyed from different areas of the country, 36% were women. The proportion of women who adopted the technology was highest (65%) in low-lying flood prone areas and lowest (27%) in the gangetic plain. In floodland and brackishwater areas, the proportions of women adopters were 42 and 41%, respectively (Table 2).

OCCUPATION

Occupational distribution of the respondents, by gender, before the introduction of the technology, indicated that no farmers surveyed whether male or female had fish farming as primary occupation (Table 3). More than 52% of the male respondents had farming as principal

Table 2. Gender distribution of adoptors of *Puntius gonionotus* culture by ecosystem.

Ecosystem	Male		Female		All	
	No.	%	No.	%	No.	%
Gangetic plain	99	73	37	27	136	100
Low-lying flood-prone	9	35	17	65	26	100
Floodland	15	58	11	42	26	100
Brackishwater	23	59	16	41	39	100
Total	146	64	81	36	227	100

Table 3. Occupational distribution of *Puntius gonionotus* farmers by gender, before introduction of the technology.

Occupation type	Principal				Secondary			
	Female		Male		Female		Male	
	No.	%	No.	%	No.	%	No.	%
Farming	-	-	76	52.1	-	-	15	10.3
Agricultural labor	-	-	11	7.5	-	-	3	2.1
Nonagricultural labor	4	4.9	11	7.5	-	-	1	0.7
Housekeeping	74	91.4	3	2.1	6	7.4	-	-
Salaried job	-	-	5	3.4	-	-	2	1.3
Small business	3	3.7	30	20.5	2	2.5	18	12.3
Fish farming	-	-	-	-	11	13.6	15	10.3
Rickshaw pulling	-	-	7	4.8	-	-	-	-
Others	-	-	3	2.1	5	6.2	4	2.7
No secondary occupation	-	-	-	-	57	70.0	88	60.3
Total	81	100	146	100	81	100	146	100

occupation. The remaining 48% had nonfarming activities such as small businesses (20.5%), wage labor (15.0%), rickshaw pulling (4.8%) or salaried jobs (3.4%), as principal occupation. Among the female respondents, more than 91% reported housekeeping as their principal occupation. Only a few female respondents reported nonagricultural labor (4.9%) and small businesses (3.7%) as principal occupation. A majority of the female farmers (70.4%) did not have any secondary occupation and were involved only in housekeeping. Of the rest, 13.6% had fish farming as a secondary occupation. Dissemination of the technology resulted in 36% of women taking to aquaculture.

Forty per cent of the male respondents and 30% of the female respondents had secondary occupations. The most important for male respondents were small businesses (12.3%), fish farming (10.3%) and farming (10.3%), and for female respondents fish farming (13.6%) and housekeeping (7.4%).

Characteristics of the Waterbodies

PHYSICAL CHARACTERISTICS

The size of the waterbodies used for *P. gonionotus* farming ranged from 40 to 800 m². Their average size during the rainy season was 378 m² (Table 4). Their average age since last re-excavation was 8.26 years. Of all the ponds surveyed, 26% had broken dikes, 53% were shaded and only 3% were flood-prone.

Table 4. Physical characteristics of the waterbodies used for *Puntius gonionotus* culture.

Information categories	
Pond size range (m²)	40-800
Average pond area during monsoon (m²)	378
Average age of the waterbodies since last re-excavation (years)	8.26
Average minimum depth (m)	0.55
Average maximum depth (m)	2.34
Average minimum (>0.6 m) water retention period (months/year)	10.26
Condition of the waterbodies (percentage)	
- broken dikes	25.6
- fully/partially shaded	52.9
- flood prone	3.1

The maximum water depth in the waterbodies was 2.34 m and the minimum 0.55 m. On average, there was water in the ponds for about 10.3 months. Water was relatively abundant in the gangetic plain areas, which essentially had water year-round (11 months), compared to the other three ecoregions: low-lying flood-prone; floodlands; and brackishwater areas. In these, the waterbodies remained dry for more than 2.5 months in a year (Table 5). Almost 39% of the waterbodies in low-lying flood-prone areas and 23% in the floodlands were dry for more than 6 months. In gangetic plain areas, almost 62% of the waterbodies retained favorable water year-round, whereas this was so for only 50 and 46%, respectively, in the low-lying flood-prone areas and floodlands. In the brackishwater areas, only 23% of the waterbodies retained water year-round (Table 6).

TENURIAL STATUS

Sixty-seven per cent of the waterbodies in all the areas were under single ownership; 28% were under multiple ownership. For the multiple ownership ponds, 87.5% had less than five

Table 5. Average maximum and minimum depth and average water retention period of the waterbodies in different ecoregions.

Average maximum depth (m)	2.34
Gangetic plain	2.43
Low-lying flood-prone	2.37
Floodland	1.98
Brackishwater	2.26
Average minimum depth (m)	0.55
Gangetic plain	0.59
Low-lying flood-prone	0.72
Floodland	0.54
Brackishwater	0.34
Average minimum (>0.6 m) water retention period (month/year)	10.25
Gangetic plain	10.72
Low-lying flood-prone	9.38
Floodland	9.69
Brackishwater	9.59

Table 6. Distribution of sampled waterbodies used for *Puntius gonionotus* culture by ecosystem and number of months of minimum (0.6 m) water retention.

Months	Gangetic plain		Low-lying flood-prone		Floodland		Brackishwater	
	No.	%	No.	%	No.	%	No.	%
5	-	-	2	7.8	1	3.8	-	-
6	-	-	8	30.8	5	19.2	1	2.6
7	2	1.5	-	-	1	3.8	-	-
8	24	17.6	-	-	-	-	6	15.4
9	16	11.8	-	-	4	15.4	18	46.2
10	10	7.4	3	11.5	3	11.5	5	12.8
12	84	61.8	13	50.0	12	46.2	9	23.1

owners. Only 4% of the waterbodies studied were leased by the respondents; the rest of the ponds were operated by owners. Most of the waterbodies (88.1%) were single owner-operated; 7.9% were joint owner-operated. Only 3.9% were single leaseholder-operated (Table 7).

Reasons for Excavation and Uses of Waterbodies

Of the waterbodies surveyed, only 24% were excavated for fish farming. The rest were borrow pits, resulting from soil excavation for house building (69.2%) or road construction (4.4%)

Table 7. Pond tenure status of the *Puntius gonionotus* farmers surveyed.

	Respondents (n = 227)	
	Number	%
Ownership status		
Single owner	153	67.4
Joint ownership (2-5 owners)	56	24.7
Joint ownership (above 5 owners)	8	3.5
Institutional ownership/khas*	1	0.4
Leased in	9	4.0
Operator status		
Single owner operator	200	88.1
Joint owner operator	18	7.9
Lease operator	9	3.9

*Government-owned.

Table 8. Reasons for excavation and uses of the waterbodies studied prior to the introduction of *Puntius gonionotus* culture.

	Respondents (n = 227)	
	Number	%
Reasons for excavation		
Fish culture	55	24.2
House building	157	69.2
Road construction	10	4.4
Others	5	2.2
Uses other than fish culture		
Washing/cooking	197	86.8
Drinking	1	0.4
Irrigation	15	6.6
Jute retting	5	2.2
Others	1	0.4

(Table 8). Prior to introduction of *P. gonionotus* culture by the BRAC, 92% of the waterbodies were used for fish farming, but this involved only stocking of fingerlings without any regard for species or number stocked and no management practices were followed. This is evident because only 11.4% farmers indicated fish farming as their secondary occupation (Table 3).

Besides fish culture, water from most of the waterbodies (86.8%) was used for washing and cooking. Some of the waterbodies were also used for irrigation (6.6%) and jute retting (2.2%). Water from only one pond was used for drinking (Table 8). This shows that use of ponds for fish farming does not preclude household and other uses of the pond water.

STATUS BEFORE INTRODUCTION OF TECHNOLOGY

Management of the Waterbodies

Before the introduction of *P. gonionotus* culture technology, 91.6% of the surveyed farmers reported farming fish, stocking fingerlings without any subsequent management. About 95% of the ponds were stocked with carps [catla (*Catla catla*), rohu (*Labeo rohita*), mrigal (*Cirrhinus mrigala*), silver carp (*Hypophthalmichthys molitrix*) and common carp (*Cyprinus carpio*)] and 3.8% with tilapia (*Oreochromis* spp.). Farming of *P. gonionotus* was negligible, practised by only 1.4% of the farmers. Probably, this was due to the technology being new and *P. gonionotus* fingerlings being scarce. Most of the farmers (87.9%) reported having purchased carp fingerlings from vendors who usually collect riverine seed or buy seed from private and government farms. A few of the respondents (8.9%) got their supply of fingerlings through the assistance of BRAC. Only 1% of farmers got their fingerlings directly from public fish seed farms. More than 96% used their own financial resources for fish farming. A few (8.2%) borrowed money from BRAC or from relatives (2.9%).

Fish Production and Utilization Pattern

Before the introduction of *P. gonionotus* farming technology, farmers were able to produce about 771 $kg \cdot ha^{-1}$ of fish using traditional methods. The disposition of harvest is given in Table 9. This shows that traditional fish farming is practised mostly for subsistence needs, and farmers have not yet given importance to fish culture as a commercial enterprise.

Problems in Fish Culture: Farmers' Perceptions

Prior to the introduction of *P. gonionotus* farming technology, farmers were asked about the problems they were encountering in fish farming. The majority mentioned lack of capital and lack of knowledge as major constraints. These and other constraints are summarized in Table 10.

Table 9. Fish production and utilization pattern before the introduction of *Puntius gonionotus* farming technology.

