Government of the People's Republic of Bangladesh

Department of Fisheries (DoF)
Ministry of Fisheries and Livestock
Fisheries and Livestock Development Component

Strengthening Institutional Capacity of DoF Project

ASPS-II : DoF-Danida

Final Report

on

Genetic Improvement of Carp Seeds And Brood Stock Management

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Submitted by

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Strengthening Institutional Capacity of DoF Project

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Abbreviations

ASPS-II	Agricultural Sector Programme Support
BMP	Best Management Practice
BFRI	Bangladesh Fisheries Research Institute
CARITAS	Catholic Agency for International Aid and Development
CIFRI	Central Inland Fisheries Research Institute (India)
DFO	District Fisheries Officer
DG	Dirrector General
DLS	Department of Livestock Services
DOF	Department of Fisheries
ESC	Exotic Species Center
ESPC	Exotic Species Production Centers
FAO	Food and Agriculture Organization
F_1	Filial 1 or First Filial Generation of Seed
FHTC	Fish Hatchery and Training Center
FSMF	Fish Seed Multiplication Farm
FRSS	Fisheries Resources Survey System
FTEP-II	Fisheries Training and Extension Project-II
GBC	Genetic Breeding Center
GDP	Gross Domestic Product
GEO	Genetically Engineered Organism
GO	Government Organization
GoB	Government of Bangladesh
GIFT	Genetically Improved Farmed Tilapia
GMT	Genetically Male Tilapia
HRD	Human Resource Development
IMCs	Indian Major Carps
INGA	International Network for Genetic Association
LGRD	Local Government and Rural Development
MDGs	Millennium Development Goals
MoA	Ministry of Agriculture
MoPL	Ministry of Planning
MoU	Memorandum of Understanding
MoFL	Ministry of Fisheries and Livestock
M&E	Monitoring and Evaluation
MoWR	Ministry of Water Resources
MOF	Ministry of Fisheries
MTBF	Mid Term Budget Framework
MT	Metric Ton
NACA	Network of Aquaculture Centers in Asia-Pacific
NABWSS	National Aquatic Bred and Wild Seed System

NBFGR	National Bureau of Fish Genetic Resources (India)
Ne	Effective Breeding Number
NFP	National Fisheries Policy
NFS	National Fisheries Strategies
NGO	Non-Government Organization
PRA	Participatory Rapid Appraisal
PRS	Pooverty Reduction Strategy
POS	Point of sale
QMS	Quality Monitoring System
RFLDC	Regional Fisheries and Livestock Development Component
SU	Support Units
SICD	Strengthening Institutional Capacity of DoF Project
SRT	Sex Reversed Tilapia
SQIC	Seed Quality Inspection Center
SPS	Sanitary and Phytosanitary
SUFO	Senior Upazila Fisheries Officer
ToR	Terms of Reference
TSU	Technical Support Units
WVCC	Wild Variety Collection Center
WFC	World Fish Center
WBVA	Wild/Bred Variety Amplifier
WHO	World Health Organization
WTO	World Trade Organization

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Executive Summary

In order to address the problem Strengthening Institutional Capacity of DoF Project has initiated activities to improve seed quality and brood production system and also provide an overview of hatchery registration and certification procedure. Fish and fisheries are important agricultural sub-sector where land, water, seed and feed collectively plays as important resources to aquaculture. Beside the human and technological resources are necessary to assure optimum production from aquaculture. For sustainable aquaculture, quality seed is a must. In Bangladesh the most awkward blocks to hamper the increasing trend of aquaculture production is the genetic deterioration (occurrence of inbreeding, genetic drift, negative selection and hazardous hybridization) of hatchery produced seeds and broods.

At present about 972 (860 private and 112 government) hatcheries are producing carp seeds to meet the aquaculture demand which covers more than 99% of total seed required and rest 1% are coming from natural sources. Further more, hatchery operators are producing seeds on commercial basis overlooking the quality. As a result, farmers are deprived from getting quality seed for increasing the aquaculture production. Inadequate knowledge of hatchery owners and insufficient logistic support e.g. shortage of pond facility, small number of population size (Ne), occurreneces of hybridization, etc. are main reasons for low quality of seed. The development of breeding and hatchery technology, genetic improvement and domestication are additional key objectives for ensuring quality seed supply for major aquaculture species.

The extensive field visits and interview with hatchery managers, it revealed that the shortage of quality broods and unequal ratio of male and female caused less potential seed production. Also lack of skilled manpower having enough knowledge on genetic methodologies hindered the production of quality seeds of aquaculture species. For this establishment of regional/divisional unit, regarded as satelitte station, is suggested to monitor the quality of seed/brood production and provide all logistic supports including demonstration of new technologies. Simultaneously, the hatchery owners/farmers will get quality seed/broods from the Govt. established Brood Banks. The guidelines for production of quality brood stocks using natural sources of spawns and the pre-requisute for certification of seed quality have been mentioned in this report.

To increase the present yield of carp and its sustenance linebreeding, generation maintaining, gynogenesis and androgenesis, sex reversal, and chromosomal manipulation are suggested. Standards and requisite guidelines would be developed inclusive of a long-term plan for seed quality improvement, safeguarding of genetic purity. Studies should also be undertaken to findout the implication of mass stocking of hatchery produced fingerlings into openwaters like gene introgression, impact on natural brood stock and the like. The researchable issues those are needed to explore for the improvement of carp seeds and brood stock management are also mentioned in this report.

Chapter 1

Introduction

1.1 Background

Fish and fisheries, an agriculture sub-sector, contribute 63% of total animal protein consumption, 5.8% of foreign export earnings and 5.3% of GDP in Bangladesh (DoF, 2005). Aquaculture contributes about 40% of the total fish production of the country. Aquaculture practices (domestication, typical genetic manipulations: selection, sex reversal, hybridization and crossbreeding) and release of fish fry into natural water bodies may also contribute to degradation of indigenous fish species biodiversity. For sustainable aquaculture, quality seed is one of the pre-requisites. Today the most stumbling blocks to hamper the increasing trend of aquaculture production in Bangladesh are the genetic deterioration and occurrence of inbreeding depression in hatchery-produced seeds of farmed fish species (indigenous and exotic carps, catfishes, tilapias and shrimps/prawns). Over the last decade, source of natural seed stock has decreased to a critically low level supplying less than 1% of the total requirement at present while the rest 99% of the seeds are produced by about 900 public and private fish hatcheries in Bangladesh. Considerable percentage of hatchery produced seed has shown low growth. Some recent studies indicate serious genetic deterioration i.e. loss of heterozygosity in hatchery and some natural stocks (Hansen *et al.*, 2006). The decade-long practice of stocking exotic and indigenous carp seed in the rivers and reservoirs already made it difficult to determine the negative impact resulting from gene introgression and inbreeding. Inbreeding and indiscriminate hybridization in the hatcheries and mass release of hatchery produced seeds in the natural water bodies are held responsible for such damage (Simonsen *et al*., 2005). Hybridization and cross breeding are endangering the genetic diversity of indigenous wild stocks of major carps and it may result irreversible damage to their gene pool.

Natural levels of genetic diversity can be maintained by reducing the movement of genetically diverse populations within the country. The existence of distinct strains in Bangladesh is not yet identified accurately, due to lack of equipment and facilities. Escapes of aquaculture stocks are frequent, due to extended flooding almost all over the country. In fact, most of the hatcheries are functioning with non-pedigreed broodstock to achieve their target driven seed production without considering the genetic quality. As a result, the aquaculture production can not reach to the satisfaction level due to poor management of broodstocks and the low quality of seeds. To overcome this problem production of sufficient quality seeds in the hatchery and their distribution to the farmers is one of the ways. Quality seeds can be produced through appropriate breeding strategy and stock improvement. Besides, genetically improved broodstock attributes is important to develop a live and cryogenic gene (brood) bank that will help producing quality seeds and conserving biodiversity. The main objective of this assignment is to improve seed quality using genetic improvement methodologies, trained skilled manpower and to make a plan for distribution of quality (genetic) seeds and certification of hatcheries in Bangladesh.

The Government of Bangladesh is implementing a Danida-supported Agricultural Sector Support Programme (ASPS-II) which was initiated in October 2006 with a time frame of five years. The programme covers the crops, fisheries, livestock and rural road sub-sectors,

with extensive field activities implemented through relevant line departments and coordinated by three institutional support units located in the Ministry of Planning (MoPL), the Ministry of Agriculture (MoA), and the Ministry of Fisheries and Livestock (MoFL). The development objective of ASPS-II is "Improved living conditions of poor, marginal and small farmer households through enhanced, integrated and sustainable agricultural productivity".

The Regional Fisheries and Livestock Development Component (RFLDC) of the programme have four outputs to achieve the immediate objectives. The component has Support Units (SU) in Department of Fisheries (DoF) and Department of Livestock Services (DLS), and Technical Support Units (TSU) located in Noakhali and Barisal for field based activities.

The Support Unit at the DoF supports the department in implementing activities under Output 5 of the Programme: 'Capacity of DoF to deliver public goods (supporting legislative and regulatory framework, quality control of inputs and products, disease control, relevant research, monitoring) enhanced'. The main activities are: rehabilitation and extension of the department's management information system; human resources development; improvement of seed quality, certification and traceability in the shrimp culture sector; community based fisheries management, review of the National Fisheries Policy, implementation of the National Fisheries Strategy, studies and research.

The DoF launched a comprehensive programme during the Fourth Fisheries Project to establish the National Fisheries Strategy and Action Plan. In addition the department needs quality brood bank center for the fulfillment of aquaculture demand and conservation of national resources. The department, however, needs enhanced capacity to genetic methodologies to ensure the quality of carps broodstock with adequate knowledge. The Strengthening Institutional Capacity of DoF Project of ASPS-II will also provide support for human resources capacity development in improvement of quality seed and broodstock management.

1.2 Goals and Objectives

The overall objective of the assignment was "Improvement of carp seed quality in two/three selected hatcheries and develop a plan/protocol for production of quality seed and its distribution". The specific objectives of the consultancy also includes are:

i) To assess the present status of carp broods and breeding techniques in hatcheries;
ii) To improve the seed quality of selected hatcheries;
iii) To train relevant DoF personnel on genetic improvement methodologies;
iv) To make a long-term plan for improvement of quality seed and adoption by the Department of Fisheries (DoF);
v) To prepare the guidelines for hatchery registration and seed certification protocol; and
vi) To explore and detect the issues for future research and development.

1.3 Activities

Main activities **(ToR, Annexure 1)** performed during the consultancy period were-

i) Consulting and attending initial meetings with partinent personnel of the DoF, MoFL, BFRI, and Universities and private hatchery operators;

ii) Review the existing scenario of carp seeds production and brood stock management;
iii) Participation in Divisional meetings to find out the focus groups to achieve the goal;
iv) Preparation of an inception report including an action plan for the consultancy;
v) Preparation of training manual on fish genetic methodologies and extension materials (leaflets, posters, lecture notes etc);
vi) Conduct training for the officers/farm managers/hatchery officers of DoF;
vii) Develop guidelines for hatchery registration and seed certification procedure;
viii) Prepare draft final report including the work plans and training needs for genetic improvement of carp seeds;
ix) Workshop presentation with the relevant stakeholders of DoF to get feedback; and
x) Prepare and submit final report to project authority.

1.4 Assumption and Risks

The duration of the assignment was 6 months which is not sufficient to prepare a comprehensive training module on improvement of carp seeds and brood stock improvement and conduct training to farm mangers/hatchery officers/Upazila fishery officers of DoF. The selection of two/three hatcheries from government and private sector to intervene genetic improvement and broodstock development activities is also found difficult under the prevailing situation. Moreover, there exists 'Brood Bank Establishment Project", where similar activities are included which needs to be synchronized with this project. Another important task was the preparation of guidelines for hatchery registration and certification, need long-term plan with rearrangement of present fisheries policy and having guidelines for central monitoring and evaluation. Also collection of pure seed from wild sources and their maintenance in government existing system, seed distribution channel and quality assurance or control of hazardous hybridization will be difficult.

1.5 Relevant Policies and Strategies

The project 'Strengthening Institutional Capacity of DoF (SICD) Project' has aimed to develop management capacity of fisheries department to accelerate the decision making process in order to accomplish their immediate and long term sectoral demand. The main activities are: rehabilitation and expansion of the department's management information system; human resources development; improvement of seed quality, certification and traceability in the shrimp culture sector; community based fisheries management, review of the National Fisheries Policy, implementation of the National Fisheries Strategy, studies and research. The national fisheries strategy and action plan for the implementation of the national fisheries strategy have been developed by the Fourth Fisheries Project.

Implementation of the project will ensure the aim of the national fisheries policy and startegy. It will provide support to the department in its brood stock management plan and improvement of quality seed production from registered and certified hatcheries.

Among them important policies and strategies consulted are summarized below:

1.5.1 National Fisheries Policy 1998

The National Fisheries Policy was approved in 1998 (NFS, 1998) with the endorsement of the Government of Bangladesh. This for the first time set out the policy framework for directing the management of the fisheries sector. In addition to the National Fisheries Policy the government has approved a Poverty Reduction Strategy (PRS) paper which has implications for all sectors of the government and every sector should undertake proper

activities. The government has also signed up to conventions on the Millennium Development Goals (MDGs) (PRS and MDGs, 1998). The objectives of the National Fisheries Policy are:

i) To enhance fisheries production and development;
ii) To alleviate poverty through creating self-employment and improvement of socio-economic conditions of fishers;
iii) To meet the demand for animal protein;
iv) To achieve economic growth and increased foreign currency earnings by exporting fish and fisheries products; and
v) To maintain an ecological balance, conserve biodiversity and improve public health.

Under the National Fisheries Policy the following tasks are specific to this sub-strategy:

i) The private sector shall be responsible for the commercial production of fish fry. The private sector will be encouraged to establish more hatcheries for fry production (Ref. National Fisheries Strategy- 01. Aquaculture Sub-Strategy 6.11).
ii) Arrangement will be made to transfer the improved technologies of aquaculture through regular training in the government fish farm and training centers. Brood banks shall be established in the government farms for distribution of quality broods to the private hatcheries. The government hatcheries/farms will also be used as centers for training of farmers and entrepreneurs in fish culture management, fish breeding and fry production technologies (Ref. National Fisheries Strategy- 01. Aquaculture Sub-Strategy 6.12).

1.5.2 National Fisheries Strategy

Formally the fisheries sector is controlled by the Government through its agency principally the DoF. The strategy reflects the management and control with direct involvement in some of the inputs such as fingerling supply. The strategy advocates that their activities move to one of nurturing participation with local communities, the private sector and NGOs; the provision of advice; and establishing a regulatory framework in which the sector can function. The strategy also emphasizes collaboration, linkages and partnerships through:

(i) Coordination among DoF, Universities, BRFI, GOs and NGOs for resource utilization with technical assistance;
(ii) Identify researchable issues for future; and
(iii) Provide support for poverty alleviation.

1.5.3 Review of PRS policy matrix

The Poverty Reduction Strategy (PRS) offers important opportunities to identify key obstacles to poverty reduction, prepare a plan to overcome them, strengthen partnerships with donors, and improve coordination (Table 1).

1.5.4 Aquaculture Sub-strategy

The purpose of the aquaculture sub-strategy is to create provision, by the DoF and partners, of a support and regulatory framework that will enable the aquaculture sector to develop its ability to generate a livelihood for the rural dwellers and in so doing provide employment for the rural populace and by supplying quality fish at an affordable price to the consumers.

