7. Country case studies

7.1 Freshwater fish seed resources in Bangladesh

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ABSTRACT

Fisheries of Bangladesh play an important role in mitigating animal protein shortage as well as providing jobs to millions of people. The aquatic resources of the country are comprised of inland and marine waters in which inland waters are further segregated into closed and open water systems. Closed water culture system contributes about 43.52 percent to the total 78.34 percent inland fish production. Indian major carps, some exotic carps and catfishes are the main cultured species for the closed water system and production of these species completely depends on timely and adequate supply of quality seed. Until 1978, the country was completely dependent on natural sources for fish seed and spawns were collected during the monsoon season (May-August) from different rivers but in the course of time, production of fry in the rivers had been reduced and alternatively artificial breeding system through hypophysation evolved to compensate the production. So far, 878 hatcheries (112 public and 756 privately owned units) have been established and they provide almost entirely the required seed (99.55 percent) of both endemic and exotic carps of the country. Like carps, fry of freshwater prawn are produced in hatcheries and in the last 20 years, a good number of prawn hatcheries have been established both in private (Bangladesh Rural Advancement Committee and Proshika) and public sectors.

While Bangladesh is self-sufficient in meeting farmers' demands for seed, the quality of seed has deteriorated over the years mostly in private hatcheries for many reasons and among them, inbreeding, inter-specific hybridization, negative selection, improper broodstock management are most important. These factors result in low growth rate, high mortality, disease susceptibility, deformities, less fecundity of fish, etc. The high rate of inbreeding and inter-specific hybridization in both endemic and exotic carps results from the following: (i) keeping a very small number of broodstock in the hatcheries and rarely recruit new ones from outside, (ii) recruiting broodstocks from the subsequent generations of the same stock and (iii) breeding of the same brood twice, thrice in a season. To mitigate these genetic problems and to improve the quality of seed, the Department of Fisheries and the Bangladesh Fisheries Research Institute have taken some initiatives, such as establishment of brood banks, distribution of broods to government and private hatcheries from the brood banks and broodstock management trainings for hatchery and farm operators. In addition to brood bank, the Government

of Bangladesh in collaboration with donor agencies and non-governmental organizations established a number of fish sanctuaries in inflowing rivers, dead rivers, *haors* and *beels* (natural depression) to promote natural recruitment. The local fishing communities are the beneficiaries of the project but the success of the project is yet to be determined.

INTRODUCTION

Bangladesh is a South Asian country located in between latitude 20°34' and 26°39' north and longitude 80°01' and 92°41' east. It is a small country having an area of 143 000 sq. km but she accommodated about 140 million population, probably the highest density in the world within her boundary. Fisheries in Bangladesh play an important role in mitigating animal protein shortage as well as providing jobs to millions of people. Fish provides 63 percent of the total animal protein supply and the per capita annual fish intake is about 15.04 kg. The total fish production in Bangladesh is about 2.10 million tonnes in 2003-2004 with an annual growth rate of production of 5.20 percent (DOF, 2005). The fisheries sector contributes 4.92 percent to GDP, 23 percent to the agriculture sector and 5.10 percent to foreign exchange earnings through export.

Situated in the delta of the Bramaputtra, Meghna and Ganges river systems, Bangladesh is endowed with unique water resources comprised of both inland and marine waters. The inland waters are consisted of closed water bodies (ponds and ditches, oxbow lakes, shrimp farms) with an area of 513 548 ha. and open water bodies (river, estuary, beel, kaptai lake, flood plain, polder/encloser) with 4 920 316 ha. In addition to inland waters, Bangladesh has 166 000 sq km of marine water area including EEZ (200 nautical miles from the base line). According to the Fisheries Resources Information of Bangladesh (2003-2004), closed water culture system contributes about 43.52 percent to the total 78.34 percent inland fish production, while open water capture fisheries contribute 34.83 percent. The marine water contributes 21.66 percent to total production. Although Bangladesh is enriched with high biodiversity having 260 freshwater fish and 24 freshwater prawn species, not so many species are being commercially cultured. So far 12 exotic species have been introduced to Bangladesh. The main production in closed water inland fisheries comes from Indian major carps along with exotic carps, catfishes and tilapia. The following table presents the commonly cultured freshwater fish species in Bangladesh.

Both endemic and exotic carps have enormously contributed to the total aquaculture production since 1990s and from 1997 to 1998 it contributed 35 percent to the total fish production and 90 percent to aquaculture production (Hussain and Mazid, 2001).

TABLE 7.1.1
List of cultured fish species in Bangladesh

No.	Scientific name	Common name
1	*Catla catla*	catla
2	*Labeo rohita*	rui
3	*Cirrhinus cirrhosus*	mrigal
4	*Labeo calbasu*	kalbaush
5	*Hypophthalmicthys molitrix*	silver carp
6	*Cyprinus carpio*	common carp
7	*Ctenopharyngodon idella*	grass carp
8	*Aristicthys nobilis*	bighead carp
9	*Barbodes gonionotus*	silver barb
10	*Pangasius sutchi*	Thai pangas
11	*Anabas testudineus*	Thai koi
12	*Oreochromis niloticus*	Nile Tilapia
13	*Labeo bata*	Ilsha Bata
14	*Labeo gonia*	Kurio labeo
15	*Clarias batrachus*	Asian catfish
16	*Heteropnuestes fossilis*	Asian catfish

Indian, Chinese and common carp polycultures in small ponds produced 700 000 tonnes in 2002 which covered 80 percent of the total freshwater aquaculture production in Bangladesh (Collis, 2003). According to the statistics of the Department of Fisheries (DOF), silver carp contributed 23 percent of the total fishpond production in 2001 and has become an important food fish for the poor, together with silver barb and Nile tilapia. In recent times, culture of monosex male tilapia has got more popularity among fish farmers and it is becoming

a big industry in Bangladesh. It is undoubtedly clear that in Bangladesh total fish production through aquaculture increased many folds in two decades. Such enormous increase of production has been possible due to many factors, among which production of fry of different species and the timely supply to the farmers are considered the most important. It is obvious that to uphold the existing increasing trend of aquaculture production and also to maintain its sustainability, quality seed production and its continuous supply need to be assured.

SEED RESOURCES SUPPLY

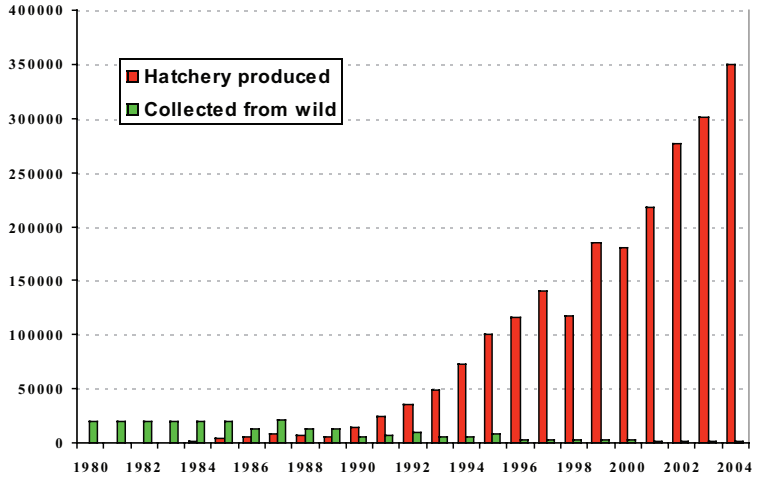
There are two major sources of seed of Indian major carps, i.e. hatcheries and natural sources such as rivers. Until the year 1978, the country was completely dependent on seed produced in rivers. Spawns are collected during the monsoon season (May-August) from different rivers of Halda, Padma, Jamuna, Brahmaputra and their tributaries. Carp fry are collected from Padma-Brahmaputra river systems while fertilized eggs are collected from the Halda River. Fishermen collect the eggs from the upstream of Halda River and incubate the eggs in earthen pits on the river bank for hatching. This unscientific hatching system is responsible for the low rate of hatching and high rate of fry mortality. With the course of time, the production of fry in the rivers has been reduced due to the destruction of many breeding grounds caused mainly by siltation. Production of fry is also hampered by the lack of broods as they are caught by extreme fishing pressure. Combining both reasons, the production of fry in rivers becomes critically low. For example, in 1984, the spawn production in the river systems in Bangladesh was estimated to be 24 551 kg and all hatcheries produced 652 kg; whereas in 2003-2004, the spawn production in hatcheries was estimated to be 345 227 kg and only 1 577 kg was reportedly collected from natural sources (FRSS, 2003-2004).