Disposal pattern	Quantity $kg \cdot ha^{-1}$	%
Self consumption	485	62.9
Given away	49	6.4
Sold	237	30.7
Total production	771	100.0

Table 10. Fish farming constraints identified by farmers before the introduction of *Puntius gonionotus* farming technology.

Problem	No. of farmers (n = 208)	%
Lack of capital	171	81.5
Lack of knowledge	153	72.2
Nonavailability of fingerlings	44	23.3
Risk of theft	13	7.0
Risk due to fish disease	51	23.8
Multiple ownership	4	2.2
Damaged pond embankments	48	22.0
Flooding of ponds	11	4.8
Others	2	0.9

IMPACT OF *P. GONIONOTUS* FARMING TECHNOLOGY

The Technology Profile

The extension workers of BRAC disseminated the technology developed by FRI, for monoculture of *P. gonionotus* in seasonal ponds and ditches. The steps recommended were as follows:

Pond preparation. Before starting pond farming operations, the pond embankments are to be repaired if necessary and weeds and grasses, if present in the pond, are to be removed. Lime in powder form if the pond is dry, or dissolved in water and sprayed if the pond has water, should be applied at 250 kg·ha^{-1}. Three days subsequent to application of lime, the pond should be fertilized with manure from cattle or chicken at 10 and 5 t·ha^{-1}, respectively.

Stocking. Seven days after this basal fertilization, the pond is to be stocked with 5-7 cm size fingerlings of *P. gonionotus* at 15,000-16,000 fingerlings·ha^{-1}.

Fertilization. The ponds are to be fertilized thereafter at fortnightly intervals with cattle manure, alternating with inorganic fertilizers: at 750 kg·ha^{-1} of cattle manure; and 8 kg·ha^{-1} triple super phosphate (TSP) plus 16 kg·ha^{-1} urea.

Feeding. The stocked fish are to be provided daily with supplementary feed: rice bran at 4-5% of the fish biomass.

Harvesting. The fish are to be harvested when they reach an average size of 100-200 g each, or before the pond dries.

Management of the Waterbodies

COMPOSITION AND STOCKING DENSITY OF FINGERLINGS

Farmers were advised by the extension workers to stock *P. gonionotus* only, but the survey revealed that only 46 (20.3%) out of 227 farmers surveyed did so. The remainder practised polyculture (Table 11). There were no perceivable differences between male and female farmers in the choice of species. Farmers who practised monoculture of *P. gonionotus* stocked an average 14,383 fingerlings·ha^{-1}, whereas for polyculture, farmers stocked 17,821 fingerlings·ha^{-1}, against a suggested stocking density of 15,000-16,000. In both cases, female

Table 11. Details of fish species stocked by male and female farmers of *Puntius gonionotus*, in mono- and polyculture.

Species	Male (n = 146)		Female (n = 81)		All (n = 227)	
	No.	%	No.	%	No.	%
Monoculture (n = 46)						
Puntius gonionotus	22	100	24	100	46	100
Polyculture (n = 181)						
Puntius gonionotus	124	100	57	100	181	100
Catla	97	78	40	70	137	76
Rohu	100	81	41	72	141	78
Mrigal	52	42	19	33	71	39
Silver carp	89	72	32	56	121	67
Mirror carp	23	19	4	7	27	15
Tilapia	7	6	5	9	12	7
Others	14	11	1	1	15	8

farmers stocked slightly more fingerlings than male farmers (Table 12). Monoculture of *P. gonionotus* was suggested for seasonal ponds, but the extension workers, in their zeal for extending the technology, also suggested its culture in perennial ponds: note that the average period of minimal water retention (>0.6 m) in the ponds surveyed was 10.3 months (Table 4). Since these ponds were already used for carp culture, the farmers preferred to stock *P. gonionotus* along with carps in polyculture. Mean stocking density was 23% higher for polyculture: 17,821 fingerlings·ha^{-1} compared to monoculture (14,383·ha^{-1}). The latter was close to the extension agents' suggestion (15,000·ha^{-1}).

Table 12. Density of different species of fingerlings stocked by male and female farmers of *Puntius gonionotus*, in mono- and polyculture.

Species	No. of fingerlings stocked per ha					
	Male (n = 146)		Female (n = 81)		All (n = 227)	
	No.	%	No.	%	No.	%
Monoculture (n = 46)						
Puntius gonionotus	13,593	100	15,106	100	14,383	100
Polyculture (n = 181)	17,819	100	17,823	100	17,821	100
Puntius gonionotus	8,710	49	9,932	56	9,095	51
Catla	2,249	13	2,439	14	2,309	13
Rohu	2,204	12	2,058	12	2,158	12
Mrigal	881	5	641	4	805	5
Silver carp	3,093	17	2,229	13	2,821	16
Mirror carp	415	2	103	1	317	2
Tilapia	117	1	403	2	207	1
Others	150	1	19	<1	109	<1

Different species combinations were used by different numbers of farmers (Table 13). Most farmers (19.3%) chose a *P. gonionotus*-catla-rohu combination, or a *P. gonionotus*-catla-/ rohu-mrigal-silver carp combination (17.1%). The large array of species combinations in stocking followed by farmers indicates that stocking is not based on any logical combinations that can give higher production, but was mostly dictated by the availability of fingerlings to the farmers.

The average total length of fingerlings at stocking ranged from 2.9 to 6.4 cm (Table 14). Again, the size of fingerlings at stocking was mostly dependent on what was available. Also, farmers in general preferred to stock smaller-sized fingerlings as these cost less.

Table 13. Species combinations used by farmers growing *Puntius gonionotus* in polyculture.

Species combination	Farmers practised (n = 181)	
	Number	%
P+C+R	35	19.3
P+C+R+M+Si	31	17.1
P+C+R+Si	27	14.9
P+Si	17	9.4
P+C+R+M	13	7.2
P+C+R+M+Si+Mi	10	5.5
P+C+R+Si+Mi	7	3.9
P+R+M+Si	5	2.8
P+C	5	2.8
P+C+R+Mi	4	2.2
P+Si+Mi	3	1.7
P+C+R+M+Si+T	2	1.1
Other combinations	22	12.2

P = *Puntius gonionotus*, C = catla, R = rohu, M = mrigal, Si = silver carp, Mi = mirror carp (common carp), T = tilapia.

SOURCES OF FINGERLING SUPPLY

Ninety-two percent of the farmers surveyed purchased *P. gonionotus* fingerlings from BRAC nurseries, whereas 66% farmers procured fingerlings from local vendors also. Only 1.3 and

Table 14. Average size of fingerlings for stocking ponds used by male and female farmers for *Puntius gonionotus* mono- and polyculture.

	Average total length of fingerlings (cm)		
Species	Female farmers	Male farmers	All
Puntius gonionotus (n = 181)	4.39	4.09	4.20
Tilapia (n = 12)	3.04	2.90	2.96
Catla (n = 137)	5.97	5.42	5.58
Rohu (n = 141)	5.58	5.18	5.30
Mrigal (n = 71)	6.28	5.52	5.30
Silver carp (n = 121)	5.95	5.39	5.72
Mirror carp (n = 27)	6.35	4.31	5.54
Others (n = 15)	5.08	5.80	5.76

0.9% of the farmers procured fingerlings from government and private seed farms, respectively (Table 15). A majority of polyculture farmers (80%) also procured fingerlings from vendors, as compared to only 11% of the monoculture farmers (Table 16). This is because BRAC had not suggested stocking of carps along with *P. gonionotus* and the farmers did it on their own initiative, procuring seed from vendors.

Table 15. Sources of fingerlings supply for farmers practising *Puntius gonionotus* monoculture and polyculture with carps.

	BRAC		Vendor		Government seed farms		Private seed farms	
	No.	%	No.	%	No.	%	No.	%
Monoculture (n = 46)	39	85	5	11	2	4	1	2
Polyculture (n = 181)	170	94	144	80	1	0.6	1	0.6
All	209	92	149	66	3	1.3	3	0.9

Table 16. Details of stocking and harvesting of ponds by *Puntius gonionotus* farmers.

	Number of farmers n = 226	%
Months of stocking:		
April 1991	3	1
May 1991	-	-
June 1991	3	1
July 1991	139	61
August 1991	81	36
September 1991	1	<1
Months of harvesting:		
September 1991	2	1
October 1991	7	3
December 1991	26	12
January 1992	69	30
February 1992	59	26
March 1992	62	27
June 1992	2	1
Average rearing period (months)	6.3	

PERIOD OF STOCKING AND HARVESTING

Farmers stocked fingerlings during periods of high availability, mostly during the months of July (61%) and August (36%). Harvesting of ponds started in December and continued till March, depending on water retention. On average, the farmers cultured fish for 6.3 months (Table 16).

Inputs

A great variety of inputs were used by the farmers as feeds and fertilizers. Lime was used for pond preparation, and cattle manure, poultry manure, compost and inorganic fertilizers (urea and TSP) were used for fertilization of ponds. Kitchen waste, rice bran, wheat bran, oil cake and duckweed were used as supplementary feeds. Ninety-one per cent of the farmers fertilized their ponds with cattle manure and 52% with inorganic fertilizers (Fig. 2). Fifteen per cent of the farmers fertilized their ponds with poultry manure and 3% with compost. Rice bran was used by most (90%). Few (22%) used oil cake as a fish feed. Kitchen waste, duckweed and wheat bran were used by only 2, 4 and 2% of the farmers, respectively.