Table 1. PRS policy matrix-04, Agricultural growth towards poverty reduction:

Strategic goal	Key targets/Activities	PRS policy agenda	MTBF targets/ Specific programmes-Projects
1. Increasing productivity in inland aquaculture	-Increase fish yield pond poly-culture -Cover 90% of ponds for fish culture -Fisheries contribute 5% to GDP and 5.7% of total export earnings.	-The total production of inland aquaculture (ponds) in FY 2006 was 7,59,628 mt showing 11.34% increases over FY 2005. -Export target of fish & fish products has been set at 77,638 mt in FY 2008 against 73,704 mt exported in FY 2007.	-Yield of fish will increase by 10%, production and income of fishery farmers/fishers will also increase by 20% over the next 5 years. -As against total demand of fish estimated at 32.20 lakh mt by FY 2011 the projection for production in FY 2011 has been set at 29.75 lakh mt against production of 23.80 lakh mt in FY 2006 under closed- and semi-closed inland fisheries. -The projected fish export in FY 2011 has been set at 93,251 mt.
2. Raise income of the poor fishers	-Increase income from cage, pen culture and seed and fry production.	--Encourage NGO participation for organizing fishers.	-Alternative job oppurtunities for 1,00,000 people will be explored in the open water fisheries by FY 2011 over 86,791 employed up to FY 2006.
3. Strengthening fisheries research and extension	-Target promotion of rural aquaculture as pro-poor growth strategy.	-Further financial support is to be provided for fisheries research. -Developed 42 improved technologies & fish culture management and 5 low cost technologies up to 2005-06. Another 10 new technologies are under process to be developed for dissemination by FY 2011. -Conserved 13 rare species for breeding purpose upto FY 2005-06 will be restored.	-MTBF target has been set to develop 5 new low-cost technologies by FY 2010 as against 5 technologies developed so far and disseminated. -MTBF is to impart training to 420 cadets by FY 2010 as against 1000 cadets so far trained up to FY 2006.

The major problems to the quality of the inputs are especially the supply of quality fingerlings. To resolve this issue placement of regulations through government in the form of granting of licenses to operate and through self-certification need to be considered:

(i) Establishment of a regulatory framework to ensure the provision of quality inputs to the fisheries sector;
(ii) Development of a registration scheme for all hatcheries concerned in the production of fish/shrimp fingerlings;
(iii) Development of a certification scheme to offer quality assurance for fingerlings produced by hatcheries i.e. industrialized; and
(iv) Development of regulations, registration and certification protocol for other input supplier i.e. feed producers, chemicals, hormones, etc.

Apart from these, a principal role of the DoF till nineties was to stimulate aquaculture through mass production of fingerlings and extend the know how to establish more hatcheries in the private sector. The DoF has successfully built the required hatcheries for fingerlings production. But the new set of roles required for quality assurance of hatchery produced spawns, fries and fingerlings through:

(i) Establishment of selected hatcheries to act as quality fish brood banks;
iii) Provide fingerlings in areas where private sector can not meet up the requirements; and
(ii) Provide facilities for adaptive research and for demonstration of new management techniques to local farmers.

The main components of the Aquaculture Sub-strategies are:
-Aquaculture Resources
-Regulatory Framework
-Certification and Quality Assurance
- Support Services
-Co-ordination, Collaboration and Linkages

1.5.4.1 Aquaculture Resources

The future development of aquaculture depends on the present status of resources and the potential for bringing more resources under management using scientific aquaculture principles. The rapid growth of the aquaculture sector will result in rapid changes in existing resources through improved cultivation. Growth has also been faster in areas where the environment and climate is more suited to aquaculture. For future development the following steps need to be undertaken:

i) Develop specific approaches for different areas depending on comparative advantages;
ii) Details of shortfalls in resources are needed to support the area of development and identify the measures to remedy the shortfalls;
iii) Develop monitoring systems to determine the impacts of the continued aqua-cultural expansion.

A key resource for the continued growth of the sector is the availability of genetically pure brood to supply to the commercial hatcheries. For this priority should be taken to:

i) Support the protection of areas declared as national fish sanctuaries to protect broods and spawn of nominated species;
ii) Establish the genetic purity of all sources of indigenous and exotic broods; and
iii) Develop a national plan for the conservation and production of indigenous and exotic fishs' broods.

1.5.4.2 Regulatory Framework

The aim of the regulatory framework is to provide a framework of controls that will direct growth and ensure that the sector is able to expand through access to quality inputs.

The expansion of aquaculture has been remarkable, but it has largely been unfettered. Poor genetic quality of fingerlings due to poor brood selection, inbreeding and hybridization has

reduced the growth potential of many of the species and has serious environmental consequences for any fingerling that might find their way into wild either through stocking or inadvertently during floods. The preparation and the enforcement of regulations has now become a priority:

i) Prepare a basic set of requirements to be complied with by all registered hatcheries;
ii) Draft legislation requiring all hatcheries to be registered and ensure they comply with the requirements as laid down;
iii) Provide training and support (both technical and financial) to enable hatcheries to fulfill the regulations.

1.5.4.3 Certification and Quality Assurance

The main objective is to provide support to private sector initiatives for self-certification and improve the sector where the stakeholders' and producers both have confidence in the quality of their inputs and the consumers are given a product that can meet their requirements.

In the development and enforcement regulations, there is a need for development of standards within the industry. These can be seen as self-certification or quality assurance standards that members of an association impose on its members and are determined either by the industry itself or a nominated organization or group of stakeholders.

For Hatcheries:

i) Promote the development of a certification and quality assurance scheme for hatcheries based on genetic quality of fingerlings and their health and potential to grow as per expectations;
ii) Formation of hatchery association to promote the improvement of standards within the sector to ensure quality broodstock and that of fish seeds;
iii) Support the development of certification scheme through access to soft-loans and training;
iv) Develop awareness amongst fish farmers on the merits of fingerlings from certified hatcheries and endorse a premium pricing structure; and
v) Provide support to monitor and certification of hatcheries through monitoring of genetic quality of produced seeds.

1.5.4.4 Support Services

The aim of the support services is to develop key institutions both at public and private sectors to provide required technical assistance to enable the continued growth of the aquaculture sector. To ensure rapid and sustainable development of the fisheries sector, the service delivery system of the extension provider should be efficient and improved. Gradually as the capabilities of the private sector develop, support services provided by the government will reduce. Roles identified for these key support services are:

For Brood Banks:

The need to secure quality brood and rear these for supply to the private sector hatcheries has already been identified. To ensure this:

i) Identify sources of pure brood and develop the infrastructure (government and private sector) to supply the industries needs;
ii) Develop a brood action plan to ensure that the private sector introduce a controlled breeding programme for the maintenance of genetically pure brood;
iii) Identify the best genetic stock of exotic species i.e. Silver carp and develop breeding programmes to develop parent lines for future brood production; and
iv) Through the identification of key private sector hatcheries regulate the production and distribution of quality broods for commercial hatchery use.

For Research:

i) Develop adaptive research programme between all stakeholders including farmers, researchers and the DoF; and
ii) Monitor international research for information relevant to Bangladesh and test its applications.

For Field Research stations:

i) Develop linkages with research institutes to undertake relevant adaptive research under field conditions; and
ii) Establish MoU between the DoF and research institutes for the use of DoF's Fish seed Multiplication Farms for farmer oriented research, particularly on the development of early and quality broods, preserve quality milt and their distribution.

For Demonstrations:

i) Fully utilize the Fisheries Extension Training Centers as part of a holistic extension approach to demonstrate key aspects of aquaculture and new innovations; and
ii) Demonstrations on the propagation of a wide range of indigenous fish species (shing, local magur, koi, pabda, sharputi, bata, foli, meni, etc).

1.5.4.5 Co-ordination, Collaboration and Linkages

Improve coordination through increased collaboration of all stakeholders involved in the management and production of fish for aquaculture.

It requires closer collaboration at the field level to help facilitate planning of the local resources.

For National Planning linkages:

The coordination between the Ministries such as Agriculture, Land, Water, Local Government and Fisheries is essential to ensure harmony amongst the different policies:

i) Formation of a National Resources Management Committee at Ministerial level; and
ii) Formation of a Fisheries Management Executive Committee at Secretarial level.

For Field Level linkages:

i) Formation and execution of a local Upazila Fisheries Committee to monitor and regulate all large fishery developments.

For Inter-industry linkages:
The different sector of the aquaculture industry needs to be coordinated and grouped to enable them to have effective dialogue with policy makers during the preparation of regulations. For this to be effective a wide range of associations are needed to be established including, but not limited to:

i) Hatchery operators;
ii) Fish producers; and
iii) Traders and merchants.

1.5.5 Aquaculture Extension Sub-strategy

The aim of the aquaculture extension sub-strategy is to create provision by the DoF and its partners, of an efficient, effective, need based extension service to all categories of farmers to enable them to increase production to an optimum sustainable level by using appropriate aquatic resources.

The extension services have primarily focused on aquaculture. The extension services are required to continue the growth and improve their output, there is also a need to improve extension services to support the improved management of the inland capture fisheries and the marine sector. The main activities are:

(i) Develop a need based decentralized extension system;
(ii) Promote the collaboration of other extension providers to ensure the maximum coverage of the target farmers etc.;
(iii) Encourage private sector initiatives to provide extension services.

1.5.6 Research

The aim of the research is to strengthen the knowledge and understanding of the resource through research based on the needs of the sector and determined through assessments of the needs of the key stakeholders. There are many key issues in aquaculture that requires further research and skills which are not always available:

(i) Reconsider the research skill base and develop the institutional capacity to undertake the redefined research priorities;
(ii) Ensure the relevance of the research by effecting a sound communication strategy with the key beneficiaries of the research; and
(iii) Ensure strong linkages with international research institutes to stimulate research, new technology and feed required knowledge.

1.5.7 Human Resource Development Sub-strategy

The main objective is to strengthen the human resource capacity of the DoF, its partners and stakeholders to ensure all levels have the requisite knowledge, skills and techniques to enable them to make productive use of their potential.

There is a need for commitment to institute the recommendations made in the HRD strategy which largely comes from institutional assessments of the DoF's capacity and the resources at its disposal.

Chapter 2

Framework of the plan

2.1 Basis of the plan

Land, water, seed and feed constitute four of the most important resources to aquaculture outside human and technological resources. Efficient use of these resources is necessary to ensure optimum production from aquaculture. Availability of quality fish seed is a pre-requisite for adoption of sustainable aquaculture. Production based technology can mitigate the existing obstacle to produce quality fish seed.

The present structure of carp seed production and brood bank management program has been developed by several GoB and foreign funded projects but the requirement is not fulfilled yet. The present assignment on improvement of carp seed and brood stock management has proceeded with new interventions and mitigating measures of genetic deterioration to make it more realistic and implementable. The development of breeding and hatchery technology, genetic improvement and domestication are additional key objectives for securing the quality seed supply for major aquaculture species.

2.2 Structure and Content

2.2.1 Structure

This plan is in the form of an Action Plan with a set of activities where comprehensive action is to be implemented by the DoF through its respective wing and also by various development projects. Action may segregate into different perspectives such as innovation with new genetic methodologies; development of skilled officers; support need-based requirement to the selected farms and analyze the current status of seed certification protocol and refinement. The Action Plans will secure the coordination between the farm/hatchery activities of the field/divisions and multi level offices of the DoF.

2.2.2 Content

The plan has covered all the contents of fish genetic program such as quality of carp seeds, existing scenario of hatcheries, training conducted so far in local and abroad, preparation of guideline for hatchery registration, etc. Hence then DoF would be able to conduct all activities to achieve the target through long-term genetic plan.

2.3 Approach to prepare the plan/Working process (Fig. 1)

2.3.1 Collection of information

2.3.1.1 Field (Farm/Hatchery) information

a) Baseline survey

To acquient with the real situation of present status of government and private carp farms/hatcheries in six divisions the survey of baseline information on “Improvement of carp seeds and brood stock management” were developed and information were collected (**Annexure 2)** through visiting some hatcheries and questionnaire.

b) Focus group discussion

To obtain the present scenario of carp seeds and brood stock management, attendened several Divisional meetings (Rajshahi, Chittagong and Sylhet) and explored the mission of

the assignment on "Improvement of carp seeds and brood stock management". The following key points are discussed:

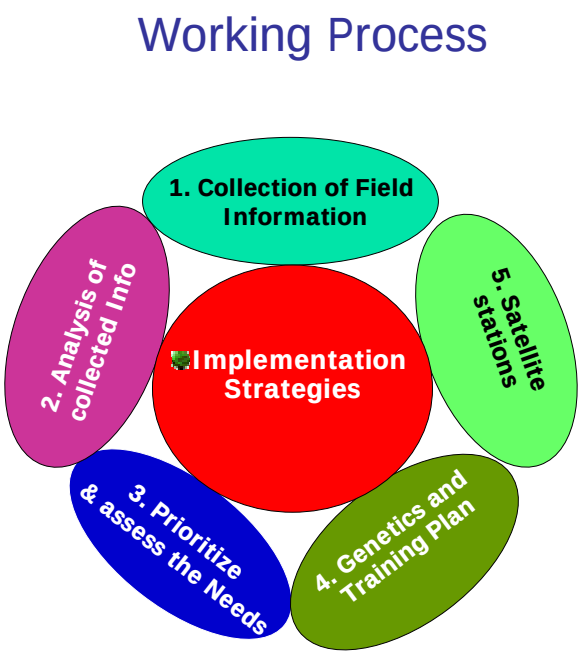

Fig. 1. Working Process model.

Rajshahi Division

- Production of hybrid fish (female Mrigal X male Bata; Female silver X male bighead; female calibaus X male rohu) should be stopped;
- The production of silver and bighead carp is being reduced due to genetic degradation so pure line should be imported;
- Hatchery water should be iron free;
- Private sector participation should be ensured;
- Quality carp seed should be supplied from natural sources;
- Control of inbreeding in hatchery origin stocks; and
- Revenue based production target should be replaced by quality seed production target.

Chittagong Division

- Hatchery registration should be done;
- River sources of carps stock should be protected;
- Control of inbreeding in hatchery origin stocks;
- High yielding trait of carps should be conserved and propagated;
- Line generation of each species should be conducted;
- Floodplain production should be increased through the culture propagation of 5/6th line generated spawns;
- Priority of quality should be encouraged over target based production; and
- Overseas training should be conducted for both officers and farmers.

Sylhet Division

- Pedigreed mating should be conducted;
- Ensure supply of quality carp seeds from present government brood bank stocks;
- Control of inbreeding in hatchery origin stocks;
- Priority of quality should be encouraged than target based production;
- Need training on genetics for Fisheries Officers/Farm Managers;
- Mixing of carps spawn (river origin mixed with hatchery origin) should be stopped;
- Present hatchery target should be reformed by the Farm Managers/Hatchery owners; and
- Production of monosex tilapia should be evaluated for human health issue.

2.3.1.2 Institutional information

Department of Fisheries (DoF)

The brood stock management and breeding plan of fishes in Bangladesh has been compilated by the Fourth Fisheries Project/World Bank in 2006. The aquaculture species including exotic fishes are briefly discussed in regard to their breeding and propagation for sustainable culture stocks. Also the genetic status of indigenous fish species and genetic erosion of cultured fish species in Bangladesh are emphasized for necessary genetic improvement

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Objective of Brood Stock Management and Breeding Plan of Fishes in Bangladesh, 2006

The objective of this plan is to improve the genetic quality of fish to be used in aquaculture and culture-based fisheries programs. The proposed plan is suggesting alternative ways to improve growth performance and genetic diversity of brood stocks. Establishment of Brood Bank is proposed. Subsequently, these farms will be used to distribute quality seed as well as to demonstrate and train hatchery operators an appropriate brood stock management and nursery techniques.

Bangladesh Agricultural University, Mymensingh

Recently preliminary work of genetic assessment on Indian major carps (rohu, catla, mrigal and kalbasu) including other endangered fish species (local sarpunti, koi, meni, shing, bata and baghna) through molecular markers from the Department of Fisheries Biology and Genetics, Bangladesh Agricultural University, Mymensingh has been developed and their research based information would be a guide line for future quality carp seed production using genetically pure broodstocks.

Bangladesh Fisheries Research Institute (BFRI)

The super breeds developed by selective breeding technique of silver berb and GIFT tilapia and production of outbreed stocks by crossing of wild land races (F_1 superior stock of Catla, *Catla catla*; and Rohu, *Labeo rohita*) by Bangladesh Fisheries Research Institute (BFRI), Mymensingh has been initiated and the methodologies of implementation through contact farmers are being conducted.