Along with the collection of spawn from rivers, induced breeding of carps through hypophysation was initiated in 1967. With the success of fish seed production through artificial breeding techniques, the Government of Bangladesh established a number of hatcheries in the public sector in different parts of the country. These hatcheries were not only used for seed production but also acted as centers of technology transfer providing training on seed production and broodstock management to a large number of entrepreneurs interested in establishing hatcheries on their own. In 1982, only three hatcheries were established in the private sector but due to easy and high returns, the number of hatcheries increased many times in the last two decades. Like indigenous carps, the fry of exotic carps are produced in the hatcheries by artificial propagation and only common carp and silver barb can reproduce in nature. Figure 7.1.1 shows the comparative fry production in hatcheries and rivers over two decades.

SEED PRODUCTION FACILITIES AND SEED TECHNOLOGY

Aquaculture practices in Bangladesh started with seed collected from rivers, but now it is almost entirely (99.55 percent) replaced by hatchery-produced seed (FRSS/DOF, 2003-2004). Artificial fish breeding techniques and low cost hatchery designs have been successfully adapted to Bangladeshi conditions since 1975. Breeding techniques for the major carps (rohu, catla and mrigal) and Chinese carp were introduced by the DOF through donor-assisted projects such as the Chandpur Irrigation and Fisheries Project (1977-1982) and the Oxbow Lake Project I (1981-1986). Both projects were funded by the World Bank (WB) and a large number of public sector hatcheries were constructed and operated by the projects. During project implementation, induced breeding technologies were widely adopted by the private sector; they came forward and took the leadership to set up hatcheries all over the country. For example, from three hatcheries built by the private sector in 1982, the number of hatcheries rose to 40 in 1985 and 214 in 1987 (Aminul Islam, 1989). Presently, the number of fish hatcheries has reached to 878 consisting of 112 public and 756 privately-owned units. In 2004,

FIGURE 7.1.1
Production of Indian major carp fry in hatcheries and rivers from 1980-2004



both public and private sectors jointly produced 3 500 029 kg of 4–5-day old carp fry, while the quantity of fry collected from natural sources was only 1 577 kg (DOF, 2005). Production from hatcheries is sufficient to meet up internal demands and private hatchery sector accounts for over 98 percent of all hatchling production. Government hatcheries account for less than 1.5 percent of spawn production. The production of hatchlings in private and public hatchery sectors is presented in Table 7.1.2.

Alongside with the three Indian major carps, few other major and minor carps and catfishes have been successfully bred in hatcheries. So far, 14 endemic finfish species are used in hatcheries for seed production. Among them catla, rohu, mrigal, calbasu and Asian catfishes (Deshi magur and shing) are predominant. Other species are being used for seed production either under limited scale or for conservation purpose. Table 7.1.3 lists the species of endemic carp and other finfish used for artificial seed production in Bangladesh.

TABLE 7.1.2
Production of hatchlings in government and private sector hatcheries in 2004

	Government		Private		
Hatchery	**Number of hatchery**	**Quantity of hatchling produced (kg)**	**Hatchery**	**Number of hatchery**	**Quantity of hatchling produced (kg)**
1. Fish seed/farms and hatcheries of					
a) Dhaka Division	28	1 069	Dhaka Division	155	75 600
b) Chittagong Division	17	343	Chittagong Division	176	61 643
c) Khulna Division	19	250	Khulna Division	165	82 976
d) Rajshahi Division	23	1 128	Rajshahi Division	217	112 369
e) Sylhet Division	8	184	Sylhet Division	13	3 465
f) Barisal Division	11	59	Barisal Division	30	9 174
2. Central Hatchery of Baor Development Project (Jhenaidah)	1	602			
3. Raipur Fish Hatchery and Training Centre	1	504			
4. Hatchery of Fisheries Research Institute, BFRI, Mymensingh	1	261			
5 Hatchery of Riverine Station, BFRI, Chandpur	1	34			
6. Parbatipur Hatchery, Dinajpur	1	337			
7. Faridpur Training and& Extension Centre	1	31			
Total	**112**	**4 802**		**756**	**345 227**

PLATE 7.1.1
Carp hatcheries in Bangladesh

About 13 exotic fin fish species used in hatcheries for seed production (Table 7.1.4). Among them silver carp, bighead carp, grass carp, silver barb, common/mirror carp, Thai pangus, Thai koi, Nile tilapia and other improved tilapia strains are predominant. Mahseer and black carp are being bred for conservation purpose. Red tilapia is being used for seed production under very limited scale.

For artificial induced breeding of endemic and exotic carps, fish pituitary gland (PG) extract and Human Chorionic Gonadotropic (HCG) hormone are usually used as inducing agent. Besides these, some synthetic agents such as Ovaprim, Profasi, Pregnyl, Luteinizing hormone releasing hormone (LH-RH) etc., are also used. Prior to hypophysation, the injectable dosages of the pituitary extract is calculated in terms of mg of PG/kg body weight of the recipient fish. The required amount of PG is weighed and thoroughly pulverized in a tissue homogenizer with 0.7 percent physiological saline/distilled water. The homogenate is centrifuged, the supernatant separated, and

TABLE 7.1.3
List of endemic carp and other finfish species used for artificial seed production in Bangladesh

Species	Common name
Labeo rohita	rohu
Catla catla	catla
Cirrhinus cirrhosus	mrigal
Labeo calbasu	calbasu
Cirrhinus ariza	Reba carp
Labeo bata	Bata
Labeo gonious	Kurio labeo
Puntius sarana	Olive barb
Clarias batrachus	Asian catfish
Heteropnuestes fossilis	Asian catfish
Ompok pabda	Butterfly catfish
Mystus cavasius	Gangetic mystus
Anabas testudineus	Climbing perch

TABLE 7.1.4
List of exotic carp and other finfish species used for artificial seed production in Bangladesh

Species	Common name
Hypophthalmichthys molitrix	silver carp
Aristicthys nobilis	bighead carp
Ctenopharyngodon idella	grass carp
Mylopharyngodon pices	black carp
Cyprinus carpio var. *communis*	common carp
Cyprinus carpio var. *specularis*	mirror carp
Barbodes gonionotus	silver barb
Tor putitora	Putitor mahseer
Pangasius sutchi	Thai pangus
Clarias gariepinus	African catfish
Oreochromis niloticus	Nile tilapia
O. niloticus	GIFT tilapia
0. mossambicus x O. niloticus	Red tilapia
Anabas testudineus	Climbing perch (Thai koi)

withdrawn into a hypodermic syringe for injection. The HCG solution is prepared by adding the required amount of physiological saline/distilled water to it as it is imported in powder form. The PG extract/ HCG injection of female fish is always administered with one or two doses; in case of two doses six hr interval is maintained between two injections (Table 7.1.5). Males are injected with a single dose of PG or HCG at the time of the first injection of the females and kept with female partners in circular spawning tanks or suitable concrete tanks provided with a continuous flow of fresh water. The dosage varies with the temperature, potency of the pituitary gland, gonadal maturity of the recipient and the prevailing climatic conditions (Jhingran and Pullin, 1988).

Fertilization of eggs can be done by two ways: i) natural fertilization and ii) artificial fertilization by stripping. In case of natural fertilization, the induced males are kept in the circular tank and take part in the spawning just after the start of ovulation of the females; females release the eggs and at the same time the males eject the milt and

PLATE 7.1.2
Freshwater fish breeding and nursery facilities in Bangladesh

TABLE 7.1.5
Optimum female and male hormone doses for the artificial propagation of different carps and catfishes

Species		Preliminary dose (for each kg)	Interval between two doses (hrs)	Final dose (for each kg)	Ovulation (hrs after final dose)
Labeo rohita	Female	PG 2 mg	6.0	PG 6 mg	4-6
	Male	-	-	PG 2 mg	
Catla catla	Female	PG 1-2 mg	6.0	PG 5-6 mg	5-6
	Male	-	-	PG 1-2 mg	
Cirrhinus cirrhosus	Female	PG 1-1.5 mg	6.0	PG 5-6 mg	4-6
	Male	-	-	PG 1-1.5 mg	
Labeo calbasu	Female	PG 1-1.5 mg	6.0	PG 4-5 mg	5-6
	Male	-	-	Pg 1.5-2 mg	
Hypophthalmicthys molitrix/*Aristicthys nobilis*	Female	a) PG 2 mg b)HCG 200-250 IU	6-9 9-12	a) PG 6 mg b) HCG 500 IU+PG 3 mg	6-8
	Male	-	-	PG 2 mg/kg	
Ctenopharyngodon idella	Female	PG 1.5-2 mg	6-8	PG 4-6 mg	5-7
	Male	-	-	PG 2 mg	
Cyprinus carpio var. *communis* *Cyprinus carpio* var. *specularis*	Female	PG 1 mg	6	PG 4 mg	6
	Male	-	-	PG 2 mg	
Barbodes gonionotus/ *Puntius sarana*	Female	-	-	PG 4-5 mg/kg	6.0
	Male	-	-	PG 2 mg	
Pangasius sutchi	Female	PG 2 mg	9	PG 6 mg	8-9
	Male	-	-	PG 2 mg	
Clarias batrachus	Female	PG 50 mg	6-8	PG 100 mg	9-12
	Male	-	-	-	
Heteropnuestes fossilis	Female	PG 70 mg	6-8	PG 70 mg	8-10
	Male	-	-	-	
Ompok pabda	Female	PG 3 mg	6	PG 15-17 mg	7-8
	Male	-	-	PG 7-8 mg	
Anabas testudineus	Female	PG 3-4 mg	-	-	9-12
	Male	PG 2 mg	-	-	

fertilization takes place. Fertilized eggs are collected through the outlet of the circular tank and placed into the incubator for hatching. Prior to spawning, a sufficient quantity of aquatic grasses should be placed in the breeding tanks of common carp or mirror carp to collect the sticky fertilized eggs.