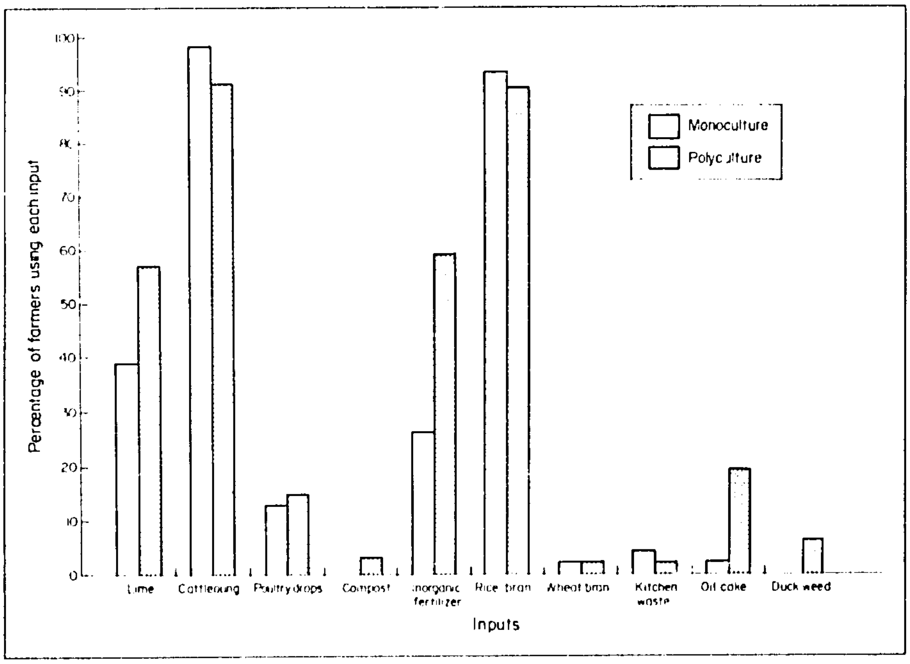


Fig. 2. Percentage of farmers using different inputs in mono- and polyculture of *Puntius gonionotus*.

Although use of lime during pond preparation was an essential component of the technology extended, only 57% of farmers used lime in their ponds. Use of lime, inorganic fertilizers, oil cake and duckweed was greater for polyculture than monoculture.

Farmers used organic and inorganic fertilizers during their pond preparation and culture periods. Organic fertilizer application during the entire culture period amounted on average to 2,367 kg·ha^{-1} of cattle manure, 138 kg·ha^{-1} of poultry manure and 79 kg·ha^{-1} of compost (Table 17). The average use of inorganic fertilizers during the culture period amounted to 112 kg·ha^{-1} and for lime, 93 kg·ha^{-1}. Feed use is summarized in Table 17. However, averaging the use of inputs among users and nonusers does not give a clear picture. Therefore, the data for users of different inputs is segregated and presented in Table 18. As can be seen, the use of different inputs by users is slightly higher than would appear by averages of all farmers.

Except for rice bran, farmers who practised polyculture used higher quantities of different inputs compared to monoculturists. Compost and duckweed were used in polyculture, but none

Table 17. Inputs use (kg·ha^{-1}) by *Puntius gonionotus* farmers, categorized by mono- *vs.* polyculture and gender.

	Quantity of inputs (kg·ha^{-1})						
	Monoculture			Polyculture			Average (kg·ha^{-1}) (n = 227)
	Male (n = 22)	Female (n = 24)	All (n = 46)	Male (n = 124)	Female (n = 57)	All (n = 181)	
Lime	67	32	49	109	100	105	93
Cattle manure	2,344	1,623	1,968	2,378	2,671	2,470	2,367
Poultry manure	116	59	86	59	354	151	138
Compost	-	-	-	116	65	100	79
Inorganic fertilizers	52	27	40	136	121	132	112
Rice bran	1,688	1,918	1,808	968	1,153	1,027	1,185
Wheat bran	-	5	3	4	-	3	3
Oil cake	14	11	12	62	66	63	53
Duckweed	-	-	-	71	106	82	66

Table 18. Use of feeds and fertilizers (kg·ha^{-1}) by *Puntius gonionotus* farmers expressed as averages from only those farmers who used each input type. The source of each input (on-farm *vs.* off-farm) is given. Figures in parentheses are the numbers of farmers who used corresponding inputs.

	Monoculture (n = 46)			Polyculture (n = 181)			Total (n = 227)		
	On-farm	Off-farm	All	On-farm	Off-farm	All	On-farm	Off-farm	All
Lime	-	125 (12)	125 (12)	-	186 (103)	186 (103)	-	177 (121)	177 (121)
Cattle manure	1,904 (42)	2,635 (4)	2,011 (45)	2,713 (162)	1,268 (6)	2,710 (165)	2,547 (204)	1,815 (10)	2,560 (210)
Poultry manure	662 (6)	-	662 (6)	930 (26)	1,081 (3)	979 (28)	880 (32)	1,081 (3)	923 (34)
Compost	-	-	-	3,005 (6)	-	3,005 (6)	-	3,005 (6)	3,005 (6)
Inorganic fertilizers	-	152 (12)	152 (12)	-	222 (107)	222 (107)	-	215 (119)	215 (119)
Rice bran	1,032 (30)	1,411 (37)	1,934 (43)	1,118 (125)	768 (60)	1,147 (162)	1,101 (155)	1,013 (97)	1,312 (205)
Oil cake	-	189 (3)	189 (3)	236 (8)	227 (42)	233 (49)	236 (8)	224 (45)	230 (52)
Wheat bran	124 (1)	-	124 (1)	114 (2)	124 (2)	119 (4)	117 (3)	124 (2)	120 (5)
Kitchen waste	206 (2)	- -	206 (2)	429 (4)	-	429 (4)	355 (6)	-	355 (6)
Duckweed	-	-	-	-	1,491 (10)	1,491 (10)	-	1,491 (10)	1,491 (10)

of the monoculturists used these inputs. This suggests that those who practised polyculture took fish farming somewhat more seriously. There was no perceivable difference in input use among male and female farmers.

In general, the farmers used much less than the suggested quantities of feeds and fertilizers (Fig. 3). Details of two major inputs - rice bran and cattle manure - used by farmers as

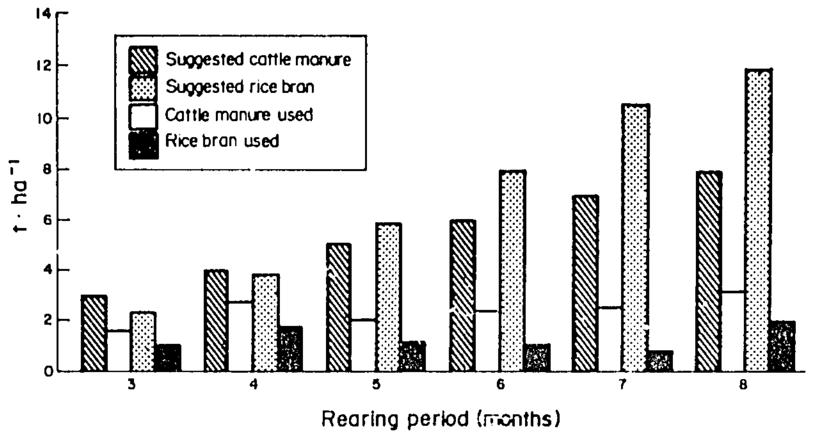


Fig. 3. Suggested and actual input use of cattle manure and rice bran in *Puntius gonionotus* culture.

supplementary feed and fertilizer, respectively, are presented in Table 19. Actual use compared to recommended rate was higher for cattle manure (33-68%) than rice bran (7-47%). Moreover, there was not much decrease in cattle manure input as the rearing period progressed, unlike the case of rice bran. This was probably because the cattle manure was obtained on-farm, whereas some rice bran had to be purchased. Ahmed et al. (1992) observed that silver barb farmers in Kapasia thana of Gazipur district in Bangladesh used 13% more cattle manure than what was suggested while use of rice bran was only 43% of the quantity suggested.

Table 19. Suggested rate and actual use of rice bran and cattle manure by farmers and fish production by rearing period.

Rearing period (months)	Rice bran ($t \cdot ha^{-1}$)			Cattle manure ($t \cdot ha^{-1}$)			Production ($kg \cdot ha^{-1}$)
	Suggested	Used	% used	Suggested	Used	% used	
3	2.3	1.03	45	3.0	1.56	52	772
4	3.8	1.77	47	4.0	2.70	68	946
5	5.8	1.09	19	5.0	1.55	40	1,177
6	8.0	1.00	13	6.0	2.13	37	1,321
7	10.6	0.78	7	7.0	2.29	33	1,477
8	12.0	1.91	16	8.0	3.41	43	1,579

An analysis of input use by farmers in different ecosystems revealed that farmers in the floodland area used more inputs than farmers in the other areas (Table 20). Farmers in the floodlands used duckweed only as a supplementary feed, probably due to its easy availability unlike in other areas.

Extent of On-farm Input Use

It is expected that the farmers will apply on-farm byproducts and bioresources at a higher rate than the resources that must be collected or purchased off-farm. Monoculturists obtained 88% of the cattle manure, 64% of rice bran and 100% of poultry manure, kitchen waste and wheat bran from on-farm sources (Table 21). Polyculturists obtained 98% of their cattle

Table 20. Average use of supplementary feed and fertilizers (kg·ha⁻¹) by *Puntius gonionotus* culture farmers in different ecosystems. Figures in parentheses are ranges of inputs used.