2.3.1.3 Internet browsing

The issues on genetic improvement of carp seeds and brood stock management program held in south east Asian countries and the technical paper developed were collected from following internet sites;

- Network of Aquaculture Centres in Asia-Pacific (NACA) - International hands-on training programme on Molecular Biology Technology-Genetics and biodiversity - news-CIFRI (Central Inland Fisheries Research Institute), Bhubeneshar, India
- Aquaculture in the Third Millennium-Review of the Status of Aquaculture Genetics files
- NACA-Network of Aquaculture centers, Asia Pacific-2008 Forum on Fisheries Science and Technology, 25-27 September 2008, Shanghai, China
- Training on brood stock management and sex reversal of tilapia (SRT)
- International workshop on Bio-safety Science of Aquatic Genetically Engineered Organisms- The Department of Aquatic Sciences, Burapha University, Thailand and the Institute for Social, Economic and Ecological Sustainability (ISEES), University of Minnesota, organized a **Workshop on Biosafety Science of Genetically Engineered Organisms** (GEOs*)* at Burapha University, Chonburi, Thailand during 27-28 October 2003. The Workshop was organized through a Biotechnology-Biodiversity Interface competitive grant from the U.S.
- INGA NEWS-Management of Broodstock and Quality Control of Fish Seed in Hungary- The GIFT Foundation Board of Trustees held its 15th Board of Trustees and Annual Members' meeting at the WorldFish Center Headquarters, Penang, Malaysia on 17 September 2002.

2.3.1.4 Consultation with DoF personnel/working group

For the development of brood stock management strategies and subsequent propagation of quality carp seeds, the relevant sectors such as brood bank establishment projects, aquaculture extension, quality control and action group of SICD project were consulted on the present brood management scenario and hatchery activities in Bangladesh.

2.3.2 Analysis of collected data

Brood stocks

In general, no pedigreed brood stocks are found in existing Fish Seed Multiplication Farms (FSMF)/hatcheries in Bangladesh, except for the Raipur Fish Hatchery and Training Center, Laxmipur and Fish Seed Multiplication Farm, Natore. In these two govt. carp hatcheries brood stocks are reared in species-specific ponds. In these hatcheries, managers have the policy to recruit their brood stock every year through spawn collected from natural sources. In regard to the quality, brood stocks of most farms/hatcheries are deteriorated due to inbreeding, genetic drift and negative selection. Hybrid carp spawns (cross between two IMCs species) are also often produced in some farms/hatcheries.

Brood ponds

The existing and newly recruited brood fishes are stocked in the same pond due to shortage of ponds. Moreover, the broods are not reared with sufficient balanced diet to make them as breeder stocks due to lack of sufficient logistics. As a result, the produced spawns are not of

good quality. Some ponds are very old, not re-excavated, dykes are broken and water quality often deteriorates, can not be considered them as brood ponds.

Hatchery

Most of the govt. fish seed farms/hatcheries are not running smoothly due to lack of farm facilities e.g. oxygenated water source, iron free water, adequate numbers of cisterns, incubators and skilled labor. There are no laboratory facilities in fish seed farms/hatcheries. The allocated fund for pond and hatchery renovation is not sufficient and often do not receive in time.

Training

Fish farmers/hatchery officers are not well trained to produce quality brood stocks and seeds. Local and overseas trainings for farm managers and some private owners should be conducted.

2.3.3 Prioritize and assess the needs

Based on the initial meeting at divisional monthly meeting and through questionnaires to the farm managers/hatchery owners the following issues are selected:

i) Target driven hatchery practice should be replaced by quality driven targets;
ii) Genetic deterioration of broods and offsprings in hatcheries need to be controlled;
iii) Remodeling of hatchery;
iv) Production and distribution of quality broods through government Brood Bank Establishment Project;
v) Training on genetic methodologies for govt. farm managers/hatchery officers;
vi) Establishment of private hatchery registration and certification protocol;
vii) Establishment of satellite station in each division with logistic facilities;
viii) Conduct research for farmers demand/new technologies e.g. YY tilapia production;
ix) Establishment of monitoring and evaluation center (MEC) cell; and
x) Provide sufficient fund to the farm managers in time.

2.3.4 Genetics and training plan

Genetics is the branch of science which deals with heredity and variation. The proper use of hereditary characters/traits can be achieved through breeding technology of fishes. Many business-minded hatchery operators have learned only mechanically the techniques of induced breeding while maintenance of genetic quality of breeders has been neglected, resulting in production of poor quality fish seed and affecting aquaculture output by which the genetic diversity of wild indigenous stocks are threatened.

The aquaculture of Bangladesh is based on 98% seed produced from about 900 private hatcheries and <1% natural seed. The hatchery produced seeds are not generated from genetic diversified brood stocks. Poor (genetic) quality of fingerlings due to poor brood selection, inbreeding and hybridization has reduced the growth potential of many fish species and has serious environmental consequences for any fingerling that might find their way into the wild either through stocking or inadvertently during floods. The genetic improvement of brood stock in over 900 private hatcheries is a precondition to further increase the production, improve livelihood of poor fish farmers as well as maintain genetic diversity and purity of endemic and exotic carp species.

To achieve the demand of fish estimated at 3.22 million mt by FY 2011 the PRS projection for production in FY 2011 has been set at 2.975 million mt against production of 2.380 million mt in FY 2006 under closed and semi-closed inland fisheries. Also it is mentioned in PRS and MGDs Fisheries Sub-sector that a total of 1,500 private hatchery owners/farm managers (operator)/ and Nursery operators will be trained on control of inbreeding, production of genetically improved brood and preservation of germ-plasm, hatchery management and fingerlings/fry rearing. This training should be continued for all hatchery and nursery owners and operators on production of quality seed.

2.3.5 Satellite station

The present development strategies of aquaculture and subsequent agendas need to be propagated to the farmers' regional/divisional unit, the satellite station. The main activity of the station/unit will be monitoring the quality of seed/brood production and provide all logistic supports including demonstration of new technologies.

Chapter 3

Existing Practices

In Bangladesh the freshwater fisheries and aquaculture are based mainly on carps. Among these, the Indian Major Carps (Catla, Rohu and Mrigal), Chinese Carps (Silver Carp, Bighead Carp, Grass Carp, Black Carp), Silver Barb and varieties of Common Carp are the most widely cultured species. In recent years, intensive culture of Thai Pangas and Tilapia has also increased. At present the major proportion of fish seed for aquaculture is produced by about 900 hatcheries. The capacity of most hatcheries is too small to produce good quality breeders of their own, while 10-15 consecutive generations of breeders have been produced. This has been exacerbated by negative selection and hybridization. All these malpractices result in production of poor quality fish seed. The genetically eroded seed is affecting aquaculture output. The danger of genetic degradation is also extended to the wild endemic fish population, because the mass release of low quality seed in floodplains is threatening the purity of wild stocks.

The best solution for maintaining the genetic quality of brood stocks in commercial hatcheries is to always procure quality breeder candidates from brood banks. That means commercial hatcheries should never produce breeders from their own-produced fry. Establishment of brood banks-1st phase is completed and 2nd phase is under way, some of them are already operating and it is expected that the country-wide network of brood banks will be completed in the next few years. But the activities of brood banks should be strictly maintained; otherwise it will not be possible to stop detrimental hybridizations in commercial hatcheries. The genetic deterioration prevalent in aquaculture practices includes following:

3.1 Inbreeding

Inbreeding happens when brother-sister or closely related breeders are used for reproduction. The level of inbreeding is increasing when successive generations of closely-related breeders are used in hatcheries. It results in slow growth, deformed fins and reduced resistance to diseases. The production performance of stocks affected by inbreeding depression is poor (Fig. 2).

Fig. 2. Inbreeding depression of catla spawn.

Effects of inbreeding

i) Fish farmers are frequently facing the retarded growth because of inbreeding, one of the main reasons is the unknown pedigreed of brood fishes;
ii) Farmers frequently exchange broods with other hatchery stocks where the quality is more deteriorated;
iii) Most of the hatchery started with unknown broods or hatchery originated broods for this reason inbreeding depression is occurring even in 2^{nd} generation of offsprings; and
iv) In most cases hatchery owners are unknowingly using the negatively selected broods which have no genetic quality to produce additive genetic characteristics in the following generations.

3.2 Genetic drift

Genetic drift is random changes in gene frequency caused by sampling error (shipment of fish from one station to another; brood stock selection). The ultimate effect of genetic drift is the loss of genetic variance. The only way to prevent sampling error is to have an infinitely large population which is often impossible. Commonly sampling error is choice of brood fish that are allowed to spawn and produce next generation. Genetic drift causes problems when the random changes in gene frequency cause some alleles to be lost i.e. frequency goes to 0.00 or 0%.

How valuable are the rare alleles? i.e. What is the frequency of the alleles that will be saved?

In general, each fish have some rare alleles those frequencies are <0.01 and function for growth performance, will be lost more easily than common alleles. A hatchery manager who wants to manage his hatchery population in order to prevent genetic drift from loss of alleles must also manage the population.

Prevention of Genetic Drift

The effective breeding number (Ne) that is needed to prevent genetic drift from robbing the population of rare alleles is determined by using the following formula:

$$P = (1.0-q)^{2Ne}$$

Where,

P is the probability of losing the allele in a single random sample (the fish that mate to produce the next generation or the transfer of fish from one hatchery to another);

q is the frequency of the rare allele that is to be saved (q = 0.01 or 0.05 or whatever value is chosen); and

Ne is the effective breeding number.

For example, if *Ne* is 50, the probability of losing an allele whose frequency is 0.1 (q=0.1) is:

$$P= (1.0-0.1)^{2(50)}$$
$$P= (0.9)^{100}$$
$$P= 0.0000265$$

If *Ne* is 10, the probability of losing the same allele is:

$P= (1.0\text{-}0.1)^{2(10)}$

$P= (0.9)^{20}$

$P= 0.12158$

These examples clearly show that the probability of losing an allele is inversely related to *Ne*; the probability of losing the allele is 4,588 times greater when *Ne* decreased from 50 to 10.

3.3 Negative selection

Negative selection is occurring in some hatcheries, where the smallest individuals are selected for reproduction and the largest ones are discarded from the brood stock. This results in degraded genetic diversity of the next generation, reduced size, slower growth and sexual maturation at a smaller size. Some genetically degraded carps are already maturing as small as 100-200 g size in badly managed hatcheries. This is affecting aquaculture production and threatening the genetic diversity of wild stocks.

How to avoid negative selection?

Negative selection for small size can be easily avoided by discarding the smallest individuals from the breeder candidates. This requires knowledge of the age of the individual breeder candidate. The standard minimum weight of breeders should be respected and maintained. The selection of only the largest sized breeders will result in better aquaculture production, but may also cause changes in the genetic pool of original wild species, thus threatening the genetic diversity of wild stocks –if released (Fig. 3).

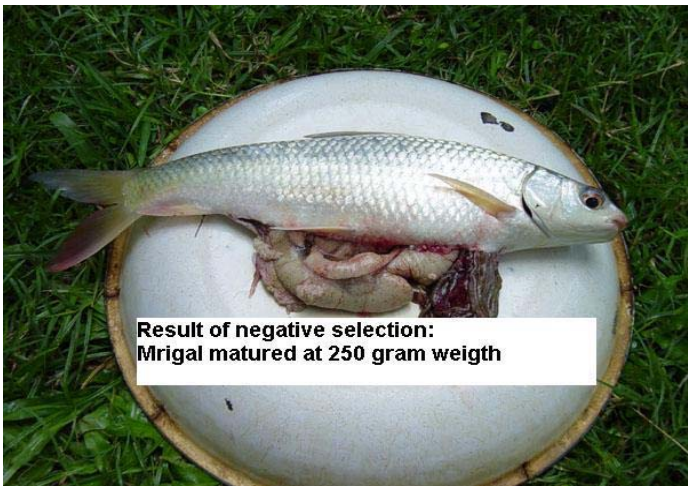


Fig. 3. Negative selection of mrigal.

3.4 Hybridization

Hybridization is breeding individuals of two separate species whilst crossbreeding is mating two different varieties/strains within a species. The main objectives of both the crosses are exploiting non-additive genetic variance through identification of significant positive heterosis which is also known as hybrid vigour.

Hybridization has an immediate impact on performance within one generation and only present in the F_1 hybrid. Planned hybridization is based on the exploitation of the desired, defined and predictable traits of the F_1 hybrids between the two parental species. Hybridization between closely related fish species can be haphazard, for example in the production of major carps in Bangladesh.

Intraspecific crossbreeding

Intraspecific crossbreeding (crossing of different strains) may increase growth rate but heterosis (differences between offspring and parents) may not be obtained in every case. Increases of 55 % and 22 % in growth rate of channel catfish and rainbow trout crossbreeds, respectively, were achieved using this technique (Dunham and Smitherman, 1983; Dunham, 1996b). Chum salmon crossbreeds, however, have shown no increase in growth rates compared to parent strains (Dunham, 1996a).

Interspecific hybridization

Interspecific hybridization has been used to increase growth rate, manipulate sex ratios, produce sterile animals, improve flesh quality, increase disease resistance, improve tolerance of environmental extremes, and improve a variety of other traits that make aquatic animal production more profitable. Although interspecific hybridization rarely results in an F_1 suitable for aquaculture application, there are a few significant exceptions (Figs. 4 a-c, d-g & h-j). The hybrid fish can be identified compared to their pure parental species by their meristic characteristics (Table 2).

Occurrences of hybrids

i) Catla and its hybrids

Fig. 4. a. Pure catla.

Fig. 4. b. Catla-mrigal hybrids.

Fig. 4. c. Catla-rohu hybrid.

i) Rohu and its hybrids

Fig. 4. d. Pure rohu.

Fig. 4. e. Rohu-catla hybrid.

Fig. 4. f. Rohu-gonia hybrid.

iii) Mrigal and its hybrids

Fig. 4. g. Pure mrigal.

Fig. 4. h. Mrigal-rohu hybrid.

Fig. 4. i. Mrigal-catla hybrid.

Fig. 4. j. Pure calbasu.

Table 2. Characteristics of pure species and their hybrids

Species/ Characters	Pure Rohu	Rohu-Mrigal	Pure Mrigal	Pure Catla	Catla-rohu	Rohu-Gonia
Dorsal fin rays (soft/hard)	3/12-13	15	3/13	1/17	16	16
Pectoral fin rays – L/R	18-18	17/17	17/17	1/18-1/18	18/18	17/17
Pelvic fin rays-L/R	9/9	9/9	7/7	9/9	1/8-1/8	9/9
Anal fin rays (soft/hard)	7	7	3/5	1/7	7	7
Caudal fin rays	24	22	24	24	25	24
No. of Branchiostegal	3	3	3	3	3	3
Scale above lateral line	7.5	6.5	6.5	7.5	7.5	9.5
Scale below lateral line	6.5	5.5	6.5	6.5	6.5	8.5
Scale along lateral line	42	42	44	48	41	55

3.5 Unknown origin of breeders

Why is the origin of breeders important?

Procurement of breeders from commercial grow-out ponds is endangering the genetic quality of produced seeds. In the farmer's pond, frequently the larger fishes are sorted out and sold, while the smaller ones are retained for another year and the pond restocked. Those remaining show slow growths, but being older fishes they are attaining sexual maturity first among the population of the pond. This practice leads to negative selection and results in the production of low quality seeds (Fig. 5).

From where to collect breeder candidates

Good quality breeders can be obtained only from seed of known origin.

i) The breeders of standard indigenous species should be obtained from the wild, or from the same river-basin as the geographic situation of the concerned hatchery, preferably from a Govt. brood bank.
ii) Breeders of exotic species should be collected from Govt. brood banks where the genetic diversity of brood stocks and pedigreed are maintained.

Fig. 5. Low quality fingerlings.