For artificial fertilization of eggs, six hrs after the second injection, eggs and sperms are collected from the ovulated females and males by stripping the abdomen of the fishes with a gentle hand. Eggs are collected first into a plastic bowl. Then males are stripped over the same container. The eggs and sperms in the bowl are mixed together with a soft feather for 1 min or by shaking the bowl for five min and then washed with fresh water. The fertilized eggs are washed three to four times by changing the water, broken eggs and any other unwanted particles are removed. The swollen eggs are transferred into a Chinese type circular incubating pool or a series of funnel type incubating jars that are connected with a flow of clean water to keep the eggs moving. Usually hatching of carp eggs takes place within 20 to 30 hrs if the water temperature of the incubating system remains 24 °C to 27°C.

Just after the hatching of eggs much care should be taken as high rate of mortality of the fry may occur due to inadequate aeration or any other poor condition of the incubating system. The inflowing water should be free from plankton especially from *Cyclops* (a zooplankton belonging to Copepod group) that may kill larvae during early development. Fries of four to five day old when they begin swimming are transferred to nursery ponds or suitable cement cisterns for selling to nurseries.

For induced breeding of catfishes, Magur (*Clarias batrachus*) females are injected with PG extract and checked for ovulation on an hourly beginning from six hrs post-injection and continued up to 12 hrs of injection. As soon as the females are ovulated, eggs are collected by stripping and then fertilized with sperm. For collecting milt, males are sacrificed as milt could not be collected by stripping but by macerating the dissected testes in 0.85 percent sodium chloride solution. As eggs of catfishes are sticky, fertilized eggs should be spread as quickly and as homogenously as possible in incubation trays which receive continuous gentle shower through porous pipes for aeration. Similar to magur, shing (*Heteropneustes fossilis)* are bred using artificial breeding technique. In some cases, both female and male shing fishes are induced with hormone injection but males receive one injection during female's second injection with the first dose of female. The induced female and male are kept in a hapa where the female release the eggs and males release sperm and where fertilization takes place. The fertilized eggs are collected from the hapa and kept in cisterns for hatching. For Pabda breeding, the techniques described for shing are used. For Thai Pangas breeding, females are given two and males are given one injection (same dose of female's second dose and second injection time) and kept in circular breeding tank for ovulation. When females start to release eggs, females are caught and stripped for collection of eggs. Milt is collected by stripping the males and fertilized the eggs. As the eggs are sticky, fertilized eggs are washed with fresh milk or clay water to remove the stickiness of the eggs and kept in incubation jars for hatching.

A number of catfishes such as magur, shing, pabda are successfully bred and reared in the Faculty of Fisheries, Bangladesh Agricultural University (Mollah, Sarder and Begum, 2003). Thai Pangas was extensively bred in Jessore, Bogra and Mymensingh regions in mid-1990s and onwards where millions of spawn and fingerlings were produced. According to the farmers at Jessore and Adam Dhigi, Bogra, Thai Pangas production exceeded 50 million juveniles in 1997 (FFP, 1997). As Thai Pangas is a very fast growing cash-crop fish species, its culture received highest popularity during the period of 1995-2002, but due to the falling of market price resulting from bad muscle flavour and high feeding cost, farmers lost their interest to culture pangas.

For tilapia breeding, no inducing agent was applied but the fertilized eggs are collected from the mouth of the brood mother. The captive brood parents are normally kept in hapa (fine mesh net cage) where females release eggs and males release sperm and fertilization takes place. Immediately after fertilization, females take the eggs into the mouth and incubate them there until the eggs hatch out. During the mouth-incubation process, fertilized eggs are collected from the female and placed in incubating trays or plastic jars for hatching that takes around 6 days. In some parts of Bangladesh especially in the north, brood tilapia are released in paddy fields where breeding takes place and fries are collected from the field for culture in ponds. Poor people in northwest Bangladesh also developed techniques to breed the easily-bred and fast-growing species (e.g. common carp, silver barb, and tilapia) by using a small hapa suspended in a water body, or in a flooded rice field (Little, Golder and Barman, 1999).

Freshwater prawn (golda) fry production

Prawn juveniles are traditionally collected from rivers, canals and natural depressions by netting followed by stocking in ponds. Sometimes prawn fry are collected by entrapping them in the low lying coastal areas by constructing embankments (locally called ghers) and allowing tidal water to enter into the ghers. In southwest Bangladesh, freshwater prawn culture still depends on wild post-larvae (PL). Farmers prefer to stock wild PL rather than hatchery-produced PL, since fry production in hatchery is limited. The quality and survival rate of hatchery-produced PL is inferior to the wild PL (Ahmed, 2004). Thousands of rural poor are involved in prawn PL collection on

the Pasur River from Mongla to Heron Point on the south coast from April to June as part of their livelihood. Two types of nets are used for PL collection: the *behundi* net and the pull net. However, the catching and marketing systems are not well developed and high rate of PL mortality occurs due to poor handling (Ahmed, 2003).

Due to unavailability of juveniles in the natural waters and realizing the need of large number of prawn fry for commercial culture, work on prawn hatchery began in the 1980s but it was not expanded well. In 1988, the first commercial PL production was successfully done in Khulna region under the Prawn Culture Project. In 1993, the Riverine Station of the Bangladesh Fisheries Research Institute (BFRI) and the Department of Fisheries (DOF) in Chandpur jointly started work on the establishment of backyard prawn hatchery and provided training to NGOs, unemployed youth and interested farmers.

During last 20 years, a good number of prawn hatcheries have been established both in private and public sectors and millions of fry/PL are produced. In the private sector including NGOs, 18 prawn (golda) hatcheries are currently in operation and produced 50 million fry, while in the public sector, 12 prawn hatcheries produced 5 million fry (FRSS, DOF, 2003-2004). For breeding, berried prawns are collected from rivers, cultured ponds and ghers from March to July. The availability of berried prawn during breeding season is limited. It is very important that care should be taken during handling and transporting of berried prawn.

Nursery

Nursing of larvae/spawn is an important stage in fish culture. In Bangladesh, there are about 7 057 private carp nurseries, with an average area of 1 ha each. Besides these, most of the government Fish Seed Multiplication Farms (GFSMF) are used for nursing the fry. About 5 030 million fingerlings are produced from private sector nurseries compared to 18.4 million fingerlings produced from public sector nurseries (FRSS, 2003-2004).

Both seasonal and perennial ponds are used as nurseries in Bangladesh. Seasonal ponds are prepared without using pesticides. In case of perennial ponds, they are prepared by dewatering or by applying insecticides/piscicides such as Rotenone, Phostoxin, Cellophos, etc. After drying or poisoning the pond, lime is applied at 1-2 kg/decimal and cow dung at 5-7 kg/decimal, five to seven days before stocking. Inorganic fertilizer such as urea and TSP (triple super phosphate) are also used at 100-150 g and 50-75 g/decimal, respectively. Pesticides namely Dipterex or Sumithion are usually used at 0.15-0.25 ppm just one day before stocking for eradicating insects (water pleas) and large-sized planktons like cladocerans. TSP and urea are regularly used at 25 and 20 kg/ha/month, respectively, after stocking the spawn (Aminul Islam, 1989).

Two main types of nursing are practiced in Bangladesh: i) single-stage nursing and ii) two-stage nursing. In single-stage nursing, hatchlings are grown to fingerlings in one operation. The stocking density is maintained at 1.0 to 2.0 million spawn/ha and 2-3 inch-sized fingerlings are obtained within four to six weeks. In two-stage nursing, hatchlings are reared for 10-15 days in nursery ponds with a density of 6.0 million spawn/ha for obtaining 1 inch size fry. Then the fries are thinned out and stocked at a density of 0.2-0.3 million/ha and reared for another four to six weeks for growing up to fingerling size (2-3 inches). Some nursery operators specially in south Bangladesh carry out nursery rearing in three stages such as: i) early fry raising (spawn to early fry for 6-8 days); ii) fry raising (early fry to fry for 20-30 days) and iii) fingerling raising (fry to fingerling for 90-100 days) (Hasan and Ahmed, 2002).