Inputs	Gangetic plain (n = 136)	Low-lying flood-prone (n = 26)	Floodland (n = 26)	Brackishwater (n = 39)
Lime	47 (0-741)	5 (0-35)	367 (0-741)	137 (0-296)
Cattle manure	2,213 (0-16,364)	1,488 (309-7,136)	4,894 (593-9,880)	1,814 (371-3,293)
Poultry droppings	107 (0-2,223)	46 (0-494)	507 (0-4,117)	64 (0-926)
Compost	5 (0-741)	-	665 (0-6,175)	-
Inorganic fertilizers	109 (0-1,996)	2 (0-62)	157 (0-1,112)	171 (0-1,029)
Rice bran	759 (0-5,928)	1,828 (329-6,274)	3,670 (0-9,386)	586 (0-2,058)
Wheat bran	1.7 (0-154)	-	-	9.3 (0-165)
Oil cake	84 (0-741)	-	-	13 (0-412)
Kitchen waste	15.6 (0-41)	-	-	-
Duckweed	-	-	573 (0-3,705)	-

Table 21. Utilization of on-farm and off-farm inputs (kg·ha⁻¹) for mono- and polyculture of *Puntius gonionotus*.

Input	Monoculture (n = 46)			Polyculture (n = 181)			Total (n = 227)		
	On-farm	Off-farm	All	On-farm	Off-farm	All	On-farm	Off-farm	All
Lime	-	100	100	-	100	100	-	100	100
Cattle manure	88.3	11.7	100	98.3	1.7	100	96.6	3.4	100
Poultry manure	100	-	100	88.2	11.8	100	89.7	10.3	100
Compost	-	-	-	100	-	100	-	100	100
Inorganic fertilizer	-	100	100	-	100	100	-	100	100
Rice bran	63.8	27.2	100	75.2	24.8	100	63.5	36.5	100
Oil cake	-	100	100	16.5	83.5	100	15.8	84.2	100
Wheat bran	100	-	100	47.9	52.1	100	58.6	41.4	100
Kitchen waste	100	-	100	100	-	100	100	-	100
Duckweed	-	-	-	-	100	100	-	100	100

manure, 88% of poultry manure, 100% of compost, 75% of rice bran and 16% of oil cake from on-farm sources. This implies that introduction of aquaculture has increased the importance and value of on-farm resources. It is interesting to note that some farmers identified duckweed as an important supplementary feed.

Harvesting Methods and Costs

Netting, angling and drainage were the harvesting methods used. Netting was the single most important method (Table 22). Fifteen per cent of the farmers also harvested their fish by

Table 22. Methods and costs for fish harvesting, for male and female farmers.

Methods/cost of harvesting	Male (n = 146)		Female (n = 81)		All (n = 227)	
	No.	%	No.	%	No.	%
Fish harvesting methods						
Netting	143	98	78	96	221	97
Drainage	7	5	1	1	8	4
Angling	20	14	14	17	34	15
Cost of harvesting						
Share of fish (kg·ha^{-1})	73		99		90	
Cash cost (Tk.ha^{-1})	757		1,046		860	

[US$1.00 = Tk.38.00]

angling, while few farmers (3.5%) dewatered their ponds. There were no significant differences in fish harvesting practices followed by male and female farmers. Dewatering was followed mostly by the male farmers, probably because of manual labor involved.

Because seine nets are expensive, farmers engage professional fishers for harvesting fish at the end of culture period. However, in between they catch small quantities of fish for consumption by angling or using a cast net. Farmers pay for seine netting services either in kind, in terms of shares from fish caught, or a fixed amount of cash. Harvesting costs amounted to an average of 90 kg of fish·ha^{-1} in case of payment in kind or Tk.860 in case of cash payment. Payment in kind is quite expensive (Tk.3,600·ha^{-1} at a value of Tk.40 per kg of fish) but farmers resort to this in quite many cases due to lack of cash to pay for the services.

Fish Production and Utilization

The fish culture period varied from 3 to 8 months, depending on the water retention in different farm ponds. As evident from Table 23, fish production increased with longer rearing periods from 772 kg·ha^{-1} in three months to 1,563 kg·ha^{-1} in eight months. A significant difference in fish yield was observed between mono- and polyculture. Monoculturists were able to produce on average 815 kg·ha^{-1} in five months rearing, whereas polyculturists were able to produce 1,373 kg·ha^{-1} during the same period and 1,480 kg·ha^{-1} in seven months. Subsequent

Table 23. Average gross production from mono- and polyculture of *Puntius gonionotus* for different rearing periods.

Rearing period (months)	Monoculture (kg·ha^{-1})	Number of cases	Polyculture (kg·ha^{-1})	Number of cases	All (kg·ha^{-1})	Number of cases
3	-	-	1,544	1	772	1
4	834	11	1,256	4	946	15
5	676	11	1,373	28	1,177	39
6	896	14	1,427	56	1,321	70
7	934	6	1,539	53	1,477	59
8	1,367	2	1,573	39	1,563	41

to introduction of the *P. gonionotus* farming technology, farmers obtained an average gross production of 1,345 kg·ha^{-1} (in mono- and polyculture together) in six months: 74% higher than the pre-intervention production of 771 kg·ha^{-1} (Table 24). Production in both monoculture and mixed culture was slightly higher among male farmers compared to female farmers (Table 25).

Of the fish produced, 40% was sold and the rest was consumed by households or given to neighbors. This shows an increase in the sale of fish compared to fish sales before the dissemination of the technology, which was only 31% of the fish produced (Table 9 and Fig. 4). Increases in production and in sales of fish resulted in higher cash incomes to farmers. At the same time, household consumption also increased.

Table 24. Gross fish production and other changes in pond culture before and after extension of *Puntius gonionotus* farming technology. Figures in parentheses represent standard deviations of means.

Details	Monoculture (n = 46)	Polyculture (n = 181)	All (n = 227)
Pre-intervention production (kg·ha⁻¹)	477 (417)	847 (553)	771 (321)
Post-intervention production (kg·ha⁻¹)	815 (363)	1,480 (240)	1,345 (444)
Average rearing period during post-intervention (months)	5	7	6
Increase in production (%)	71	75	74
Number of ponds under culture before introduction of *Puntius gonionotus*	30	178	208

Table 25. Production and disposal patterns of farmed fish, after the introduction of *Puntius gonionotus* farming technology. Figures in parentheses represent standard deviations of means.

	Monoculturists			Polyculturists			Total (n = 227)
	Male (n = 22)	Female (n = 24)	All (n = 46)	Male (n = 124)	Female (n = 57)	All (n = 181)	
Pond size (m^2)	327	283	304	400	384	395	377
Average rearing period (months)	5 (1)	5 (1)	5 (1)	7 (1)	7 (1)	7 (1)	6 (1)
Total production (kg·ha⁻¹)	906 (400)	731 (309)	815 (363)	1499 (355)	1440 (348)	1480 (353)	1,345 (444)
Home consumption and given away	454 (388)	217 (119)	330 (322)	852 (382)	799 (346)	835 (371)	733 (414)
Sold (kg·ha⁻¹)	452 (420)	514 (346)	485 (380)	647 (394)	640 (323)	645 (372)	612 (379)

An analysis of fish production in different ecosystems (Table 26) has shown that production, both pre- and post-technology intervention, was higher in the gangetic plain and brackishwater areas than in low-lying, flood-prone areas and floodlands. The higher production in the gangetic plain and brackishwater areas might be due to their more stable environment and to higher input use. The other two areas are subject to flooding, with resultant loss of fish.

Factors Affecting Production: an Econometric Analysis

Two basic functions were estimated: one on a per farm basis and the other on a per hectare basis. The ordinary least square (OLS) estimates of the parameters of the Cobb-

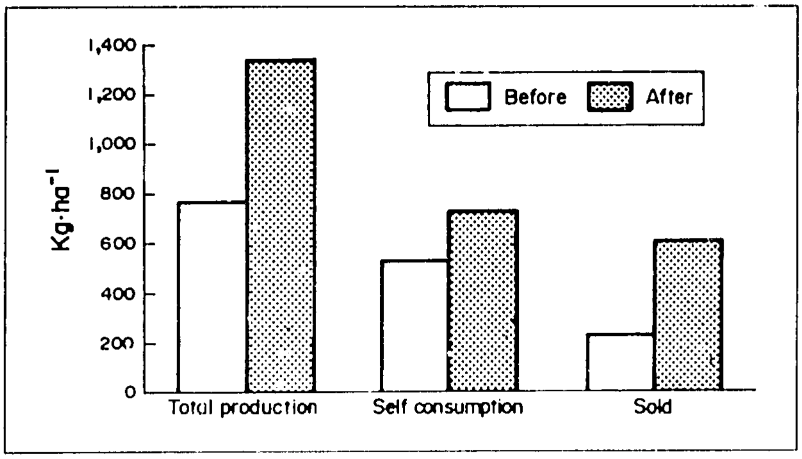


Fig. 4. Fish production and utilization patterns before and after introduction of *Puntius gonionotus* farming technology.

Table 26. Impact on production in different ecosystems of the extension of *Puntius gonionotus* farming technology.

Ecosystem	Pre-intervention production (kg·ha^{-1})	Post-intervention production (kg·ha^{-1})	Post-intervention rearing (months)	Per cent increase in production
Gangetic plain (n = 136)	886	1,439	7	62
Low-lying flood-prone (n = 26)	315	785	5	149
Floodland (n = 26)	645	1,279	7	98
Brackishwater (n = 39)	764	1,437	6	88

Douglas production function (equations i and ii) are presented in Tables 27 and 28. The regression coefficients (Bi) or exponents in Cobb-Douglas form are the elasticities of production. The goodness of fit of the production function to the observed data is evident from the significantly high values of R^2, except for monoculturists in equation ii. Higher values of adjusted R^2 were given by production function estimates on a per farm basis. Separate production functions were estimated for mono- and polyculturists to show the variations in the contribution of each input. For monoculture, no single material input was found significant probably due to irregular use of inputs, and the wide variability between farmers. For the same farmers, nonmaterial inputs like area of the waterbodies, gender and floods were found significant. Production of *P. gonionotus* was significantly affected by flood.