3.6 Experiance of Brood Bank Establishment Project

1st phase (2001-1006)

Government established Fish Seed Multiplication Farm (FSMF) during 1974-75. The farms at that time were used only for nursery rearing for the spawn and fries collected from natural sources. After 1974-75, hatchery facilities were introduced into the government FSMFs to ensure the supply of quality fingerlings. The main objective of the 1st phase of the Brood Bank Establishment Project was to ensure extension of carp breeding, fingerling production, nursery technology to the private sector through training and extension service provided by the govt. farms and hatcheries. Considering the importance and potentials of fisheries sector in the overall economy, the first phase of the project has been implemented on pilot basis. The outputs of the 1st phase in brief are as follows:

Produced and distributed brood in Govt. and Private hatcheries about 94 MT
Production cost of brood was = Tk. 52/- per kg
Selling price of brood was = Tk. 80-100/- per kg
Training received = 1000 persons
Facilities improved in FSMF = 12 nos.

2nd Phase (2007-2012)

Governments FSMF's have already been instructed to pay attention in producing quality seeds and inbreed production have been discouraged. Several training courses will be arranged through this project to aware the farm managers of Govt. FSMF, operators/proprietors of private hatcheries about the danger of inbreeding. The objective of the 2nd phase of the project includes:

i) To overcome inbreeding problems and ensure supply of quality broods/fingerlins to be used in aquaculture and culture-based fisheries programs through FSMF;
ii) To ensure the improvement of growth performance and genetic improvement of brood stock achieving national target of fish production;
iii) To ensure quality fingerlings supply through enhancing production capacity of farm/hatchery through mitigating inbreeding problems;
iv) To augment skillness of fish farmers/hatchery/nursery owners and personnel through piloting of appropriate aquaculture technologies demonstration and training; and
v) To create employment opportunities and reduction of poverty through supply of improved brood fish and fingerling.

Chapter 4

Proposed action plan

4.1 Support to three selected hatcheries

As per the ToR agreement it was targeted that three carp hatcheries would be under consideration for quality seed production and brood stock management model plan. Also it was mentioned that the Raipur Fish Hartchery and Training center (FHTC), Laxmipur, is needed to be under the plan. After completion of a series of field visits and consultation with the working group personnels it was difficult to stop the revenue activities of FHTC for brood development program. Even though initially it was decided to spare 10-12 ponds from the target activities for brood development program but from management point of view both of two programs will not be effective due to the shortage of skilled manpower. Finally, the DoF personnel of the working group has decided to take two Fish Seed Multipllication Farms (FSMF) namely, Netrokona and Kishorganj for future brood development program.

4.2 Preparation of training manual on genetic improvement of carp seeds and brood stock management

The title of the training program is "**Genetic Improvement of Carp Seeds and Brood Stock Management**". The content of the manual is furnished below:

Day-1

Class-1: Course Instruction & Pre-assessment test
Class-2: Introduction to Fish Genetics in context to our cultured species and hatchery practices
Class-3: Brood selection criteria and choice of various inducing agents
Class-4: Carp breeding grounds and spawn collection centers of Bangladesh
Class-5: Existing practices in the carp hatcheries
Class-6: Main cultured fish species of Bangladesh and their genetic status

Day-2

Class-1: Genetic deterioration (Inbreeding, Genetic drift)
Class-2: Genetic deterioration (Negative selection, Hazardous hybridization & others)
Class-3: Improvement of genetic diversity of cultured stocks (Linebreeding & Generation maintaining)
Class-4: Pedigreed recording
Class-5: Recent developments (Sex reversal & Monosex tilapia)
Class-6: Recent developments (Gynogenesis, Androgenesis & Chromosomal manipulation)

Day-3

Class-1**:** Genetic resource conservation (Ex-situ & In-situ conservation) and Cryopreservation (Fish gene banking).

The complete training manual (Genetics Compendium-SICD project, 2008) is under preparation in the form of a training modulesoon.

4.3 Conduct training in six divisions

After the completion of inception work and group discussion with divisional officers (Deputy Directors, District Fisheries Officers, Farm Managers, Hatchery Officers, Senior Upazila Fisheries Officers and Upazila Fisheries Officers) a need based 03-days long training program on "*Genetic Improvement of Carp Seeds and Brood Stock Management*" for six divisions have been conducted. The list of trainees and trainers are arranged after consultation with the Director General (DG), DoF and the Project Director, SICD project, DoF (Table 3).

Table 3. Six divisional training dates, venue and the no. of trainees

Division	Date	Venue	No. of the trainees
Dhaka	28-30 April, 2008 .	Conference Room, BFRI, Mymensingh	34
Rajshahi	06-08 May, 2008	Fish Seed Multiplication Farm, Natore	31
Khulna	13-15 May, 2008	District Fisheries Office, Matshya Bhaban, Arabpur, Jessore	28
Barisal	26-28 May, 2008	CARITAS, Sagardi, Barisal	24
Sylhet	04-06 June, 2008	Conference Room, DoF, Sylhet Division, Sylhet	25
Chittagong	22-24 June, 2008	BARD, Kotbari, Comilla	30

Chapter 5

Seed and Seed Quality

5.1 Understanding seed and seed quality

Seed
Seed can mean fertilized eggs, fry, fingerlings or nursed animals. The promotion of aquaculture is not possible unless there is an assured supply of quality seed from hatchery sources.

Seed Quality
Seed quality is that which optimizes the potential for aquaculture production and is related to the quality of the broodstock used and the seed produced. In genetic term, quality seed may be defined as those having better food conversion efficiency, high growth rate potential, better ability to changing environmental conditions and resist diseases (Padhi and Mandal, 1999). The quality considerations are those which meet the expectations and demands of the producer (grow-out operations) and the final consumer of the end product. Availability of quality fish seed is pre-requisite for acceptance of sustainable aquaculture. In the Asian region, Kongkeo (2001) emphasized that one of the technical constraints in Asian aquaculture is the inadequate and unreliable supply of quality fish seed.

The important features of good quality seed are divided into two categories.

Category-1: Genetic quality
Genetic quality which concerns the following attributes:

i) genetic management of domesticated stocks;
ii) development of improved brood stock;
iii) availability of good quality brood stock; and
iv) access to good quality brood stock.

Category-2: Good hatchery and/or nursery management which concern the following aspects:

i) good nutrition of broodstock, larvae and fry;
ii) good record keeping;
iii) bio-security;
iv) disease resistance capacity;
v) standardization of protocols;
vi) implementation of new technology (triploid, and monosex)
vi) human resource capacity (training, skills development); and
vii) knowledge base/ information resources.

5.2 Assurance of quality seed

Poor quality seed, perceived as a major constraint to expansion of fish culture, have deleterious effect on fish production and broodstock development. The parameters for quality assurance may include the following aspects:

(i) Meet up the producers' needs and expectations, e.g.

- uniformity of size and age
- fast growing
- consistency

- genetic potential
- purity
- minimize risk to the farmers (e.g., high survival, disease resistance, healthy)

(ii) Conforms to market needs

- colour
- body shape (meat yield)
- safe (free of human disease causing organisms)

Some countries have adopted several approaches to ensure fish seed quality.

China has established an institutional approach to ensure fish seed quality. They developed "Aquatic Seed Management" which is controlled by the Ministry of Agriculture. Fish breeders should obtain the broodstock from one of the centers established under the "National Aquatic Bred and Wild Seed System **(NABWSS)**", which includes Genetic Breeding Center (**GBC**), Wild Variety Collection Center (**WVCC**), Wild/Bred Variety Amplifier (**WBVA**), Exotic Species Centers (**ESC**) and Seed Quality Inspection Center (**SQIC**).

5.3 Hatchery registration/certification

5.3.1 Pre-requisite for hatchery establishment in Bangladesh

1. Location:
   -well communication (road, train etc.)
   -Inland, coastal, offshore side
   -area free from surface oil, gas pipeline, electric tower, radio tower etc
   -area should be free from flood
   -suitable temperature, rainfall, evaporation, humidity, solar intensity etc
   -free from tornado, earthquake, etc.
   -demands of hatchery products

2. Soil and Water quality:
   -iron free
   -soil organic matter content, microbial content
   -soil content adequate clay to hold water
   -sandy clay to clay loam is the best for pond construction
   -pH ranged from 6.5-9.0
   -high water retention capacity
   -suitable gravity flow to fulfill ponds, tanks etc
   -no industrial, domestic and pesticide pollution

3. Water source:
   -under ground/deep tube well
   -surface water

4. Brood pond:
   -earthen ponds should be used
   -5-6 rectangular ponds 20-40 decimal of each

5. Source of brood:
   -natural sources (the Halda, the Jamuna and the Padma)

6. Biological factors:
   -species selection, predator and disease control

7. Hatchery unit:
   -6-10 cisterns
   -2-3 circular tanks
   -10-12 incubators
   -2-5 oxygen cylinders
   - freezers
   - pump, aerator and telephone facilities
   - availability of building materials
   -availability of educational and medical facility
8. Power supply:
   -electricity or generator

9. Technical manpower:
   -technical manpower having capability of running the hatchery

10. Marketing facility:

11. Safe and security:

12. Legal matter:
   - local state and national legal requirement for culturable species eg. African magur, piranha.

5.3.2 Guidelines for hatchery registration and regulation

5.3.2.1. Introduction

There is no seed certification system for hatcheries in Bangladesh. However, considering the need of seed certification for controlling seed quality in carp and prawn hatcheries, the MoFL (Ministry of Fisheries and Livestock) created a National Committee by selecting personnel from different pertinent institutions to prepare a policy for seed certification. The committee made draft policies as "Matsha and Chingri Hatchery AIN 2005" (Law for Fish and Shrimp Hatchery 2005) for seed certification. The law consists of the clauses for registration of hatcheries and the rules for fish and shrimp hatchery operation. Finally, more explanation which are necessary for hatchery operation such as facilities of hatchery, ponds, selection of brood fish for breeding, source of selected brood fish, environment, etc. are included and reformed as "Fish Hatchery Ordinance- 2008" which is going to be approved by the MoFL

The objectives of the norms for registration of carp hatcheries are to ensure that the hatcheries are set up and function as per the Guidelines (Pre-requisite for hatchery establishment in Bangladesh) and the seed produced and distributed to the farmers is of high quality and conforms to the standards (fixed) for the purpose.

What is certification?
Procedure by which an official certification body or officially recognised certification body gives written or equivalent assurance that a product, process or service conforms to specified requirements. Certification may be, as appropriate, based on a range of audit activities that may include continuous audit in the production chain (Draft FAO Guidelines for Aquaculture Certification, 2008).

Certified hatchery
Certified hatcheries are those hatcheries which remain to a plan of production under a "code of practice" or similar system for ensuring the quality of their product and/or those who produce seed from certified quality broodstocks. Monitoring for certification can take place during several stages of seed production through self-monitoring and record keeping.

Certification standards
Document approved by a recognized organization or entity, that provides, for common and repeated use, rules, guidelines or characteristics for products or related processes and production methods, with which compliance is not mandatory under international trade rules. It may also include or deal exclusively with terminology, symbols, packaging, marking or labelling requirements as they apply to a product, process or production method.

Certification body
Competent and recognized body that conducts certification (signatory of quality assurance) and audit activities. A certification body may oversee certification activities carried out on its behalf by other bodies.

Accreditation (body)
i) Procedure by which a competent authority gives formal recognition that a qualified body or person is competent to carry out specific tasks;
ii) Body that conducts and administers an accreditation system and grants accreditation.

International Regulatory Framework
- *Codex Alimentarius* (FAO/WHO, 1962)
- Code of Conduct for Responsible Fisheries (FAO, 1994. Article 11)
- SPS/TBT Agreements (WTO, 1995)
- Guidelines for Aquaculture Certification

International Better Management Protocols (BMPs) for Carp Farming
- **Main Principles**
    1. Site selection
    2. Pond design
    3. Water management
    4. Brood stock management
    5. Feed management
    6. Health management
    7. Food safety
    8. Social equity

- **Major issues and challenges to be addressed have been**
    1. Development of BMPs

2. Social equity
3. Strong focus on small-scale farmers
4. Environmental sustainability
5. Food safety aspects of aquaculture
6. Role of aquaculture in food security

- **Many of the issues and challenges are interlinked**

Minimum Substantive Criteria

1. Social
2. Environmental
3. Food safety
4. Animal health and welfare

Institutional and Procedural Requirements

1. Standard setting
2. Accreditation
3. Certification

Certification and small-scale aquaculture farmers

i) No certification scheme yet targets the small-scale sector
ii) No "Fair Trade" scheme to date
iii) Small size and large numbers of farmers
iv) Some farms may not be formally registered
v) Small volumes and value of product from individual farms may not cover the costs of certification
vi) Low or no market incentives
vii) Complex marketing channels make traceability difficult
- Middlemen or direct to a local market
- Trader-credit relations

viii) Record keeping
ix) May not be organized into producers' groups

- Objectives
  - Reduce the risk of disease outbreaks and improve production
  - Organize the farmers under "Self Help Groups" or "Aquaclubs"
  - Produce better quality fish in a responsible and economically viable manner.

- Key elements of success
  - "Better management practices"
  - Farmer club formation
  - Partnerships

Farm level management - "BMPs"

i. Good pond preparation
ii. Good quality seed selection
iii. Water quality management
iv. Feed management

v. Health monitoring/Biosecurity
vi. Pond bottom monitoring
vii. Disease management
viii. Better Harvest and post-harvest Practices
ix. Record maintenance/Traceability
x. Environmental awareness

Considerations for carp seed certification: - ***based on FAO draft guidelines***

- Standards and standard setting
  - Transparency
  - Stakeholder participation
  - Content and comparable systems
  - Notification provisions
  - Records
  - Review and revision
  - Validation

5.3.2.2. Procedure for Registration of Carp Hatcheries

2.1 Scope of registration

2.1.1 Species

Most of the carp hatcheries in Bangladesh prefer to breed rohu, catla, mrigal, kalbasu, other monir and exotic carps, catfishes as these species are in high demand to the farmers. Presently, technology also exists for some of the other species e.g. Thai koi and attempts are made by hatcheries to produce seed of different species.

2.1.2 Siting:

All hatcheries will be abiding the site selection criteria as defined in the pre-requisite for hatchery establishment in Bangladesh guidelines.

2.1.3 Type of carp hatcheries/ seed production centers:

The existing carp hatcheries in Bangladesh are of two types:

i) **Government**: The total no. of Govt. hatcheries and fish seed farms is 112 producing about 62,44 kg of hatchlings (FRSS, 2007).
ii) **Private**: At present the total no. of private hatcheries is 760 producing about 4,57,288 kg hatchlings all over the country (FRSS, 2007).

2.2 Application for registration and the fees to be paid

2.2.1 Every application for registration of carp hatchery shall be made to the Monitoring and Evaluation Cell in DoF (MEC).

2.2.2 Each application shall be accompanied by a list of infrastructure facilities available at the hatchery and a declaration signed on a non-judicial stamp.

2.2.3 The amount of the fee is to decided by the MoFL or DoF authority.The fees for registration shall be payable in the form of Demand Draft in favour of MEC of DoF.

2.3 The manner for considering application for registration

2.3.1 On receipt of an application, the Divisional Fisheries Office (e.g. Dhaka or Rajshahi) shall verify the particulars given in the application.

2.3.2 A Panel shall inspect the hatchery within one month of receipt of the application to ensure that the hatchery meets the norms specified in the application form and the Guidelines.

The composition of the Panel /committee will be formed and approved by component authority. The detail TOR of the committee will be developed and would be executed during registration of hatcheries.

5.3.2.3 Criteria for selection of hatcheries

3.1 Infrastructure
The design and infrastructure facilities of a carp hatchery would vary according to activities undertaken by the hatchery. Some hatcheries are producing carp seeds and some are producing monosex tilapia and Thai magur. Keeping in view the above developments, the hatchery infrastructure to be considered for registration shall be as follows:

3.2 Manpower
Each carp hatchery with facilities for all commercial species should have an adequate complement of supervisory, technical and supporting staff to operate the facilities.

5.3.2.4 Important management norms

4.1 Biosecurity (including health and hygiene)

Hygiene and Sanitation: The hatchery should have a clean appearance and should adopt high standards of hygiene to ensure strict bio-security. The equipments and tools used in the hatchery should be made from non-toxic materials and should be cleaned and sterilized/ disinfected properly.