For both types of nursery practice, newly hatched spawn are fed with boiled egg-yolk finely mixed with water. Then in the next four to five days, cooked wheat flour and boiled egg-yolk dissolved in water are provided. After that, fry are regularly fed with overnight-soaked mustard oil cake in water until reaching fingerling size.

Prawn fry nursing

Before stocking of larvae, the larvae rearing tank is filled up with de-chlorinated water. About 50 000 to 100 000 larvae can be stocked per tonne of conditioned water in the tank. Usually no feed is supplied to larvae for the first 24 hrs of stocking. After 24 hrs of stocking, two to three decapsulated *Artemia* is supplied to each larva with two hrs interval. It is continued up to seven to eight days. After that prepared custard is provided with a size of 100-150 µ and it is supplied at daytime while *Artemia* is supplied at night time. With this feeding regime, the larvae develops into post-larvae (PL) within 25-30 days. The PL is stocked in the nursery pond at the rate of 50 000-60 000/acre and 1.0-1.5 acre sized pond is better for PL nursery.

Gene bank

Gene banking of fish can be of two types: i) live gene banking and ii) cryogenic gene banking. Both types of gene banking are new in Bangladesh although the idea and the urge for establishment of such banks have been realized quite long ago. Production of fry from the hatcheries is sufficient to meet the domestic demand but the quality of fry has deteriorated over the years. Among many reasons, ignorance and lack of knowledge on scientific broodstock management techniques, inbreeding and intentional interspecific hybridization, negative selection, use of immature fish for breeding, etc. are held responsible for such quality degradation. Realizing the need to stop further quality deterioration as well as to improve the quality, the DOF has launched two big brood bank projects namely Brood Bank Establishment Project directly funded by DOF and Brood Bank Project under the Fourth Fisheries Project of DOF. BFRI also takes some programmes to improve broods' quality. The Northwest Fisheries Extension Project (NEFP) imported fry of silver carp, bighead carp and grass carp from the river of Yangtze, China with the help of Network for Aquaculture Centres in Asia (NACA) in 1994 and reared them to broods. In the year 1997, NEFP started to breed the Chinese carps and distributed the fry to eight government farms, BFRI, Bangladesh Agricultural University (BAU), NGOs such as Bangladesh Rural Advancement Committee (BRAC), CARITAS, Grammen Matsha Foundation (GMF), Rangpur Dinajpur Rural Services (RDRS) and private hatcheries for future broodstock development. In 2002-2003, the Brood Bank Establishment Project of DOF has started its work to set up 12 brood banks in the Government Fish Seed Multiplication Farms in six divisions with a target of 110 tonnes of genetically improved broods, 1 800 kg spawn and 0.5 million fingerlings production. Fry were collected from different rivers such as Halda, Jamuna and Padma and reared in the selected hatcheries following specific brood production techniques. In the mean time, 85 tonnes of broods were produced and from this the required number of broods are being sold and distributed to different public and private hatcheries following newly formulated policy of DOF for selling and distribution of broods, fry and fingerlings. In addition to the government initiatives, NGOs especially BRAC has already established one carp brood bank for their own hatchery purposes and they are going to set up another brood bank for tilapia soon.

Similarly 20 brood banks were established by collecting fry from natural sources and rearing in 20 Fish Seed Multiplication Farms and one Fish Breeding and Training Centre with the funding from the Fourth Fisheries Project. Brood fishes from the bank are being distributed to different government hatcheries. Necessary training for government and private hatchery operators and owners on broodstock management are being provided from both brood bank projects.

For the establishment of cryogenic gene bank (sperm cryopreservation) for fish, no initiative has been taken yet. However, project-based research work on cryopreservation of sperm of Indian major carps, *Catla catla, Labeo rohita, Cirrhinus cirrhosus*, exotic carps, *Cyprinus carpio, Ctenopharyngodon idella, Hypophthalmichthyes molitrix, Aristhicthys nobilis, Barbodes gonionotus* were conducted with the collaboration of

BAU, DOF and BFRI. More research on Indian major carp sperm cryopreservation and cryogenic gene banking are presently going on in the Faculty of Fisheries of BAU.

SEED MANAGEMENT

Husbandry management of broodstock

Brood fish is considered as the heart of the hatchery and management of broodstock is the key of quality seed production. Success of induced breeding depends on availability of sufficient number of brood fish. Therefore broodstock should be maintained scientifically so that ripe broods could be obtained during the whole breeding season. Most of the government hatcheries have own broodstock and around 25 percent recruitments take place in every year. On the other hand, few private hatcheries have their own stock and maintain them more or less scientifically but there are many private hatcheries that do not have the required number of broods. During breeding season they instantly buy broods from others and produce fry from them to fulfill their target. Besides this, most of the private hatcheries make new brood recruitment from the subsequent generations of few pairs of original parents that result in inbreeding.

The management techniques adopted by different hatcheries are varied from each other. Brood fish are reared in ponds having the area of 0.5 to 1.0 acre and water depth between 1.5-1.8 meter. During preparation of brood fish ponds, the usual practice is to eradicate the predator and weed fishes by dewatering and drying. Sometimes toxins such rotenon, phostoxin, etc. are also applied to kill the unwanted fish species. Aquatic weeds and other submerged plants are manually cleaned. After cleaning the pond, lime is applied at the rate of 1-2 kg/decimal and five to seven days after liming cow dung is used at the rate of 5-7 kg/decimal or 3-4 kg/decimal of poultry droplets as organic fertilizer. Inorganic fertilizers such as urea, TSP are also used at the rate of 150 g, 75-100 g per decimal respectively. Even after stocking the broods, liming (250-300g/decimal) and fertilization (cow dung 1.5-2.0 kg, urea 40-50 g, TSP 20-25 g per decimal) are continued for whole season with fortnightly intervals to keep the water quality suitable and to make the planktonic food available to the broods.

Most of the government hatcheries maintain the stocking density of 2 500-4 000 kg/ha which is much higher (5 000-6 000 kg/ha) in private hatcheries. Usually seven carp species are stocked and reared together with the following ratios (Table 7.1.6):

TABLE 7.1.6
Species composition and ratio in a broodstock pond

Fish species	Stocking rate
Silver carp	30%
Catla	5%
Rohu	20%
Mrigal	25%
Grass carp	10%
Bighead carp	5%
Silver barb (Thai Sarputi)	5%

Apart from the availability of natural food, most of the fish farms feed their brood stock with supplementary feed by maintaining 25-30 percent protein level. The composition and ingredients of the supplementary feed are as follows (Table 7.1.7):

In addition, 200-300 g Embavit-L per 100 kg of feed is provided to enhance the gonadal development of fish. The supplementary feed is applied at 2-3 percent of standing crop. For grass carp and silver barb, a soft grass (*Topa pana*) cut into small pieces are supplied to the pond.

TABLE 7.1.7
Ingredients and doses of supplementary feeds for broods

Ingredients	Dose
Mustard oil cake	30%
Wheat bran	15%
Rice bran	30%
Fish meal	15%
Wheat flour	5%
Molasses	5%/2%

Besides regular liming, fertilizing and feeding, Horra is pulled along the bottom of the pond to remove any accumulated gas in the bottom. Water exchange is done with removing some old water and

adding some new underground water. To check the health of the fish and to calculate the feeding ration, the fish is netted at least one or two times per month. Except for *Argulus* infection, no other diseases are encountered in brood fish ponds in Bangladesh. For *Argulus* treatment 0.25 ppm Sumithione or 0.5 ppm Dipterex is used twice a week with five to seven days interval.

Fingerling feed management

Prior stocking of fingerlings, ponds are prepared by dewatering or by using toxins to remove unwanted fish. Aquatic weeds are manually removed. Liming and fertilizing procedures are more or less same as brood stock pond preparation.

Along with some supplemental feeding farmers are mostly dependent on natural foods produced in the ponds for fingerling rearing. To grow enough planktonic food, urea, TSP and cow dung are applied with high doses. Preparation of composed at the corner of the ponds is common. As supplementary feed, mustard oil cake, rice bran, wheat bran and sometimes fish meal are used.