For polyculture, the number of significant variables increased. Among the material inputs, fingerlings and rice bran were significant. The coefficients for cattle manure, lime and inorganic fertilizers were negative, but were also small and not significant. Coefficients of all nonmaterial inputs, except gender, were significant.

The production function for all farmers taken together shows similar results and a higher value of R^2. Among the coefficients for material inputs, only that for fingerlings was significant. Coefficients of the nonmaterial inputs, except operator type, were significant. The positive and significant coefficient for gender implies that male farmers were able to produce more than the female farmers. Moreover, polyculturists produced significantly more fish than monoculturists.

Table 27. Estimated production function (Cobb-Douglas) per farm for *Puntius gonionotus* farmers.

Variables	Monoculture		Polyculture		All	
	Regression coefficient	T-value	Regression coefficient	T-value	Regression coefficient	T-value
Intercept	0.1716	0.119	0.1654	.553	.2458	.775
	(1.4470)		(.2993)		(.3170)	
Fingerlings	0.2503	0.941	.2288	4.259*	.2269	4.075*
	(0.2659)		(.0537)		(.0555)	
Rice bran	0.0073	0.315	.0093	1.932**	.0056	1.134
	(0.0231)		(.0048)		(.0050)	
Cattle manure	-0.0143	-0.405	-.0056	-1.138	-.0020	-.385
	(0.0353)		(.0049)		(.0052)	
Lime	-0.0009	-0.067	-.0009	-.256	.0002	.061
	(0.0136)		(.0036)		(.0036)	
Inorganic fertilizers	0.0186	1.304	-.0002	-.050	.0023	.614
	(0.0143)		(.0035)		(.0035)	
Culture period	0.2956	1.169	.2496	2.52*	.2951	3.140*
	(0.2529)		(.0990)		(.0939)	
Area of the waterbodies	0.5866	2.692*	.7775	12.628*	.7302	12.24*
	(0.2179)		(.0615)		(.0596)	
Gender	0.2606	2.071**	.0501	1.262	.0966	2.45**
	(0.1258)		(.0391)		(.0394)	
Flood	-0.3168	-1.983	-.1758	2.367**	-.2169	-3.53*
	(0.1598)		(.0743)		(.0646)	
Operator type	0.1531	-0.892	.1449	2.44**	.0683	1.18
	(0.1717)		(.0594)		(.0579)	
Mono- *vs.* polyculture	-	-	-	-	-.4666	-8.841*
					(.0527)	
Adjusted R^2	0.50	-	79	-	.82	-
F-Statistic	5.38*	-	68.87*	-	93.90*	-

*significant at 1% level of significance.
**significant at 5% level of significance

Table 28. Estimated production function (Cobb-Douglas) per ha for *Puntius gonionotus* farmers.

Variables	Monoculture		Polyculture		All	
	Regression coefficient	T-value	Regression coefficient	T-value	Regression coefficient	T-value
Intercept	4.2787	1.523	4.41	8.033**	4.495	7.721*
	(2.809)		(.5490)		(.582)	
Fingerlings	.2483	.942	.2278	4.260**	.2249	4.068*
	(.2637)		(.0534)		(.0552)	
Rice bran	.0061	.326	.0074	1.933**	.005	1.147
	(.0185)		(.0038)		(.004)	
Cattle manure	-.0118	-.421	-.0045	-1.51	-.0017	-.406
	(.0282)		(.0039)		(.0042)	
Lime	-.0002	-.028	-.0005	-.208	.0003	.138
	(.0101)		(.0027)		(.0028)	
Inorganic fertilizers	.0136	1.29	-.00002	-.007	.0019	.721
	(.0105)		(.0027)		(.0027)	
Culture period	.3025	1.193	.2514	2.54*	.2969	3.16*
	(.2536)		(.0989)		(.0939)	
Area of the waterbodies	-.1582	1.104	.0084	198	-.0387	-.924
	(.1433)		(.0427)		(.0419)	
Gender	.2577	2.04**	.495	1.247	.0958	2.43*
	(.1264)		(.0397)		(.0394)	
Flood	-.3181	1.974**	-.175	-	-.2169	-3.35*
	(.1611)		(.0743)		(.0647)	
Operator type	-.1545	-.009	-.1459	2.356**	.0693	1.198
	(.1717)		(.0594)		(.0578)	
Mono- *vs.* polyculture	-	-	-	2.458**	-.4642	-8.789*
					(.0528)	
Adjusted R^2	.23	-	.18	-	.50	
F-Statistic	2.30**	-	4.94*	-	21.41*	

*significant at 1% level of significance
**significant at 5% level of significance.

COSTS AND BENEFITS

Production Costs

Mono- and polyculture of *P. gonionotus* involved both cash and noncash costs. On average, taking all the farmers together, total cost of production was estimated at Tk.13,156·ha^{-1}, of which almost 90.4% were cash costs (Table 29). The average cost of production was higher by 18% for polyculture, due to higher quantity of inputs used (Table 17). Fingerlings and harvesting were the major operating costs: 46 and 29% of the total costs, respectively. Inorganic fertilizers and lime accounted only for 4.6 and 3.5% of the total costs, respectively, whereas organic fertilizers and fish feed comprised 15.3% of costs. Cost composition varied between mono- and polyculture: for monoculture, fingerlings, harvesting and organic fertilizers and feed accounted for 54, 20 and 20% of total costs, respectively; for polyculture the corresponding figures were 44, 31 and 14% (Table 29).

Table 29. Average cost of production (Tk.ha^{-1}) for *Puntius gonionotus* farming, by major inputs. Figures in parentheses are standard deviations of means.

	Monoculture			Polyculture			Total Item (n = 227)
	Male farmers (n = 22)	Female farmers (n = 24)	All (n = 46)	Male farmers (n = 124)	Female farmers (n = 57)	All (n = 181)	
Cash costs							
Fingerlings	5,710	6,674	6,213	6,028	6,086	6,046	6,080
Lime	304	190	244	521	501	515	460
Inorganic fertilizers	260	140	197	732	651	707	603
Organic fertilizers	29	20	24	3	11	6	10
Fish feed	956	1,438	1,208	536	813	623	741
Harvesting	2,723	1,990	2,341	4,306	4,181	4,266	3,876
Carrying	191	197	194	99	74	91	112
Piscicide	-	-	-	12	2	9	7
Total cash costs	10,173	10,649	10,421	12,237	12,319	12,263	11,889
	(7,588)	(4,298)	(6,031)	(6,852)	(6,683)	(6,782)	(6,664)
Noncash costs							
Organic fertilizer	386	338	361	417	491	440	424
Fish feed	846	583	709	886	855	876	842
Total noncash costs	1,232	921	1,070	1,303	1,346	1,316	1,266
	(2,129)	(1,042)	(1,641)	(1,718)	(1,855)	(1,757)	(1,734)
Total cost	11,406	11,570	11,491	13,540	13,665	13,579	13,155
	(7,856)	(4,354)	(6,205)	(7,488)	(7,418)	(7,445)	(7,247)

Benefits Gross and Net Income

On average, farmers' gross income from *P. gonionotus* culture amounted to Tk.44,590·ha^{-1}. The average net income of mono- and polyculture farmers was Tk.31,431·ha^{-1} (Table 30): 2.4 times the total cost of production (including noncash costs). Average net income of the polyculture farmers was almost double (1.9 times) the monoculture farmers. While cost of production was higher by 18% in the case of polyculture, production was higher by 81% and

Table 30. Gross and net income from farming *Puntius gonionotus* in mono- and polyculture, by gender and ecosystem. Figures in parentheses are standard deviations of the respective means; * indicates that the data in this column subset are significantly different (p=0.01).

	Size of water-bodies (m^2)	Gross income (Tk)		Net income (Tk)		Net income excluding noncash costs (Tk)	
		Per farm	Per ha	Per farm	Per ha	Per farm	Per ha
Monoculture (n = 46)	304	838* (491)	29,977* (14,404)	506* (461)	18,485* (13,220)	528* (460)	19,555* (13,432)
Polyculture (n = 181)	395	1,922 (1,005)	48,303 (15,840)	1,411 (846)	34,725 (14,171)	1,455 (853)	36,041 (14,069)
Gender:							
Male (n = 146)	389	1,801* (931)	46,704 (16,885)	1,311 (807)	33,486* (15,097)	1,354 (812)	34,778* (15,130)
Female (n = 81)	354	1,525 (1,151)	40,779 (17,193)	1,078 (950)	27,735 (15,377)	1,112 (956)	28,955 (15,134)
Ecosystems							
Gangetic plain area (n = 136)	326	2,148* (1,028)	50,823* (17,217)	1,582* (894)	37,145* (15,913)	1,616* (911)	37,935* (16,130)
Low-lying, flood-prone (n = 26)	278	818 (356)	29,689 (10,297)	486 (309)	17,287 (9,888)	510 (302)	18,268 (9,613)
Floodland (n = 26)	205	916 (469)	44,582 (13,251)	539 (279)	25,712 (7,378)	626 (313)	30,241 (8,231)
Brackishwater (n = 39)	386	1,262 (592)	32,791 (9,280)	948 (505)	24,765 (9,555)	983 (508)	25,708 (9,438)
All (n = 227)	377	1,702 (1,021)	44,590 (17,195)	1,227 (865)	31,434 (15,412)	1,267 (872)	32,700 (15,417)

net benefit by 188%, compared to monoculture, indicating that polyculture is much more profitable than monoculture without much additional operating costs.