4.2 Health Management (including laboratory facilities)
It is well known among aquatic animal health scientists/ workers, if feed and environment in hatchery are well managed, the animals will have less stress. Stress is usually followed by disease infection. Treatment of disease should be carried out only when it has been scientifically diagnosed.

4.3 Seed specifications
The following specifications are prescribed for production and marketing of seed by the hatcheries:

-Seed supplied by the hatcheries must be healthy;
-They should survive standard stress tests conducted in the hatchery for temperature, salinity (or both) or chemicals such as formalin;
-Healthy seeds should have the characteristics under naked eye and microscopic observations as detailed in Annexure 3.

4.4 Feed and feed management

Live, fresh and artificial feeds constitute the key factors for the success of hatchery and nursery operations. They also contribute to the bulk of the input costs in a hatchery. Remnant feed will generally cause deterioration of water quality in hatchery tanks. If quality feed is used with a proper feed management, it can prevent feed waste and deterioration of water quality. The recommendations for good practices for feed and feed management are as follows:

- Dry feed should be of high quality, which is stable and can remain long enough in the water without decay;
- Live feed production should be need-based and such populations of organisms should not be maintained over longer periods;
- Hatcheries should have adequate facilities for selling of hatchling;
- Dry feed should be kept in dry, cool and indoor area;
- Feeding and its schedule should be recorded daily, in detail.

4.5 Use of drugs and chemicals

Banned drugs and chemicals should not be used under any circumstances.

4.6 Traceability and record keeping

All records pertaining to the operation of the hatchery should be maintained. The various procedures adopted in the hatchery right from the sourcing of brood stock to the sale of seeds should be properly recorded. A systematic approach to record keeping can help in effective monitoring. Ensuring traceability in the seed production phase is a pre-requisite for a standard hatchery and therefore all records/ register maintained by the hatchery will be subjected to verification during the inspections. Such arrangements should also be adequately demonstrated to ensure that the traceability programme is in place.

4.7 Waste water management

4.7.1 Effluent and Waste: The effluents from the hatchery should be properly treated before discharge and the hatchery should have necessary treatment facility for treating wastewater produced during the production period. The effluents discharged from the hatchery should meet the standards stipulated for the same and should be disposed off in a manner not polluting the environment.

In general, hatchery effluents will consist of nutrient loads, sediment sludge and some chemicals. Good hatchery management practice will be able to improve effluent quality and reduce its volume and subsequently environmental impact. Hatchery waste and garbage should be well packed in plastic bag and kept in close container before disposal. Recommendations on effluent and waste management are as follows:

- Effluent discharges should be reduced to the minimum possible.

- The hatcheries should focus on good feeding practice and efficient use of permitted drugs and chemicals so as to minimize their residues in the wastewater.

- Drugs, chemicals, feed and other supplies should be stored in a proper place so as to prevent pollution of water source during heavy spells of rain, accident, floods, etc. The hatcheries should have a contingency plan for treatment of pollution in case of an emergency.

- Effluents should be treated in a qualified treatment system before discharge.
- Effluent should not have impacts on discharged site and surrounding natural water resources.
- Effluent should not be discharged to freshwater sources and plantation.
- Hatchery garbage and waste should be properly treated or disposed.
- The hatcheries should have in-house composting facility for solid waste of organic composition.
- Hatchery management should follow government regulations.
- Hatchery manager should continuously evaluate and improve waste treatment system.

5.3.3 Certification of seed quality

A certification system for seed production consists of four areas:

i) Assurance that the genetic status of the seed is correct;
ii)Assurance that the seed has been produced under appropriate husbandry conditions;
iii) Handling and transportation of the seed; and
iv) Final measurable quality features of the seed at the point of sale.

The first two categories relate to management practices of the hatchery that produces seed and broodstock provider. In this case, the seed itself is not certified but the hatchery and/or the broodstock provider is certified or accredited.

5.3.4 Monitoring and Evaluation Cell (MEC) of DoF

The quality features that are monitored relate to whether the product is to be certified or the production operation is to be certified. The quality checks at point of sale (POS) serve as guidelines to the buyers. This gives some indication of the quality of the production process, but cannot be used to establish the genetic quality features or traits. The following aspects are concerned:

- ✓ Seed sources/supply
- ✓ Seed production facilities and seed technology
- ✓ Seed management
- ✓ Seed quality
- ✓ Seed marketing
- ✓ Seed industry
- ✓ Support services
- ✓ Seed certification
- ✓ Legal and policy framework
- ✓ Economics
- ✓ Information of knowledge gaps
- ✓ Stakeholders
- ✓ Future prospects and recommendation

5.3.4.1 Point of sale (POS) checks

The measurable quality of the seed is its status at POS. In this case, sample of the seed for sale can be checked using a number of criteria. If this is done for each batch, then the seed can be called a **certified seed**. The measurable quality features to at POS are follows:

i) regular size (uniform sizes);
ii) no obvious deformities;
iii) free from fouling or external parasites/fungi, etc.;
iv) no obvious external damage;
v) full gut (evidence that the animal is feeding);
vi) body shape (evidence of good feeding, not overlarge head, muscle wasting, etc.);
vii) free of specific disease (that can be tested using rapid methods, e.g. gene probe or PCR test kit);
viii) fish weaned onto pellet feeds (this can be usually be observed in the hatchery); and
ivx) swimming behaviour.

5.3.4.2 Hatchery production process monitoring

A set of features are those which could be tested as the basis for regular monitoring of the hatchery for the purpose of certifying or accrediting that hatchery. The characteristics are as follows:

i) free from specific diseases (through microscopy, gene probe, etc.);
ii) normal pathology of major organs (gut, liver, etc.);
iii) evidence from records of appropriate genetic management of broodstock;
iv) evidence from records that the broodstock originated from a certified supplier;
v) records that the hatchery activities follow a code of practice or BMPs.

5.3.4.3 Better Management Protocols (BMPs)

For process of monitoring of hatchery production, the existing of protocols or BMPs can be used as basis for hatchery certification. Hatcheries that procure their broodstock from certified suppliers are also easier to certify in terms of the genetic quality of their animals. The requirement for record keeping is important where the monitoring process that would enable the renewal of certificates.

5.4 Distribution of hatchery seeds

In Bangladesh

Fingerling marketing is done by middlemen since very few fish farmers buy directly from nursery farmers. About 80% of fingerlings are supplied to farmers by middlemen (fish seed traders) and rest 20% of fingerlings are directly collected by farmers from the nursery operators (Fig. 6). At present there is no established and formal fish seed market for selling and buying seed except 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.

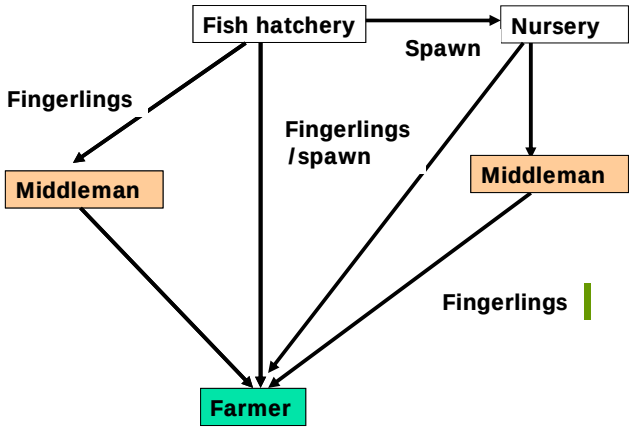


Fig. 6. Existing distribution channel of fish seed in Bangladesh.

In China

The seed industry in China is composed of many small private seed producers. In order to make progress in seed quality improvement, the government invests substantially in the sector making its role in quality seed production significantly. Since 1990, national and local governments of Chaina have increased investment on the establishment of the National Aquatic Bred and Wild Seed System (NABWSS) which includes the Genetic Breeding Center (GBC), the Wild Variety Collection Center (WVCC), the Wild/Bred Variety Amplifier (WBVA), the Exotic Species Production Centers (ESPC) and the Seed Quality Inspection Centers (SQIC).

The government has already set up 36 national classes and 100 provincial classes of Wild Variety Collection Centers (WVCC) and Wild/Bred Variety amplifier (WBVA) which have been checked and accepted.

Responsibilities:

i) WBVA is responsible for the acclimatization, selective breeding of good wild varieties, exotic species, as well as approve bred varieties officially. They provide broodstock or seed to the government, private hatcheries and farms.

ii) The ESPCs is responsible for the introduction, risk evaluation, quarantine, production testing and extension of exotic species. Government hatcheries fetching broodstock from WVCC or WBVA, are responsible for demonstrating hatchery techniques and supplying seed to farmers (Fig. 7).

Support services

i) Innovative service is provided by the GBC which is responsible for breeding (both through selective breeding and other newly developed techniques such as genetic engineering).

ii) The examination service is provided by the SQIC which is responsible for the establishment and improvement of rapid and accurate evaluation techniques to strengthen the germplasm examination. The examination service is concerned with the morphological characteristics, farming performance and other cellular and molecular authentification requirements.

iii) The extension service is composed of five levels of stairs such as national, provincial, city, country and country extension stations. The main function is for the extension and demonstration of hatchery and grow-out techniques covering the following aspects: conservation of the germplasm of good breeds, evaluation of risks, testing and expansion of induced breed/species in the appointed district.

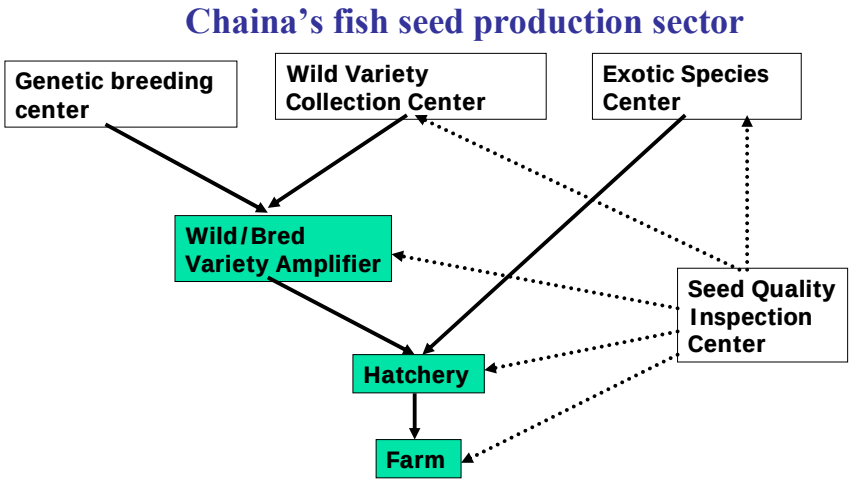


Fig. 7. Freshwater fish seed production flow chart in China-2004

In Pakistan

There are no special markets organized for fish seed sale in the Pakistan. Fish seed in hatcheries and other production units are either supplied directly to the farmers at the production points or transported to the farms. In some cases, the post-larval stages of fish seeds are purchased at low prices from hatcheries by the nursery owners who also rear them up to fingerling size.

The level of fish seed industry varies from province to province. The seed production business is affected by a number of risks like climatical hazards, power failure and outbreak of some diseases which cam cause economic losses.

As a whole the marketing system of fish seed is rather simple mostly involving producers and buyers (Fig. 8). Some of the private fish farms possess seed production facilities as well which fulfill the seed requirements of its own and in some cases the extra seeds are sold to other private fish farms.

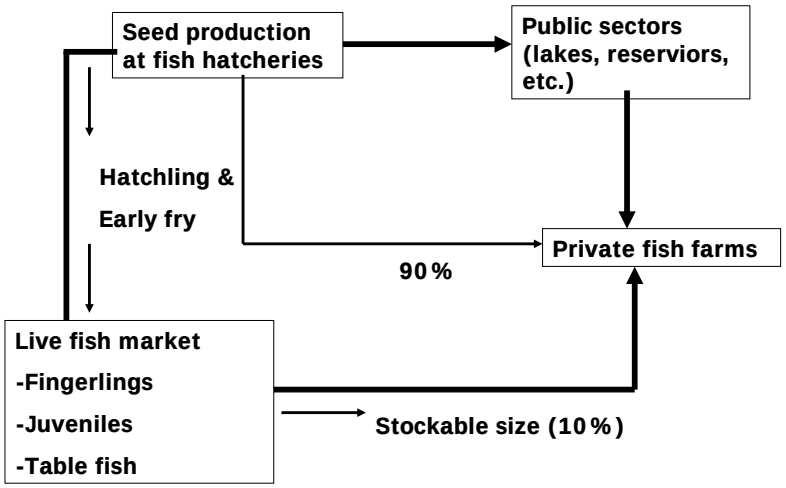


Fig. 8. Freshwater fish seed production flow chart in Pakistan-2005

In Philippines

In the Philippines, the marketing of fry and fingerlings, particularly of tilapia, is a lucrative business because there is high demand for seed. A major constraint to increasing the productivity of farming systems is widely recognized to be the adequate supply of good quality seed.

To ensure better quality and steady supply of tilapia fingerlings, the Department of Agriculture-Bureau of Fisheries and Aquatic Resources (BFAR) - National Freshwater Fisheries Technology Center (NFFTC) continuously pursue genetic improvement following the selective breeding approach protocol of the GIFT project (Eknath and Acosta, 1998). The NFFTC serves as the National Broodstock Center that produces two groups of future broodstock for the multipliers that will then produce the fingerlings for grow-out (Fig. 9).

The market channels for fish seed are still unorganized in the private hatcheries. A hatchery operator usually sells directly to grow-out farmers. The seeds are usually delivered or picked-up by the customer. A few hatchery and nursery operators use agents to incease sales, especially in remote areas.

Distribution Channel of fish seed in Philippines

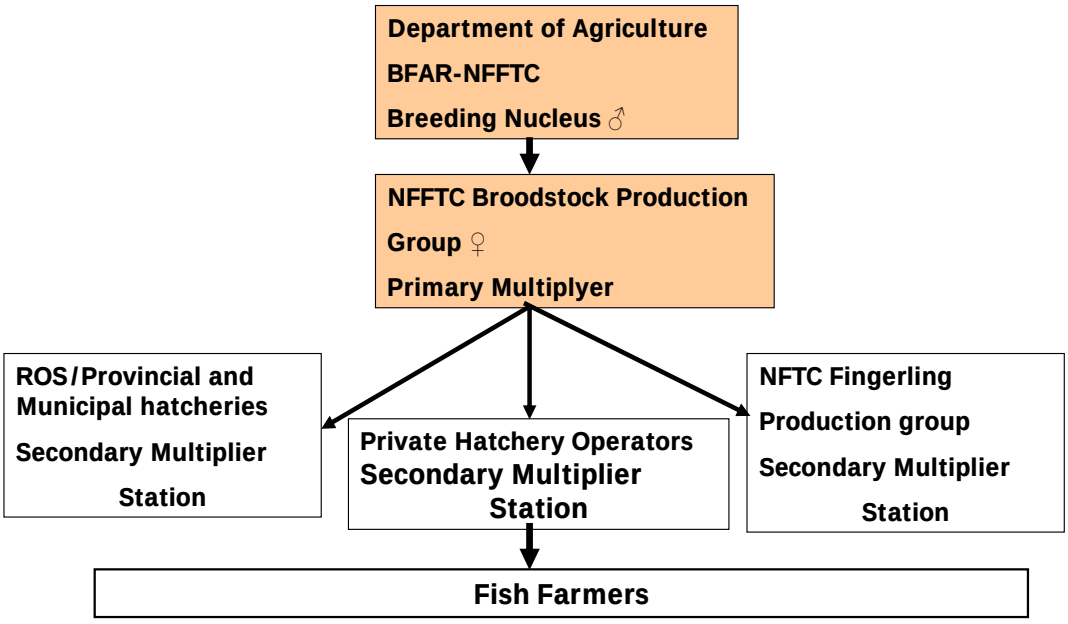


Fig. 9. Source of male broodstock of secondary multiplier in the Philippines.