SEED QUALITY

Quality fish seed production is the prerequisite for sustainable aquaculture. In Bangladesh production of seed is not a problem but the crucial factor is to maintain its quality. Over the last two decades Bangladesh became self-sufficient to produce and distribute fry to the users but the quality of seed has been deteriorated. Inbreeding, interspecific hybridization, negative selection of broods, improper broodstock management are common phenomena in hatcheries especially in the private hatcheries. These factors result in low growth rate, high mortality, deformities, less fecundity of fry and so on. Many of the private hatcheries keep very small number of broods and rarely recruit new broods from outside; if they do, recruitment takes place from subsequent generations of the same stock. Some hatchery operators/owners collect broods from the farmers' grow-out ponds during breeding season and sell them out after breeding. Breeding of same broods more than one time in a season is another common practice in many hatcheries that presumably deteriorates the larval quality and increases the occurrence of deformed larvae and death. Hussain and Mazid (1997) and Sarder (1998) reported reduced growth, physical deformities, diseases and high mortality in hatchery produced carp seed and they have identified improper management of broodstock, unconscious negative selection of broods, unplanned hybridization and inbreeding as the probable reasons behind these reduced performances. Recent studies have revealed high rate of inbreeding and inter-specific hybridization in both endemic and exotic carps (Simonsen *et al.*, 2005, Simonsen *et al.*, 2004; Alam *et al.*, 2002). In order to stop the further genetic deterioration and at the same time to improve the quality of seed, DOF and BFRI have taken some initiatives, such as brood bank establishment project, brood bank project, distribution of broods to government and private hatcheries from the brood banks and brood management trainings for the hatchery and farm operators.

Disease is considered as one of the important problematic factors for the seed industry. There are few published reports on disease in both hatcheries and nurseries in Bangladesh. Parasitic diseases in nursery are one of the most important limiting factors for growth and survival of fry and fingerling. In many Asian countries severe mortalities among carp fry have been reported and it was caused by different diseases especially by ich disease, *Trichodina* spp., *Ichthyobodo* spp., *Lernaea* spp., *Myxobolus* spp. and *Dactylogyrus* spp. *Myxobolus* and *Hennegyua* have caused heavy mortalities in *Catla catla* with the disease called gill myxoboliasis. It was reported that 61 percent of carp fry were infected with ectoparasites in nurseries of Greater Mymensingh District and highest mortality of carp fingerling was occurred by *Trichodina, Myxobolus* and *Dactylogyrus*. Chandra *et al.* (1996) reported high prevalence of myxosporean

ectoparasites in juvenile Indian major carps (*Labeo rohita* and *Cirrhinus cirrhosus*) in nursery ponds of Mymensingh. They also reported severe gill infection of these juvenile carps by five different myxosporean ectoparasites belonging to the genus *Myxobolus*.

Ahmed (1997) reported that hatchlings, PL and fry of carps are affected by gas bubble disease which is cause by supersaturated oxygen and nitrogen gases. The author also reported that in hatchery the most serious diseases of eggs are caused by the fungal infection with *Saprolegnia* and *Achlya* sp. Hasan and Ahmed (2002) conducted a survey on disease problems in 180 carp hatcheries and nurseries in southern and eastern regions of Bangladesh and reportedly found disease as a big problem for hatcheries and nurseries. They listed a number of diseases found in hatcheries and nurseries which were white spot, tail and fin rot, EUS (epizootic ulcerative syndrome), sudden spawn death, fish louse, gill rot, dropsy, malnutrition, air gulping and deformities. The reason for sudden spawn death was unknown but the operators assumed sudden sharp rise of water temperature in hatcheries and nurseries could be responsible for such massive death. In the survey study many farmers mentioned that the sudden spawn mortality and occurrence of deformed larvae are more common for spawn produced during late breeding season.

There are no specific/unique procedures for maintaining hygienic condition in hatcheries but most of the hatcheries take some precautionary measures before and during the fry production. As a part of the precaution all the components of the hatchery such as overhead tank, breeding tank, circular tank, bottle jar system, delivery pipe, shower, gate bulb etc are washed with detergent powder (wheel powder), bleaching powder and formalin. Salt water and potassium permanganate are also used to clean the hapa, bowls and beakers. If any disease appears during the fry production the hatchery operators immediately discard the diseased fry from the hatchery and the whole hatchery components are cleaned with the above mentioned cleaning agents before the start the next round of production. Hasan and Ahmed (2002) reported that during outbreak of disease in hatcheries and nurseries, farmers used different treatments such as applying chemicals and antibiotics, water exchange and manipulation of feeding and fertilization.

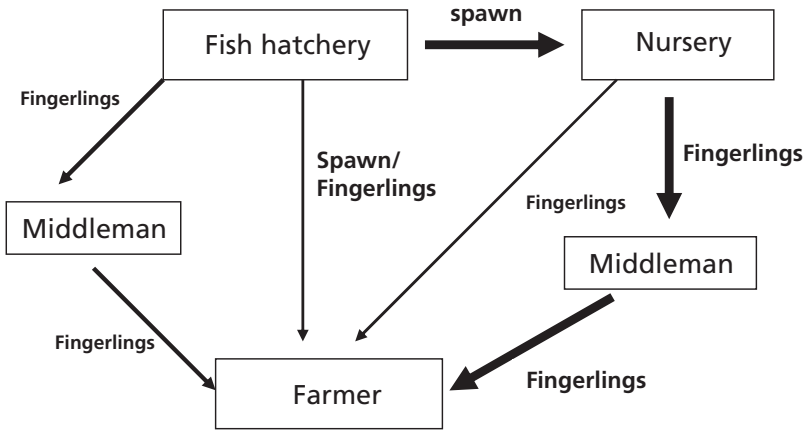
There is no available set criterion from both government or private sectors for maintaining or improving seed quality in Bangladesh. However, after discovery of inbreeding and hybridization in both private and public hatcheries, many farmers start to query on seed quality before buying the fry. Consequently many hatchery operators put their attention in keeping enough number of broods, its management, and maintaining seed quality for the sake of their business interest. The government has already taken some measurements such as establishment brood bank to improve the quality of seed.

SEED MARKETING

Next to seed production and nursing, timely supply of seed to the farmers is a very important task for aquaculture. There is a complex network of seed supply, not institutionally organized, involving hatchery operators, nursery operators, middlemen (seed trader) and fish farmers. The following flowchart shows the distribution channel of seed.

Although there are around 800 hatcheries and 7 057 private nurseries, these are not equally distributed all over the country but rather more or less clustered to few places. Among the hatcheries many of them have both breeding and nursery facilities. Many of the government fish seed multiplication farms are also used for both purposes. Fish seed traders play a vital role in providing a link between hatchery, nursery and fish farmers. They are the main actors that make seed available to the farmers' pond side. In the flow chart above, it is shown that fish spawn are directly collected by the nursery operators from the hatcheries and reared to fingerling stage.

FIGURE 7.1.2
Supply channels of fish seed from hatchery to farmers



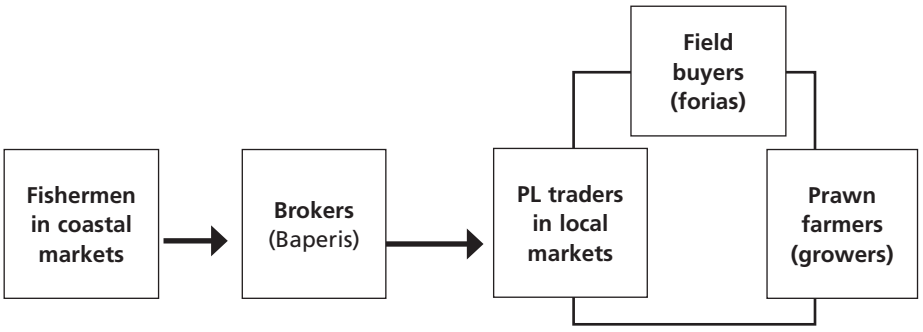
Fingerling marketing is generally done by middlemen since very few fish farmers buy directly from nursery farms. About 80 percent of fingerlings are supplied to farmers by middleman (fish seed traders) and some 20 percent of fingerlings are directly collected by farmers from the nursery operators. In addition to this, when spawn are reared to fingerling at the hatchery *cum* nursery, fingerlings also reach farmers through the same channel. At present there is no established and formal fish seed market for selling and buying seed but some spots for example, Parbatipur Railway Station (northwest part of Bangladesh) where seed are accumulated from Jessore, Bogra and Rajshahi regions by train, are used as seed market. Fish seed traders in the northwest often procure fingerlings from sources as far away as Jessore, Bogra and Rajshahi, and between 100 to 125 million fingerlings are usually traded at Parbatipur railway station every year (NEFP, M&E Annual Report, 1993-1994). It is noteworthy that fish traders are not only involved in seed supply, they also provide some advice on fish culture to farmers. Northwest Fisheries Extension Project had took a project on seed transportation and its management, and under this project a large number of fish seed traders received training on handling during transportation of seed and also some basic training on fish culture that are disseminated to the farmers during seed sale.