Female farmers obtained less benefits than male farmers from both monoculture and polyculture (Table 31). The difference in net benefit between male and female farmers was 9% for polyculture and 37% for monoculture. As indicated above, 65% of monoculturists were new to aquaculture, and this gender difference may indicate that female adopters need more training and motivation.

Farmers from the gangetic plain and floodland areas obtained higher benefits (Tk.37,141 and 25,712·ha⁻¹) due to their higher fish production, compared to the farmers in low-lying flood-prone and brackishwater areas (Tk.17,287 and 24,765·ha⁻¹) (Table 30).

Table 31. Gross and net income from *Puntius gonionotus* monoculture and polyculture, by farmers' gender. Figures in the parentheses are standard deviations of the respective means.

Gender	Gross income ($Tk.ha^{-1}$)		Net income ($Tk.ha^{-1}$)		Net income excluding noncash costs ($Tk.ha^{-1}$)	
	Monoculture (n = 46)	Polyculture (n = 181)	Monoculture (n = 46)	Polyculture (n = 181)	Monoculture (n = 46)	Polyculture (n = 181)
Male (n = 146)	32,914 (15,700)	49,150 (15,937)	21,508 (13,162)	35,611 (14,453)	22,740 (13,622)	36,914 (14,416)
Female (n = 81)	27,284 (12,850)	46,461 (15,607)	15,714 (12,925)	32,795 (13,460)	16,635 (12,843)	34,143 (13,222)
All (n = 227)	29,977 (14,405)	48,303 (15,840)	18,485 (13,220)	34,724 (14,171)	19,555 (13,431)	36,041 (14,069)

Effects of Flood and Disease on Production and Income

Culture of *P. gonionotus* was also affected to an extent by floods and disease. Fish in 14.5% of the waterbodies were affected by epizootic ulcerative syndrome (Table 32).

Table 33 gives the effects of flooding and disease on production and income of the *P. gonionotus* farmers. Fish production from flood-affected ponds was significantly lower: 962 $kg \cdot ha^{-1}$, as against 1,386 $kg \cdot ha^{-1}$ from unaffected ponds. This has resulted in lower benefits to the affected farmers: net income for unaffected farmers was nearly 77% more than affected monoculturists and 27% more than affected polyculturists. The disease outbreaks had no discernable effects on production and income, due to timely precautionary measures taken by farmers, like liming of ponds and early harvesting of diseased fish for sale.

Table 32. Numbers of *Puntius gonionotus* ponds affected by floods and disease during the rearing period.

Item	Monoculture ponds (n = 46)		Polyculture ponds (n = 181)		All (n = 227)	
	No.	%	No.	%	No.	%
Affected by flood	10	21.7	12	6.6	22	9.7
Washed away	3	6.5	1	0.6	4	1.8
Partially flooded	7	15.2	11	6.1	18	7.9
Affected by disease	5	10.9	28	15.5	33	14.5

Table 33. Effects of flood and disease on production and income of *Puntius gonionotus* farmers. Figures in parentheses are standard deviations of respective means.

Item	Production ($kg \cdot ha^{-1}$)	Gross return ($Tk \cdot ha^{-1}$)	Net income ($Tk \cdot ha^{-1}$)	Net income excluding noncash costs ($Tk \cdot ha^{-1}$)
Flood				
Affected (n = 22)	962	33,021	20,377	21,868
	(557)	(19,502)	(16,108)	(16,787)
Monoculturists (n = 10)	540	19,836	11,484	12,163
	(403)	(14,352)	(15,449)	(15,931)
Polyculturists (n = 12)	1,313	44,009	27,788	29,956
	(402)	(16,365)	(12,912)	(13,166)
Unaffected (n = 205)	1,386	45,831	32,620	33,862
	(411)	(16,505)	(14,894)	(14,842)
Monoculturists (n = 36)	891	32,794	20,430	21,609
	(318)	(13,277)	(12,061)	(12,113)
Polyculturists (n = 169)	1,492	48,608	35,217	36,473
	(347)	(15,807)	(14,158)	(14,068)
Incidence of disease				
Affected (n = 33)	1,380	44,838	30,145	32,137
	(448)	(16,889)	(15,851)	(15,936)
Monoculturists (n = 5)	1,063	38,280	26,773	27,665
	(448)	(16,400)	(17,405)	(16,929)
Polyculturists (n = 28)	1,436	46,009	30,747	32,936
	(433)	(16,995)	(15,825)	(15,967)
Unaffected (n = 194)	1,339	44,547	31,653	32,796
	(444)	(17,289)	(15,368)	(15,367)
Monoculturists (n = 41)	785	28,964	17,474	18,566
	(347)	(14,031)	(12,538)	(12,848)
Polyculturists (n = 153)	1,488	48,723	35,452	36,609
	(337)	(15,642)	(13,779)	(13,680)

FARMERS' PERCEPTION OF THE TECHNOLOGY

Attitude of the Farmers

Most farmers (91%) irrespective of the culture methods practised, expressed satisfaction with the new technology: 33% were in favor of expanding operations and 58% expressed a desire to continue on the present scale (Table 34). Eight percent were indifferent to expansion or continuation and only 1% wanted to discontinue. Farmers' perceptions of the technology was different by culture methods and gender. Forty-three per cent of the farmers who cultured only *P. gonionotus* expressed their desire to expand operations whereas only 30% of the polyculturists favored expansion (Table 34).

Table 34. Attitude of farmers regarding the future of *Puntius gonionotus* culture.

	Farmers' attitude							
	Expand		Continue		Discontinue		Indifferent	
	No.	%	No.	%	No.	%	No.	%
Monoculturists (n = 46)	20	43	21	46	-	-	5	11
Male (n = 22)	8	36	12	55	-	-	2	9
Female(n = 24)	12	50	9	37	-	-	3	13
Polyculturists (n = 181)	55	30	110	61	3	2	13	7
Male (n = 124)	38	31	73	59	3	2	10	8
Female (n = 57)	17	30	37	65	-	-	3	5
All	75	33	131	58	3	1	18	8

Difficulties Faced by Farmers

The difficulties identified by farmers in culturing *P. gonionotus* were: nonavailability of credit to buy inputs (40%); small size of waterbodies, which limits profitability (37%); too short a period of water retention in ponds (29%); risk of losing fish due to disease (28%); and difficulties in obtaining fingerlings (27%) (Table 35). Nonavailability of credit and inadequate availability of fingerlings of *P. gonionotus* were considered as major problems by majority of the farmers. This was because *P. gonionotus* fingerlings were not available from vendors and farmers had to completely depend on the BRAC for fingerling supply. Other problems such as obtaining feeds other than rice bran, difficulties in harvesting of fish due to lack of nets, poaching and flooding of ponds were also reported.

Difficulties varied among the male and female farmers. Inadequate fingerling supply was reported as a principal problem by women farmers whereas male farmers reported nonavailability of credit as their major problem. Among the polyculturists, the main problem reported by female farmers was the small size of ponds whereas for males it was credit availability (Table 35).

Table 35. Difficulties faced by *Puntius gonionotus* culture farmers.

	Monoculture						Polyculture						Total	
	Male farmers (n = 22)		Female farmers (n = 24)		All (n = 46)		Male farmers (n = 124)		Female farmers (n = 57)		All (n = 181)		(n = 227)	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Inadequate supply of fingerlings	6	27	13	54	19	41	27	22	15	26	42	23	61	27
Nonavailability of credit	11	50	11	46	22	48	52	42	16	28	68	38	90	40
Problem of getting feeds other than rice bran	1	5	-	-	1	2	19	15	13	23	32	18	33	15
Too short a period of water retention in ponds	2	9	3	12	5	11	42	34	18	32	60	33	65	29
Small size of ponds	6	27	2	8	8	17	50	40	26	46	76	42	84	37
Flooding	2	9	3	12	95	11	1	1	2	4	3	2	8	4
Harvesting problems	-	-	1	4	1	2	16	13	12	21	28	15	29	13
Poaching	2	9	-	-	2	4	9	7	4	7	13	7	15	7
Risk due to disease	5	22	5	21	10	22	42	34	11	11	53	29	63	28

Benefits of P. gonionotus *Farming*

The benefits from *P. gonionotus* farming as perceived by farmers can be categorized into technological, economic and social. A majority of the farmers perceived economic benefits from *P. gonionotus* farming as: 1. source of food for the family (66%); 2. source of income (41%); and 3. a quick return on investment (75%) (Table 36). Rapid growth, low investment and simple technology were perceived as the most important technological factors by mono- and polyculturists (Fig. 5).

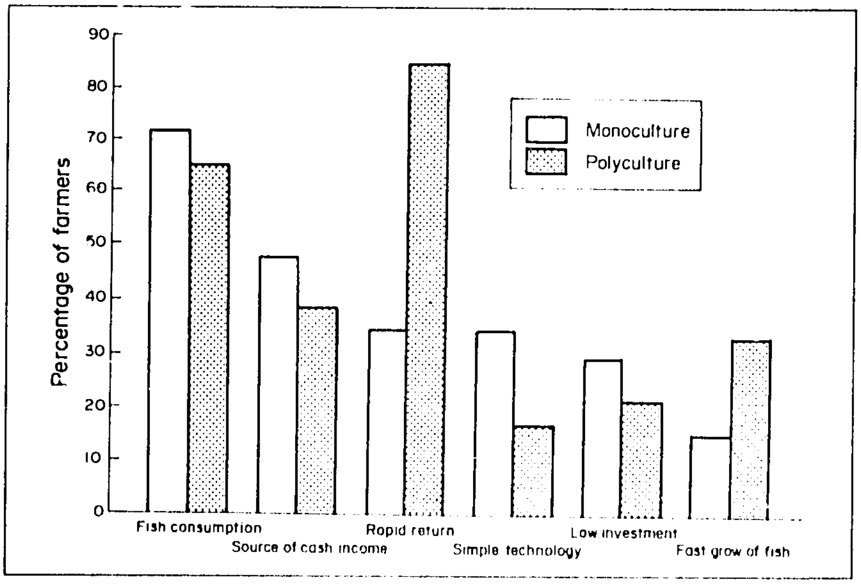


Fig. 5. Benefits from *Puntius gonionotus* culture as perceived by farmers.