5.5 Proposed seed distribution channel in Bangladesh

In Bangladesh, the seed marketing system is not organized well. There is a complex seed supply system, where hatchery owners, nursery operators, middlemen/seed trader and fish farmers are involved. Most of the fish seed traders play an important role to available fish seed and providing a link among hatchery, nursery and fish traders. More than 70% of fingerlings are supplied to farmers by middlemen and rests of 30% fingerlings are directly collected by farmers from the nursery operators.

The carp seed distribution channel in Bangladesh can be effective with the following way (Fig. 10).

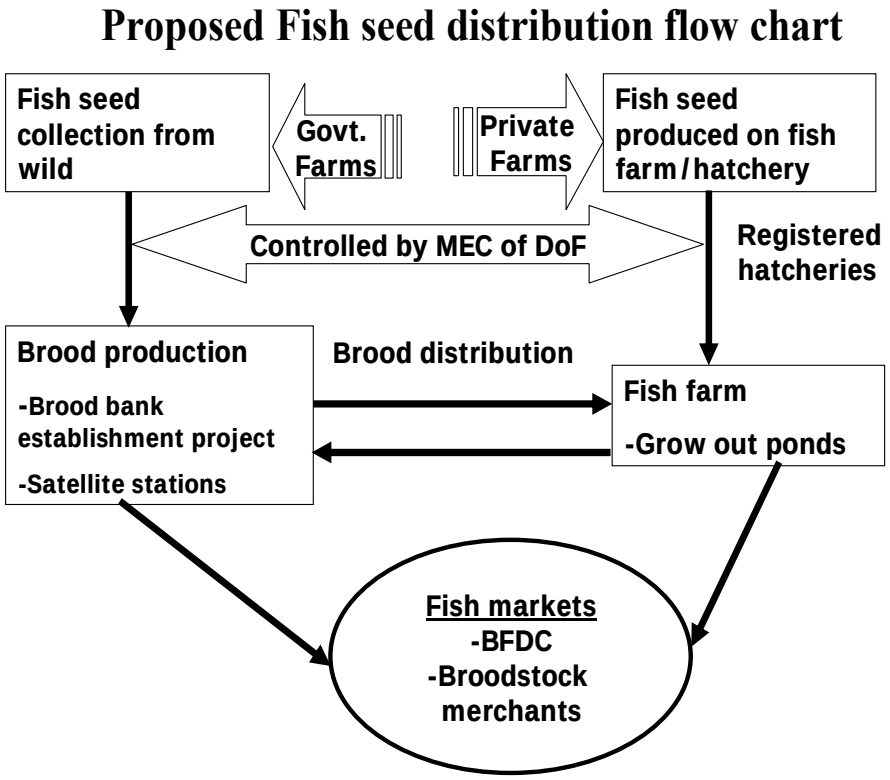


Fig. 10. Proposed freshwater fish seed production and distribution flow-chart in Bangladesh 2011.

5.6 Brood Development Process through the Brood Bank Establishment of DoF (Fig. 11).

i) Fertilized eggs/spawns collection from the wild
ii) Transfer to the stations
iii) Intensive rearing and gradeing
iv) Morphology and genetic test
v) Growth comparison following standard systems

vi) Brood developed after 2/3 years
vii) Brood/seed distribution

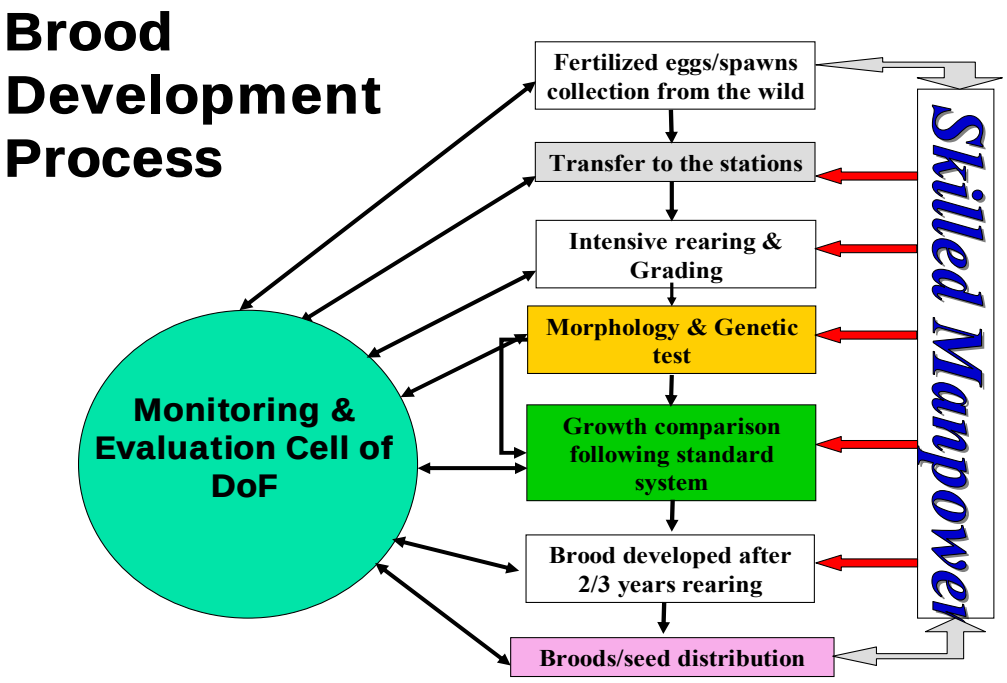


Fig. 11. Proposed Brood Bank Development Process.

5.6.1 Quality assessment

The genetic quality of hatchery stocks will be analysed at 2-3 years interval using growth performance data and allozyme markers. If the fingerlings produced from the existing stocks could not reach a level for the farmer satisfaction having inbreeding depression then the stocks are recommended for sale.

Chapter 6

Developed Materials

6.1 Training manual on Genetic Improvement of carp seeds and brood stock management

To acquire the understanding of present hatchery activities, necessity of genetic improvement of carp seeds and brood stock management, the training manual is prepared for govt. hatchery owners/farm managers/hatchery officers. The training program included subjects related to Introduction to Fish Genetics in context to the cultured species and their genetic status existing practices in carp hatcheries; Brood selection criteria and choice of various inducing agents; Carp breeding grounds and spawn collection centers; Genetic deterioration of brood stocks (Inbreeding, Genetic drift, Negative selection, Hazardous hybridization and others); Improvement of genetic diversity of cultured stocks (Line breeding and Generation maintaining); pedigree recording; Recent developments in fish genetics (Sex reversal and Monosex tilapia, Gynogenesis, Androgenesis and Chromosomal manipulation). Moreover, group actiovities followed by presentation were also arranged during the training program (Annexure 4). This manual will be helpful to govt. officers to use genetic methodologies with their hatchery stocks so that they can produce quality seeds and brood stocks management.

6.2 Poster for farmer's awareness

Three coloured posters in simple and easy language were prepared for farmer's awareness development. These are shown in the following pages.

রুই জাতীয় মাছের চাষ করুন
অন্তঃপ্রজনন নিয়ন্ত্রণে রাখুন।

অন্তঃপ্রজনন নিয়ন্ত্রণের জন্য করুণীয়ঃ

১। হ্যাচারির প্রজননক্ষম ব্রুডের সংখ্যা বাড়াতে হবে।

২। ব্রুডের বংশকুলনামা জেনে প্রজনন করাতে হবে।

৩। অন্য হ্যাচারি থেকে ব্রুড বিনিময়ের সময় ব্রুডের বিশুদ্ধতা নিশ্চিত করতে হবে।

৪। পর্যায়ক্রমিক লাইনক্রসিং করতে হবে।

সৌজন্যে: মৎস্য অধিদপ্তরের প্রাতিষ্ঠানিক দক্ষতা জোরদারকরণ প্রকল্প।

শংকর জাতের ব্রুড তৈরী বন্ধ রাখুন
নদী উৎসের ব্রুড ব্যবহার করুণ।

শংকর জাতের পোনা তৈরী থেকে বিরত থাকার জন্য করণীয় :

১। হ্যাচারিতে প্রাকৃতিক উৎসের ব্রুড মজুদ রাখতে হবে।

২। প্রজাতি অনুযায়ী স্ত্রী ও পুরুষের অনুপাত ঠিক রাখতে হবে।

৩। অজানা উৎসের ব্রুড ব্যবহার বন্ধ করতে হবে।

সৌজন্যে: মৎস্য অধিদপ্তরের প্রাতিষ্ঠানিক দক্ষতা জোরদারকরণ প্রকল্প।

মাছের কুলনামা রক্ষা করুন
মাছ উৎপাদনে সাফল্য আনুন।

মাছের কুলনামা রক্ষা করার জন্য করণীয় :

১। মাছের পূর্ব ইতিহাস, উৎস এবং সংগ্রহের সময়কাল জানতে হবে।

২। অতি ঘনত্বে (চাপের পোনা) মজুদ করা বন্ধ করতে হবে।

৩। ব্রুড মাছ ও তাদের উৎপাদিত বংশধর পৃথক পুকুরে রাখতে হবে।

৪। একই উৎসের ব্রুড মাছকে প্রজাতিভেদে পৃথক পুকুরে রেখে সনাক্ত চিহ্ন দিতে হবে।

সৌজন্যে: মৎস্য অধিদপ্তরের প্রাতিষ্ঠানিক দক্ষতা জোরদারকরণ প্রকল্প।

Chapter 7
Proposed Future Development Program

7.1 Current status of aquaculture genetics

7.1.1 Increase aquaculture production

With global population expansion, the demand for high-quality protein, especially from aquatic sources, is rising dramatically. Increased aquaculture production is obviously needed to meet this demand in the third millennium, because capture fisheries are showing precipitous declines due to overfishing, habitat destruction and pollution.

Increased demands for aquaculture production means increasing pressure for development of more efficient production systems. Major improvements have already been achieved through enhanced management, nutrition, disease diagnostics and therapeutics, water quality maintenance and genetic improvement of production traits. A common theme through all these is genetics, which has been used to meet many production challenges, such as genetic purity, disease resistance, tolerance of handling, enhanced feed conversion and spawning manipulation, i.e. all those areas to which wild animals must adapt for productive "domestication".

Aquaculture genetics began with the advent of aquaculture in China more than 2,000 years ago, at about the same time as the Romans began to hold fish in ponds and learned how to breed them. Without realizing it, the first fish culturists who completed the life cycles of species such as the common carp, *Cyprinus carpio*, began changing gene frequencies and altering the performance of the fish they were domesticating. In domestication, farmers noticed that the important components are colour, body conformation and finnage, those with attractive traits for broodstock and selective breeding.

Closely related species under wild circumstances are reproductively isolated and have species status because of their genetic differences. Thus comparison for culture suitability is a genetic comparison. Use of established, high-performance domestic strains is the first step in applying genetic principles to improved aquaculture management. Strain variation is also important, since there is a strain effect on other genetic enhancement approaches, such as intraspecific crossbreeding, interspecific hybridization, sex control and genetic engineering.

7.1.2. Domestication and strain evaluation

When wild fish are considered for aquaculture, a new set of selective pressures come into effect that often changes gene frequencies. Thus an organism better suited for the aquaculture environment begins to evolve. This process, termed domestication, occurs even without directed selection by the fish culturist. Domestication effects can be observed in some fish within as few as one to two generations after removal from the natural environment (Dunham, 1996a). In channel catfish (*Ictalurus punctatus*) an increased growth rate of 3-6% per generation was observed. Although most domesticated strains usually perform better in the aquaculture environment than wild strains, there are exceptions, e.g. wild Nile tilapia, *Oreochromis niloticus* (T. Gjedrem, pers. comm.), and rohu, *Labeo rohita*, grow better in the aquaculture environment (Dunham, 1996a). The explanation for this appears related to a lack of maintenance of genetic quality and genetic degradation in domesticated strains. Poor performance of some domestic carps is related to poor founding (parental) lines, random genetic drift, inbreeding and

introgression with slower growing species, such as *Catla catla* and slower growing strains such as *Cyprinus carpio*.

In Indonesia, strain development using artificial gynogenesis and sex-reversal resulted in 10 common carp inbred lines, which were later used for crossbreeding (Sumantadinata, 1995). In Vietnam, eight local varieties of common carp, along with "Hungary", "Ukraine", "Indonesia" and "Czech" strains are maintained, with significant heterosis observed in F_1 generations of crossbreeds.

7.2 Development Programs

7.2.1 Linebreeding/Linecrossing

Linebreeding is a form of inbreeding that is used to produce an outstanding fish (usually a male). Mating of this fish to its descendants can produce a unique generation in order to ensure successful linebreeding and to increase its percentage in an individual's or population's genome (Fig. 12).

When a farmer wants to increase the size of fish, for instance, or make an outcross to avoid too much inbreeding, taking someone else's line to do this which is risky and may loose the traits in the line that the farmers have worked hard to achieve, as well as loosing the homozygous quality.

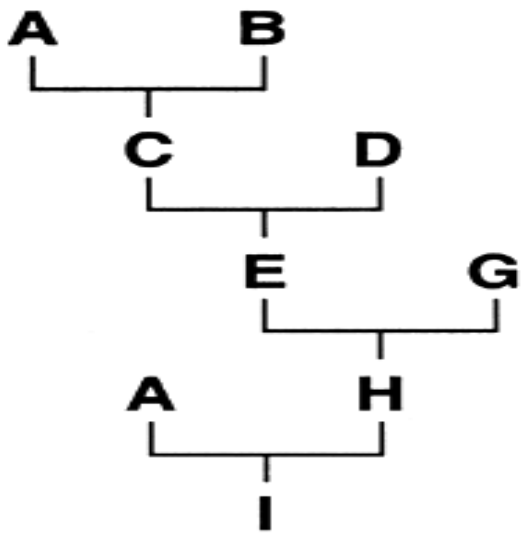


Fig. 12. Mild linebreeding.

Creation of inbred lines to produce F_1 hybrids for grow-out

Two or more selected lines are inbred to fix certain alleles. When the inbred lines are mate, the hybrids will be identical at the desire loci and will be uniform, which is often one of the goals in a cross-breeding program. Inbreeding in two or more lines followed by hybridization is the classic way of producing uniform progeny for grow-out.

Linecrossing

It can be done to increase the heterozygosity from one generation to another generation or protect the growth traits from deleterious effect of lethal genes those are commonly found in close mating system (Fig. 13).

i) When breeding program will start using natural sources of brood where the base population can be divided into several lines for avoiding inbreeding.
ii) Each line is maintained as a separate breeding unit.
iii) An existing brood stock could be arbitrarily subdivided into three groups.
iv) Eggs can be taken on three different spawning dates and the fry reared separately to adulthood.
v) Three different strains can be used.

Procedure:

At maturity, mating are made between lines
Females of line A are mated to males of lines C to advance the line A
Females of line B are mated to males of lines A to advance the line B
Females of line C are mated to males of lines B to advance the line C
Each succeeding generation is advanced by repeating this procedure

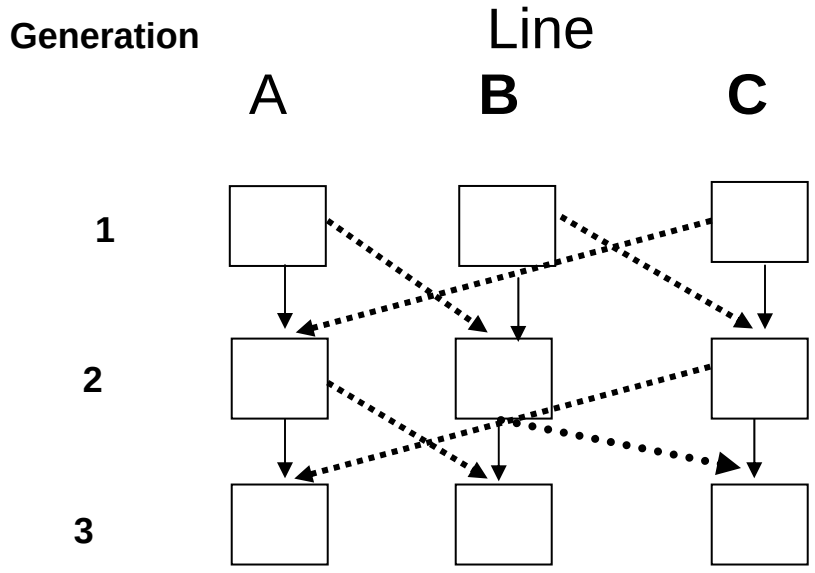


Fig. 13. Rotational linecrossing

7.2.2 Generation Manitaining

Generation means the length of time it takes to replace brood fish with their offspring. i.e. the replacement of broodfish by their offspring.Generations are not allowed to overlap. Also generation does not contain a specific time frame in terms of years. For example, if the normal time it takes for a fish to go from egg to brood fish and then for that fish to spawn and be discarded so that it can be replaced by its offspring is 2 years, the generation interval for that

species is 2 years. If the time interval for another species is 4 years, the generation interval for that species is 4 years. The simplest and least expensive technique that can be used to increase the time frame until inbreeding and genetic drift related problems cause trouble is to stretch the generation interval.