Transportation of seed

Fish spawn/hatchlings are transported in polythene bags filled with oxygen. Usually 10-12 l of clean pure water is taken into a 90 cm x 50 cm sized plastic bag and 250-500 g of four to five day old spawn are placed in the bag. The bag is then filled up with oxygen and the mouth of the bag tightly sealed with rope. For protection of the bag another polythene bag with the same size is taken and the bag with fry placed into the second bag. Finally the plastic bags are placed into jute made bag for more protection during transportation by bus, train, van, pick-up truck, etc.

Fish fingerlings are transported by using indigenous and modern techniques. Before transportation, the fingerlings are netted for two consecutive days to make them strong and accustomed. On the day of transportation, the fingerlings are caught by using soft, small mesh sized net and water is splashed for 15-20 min from outside the net so that the fish will be frightened and release faeces. This type of conditioning of fry helps to keep the water clean for longer time during transportation. Using indigenous method, earthen pots called *hundis* and other aluminum or metallic containers with hand agitation of water are generally used for transportation of fish seed. Usually 20-30 fingerlings/l of water in the container are carried either on foot

FIGURE 7.1.3
Freshwater prawn post-larvae supply chain from fishermen to prawn farming areas in Bagerhat District



or by bicycle, by rickshaw, by train, etc. A constant jolting or hand agitation of water is useful for replenishing of atmospheric oxygen in the water. During longer period of transportation, the water may get dirty and is periodically replaced with new fresh water. Dead and injured fry are also removed from the container at times preventing rotting and fouling of water. During transportation, the containers are often covered with moist cloth and gunny bags to keep the container cool.

Using modern techniques, fingerlings are transported in 90 cm x 50 cm sized polythene bags filled with oxygen. Usually 4-6 l of water are taken into the bag and 50-100 fry/l are carried. In case of large-scale seed transportation, fish hauling tank equipped with agitator and oxygen supply is used. Sometimes the body of the truck is temporary converted into a water pool using plastic pool filled with water. Plastic barrels (200 l) are also used to transport fry specially the pangas fry and the barrels are carried by pick-up van or truck. The barrels are filled with clean fresh water prior to transfer the fry from the hapa but manual water filling of barrels is time consuming and costly. Sometimes it is difficult to get available clean fresh water. To make the water available and to easily fill the barrels, recently in Mymensingh region, many water filling stations are established along the high way. It is a station where underground water is withdrawn from shallow or deep tube-well by using two to four H.P. pump and the water is delivered to the barrels using delivery pipe. In the absence of mechanized tube-well, clean pond water is delivered to the barrels by simple lift pumping.

Prawn fry marketing and transportation

The chain for transporting and marketing of prawn PL is complicated. A number of intermediaries exist: brokers (locally known as *baperis*), PL traders and field agents (*forias*) are involved in the PL marketing chain linking the fishermen to the prawn farmers (survey study conducted by Dr. Nesar Ahmed, personal communication). Usually PL collectors do not have any direct contact to the prawn farmers; they sell the PL to *baperis* who carry it to the PL traders. The PL traders sell the PL directly or via *forias* to the farmers. The *forias* play a dual role: first, to supply the PL to the farmers and second, to get the market-sized prawn from farmers to the prawn traders. *Forias* work with a little amount of capital and often take temporary loans from the PL traders.

Like carp fry, prawn PL are transported by both indigenous and modern methods. Transport of live PL to traders takes place at night or in the very early morning hrs, to take advantage of cooler temperatures. Usually aluminium containers of 10 to 20 l covered with wet cloths or nets are used to carry the PL with pick-up vans, buses, minibuses and taxis. During transportation, saline water with 10 to 15 ppt is used, normally at a ratio of two l per 1 000 PL for eight hrs transportation. PL mortality rate

following the above conditions is very low, less than 10 percent (Dr. Nesar Ahmed, personal communication). Dayue (1988) mentioned that loading density, packing and transportation methods affected survival rate of prawn PL during transport. At a loading density of 5 000 PL/l of water at 18 to 23 ppt and 15 to 20 °C temperature, the survival rate can be above 95 percent over 20 hrs of transport. Prawn PL is also transported in polythene bags filled with oxygen. One-third of total space of the bag is filled up with water and two-third with oxygen and in this condition 1 000-2 000 PL/l of water can be transported for eight to ten hrs. Venkataswamy, John and Kaleemur Rahman(1992) noted that at 26 °C packing in oxygenated bags could help in increasing survival rate of PL.

Finance

To operate the government fish seed multiplication farms, government provide money to the farms by fixing a target with either production of certain kg of spawn or earning of certain amount of money from selling spawn or fingerling for each year. However, most of the private hatcheries and nurseries are self-financed. Many hatchery/nursery operators take loans/credits from different sources: government banks such as Sonali Bank, Janata Bank, Krishi Bank, Pubali Bank, Co-operatives; private banks such as Grameen Bank, Employment Bank (karmosagnsthan Bank); NGOs such as BRAC, Proshika, Caritas, ASA. They also take money from local rich people (Mahajan) as loan with interest rate.

Sales promotion

The main customer of the fry is the rural small fish farmers. However, since many big commercial fish farms have been established in the country over the last few years, a large portion of fry are being used by these farms. From mid-1980s, the government has taken programmes to release and stock fry in open waters every year and for this purpose a large number of fingerlings are bought from both public and private hatcheries and nurseries. In addition, to rehabilitate poor farmers who suffered from flood, cyclones, the government, donor agencies and NGOs such as World Vision and Caritas procure fingerlings from hatcheries and nurseries.

SEED INDUSTRY

On the basis of the production of spawn the hatcheries can be categorized into three groups which are shown in Table 7.1.8 below.

RISKS

Socio-economic condition

Many private hatchery owners are rich and some of them are educated. They have established their hatcheries using their own capital but sometimes they take financial assistance from commercial banks. Most of them have either received training from government hatcheries and institutes or learned the technology from other existing hatcheries and operate them with the help of some labourers. In some cases, technicians have been trained by hatchery owners for smoothly running the hatchery. Nevertheless, many hatchery owners and most of the labourers are illiterate or have little education and could not understand and adopt latest technologies easily. If any problem such as disease appears they feel very nervous and could not the take right and timely decision.

TABLE 7.1.8
Type of hatcheries based on fry production

Type of hatchery	% number of total hatchery	Production of spawn (kg)/year
Small	50	50-100
Medium	40	100-300
Large	10	300-2 500

Persons who are involved in fingerlings production belong to poor lower-middle class. Some nursery operators have little

education while most of them are uneducated. They raise the fry to fingerling either in own ponds or take ponds on lease. In many cases fry is reared to fingerling stage in small-scale and homestead ponds and thus many women along with men get involved into the fish rearing business. Some nursery operators have taken training on nursery practice from government and research institutes; however, many of them share working experiences with each other.

Environment

The environment of Bangladesh is highly favourable to fish culture. Until the 1970s fish was everywhere in Bangladesh and the main source of fish was inland open water capture fisheries. But fish production from inland water fisheries declined over few decades due to implementation of flood control, drainage and irrigation schemes which resulted in depletion of flood plains used for breeding and nursery grounds of fishes. Another reason, a large number of Bangladeshi rivers have originated from India and due to the downstream location, Bangladesh is becoming a flood prone country. Almost every year, Bangladesh is affected by the flash flood water at which time many parts of the country become inundated and a large number of fish farms are partially or fully damaged. Flood water not only cause damage to farms, it also has become responsible for outbreak of different diseases.

Transportation, market, recovery money

Trading of fish seed is a seasonal occupation and in most places it starts in April and ends in September. Seed traders typically carry a few thousands seed in aluminum containers and travel on foot, by bicycle or train to reach farm customers. They face significant risk of seed losses during long transport/journeys. Sometimes bad road communication increase the risk of seed loss. Another problem for the seed traders is to sell the fingerling with a variable price and also on credit to seed buyers. Sometimes it is difficult for the traders to recover the credit money from the buyers and make profit out of the business. The practice of selling fry and fingerlings on credit is involved in all sections of fry trading, i.e. from hatchery to nursery to fish farmers.

Others

Stealing, poisoning, electricity failure, high temperatures, low underground water level just after winter season are also considered important risk factors for maintaining broods, fish seed production, trading and culture. Extremely high temperature (e.g. 40-45°C) sometimes causes massive death of fry and broods. Similarly, low underground water level especially during the month of March to May, before the start of rainy season, bring difficulties for maintaining broods as required amount of underground water can not be withdrawn and supplied.