Table 36. Perception of farmers regarding benefits of *Puntius gonionotus* culture. Percentages of responses are in parentheses.

Received benefits	Monoculture			Polyculture			Total (n = 227)
	Male farmers (n = 22)	Female farmers (n = 24)	All (n = 46)	Male farmers (n = 124)	Female farmers (n = 57)	All (n = 181)	
Fish for home consumption	15 (68)	18 (75)	33 (72)	71 (57)	46 (81)	117 (65)	150 (66)
Source of cash income	9 (41)	13 (54)	22 (48)	48 (39)	23 (40)	71 (39)	93 (41)
Improved economic status	4 (18)	4 (17)	8 (17)	19 (15)	7 (12)	26 (14)	34 (15)
Rapid return	9 (41)	7 (29)	16 (35)	109 (88)	46 (81)	155 (86)	171 (75)
Low investment	5 (23)	9 (38)	14 (30)	28 (22)	12 (21)	40 (22)	54 (24)
Fast growth of fish	5 (23)	2 (8)	7 (15)	41 (33)	21 (57)	62 (34)	69 (30)
Simple technology	7 (32)	9 (38)	16 (35)	24 (19)	6 (11)	30 (17)	46 (20)
Better social relationships	-	-	-	3 (2)	3 (5)	6 (3)	6 (3)
Utilization of derelict resources	2 (9)	4 (17)	6 (13)	2 (2)	1 (2)	3 (2)	9 (4)

Encouragement and Dropout Factors

Farmers were asked, without prompting, about the factors that influence them to continue or discontinue farming of *P. gonionotus*. Rapid growth, high demand and price for the harvested fish, a source of food for family, and low input cost were among the factors that 91% of farmers said would influence them to continue farming *P. gonionotus*. Among the three farmers who wanted to discontinue, two indicated risk due to disease and the other indicated slow growth of the fish as the reasons (Table 37).

Table 37. Encouragement and dropout factors for *Puntius gonionotus* farming.

Factors	Male farmers (n = 124)	Female farmers (n = 81)	Total (n = 227)
Encouragement factors(%)			
Rapid growth	71	60	67
High demand/price	50	53	57
Low input cost	21	25	22
Source of food for family	29	35	31
Possibility to culture in small ponds	8	4	7
Dropout factors (%)			
Slow growth	0.8	-	0.4
Risk of disease	1.6	-	0.9

CONCLUSIONS

The study revealed a number of issues in technology dissemination and adoption. Multiple ownership of ponds was identified earlier as a constraint for aquaculture development in Bangladesh (World Bank 1991). However, the study has shown that in the case of small ponds and ditches, this may not be a problem, as some 67% of the ponds surveyed were under single ownership and 28% ponds under multiple ownership were also used for aquaculture.

The technology developed by FRI was viable from social and economic view points, as evident from adoption of the technology by resource poor farmers and revenue from sale of 30% of fish produced was enough to meet the cost of production (including non-cash costs). The technology is robust, in that the farmers were able to increase their fish productions by 74%, using much less than the suggested inputs. While the technology suggested monoculture of *P. gonionotus*, polyculture with carps undertaken by farmers resulted in higher productions. Subsequent on-station studies undertaken by FRI confirmed that polyculture is a better alternative to monoculture (ICLARM 1992) and farmers are being advised to culture *P. gonionotus* along with other carps. Using the technology, a family of six members can have per caput fish consumption of more than the national average of 7.9 $kg \cdot year^{-1}$, from a pond as small as 378 m^2.

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ANNEX 1

Summary of Information on *Puntius gonionotus**

Family	:	Cyprinidae
Order	:	Cypriniformes
Species	:	*Puntius gonionotus* (Bleeker, 1849)

Common names:
English: Thai silver barb; Thai: Pla tapien khao; Malay: Lalawak; Vietnamese: Ca tra vinh; Bengali: Rajputi

Distinctive characters:
Body is strongly compressed. The back is elevated, its dorsal profile arched, often concave above the occiput. The head is small; the snout pointed; the mouth terminal. The barbels are very minute or rudimentary, especially the upper ones, which sometimes disappear entirely. Color when fresh is silvery white, sometimes with a golden tint. The dorsal and caudal fins are gray to grey-yellow; the anal and pelvic fins light orange, their tips reddish; the pectoral fins pale to light yellow. Dorsal rays IV, 8; anal rays III, 6; pectoral rays I, 14-15; pelvic rays I, 8. (see Fig. 6).

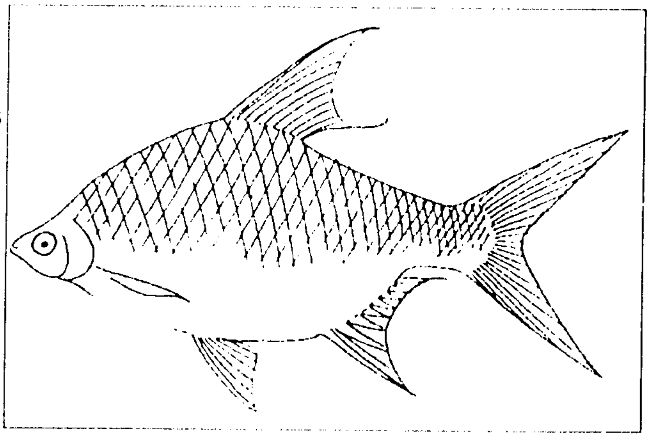

Fig. 6. *Puntius gonionotus*

Distribution:
Southeast Asia: Laos and Vietnam to Java in Indonesia. Introduced and established in Bangladesh, China, Fiji, India, Malaysia and the Philippines.

Habitat and biology:
A large migratory fish often used in aquaculture, also as a pituitary donor to induce spawning of other cultivated fish. Escapees from culture installations have become established in rivers and form the basis for capture fisheries on several Southeast Asian islands. Feeds on plant matter (e.g. leaves, weeds - *Ipomea reptans* and *Hydrilla*) and invertebrates and therefore useful in cropping excessive vegetation especially in reservoirs. Also used as aquarium fish.

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*Compiled by Liza Q. Agustin (FishBase Project, ICLARM)

ANNEX 2

Benchmark Survey of Silver Barb (*Puntius gonionotus*) Culture Farmers

I. RESPONDENT'S IDENTIFY:

Name of the farmer:__________________ BRAC Office:____________

Village:______________ Upazila:____________ District:____________

BRAC office code |__|__| 1-2
District code |__|__| 3-4

Serial number of the respondent |__|__|__| 5-7

Principal occupation : ____________ |__| 8
Secondary occupation : ____________ |__| 9

[Occupation code : Farmer-1, Agricultural labour-2, Non-agricultural labour-3, Housewife-4, Service-5, Small traders-6, Fisherman-7, Rikshaw/Van driving-8, Others-9]

Sex (Male-1, Female-0) |__| 10

II. POND INFORMATION :

1. Pond/ditch water area during monsoon (in decimal) : ___________ |__|__| 11-12

2. Age of the pond/ditch after excavation/reexcavation : _______ |__|__| 13-14

3. Depth of the pond/ditch (in ft) :
   - in the rainy season |__| 15
   - in the dry season |__| 16

4. Number of months pond/ditch retains water (at least 2 ft) :________ |__|__| 17-18

5. Ownership type : |__| 19

   - Owned by household(s) 1
   - institutional 2
   - Khas 3
   - leased 4

6. If owned by households, number of owners |__|__| 20-21

7. Operator status |__| 22

- Sole owner 1
- Co-owner 2
- Lessee 3
- Share producer 4

8. Purpose for which pond was dug |__| 23

- Fish culture 1
- House building 2
- Road construction 3
- Others (specify) 4

9. Condition of pond (Yes=1, No=0)

- Broken dykes |__| 24
- Fully/partly shaded |__| 25
- Flood prone |__| 26

10. Other uses of pond (other than fish culture) (Yes=1, No=0)

a) Bathing and washing	:	a	|__|	27
b) Drinking	:	b	|__|	28
c) Irrigation	:	c	|__|	29
d) Jute retting	:	d	|__|	30
e) Others (specify)	:	e	|__|	31

11. Is the pond presently (before June 1991) under fish culture (Yes=1, No=0) |__| 32

12. If yes, for how many years it is under culture ? |__|__| 33-34

13. If no, what factors are responsible for not culturing (Yes-1, No-0) :
(do not put the questions to the farmers, but record his reasons, against the following)

a) Lack of fish culture knowledge	:	a	|__|	35
b) Lack of capital	:	b	|__|	36
c) Non-availability of fingerlings	:	c	|__|	37
d) Natural harvest is abundant	:	d	|__|	38
e) Non-cooperation of shareholders	:	e	|__|	39
f) Washed by floods	:	f	|__|	40
g) Jute retting	:	g	|__|	41
h) Others (specify)	:	h	|__|	42

(If the pond is presently under culture ask the following questions)