For example, if the generation interval for the species a farmer cultures is 2 years and that farmer also wants to keep inbreeding below 5% for 10 generations (20 years). To do this, he needs an effective breeding numbers (Ne) of 100 per generation (Table 4). In this way, a farmer can maintain and spawn fewer fish by stretching the generations.

Table 4. Effective breeding numbers (Ne) needed per generation to produce variuos levels of inbreeding after 1-100 generations

	Maximum level of inbreeding desired									
No. of generation	**1%**	**2%**	**3%**	**4%**	**5%**	**6%**	**7%**	**8%**	**9%**	**10%**
1	50	25	17	13	10	9	8	7	6	5
2	100	50	34	25	20	17	15	13	12	10
3	150	75	50	38	30	25	22	19	17	15
4	200	100	67	50	40	34	29	25	23	20
5	250	125	84	63	50	42	36	32	28	25
6	300	150	100	75	60	50	43	38	34	30
7	350	175	117	88	70	59	50	43	39	35
8	400	200	134	100	80	67	58	50	45	40
9	450	225	150	113	90	75	65	57	50	45
10	500	250	167	125	100	84	72	63	56	50
----------	------	------	------	------	------	------	-----	------	------	------
----------	------	------	------	------	------	------	-----	------	------	------
100	5000	2500	1667	1250	1000	834	715	625	556	500

7.2.3 Gynogenesis and Androgenesis

Gynogenesis and androgenesis are techniques to produce rapid inbreeding and cloned populations. This technique is called either “mitotic gynogenesis” or “mitotic androgenesis,” depending on whether the haploid set of chromosomes of the zygote comes respectively from the mother or from the father.

7.2.3.1 Gynogenesis

Gynogenesis is the process of producing gynogens (female) through fertilization of eggs with irradiated sperm. Gynogenesis is done with haploid zygotes. This technique is of two types: (1) “meiotic gynogenesis” or (2) “mitotic gynogenesis”.

Meiotic Gynogenesis

Gynogenetic individuals (“gynogens”) produced during meiosis (“meitoic gynogens”) is “inbred”, since all genetic information is maternal. “Meiotic gynogens” are not homozygous, since cross-overs and recombination during oogenesis produce different gene combinations in the ovum and second polar body. The rate of inbreeding through gynogenesis is roughly equivalent to one generation of full-sib mating. Mitotic gynogens are totally homozygous, but are more likely to die during embryonic development due to the higher frequency of deleterious genotypes found in 100 percent homozygous individuals.

Procedure of meiotic gynogenesis

Meiotic gynogenesis is used to create the inbred fish-meiotic gynogens. It is easier than mitotic gynogenesis. It has a higher survival rate than mitotic gynogens because they have less inbreeding. A schematic flow chart of meiotic gynogenesis is shown in Fig. 14.

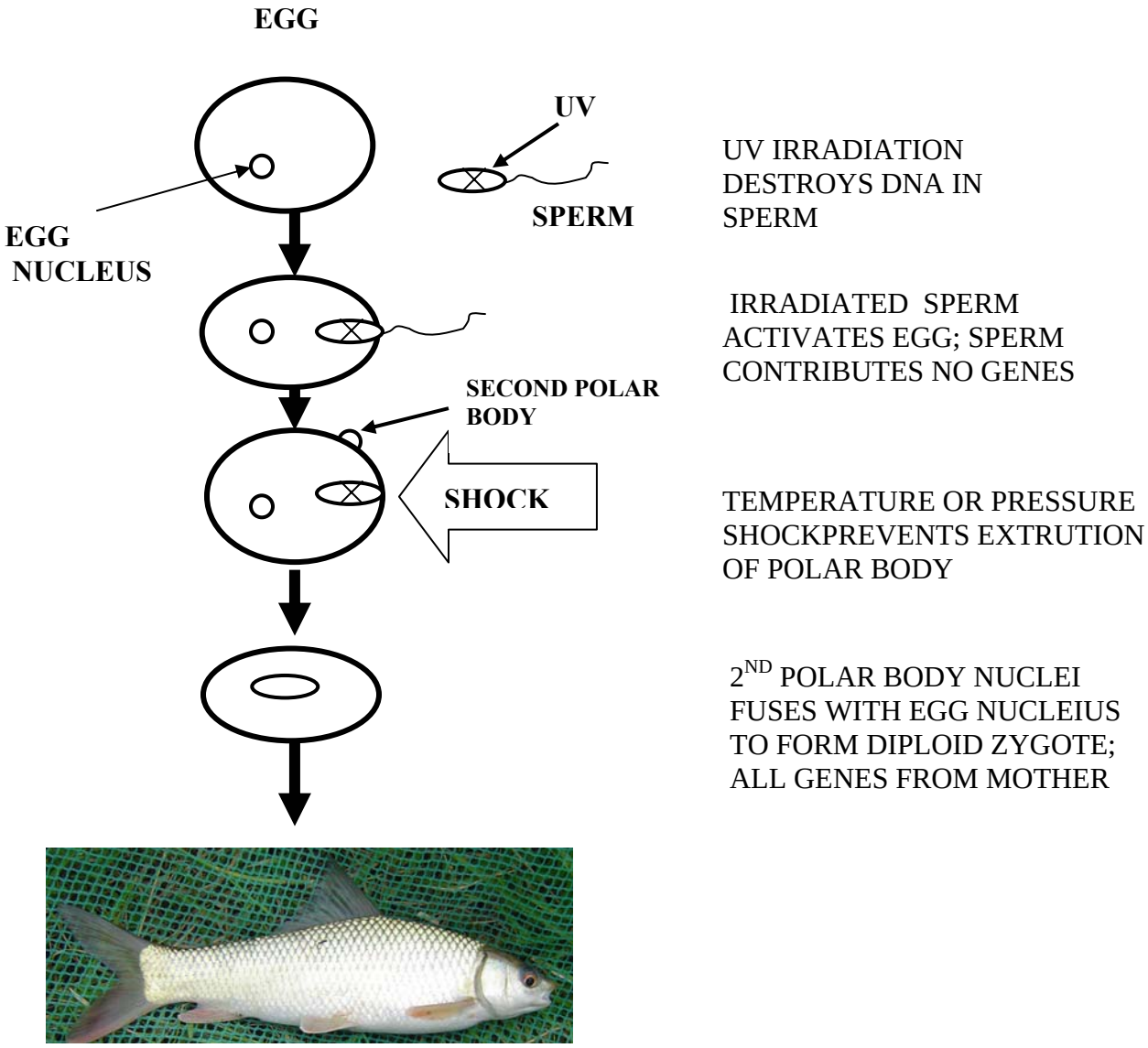


Fig. 14. Meiotic gynogenesis.

Mitotic gynogenesis

Mitotic gynogenesis can be used to create mitotic gynogens i.e. fish that are 100% inbred. The first step is the production of first-generation mitotic gynogens. The second step is the production of inbred line. The schematic diagram of mitotic gynogenesis is presented in Figs. 15 & 16.

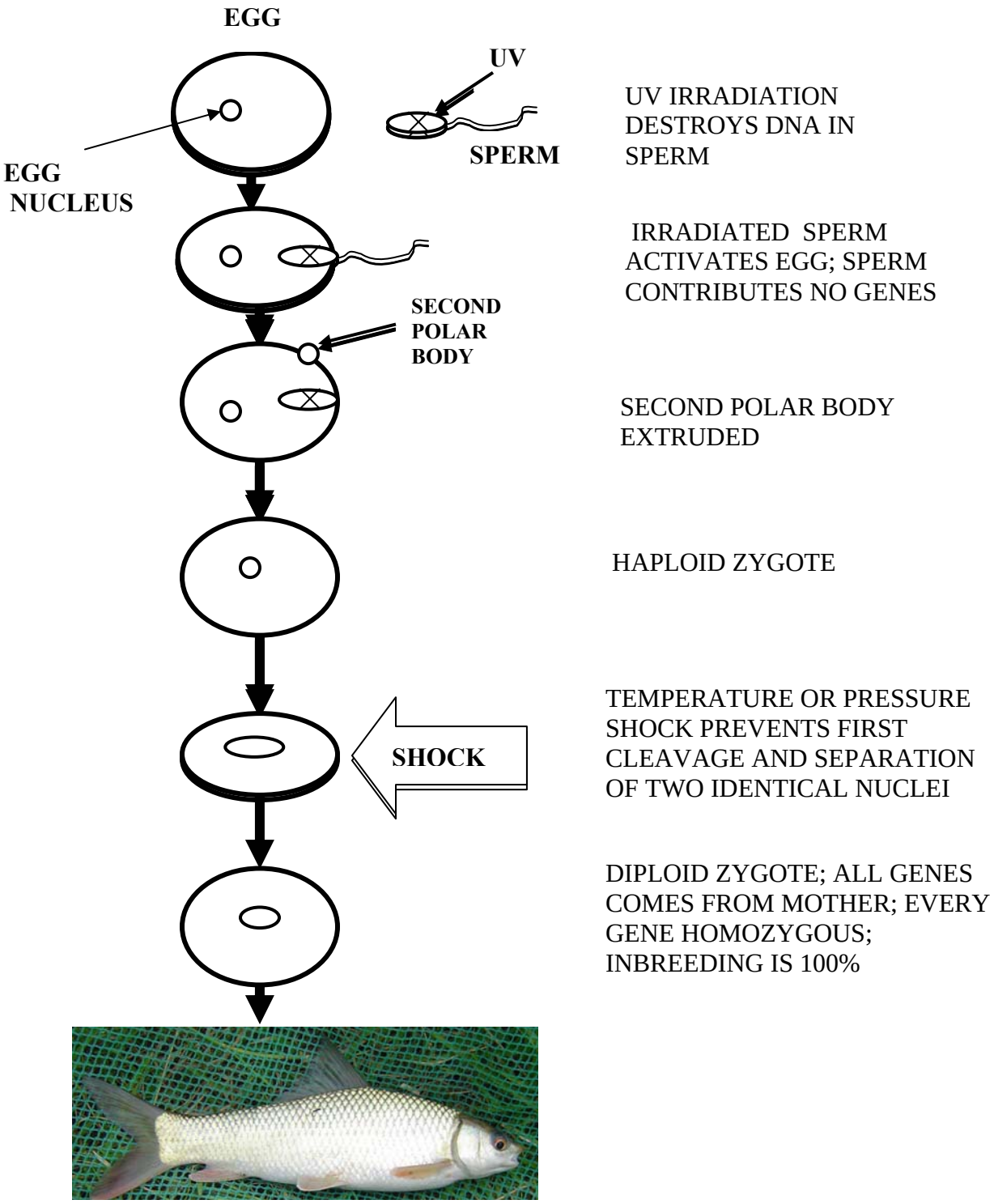


Fig. 15. Mitotic gynogenesis (First generation of mitotic gynogenesis).

PHASE 2

Production of Inbred Line

MITOTIC GYNOGEN FROM PHASE 1

EGGS

STRIP EGGS

MITOTIC GYNOGENESIS | **MEIOTIC GYNOGENESIS**

PRODUCED 2ND GENERATION GYNOGENS BY EITHER MITOTIC OR MEIOTIC GYNIGENESIS

SECOND GENERATION GYNOGENS

ALL OFFSPRING IDENTICAL; ALL 100% HOMOZYGOUS, 100% INBRED

NOTHING | **SEX REVERSAL**

SEX REVERSE HALF 2ND-GENERATION GYNOGENES FROM EACH FAMILY TO PRODUCE SEX-REVERSED MALE

XX FEMALES | **XX MALES**

MATE

MATE FISH WITHIN EACH FAMILY TO PRODUCE INBRED LINES THAT ARE 100% HOMOZYGOUS AND 100% INBRED

100% FEMALE
100% HOMOZYGOUS
100% INBRED

REPEAT SEX REVERSAL AND MATING TO PRODUCE NEXT GENERATION

Fig. 16**.** Mitotic Gynogenesis (Production of inbreed line).

7.2.3.2 Androgenesis

Androgenesis is the process of producing androgens (male) through fertilization of irradiated eggs with normal sperm. Androgenesis, or all-male inheritance, is more difficult to accomplish than gynogenesis (Scheerer *et al*., 1986), since diploidy can only be induced in androgens at first cell division, a difficult time to manipulate the embryo. Also androgens are totally homozygous, so a large percentage with deleterious genotypes probably dies (Scheerer *et al*., 1986). Gynogenesis and androgenesis can be used to elucidate sex-determining factors in fish. If the male is the homogametic sex when androgens are produced, the androgens will be 100 percent ZZ (all-male).

Androgens are produced by two ways:

- Mitotic androgenesis
- Androgens produced from tetraploid male

Mitotic androgenesis can be done with species that have the XY sex-determining system (Figs. 17 & 18).

7.2.4 Sex reversal

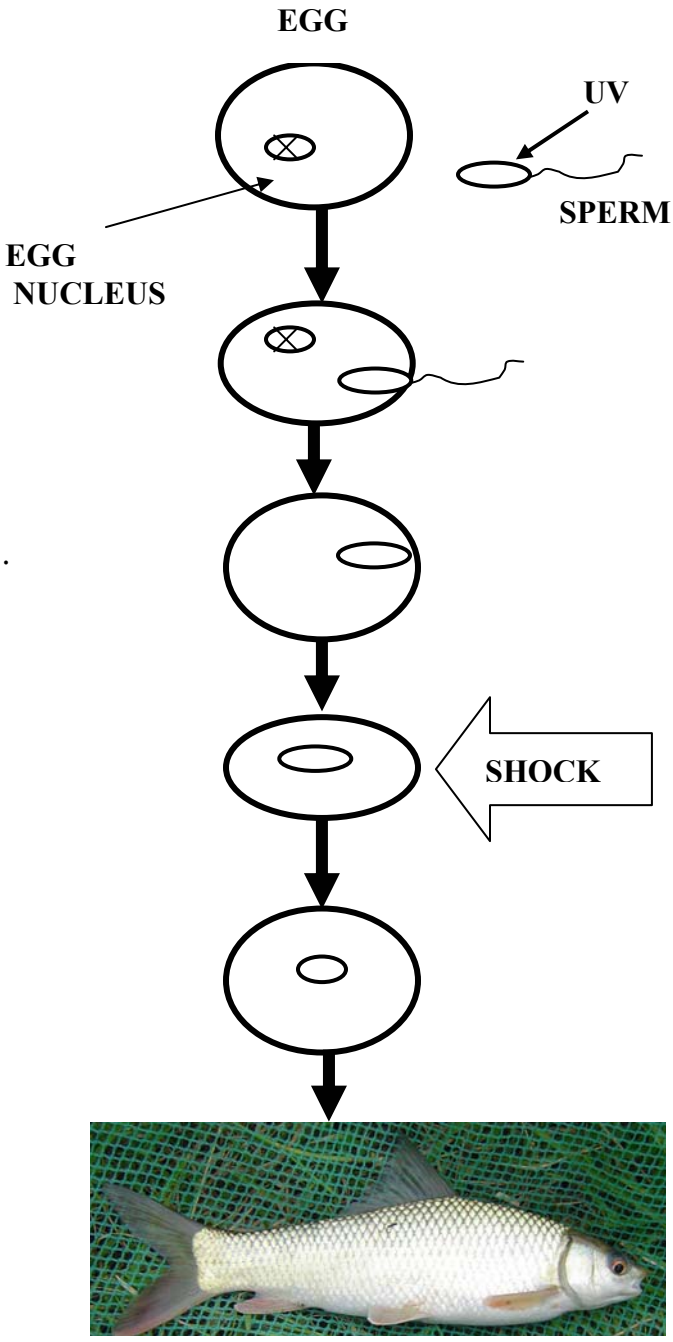
Sex manipulation and breeding
Various strategies utilizing sex reversal and breeding, progeny testing, gynogenesis and androgenesis can lead to the development of predominantly, or completely, male or female populations, or a "super-male" genotype (YY). The primary aim is to take advantage of sexually dimorphic characteristics (including flesh quality), control reproduction or prevent establishment of exotic species. All female populations have been successfully developed for salmonids, carps and tilapias. Populations of super males (i.e. fish with two rather than one Y chromosome) have been established for Nile tilapia, salmonids and marginally, for channel catfish (Dunham, 1996a).
Monosex populations may be produced by direct hormonal treatment; however, where the fish are destined for human consumption, some countries (e.g. the European Union [EU], the United States, India) may prohibit such treatment.