SUPPORT SERVICES

There are several organizations and institutions directly and indirectly involved in fisheries extension and aquaculture development in Bangladesh. However, the Department of Fisheries (DOF) under the Ministry of Fisheries and Livestock (MOFL) is the principal organization responsible for fisheries development and extension. DOF has a strong network throughout the country consisting of 6 Divisional head quarters, 64 District Fisheries Offices, 460 Upazilla Fisheries Offices and 112 fish seed multiplication farms with a staff of about 4 500 individuals. The main job of these office bearers is to develop aquaculture and extension of fisheries activities. The 460 Upazilla Fisheries Officers are directly involved in aquaculture extension. In addition, there are some other personnel such as Aquaculture Extension Officer (AEO), Extension Officer (EO) under different development projects are working for promoting extension of aquaculture. The District and Upazilla Fisheries Offices provide training on different

aquaculture aspects such as broodstock management, fry production through artificial breeding, nursery management, fish culture, integrated fish culture, prawn breeding, nursing and culture, feed management, disease control, etc. to government and private hatchery/farm operators, fish farmers, relevant NGO workers. In addition to this, the Government Fish Seed Multiplication Farms are also involved in such training programmes. For formal training for aquculture officers, hatchery/farm operators and NGO personnels, the government has established six Fish/Shrimp Training Centres and one Fish Training Academy and from these institutes short aquaculture training courses are offered (FRSS, 2004). The Youth Training Centers under the Ministry of Sports and Youth Development are providing two to three months residential training on aquaculture and other branches of agriculture to unemployed youth (men and women). The Bangladesh Fisheries Research Institutes (BFRI), another national institute under the MOFL, has seven stations and sub-stations with a manpower of 376. Research on aquaculture and fisheries are the main task of the institute but very often it also provides aquaculture training, sometimes alone or with collaboration with DOF and donor agencies such as Worldfish Centre, Danida, DFID, FAO, UNICEF, to government and private hatchery and nursery operators, NGOs, unemployed young men and women. The Fisheries Faculty of the Bangladesh Agricultural University (BAU) sometimes arranges training, mainly research project-based training, for government and private hatchery/farm operators, NGO persons and farmers. The Fisheries and Marine Resource Technology (FMRT) Discipline of Khulna University also arranges similar training programmes.

Technology developed and disseminated

So far 36 technologies, many of them related to freshwater fish and prawn seed production, have evolved and disseminated to farmer level by the DOF, BFRI and universities. A number of manuals (e.g. fish culture manual, improved brood fish production and breeding techniques, fish genetic improvement and broodstock management, fry transportation and stocking management development course, nursery management course, fundamental extension course, environmental friendly shrimp culture management course); books (e.g. genetic improvement and conservation of carp species in Bangladesh, genetic management and improvement of exotic carp species in Bangladesh, tilapia culture); booklets (e.g. pituitary gland collection techniques, improved carp hatchery management techniques, improved carp nursery management, prawn fry production in backyard hatchery and pond culture, genetic problems and remedies for induced breeding of Bangladeshi fish, carp brood bank establishment and management technique, carp and prawn fry transportation, freshwater prawn hatchery operation, freshwater prawn fry nursery management etc are published and distributed to relevant persons by DOF, BFRI and universities.

SEED CERTIFICATION

There is no seed certification system for hatcheries in Bangladesh. However, realizing the need of seed certification for controlling seed quality in carp and prawn hatcheries, the MOFL formed a National Committee in 2001 by picking up personnel from different relevant institutions to formulate a policy for seed certification. The committee already drafted policies for seed certification and submitted it to MOFL for its final approval. The name of the drafted law is “Matsha and Chingri Hatchery Ain 2005” (Law for Fish and Shrimp Hatchery 2005). It includes the clauses for registration of hatcheries, and the rules for fish and shrimp hatchery operation. The latter elaborates few things which are necessary for hatchery operation such as physical infrastructure/facilities of hatchery, ponds, selection of brood fish for breeding, source of selected brood fish, environment, etc.

LEGAL AND POLICY FRAMEWORKS

Policy framework

The Fisheries Policy of Bangladesh was adopted in 1998 to provide appropriate regulatory and supportive rules for continuing growth and development of the different sub-sectors of fisheries. The policies are summarized by Mazid (2002). It has the following objectives:

i) fisheries resources development for increased fish production;
ii) poverty alleviation through creating opportunities for self-employment and improving socio-economic conditions of fishermen and fish farmers;
iii) meeting animal protein requirement of the country;
iv) increased foreign exchange earning and the rate of economic growth through export of fish and fisheries products;
v) environment protection, biodiversity conservation and public health improvement.

Legal jurisdiction of National Fisheries Policy (Section 3.0)

The jurisdiction of the national fisheries policy is:

i) All national and multinational agencies both government and private including individuals involved in fisheries development activities within the geographical boundaries of Bangladesh shall fall within the purview of the National Fisheries Policy (Section 3.1).
ii) The conservation, development and management of all potential fisheries water bodies shall come under the purview of the policy (Section 3.2).

Policy for Inland Open Water Fisheries Development (Section 5.0)

i) Minimizing negative effects of all development activities including construction for flood control, irrigation, drainage, roads, urbanization etc. on fish and fisheries habitats.
ii) Transferring identified or part of the potential water bodies to the Department of Fisheries to establish fish sanctuary for natural propagation of fish.
iii) Natural water bodies like *khal, beel*, ditches, canals and other open water bodies not to be allowed to dry up in full.
iv) *Beels, haors* and *baors* shall be re-excavated, restored, improved and declared as the sources of fish production and these water bodies shall not be allowed to reduce.
v) Ensuring fish production as the primary use of all identified water bodies.
vi) Development of appropriate management guidelines and rigorous implementation of all acts and rules for conservation of open water fisheries.
vii) Identifying and preserving breeding and nursery grounds of fish and shrimp and protecting egg bearing fish and fish fry.

Policy for Freshwater Aquaculture (Section 6.0)

i) Demonstration of aquaculture technologies in the farmers' field at the Upazila and Union level through government initiatives.
ii) Encouraging women in aquaculture.
iii) Involving poor fishermen in community-based capture fisheries development in *haor, baor* (natural depression, oxbow lakes) and in other potential water bodies.
iv) Leasing government tanks, ponds and other similar water bodies to targeted poor or unemployed youth, both men and women, for fisheries as means of their livelihood.
v) Developing guidelines for proper application of lime and fertilizer based on location specific need assessment of soil water quality.
vi) Undertaking integrated aquaculture in inundated rice field.

vii) Providing support to private sectors to establish hatchery and undertaking programme to promote establishment of nursery in the public and private sectors for production of required fingerlings for stocking in open waters and for aquaculture as well as to establish fish seed industry.

Legal framework

For carrying out fisheries activities legally, there is a law in Bangladesh (formulated during the period of East Pakistan, former name of Bangladesh) which is generally known as the Fish Conservation and Protection Act, 1950. However, some amendments of the law were made at different times are as follows:

i) The East Bengal Protection and Conservation of Fish Act, 1950 (EB Act. xviii of 1950)
ii) The East Bengal Protection and Conservation of Fish (Amendment) Act, 1963 (E.P. Act. No. 11 of 1964)
iii) The East Bengal Protection and Conservation of Fish (Amendment) Ordinance, 1970 (East Pakistan Ordinance No. xxvi of 1970)
iv) The Protection and Conservation of Fish (Amendment) Ordinance, 1982 (Ordinance No. 55 of 1982)
v) The Protection and Conservation of Fish Rules, 1985 (SRO 442-L/85 October 16, 1985 MOFL)
vi) The Protection and Conservation of Fish Rules, 1985 (Ordinance), 1986 (No. 5/Fish/Misc 263/84/97) March 4, 1986. MOFL
vii) The Protection and Conservation of Fish Rules, 1985 (Amendment) 1987 (SRO-269-law/87) November 4, 1987. MOFL
viii) The Protection and Conservation of Fish Rules, 1985 (Amendment) 1988 (SRO-24-law/88) January 25, 1988. MOFL
ix) The Protection and Conservation of Fish (Amendment) Act 1995 (Law/9)

ECONOMICS

The market price of carp fry is highly variable depending on several factors such as species, supply and demand of the fry, season and transportation. The quality of fry is also considered as the determinant of the price. In recent times, communication system of Bangladesh has improved much and fry can be supplied to anywhere in the country in a day. In case of catfish fry, the price is also variable but less fluctuant. The following tables below show the price fry and fingerlings.