14. Types of fish cultured in the pond |___| 43

Tilapia	1	
Sharputi	2	
Polyculture (including carp)	3	
Others (specify)	4	

15. Production obtained during last one year (in kg)

Self consumption	: ________	|___|___|___|	44-46
Given away	: ________	|___|___|___|	47-49
Sold out	: ________	|___|___|___|	50-52
Total production	: ________	|___|___|___|	53-55

(Check again if production exceeds 4-5 kg per decimal)

16. Problems of fish marketing
(Yes-1, No-0)

a) No problem	:	a	|___|	56
b) Inadequate local demand/lower price	:	b	|___|	57
c) Urban marketing centres are too far	:	c	|___|	58
d) Inadequate transportation	:	d	|___|	59
e) Lack of preservation facilities	:	e	|___|	60
f) Others (specify)	:	f	|___|	61

17. Did you have any training in fish culture before :
(Yes-1, No-0) |___| 62

18. Problems faced by farmers in fish culture
(Yes-1, No-0)
(do not put these questions to the farmers, but record his reasons, against the following)

a) Lack of captial	:	a	|___|	63
b) Lack of knowledge on fish culture	:	b	|___|	64
c) Non-availability of fingerlings	:	c	|___|	65
d) Risk of theft	:	d	|___|	66
e) Risk of epizootic ulcerative syndrome	:	e	|___|	67
f) Problem of multiple ownership	:	f	|___|	68
g) Problems of repairing	:	g	|___|	69
h) Flood prone	:	h	|___|	70
i) Others (specify)	:	i	|___|	71

19. From where did you collect fingerlings
(Yes=1, No=0)

a) Public hatchery	:	a	___	72
b) Collected from rivers	:	b	___	73
c) Small traders/vendors	:	c	___	74
d) Collected from BRAC	:	d	___	75
e) Others (specify)	:	e	___	76

20. Sources of capital for fish culture :
(Yes=1, No=0)

a) Own capital	a	___	77
b) Public institutions/bank	b	___	78
c) BRAC	c	___	79
d) Relatives	d	___	80
e) Money lender	e	___	81
f) Others (specify)	f	___	82

Name of the Interviewer

Date :

Name of the Supervisor

Date :

ANNEX 3

Impact Assessment of Silver Barb (*Puntius gonionotus*) Culture

I. RESPONDENT'S IDENTITY

Name of the farmer : ______________________ BRAC office : ________

Village : ____________ Upazila : ______________ District : _________

BRAC office code
District code

Serial number of of the respondent

II. QUANTITY AND VALUE OF INPUTS USED (1991)

1. Pond preparation

Inputs	Quantity	Price/wage per unit		
Own source :				
Labour (days)	-------	---------	1	4
Cowdung (kg)	-------	---------	5	8
Chicken manure (kg)	-------	---------	9	12
Compost (kg)	-------	---------	13	16
Kitchen wastes (kg)	-------	---------	17	20
Hired resources :				
Lime (kg)	------	---------	21	24
Urea (kg)	------	---------	25	28
TSP (kg)	------	---------	29	32
Piscicide (kg)	------	---------	33	36
Cowdung (kg)	------	---------	37	40
Chicken manure (kg)	------	---------	41	44
Compost (kg)	------	---------	45	48
Carrying cost	------	---------	49	50

2. Stocking and Rearing

a) Species stocked : Number

Species		Number	Col.		Col.
P. gonionotus	:	----------	51	|__|__|__|	53
Tilapia	:	----------	54	|__|__|__|	56
Catla	:	----------	57	|__|__|__|	59
Rohu	:	----------	60	|__|__|__|	62
Mrigal	:	----------	63	|__|__|__|	65
Silver carp	:	----------	66	|__|__|__|	68
Mirror carp	:	----------	69	|__|__|__|	71
Others	:	----------	72	|__|__|__|	74

b) Size of fingerlings stocked (in inches) :

P. gonionotus	:	--------	|__|	01
Tilapia	:	--------	|__|	02
Catla	:	--------	|__|	03
Rohu	:	--------	|__|	04
Mrigal	:	--------	|__|	05
Silver carp	:	--------	|__|	06
Mirror carp	:	--------	|__|	07
Others	:	--------	|__|	08

c) Month of stocking : ------ 09 |__|__| 10

d) Cost of fingerlings (Tk.) ______ 11 |__|__|__|__| 14

e) Cost of fingerling transport : ______ 15 |__|__|__| 17

f) Principal source of fingerling supply :
(Yes=1, No=0)

- Purchased from BRAC	|__|	18
- Purchased from private vendor	|__|	19
- Purchased from Govt. farm	|__|	20
- Purchased from private farm	|__|	21

3. Fertilizers and Feed Applied

Fertilizer/ feed	Quantity	Price per unit				
Own source (kg) :						
Cow dung	------	--------	22	|__|__|__|	|__|__|	26
Rice bran	------	--------	27	|__|__|__|	|__|__|	31
Oil cake	------	--------	32	|__|__|__|	|__|__|	36
Wheat bran	------	--------	37	|__|__|__|	|__|__|	41
Waste/cooked rice	------	--------	42	|__|__|__|	|__|__|	46
Poultry droppings	------	--------	47	|__|__|__|	|__|__|	51
Compost	------	--------	52	|__|__|__|	|__|__|	56

Purchased (kg: :

Lime	------	-------	57	|_|_|_| |_|_|	61
Urea	------	-------	62	|_|_|_| |_|_|	66
TSP	------	-------	67	|_|_|_| |_|_|	71
Cowdung	------	-------	72	|_|_|_| |_|_|	76
Poultry droppings	------	-------	01	|_|_|_| |_|_|	05
Duck weed	------	-------	06	|_|_|_| |_|_|	10
Rice bran	------	-------	11	|_|_|_| |_|_|	15
Wheat bran	------	-------	16	|_|_|_| |_|_|	20
Oil cake	------	-------	21	|_|_|_| |_|_|	25
Others (specify)	------	-------	26	|_|_|_| |_|_|	30

(First three columns for quantity)

4. Harvesting and Disposal

a) Date (month) of harvesting 31 |_|_| 32

b) Harvesting method :

- Netting |_| 33
- Dewatering |_| 34
- Angling |_| 35

c) Cost of harvesting

i) Share of fish (kg) : ______ 36 |_|_|_| 38

ii) Cash (Tk.) : ______________ 39 |_|_|_| 41

d) Disposal pattern of harvested fish (kg)

Self consumed	: ________	42	|_|_|_|	44
Given away	: ________	45	|_|_|_|	47
Sold	: ________	48	|_|_|_|	50
Total production	: _______	51	|_|_|_|	53

e) Species wise harvest of fish (kg)

P. gonionotus	: ________	54	|_|_|_|	56
Tilapia	: ________	57	|_|_|_|	59
Catla	: ________	60	|_|_|_|	62
Rohu	: ________	63	|_|_|_|	65
Mrigal	: ________	66	|_|_|_|	68
Silver carp	: ________	69	|_|_|_|	71
Mirror carp	: ________	72	|_|_|_|	74
Others	: ________	74	|_|_|_|	77

f) Selling price per kg (Tk) 78 |_|_| 79

g) Whether affected by flood after stocking of fingerlings this year. (Yes=1, No=0)

h) If affected by flood, extent of damage |__| 80
- all fishes washed away 1
- fishes washed away partially 2 |__| 01

i) Whether affected by disease (Yes=1, No=0) |__| 02

IV. FARMER ASSESSMENT AND ATTITUDE TOWARDS P. GONIONOTUS CULTURE TECHNOLOGY

Note : Farmers should not be prompted. Mark farmers' reasons against list.

1. Difficulties faced by farmers (Yes=1, No=0)

a) Inadequate supply of fingerlings |__| 03
b) Non availability of credit |__| 04
c) Insufficient water in the pond |__| 05
d) Small size of pond |__| 06
e) Small size of pond |__| 07
f) Flood prone |__| 08
g) Problems of harvesting |__| 09
h) Risk of theft |__| 10
i) Risk of ulcerative disease |__| 11

2. Benefits derived from *P. gonionotus* culture by farmers (Yes=1, No=0)

a) Fish for consumption |__| 12
b) Source of cash income |__| 12
c) Help improve economic status |__| 13
d) Rapid return |__| 14
e) Low investment |__| 15
f) Fast growth of fish |__| 16
g) Simple technology |__| 17
h) Better social relationship |__| 18
i) Utilization of ditch for other purpose after fish culture |__| 19
j) Increased utilization of untouched resources |__| 20

3. Farmer's attitude towards future involvement in **P. gonionotus** culture using the new technology |__| 21

Continue 1
Expand 2
Discontinue 3
Undecided 4

4. If the farmers opted for expansion or continuation at the current scale, what are the reasons

a) ______________________________
b) ______________________________
c) ______________________________
d) ______________________________
e) ______________________________
f) ______________________________
g) ______________________________
h) ______________________________

5. If the farmers opted for discontinuation, what are the reasons

a) ______________________________
b) ______________________________
c) ______________________________
d) ______________________________
e) ______________________________
f) ______________________________
g) ______________________________
h) ______________________________

Signature of data collector

Date : ____________________

Signature of the verifier

Date : ____________________

Adoption and economics of silver barb (*Puntius gonionotus*) culture in seasonal waters in Bangladesh. M.V. Gupta and M.A. Rab. 1994. ICLARM Tech. Rep. 41, 39 p. US$3.00 surface; $5.50 airmail, P65.00.

Titles of Related Interest

Household socioeconomics, resource use and fish marketing in two thanas of Bangladesh. M. Ahmed, M.A. Rab and M.P. Bimbao. 1993. ICLARM Tech. Rep. 40, 82 p. US$5 surface, $8 airmail, P100.

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