Normally fry produced in the early breeding season received higher price as the nursery operators can sell the fingerlings with a good price. Many farmers get their farms ready with supply water and do not wait for rainwater. If they can stock the ponds earlier with the early seasoned fry, they can get return of their investment with only few months of fish culture. Nowadays, there are many hatchery owners and nursery operators who stock the nursery ponds with the late seasoned fry (at the time when the fry got lowest price), rear them over the winter season (called over-wintered fry). The price of over-wintered fry is quite high as they grow faster than new fry and reach marketable size within few months in the immediate growing season. The price of 10 cm sized over-wintered fry is about Tk1 000 per 1 000 piece.

The price of fry depends mostly on supply and demand. From 1995 to 1966, both

TABLE 7.1.9
Price of fry of indigenous and exotic carps and catfishes

Species	Price of spawn, TKk/kg
Rohu, Mrigal	500-2 500
Catla	1 000-3 000
Calbaush	1 000-2 000
Silver carp	500-3 000
Grass carp	1 000-3 000
Bighead carp	1 500-4 000
Silver barb	300-1 000
Gonia	1 000-2 000
Common carp	1 000-3 000

government and private hatcheries are producing carp spawn enough to meet farmers demand and sometimes with surplus production, the price of the spawn declined significantly. As a result many small hatchery operators are out of business or changing species such as indigenous catfishes, Thai pangas, Thai koi, etc. Big hatchery operators are producing fry less than their capacity. So hatchery operators are getting less return from their investment. Fry price also depends on species (e.g. catla receives higher price than rohu and mrigal), season (early seasoned fry receive higher price and the price get down with the commencement of full breeding and late breeding seasons), quality of seed, etc.

TABLE 7.1.10
Price of fingerlings of indigenous and exotic carps and catfishes

Species	Price of fingerling, Tk/1000 individual
Rohu, Mrigal	200-300
Catla	300-500
Calbaush	500-1 000
Silver carp	100-200
Grass carp	200-300
Bighead carp	500-1 000
Silver barb	200-500
Gonia	200-500
Common carp	200-500
Bata	400-500 (average 5 cm size)
Shing	2 000 (average 5 cm size)
Magur	2 000 (average 5 cm size)
Pabda	2 000 (average 5 cm size)
Thai koi	500-1 500 (average 2 cm)

Hatchery and nursery operation are the main and sometimes only job for most of the farmers. With the money earned from the hatchery and nursery business, they maintain their whole family activities. Hasan and Ahmed (2002) observed, in their survey study on hatchery and nursery, that the average contribution of aquaculture to household income is reasonably high, nursery contributes 79.3 percent while 95.1 percent comes from hatchery. Apart from aquaculture, the hatchery and nursery operators earn money from other economic activities such as paddy cultivation, livestock raising, vegetable and fruit production.

The average price of PL collected from rivers varies from Tk 700 to 800 per 1 000 PL, but these PLs are ultimately sold to the prawn farmers with a price of Tk 1 200 to 1 500 (Dr. Nesar Ahmed, pers. comm.). The poor PL collectors maintain their livelihood by selling the PL. According to the private prawn hatchery owner, the price of the prawn fry is ranging Tk. 1 200- Tk. 2 500/1 000 PL and early seasoned PL receives higher price than the full breeding seasoned PL.

FUTURE PROSPECTS AND RECOMMENDATIONS

Prospects

- More than 98 percent of seed are produced in both private and public hatcheries which remarkably reduced the hunting pressure for carps and freshwater shrimp fry from natural sources, a practice which is in contradiction to natural biodiversity conservation.
- Along with Indian major carps breeding, many hatchery operators are engaging their efforts on breeding of undomesticated and endangered fish species. Such activity will definitely help to save the endangered fish species from extinction.
- Establishment of brood bank will definitely help to improve the quality of seed.
- Establishment of fish sanctuary in open water bodies through community-based fisheries will increase the natural recruitment and at the same time the livelihood of the fishing community will be improved.
- Availability of fish seed and farming technology will encourage a considerable number of people including rich people to invest money into fisheries industries.

Recommendations

- Establishment of hatchery and nursery in the private sector should be encouraged in all areas of the country to ensure availability of adequate quantity of quality seed for farmers in the entire country. Since most of the hatcheries and nurseries

are clusteredly located in a few places, new hatcheries and nurseries should be established in remote areas and at the same time establishment of new hatcheries in the dominated areas should be regulated.

- Fingerlings, the main input for sustainable aquaculture, receive very poor attention. Therefore, necessary steps should be taken to establish nurseries within the government and private sectors.
- Since the quality of seed has deteriorated over the years due to inbreeding, hybridization, negative selection and improper brood stock management, special attention should be paid to improve the quality of seed. In this regard, live brood and cryogenic gene banks need to be established.
- The government in collaboration with private entrepreneurs should take necessary steps to establish brood banks in different parts of the country. Quality broods from the brood banks should be distributed to the hatcheries as required and its maintenance monitored.
- Hatcheries other than brood banks should not create their broodstock from their own produced fry, otherwise the genetic diversity of stocks will be further reduced. Breeder candidates should be procured from brood banks, where appropriate genetic diversity and adequate size of parent stocks are being maintained.
- Necessary training on broodstock management, breeding technology, nursery technology, disease control, etc. should be provided to hatchery and nursery operators, farm managers, and fish farmers. Awareness building of private hatchery operators and fish farmers should be further extended.
- To ensure quality of fish and shrimp fry, registration and seed certification system for hatcheries and nurseries should be adopted and implemented immediately.
- Since millions of fry of different fish species are coming from other countries without any check, proper quarantine system should be set up to control possible disease introduction.
- Catching or killing of broods and fry during breeding season should be banned and in this regard alternate employment for fishermen during breeding season should be arranged.
- Fish sanctuaries should be established and monitored in open water bodies as much as possible in order to promote natural recruitment.
- Total harvesting of fish by complete drying of natural water bodies should be avoided.
- Loss and destruction of breeding and nursery grounds due to construction of flood control dams, roads and embankments and irrigation should be stopped. Inter-departmental co-ordination needs to be developed to minimize the damage to fish habitats.
- Loans with little interest should be made available from government and private financial institutions for hatchery and nursery operators. The loan sanction and distribution procedures must be simplified. Since the nurseries are more vulnerable, nursery operators should get priority for loan.
- Formal fry and fingerling trading networks should be developed locally and regionally by the government and other developing partners so that fry and fingerling producers and farmers can get their actual benefit.

STAKEHOLDERS

Producers/farmers. Hatchery and nursery operators are the main producers of fry and fingerling of fish. Many of them have good knowledge of fish farming and they often offer their advice to farmers.

Local institutions. Many NGOs are involved in fisheries activities in Bangladesh and among them BRAC and Proshika are the leading organizations. They are involved in

fish breeding, nursery operation, culture and in some cases marketing. The BRAC has a good number of carp hatcheries and brood bank, and freshwater shrimp hatchery. The Proshika also has carp and shrimp hatcheries.

Small hatcheries. About 30 percent of total hatcheries are small hatchery and are involved in production of carps and other indigenous and exotic fish seed. They are only involved in fry production and sell the 2-3 day-old fry to nursery operators. Many of them do not have good facility for brood rearing. Recently some small and medium hatcheries taking initiatives for artificial reproduction of wildly-bred indigenous fish such as pubda, koi, shing, magur, chital in the captivity.

Large hatcheries. About 10 percent of total hatcheries are large-scale and its main job is to produce fry of different fish species and sell them to nursery operators. Many of them have nursery facilities and rear the fry up to fingerling size before marketing. Some of the hatcheries rear its late seasoned fry in their own nursery ponds during winter season and sell the fingerlings to farmers as over-wintered fry. Few large hatcheries are producing spawn of endangered fish species. Other than hybrid production, no hatcheries are involved in developing new strains or varieties of fish.

Associations. There are some localized hatchery associations in Bangladesh and are mostly involved in promoting fry and fingerling production and marketing. The associations play an important role in the National Fish Fortnight Programme each year.

Government institutions. The DOF and BFRI are the two government institutions directly involved in fisheries activities in Bangladesh. They provide legal and policy frameworks for the seed industry, provide necessary training to hatchery operators, farm managers and also fish farmers. Department of Fisheries has a nationwide strong extension network to promote aquaculture.

Researchers. Other than researchers from the BFRI, scientists from different universities and in some cases NGOs are involved in fisheries research activities. Among the universities, BAU is the oldest and pioneering institution for formal fisheries education and research in Bangladesh. Fisheries education is also offered by five other universities and one fisheries college. Scientists from universities are always engaged in different fundamental and applied research through MS and PhD programmes. They sometimes arrange training for hatchery operators, farm managers, NGOs and fish farmers.

Donors (funding agencies). GEF (Global Environmental Facility), DFID, DANIDA, World Bank, WorldFish Center, Caritas, CARE are providing funds to different fisheries activities in Bangladesh.

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