This has enabled the production of YY males and all male progeny, XY (known as "genetically male tilapia" [GMT] to distinguish them from sex reversed male tilapia), on a commercial scale. The YY male technology provides a robust and reliable solution to culture problems with early sexual maturation, unwanted reproduction and overpopulation (Mair *et al*., 1995; Tuan *et al*., 1998, 1999; Abucay *et al*., 1999).

Sex ratios vary widely between spawnings of Nile tilapia, but at the population level, they maintain a normal distribution of around 1:1 males to females. YY males crossed with XX females produce 95-100 percent males, and Scott *et al.* (1989) observed no females from the mating of 285 progeny of a single YY male crossed to ten separate females.

PHASE 1

Creation of First-Generation Mitotic Androgens



UV IRRADIATION
DESTROYS DNA IN EGG

SPERM FERTILIZES
ENUCLEATED EGG; EGG
CONTRIBUTES NO GENES

HAPLOID ZYGOTE

TEMPERATURE OR PRESSURE
SHOCK PREVENTS FIRST
CLEAVAGE AND SEPARATION
OF TWO IDENTICAL NUCLEI

DIPLOID ZYGOTE; ALL GENES
COMES FROM FATHER; EVERY
GENE HOMOZYGOUS;
INBREEDING IS 100%

FISH IS MALE; 100%
HOMOZYGOUS;
100% INBRED

Fig. 17. Flow diagram of Androgenesis.

PHASE 2

Production of Inbred Line

MITOTIC ANDROGEN FROM PHASE 1

SPERM

STRIP SPERM

SECOND GENERATION GYNOGENS

REPEAT PHASE 1; ALL OFFSPRING IDENTICAL; ALL 100% HOMOZYGOUS, 100% INBRED

NOTHING **SEX REVERSAL**

SEX REVERSE HALF 2ND-GENERATION MITOTIC ANDRO GENS TO PRODUCE SEX-REVERSED FEMALES

ZZ MALES **ZZ FEMALES**

MATE

MATE TO PRODUCE POPULATION OF IDENTICAL E 100% HOMOZYGOUS AND 100% INBRED LINE OF FISH

100% MALE
100% HOMOZYGOUS
100% INBRED

REPEAT SEX REVERSAL AND MATING TO PRODUCE NEXT GENERATION

Fig. 18**.** Mitotic Androgenesis (Production of inbreed line).

YY-GMT technology has strong potential for commercial application, since YY Nile tilapia, unlike channel catfish, can be sex reversed to produce functional females. The progeny of the YY-GMT males increase yields by up to 58 % compared to mixed sex tilapia of the same strain (Mair *et al*., 1995). This is also greater than yields from sex-reversed male tilapia. In addition, YY-GMTs have more uniform harvest size, greater survival and better food conversion ratios.

GMT production is relatively environmentally friendly. No hormones are applied and hormone application to the broodstock is low. Species/strain purity is maintained and the fish produced for culture are normal genetic males. Research on YY male technology has been widely disseminated in the Philippines since 1995, Thailand since 1997 and, to a lesser extent, in a number of other countries including Vietnam, China, Fiji and the United States. In the Philippines and Thailand, broodstocks are distributed from breeding centres to accredited hatcheries. This maintains quality control and, although limiting scale of dissemination, keeps it within financial viability - essential for long-term sustainability.

Here, androgens (male) and gynogens (female) can be used for commercial propagation of single sex individual (monosex). All male and all female offspring production are shown schematically in Figs. 19 & 20.

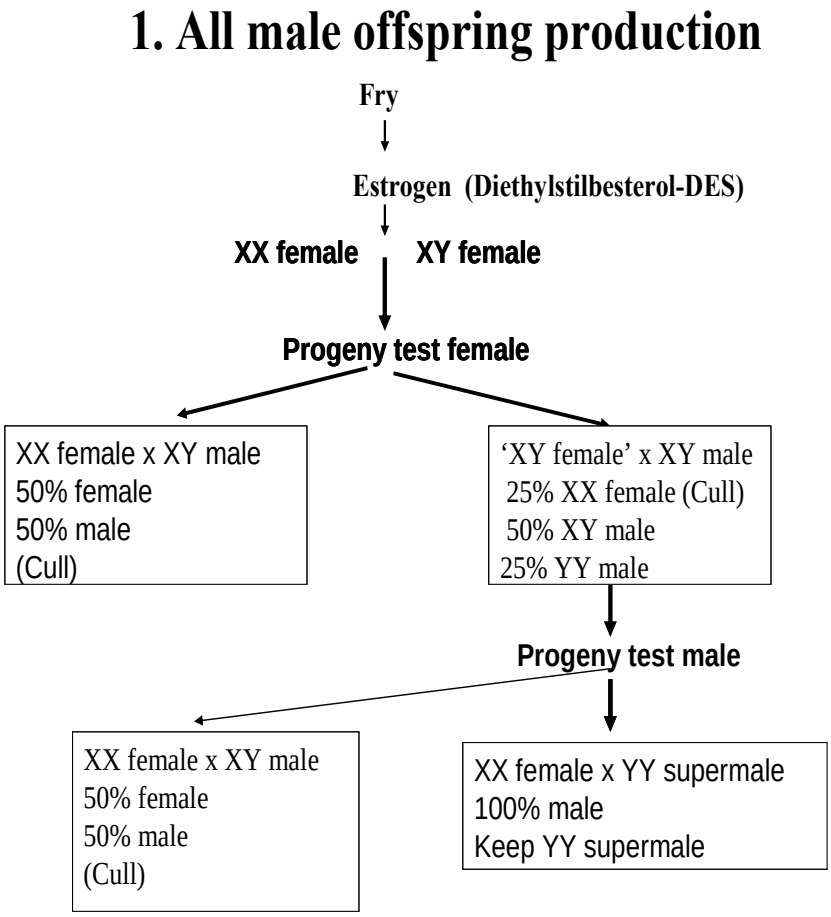


Fig. 19. All male offspring production protocol.

2. All female offspring production

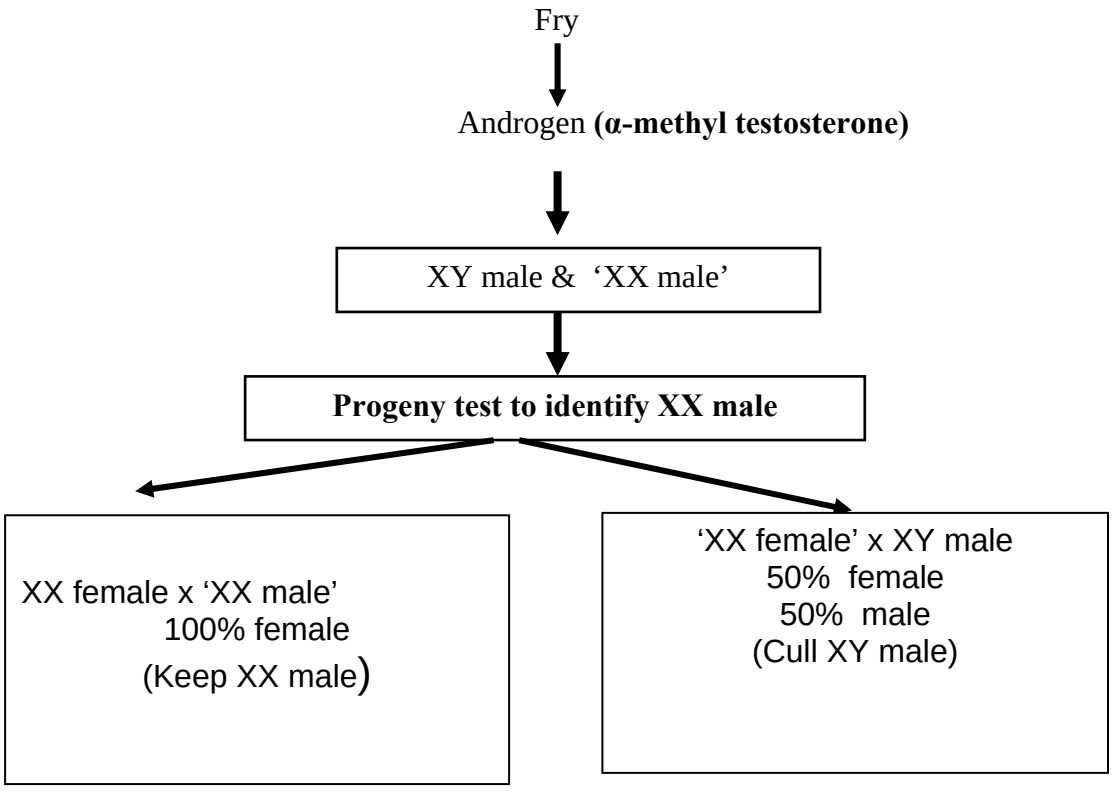


Fig. 20. All female offspring production protocol.

7.2.5 Mass selection

Mass selection is one kind of individual selection where selection is based on individual phenotypic values.

Mass selection is the most ancient and simplest method to improve seed of species used in aquaculture. Mass selection of common carp has been carried out in Viet Nam where 33% growth increase was achieved at the fifth generation (Tien *et al*., 2001). To improve seed quality measures have been taken such as establishment of brood banks (Bangladesh) or gene banks (Philippines). At present it is important to increase awareness among farmers and hatchery operators concerning genetic issues.

7.2.6 Chromosomal manipulation

Ploidy manipulation

Another aspect of genetics is ploidy manipulation. It is possible through hatchery manipulation of the fertilization process or using tetraploids to produce fish/shellfish that are triploids (having three sets of chromosomes, like many domesticated plant species).

Triploids have been a valuable tool for many fish/shellfish grow-out operators around the world and increasingly used in aquaculture. Since triploids do not expend much energy producing gametes they may exhibit increased growth. The extent of this growth advantage can only be determined by deploying them in specific grow-out system and recording their performance over non-triploid animals.

Another benefit of triploid animals is that they do not spawn and therefore do not undergo a dramatic loss of meat quality during the spawning season like their diploid counterparts. This can result in a superior quality product to market during periods of the year when diploid animals are difficult to sell.

Finally, a third advantage of triploids, because they are sterile, is that they can be farmed in close proximity to natural populations with no effect on the population genetics in wild animals. That is, they can not interbreed with natural populations (or themselves) making it possible to put side by side farming and restoration.

Despite the use of domesticated stock for farming, hatchery operators should still consider proper fertilization techniques that ensure the maximum genetic diversity among the larvae produced. Failure to use reasonable number of parents for larval batches could result in partial or total larval failure. Even in batches of larvae that successfully complete the larval period and result in seed stocks, limiting the number of broodstock can result in genetic bottlenecks that could begin to express themselves in poor performance of the stocks over time. For restoration aquaculture, genetic considerations may be quite different than for farming. Typically, every effort should be made to ensure that the effective population number of parents is as high as possible.

7.3 Long-term plan for seed quality improvement

Genetic management is the greatest quality issue in Bangladeshs' private and government hatcheries and deterioration of genetic quality of cultured species is a seriuos problem. For the high fecund carps, there is always the attraction to use the fewest number of brood fish possible to get a certain number of eggs. Offspring of minimal numbers of parents often selected for next generation of brooders and after several generation of mating, such bottlenecks lead to inbreeding which can cause in lower growth, decrease fecundity and generate deformities.

The following attempts can be taken for long-term seed quality improvement:

1) Establishment of satellite station:

2) Remodelling of selected 20 hatcheries:

3) Production of quality broods from govt. brood bank centers:

4) Certification/registration of private hatcheries:
At first seed certification system should be established for carp species.

5) Distribution of quality broods to hatchery owners:
Through certification system the number of broods required for the hatcheries will be provided from govt. brood bank centers.

6) Seed quality:
Once it is developed to distribute quality broods to the hatchery operators, the seeds that are produced from broods should be checked by molecular marker at 2/3 years interval.

7) Seed marketing:
This section includes information on supply and distribution mechanisms, fixation of seed price, people involved in the process (i.e. selling, exchange, purchase, marketing agents etc.), market, accessibility, transportation, available financing, sales promotion.

8) Training for seed production facilities and seed technology:

This section includes information on existing number of hatcheries for seed production, the number of species, available technologies (e.g. breeeding, hatching, rearing), gene banking.

9) Monitoring and Evaluation center:

To run the quality seed production activities country wide, the monitoring and evaluation center should be established having logistic supports.

10) Stakeholders:

To rise up the demand of quality seed, stakeholders should be identified and involved in seed production where some groups will act as:

a) producers/farmers-seed production and exchange;

b) local institutions such as NGOs, extension services, producer associations-promotion of use of quality seed, dissemination of technology;

c) government institutions-to provide legal and policy framework for the seed industry, extension services, training;

d) researchers-information, knowledge and technology (e.g. universities, research institutes etc.).

7.4 Safeguard biodiversity

What is the role of hatcheries and protective measures to save genetic diversity of indigenous wild stocks?

Why purity of wild stocks important?

In spite of increasing stocking of open waters with low quality hatchery-produced seed, still we have some pure stocks in the natural habitat, in rivers, haors and beels. This is the only refuge of the day-by-day weakening indigenous stocks. Pure species can be collected from these refuges, to regenerate the stocks damaged by inappropriate management in hatcheries. Therefore, the wild stocks must be protected from genetic contamination, otherwise aquaculture production cannot be improved and the biodiversity of the major carps of the Ganges-Brahmmaputra basin will be irreversibly damaged.

What should be done to save genetic diversity of indigenous wild stocks?

i) Hybridization in commercial hatcheries should be prohibited.

ii) Hatchery-produced indigenous fish seed for restocking open waters should be genetically appropriate to the area to be restocked.

iii) Escapes of domesticated and exotic stocks should be strictly prevented

iv) For protection of population size, sanctuaries are preferable to restocking.

v) Gene banks should be established, including frozen gametes, for future use**.**

7.5 Satellite stations

7.5.1 Plan for 2 farms (FSMF's-Fish Seed Multiplication Farms) for quality brood fish production in selected hatcheries

A. Introduction:

As per the ToR agreement three carp fish hatcheries, one from private sector and two from government sector (Raipur Fish Hatchery & Training Center of DoF and Freshwater Sub-Station, Jessore of Bangladesh Fisheries Research Institute) were primarily selected for quality seed

production and hatchery certification model plan. After a number of meetings with the working group it was decided that Netrokona and Kishoreganj, Fish Seed Multiplication Farms will be developed for quality brood and seed production (Fig. 21). But the recommended farm lacks sufficient number of ponds and other logistics. For interviewing such innovation venture further visit and study needs to be undertaken for selection of farms both from government and private sector. To establish the satellite model fish hatchery, the hatchery where atleast 20-25 ponds and other facilities are available should be selected. In orer to undertake the activity, a tentative plan and pertaining methodologies with a tentative budget are furnished below:

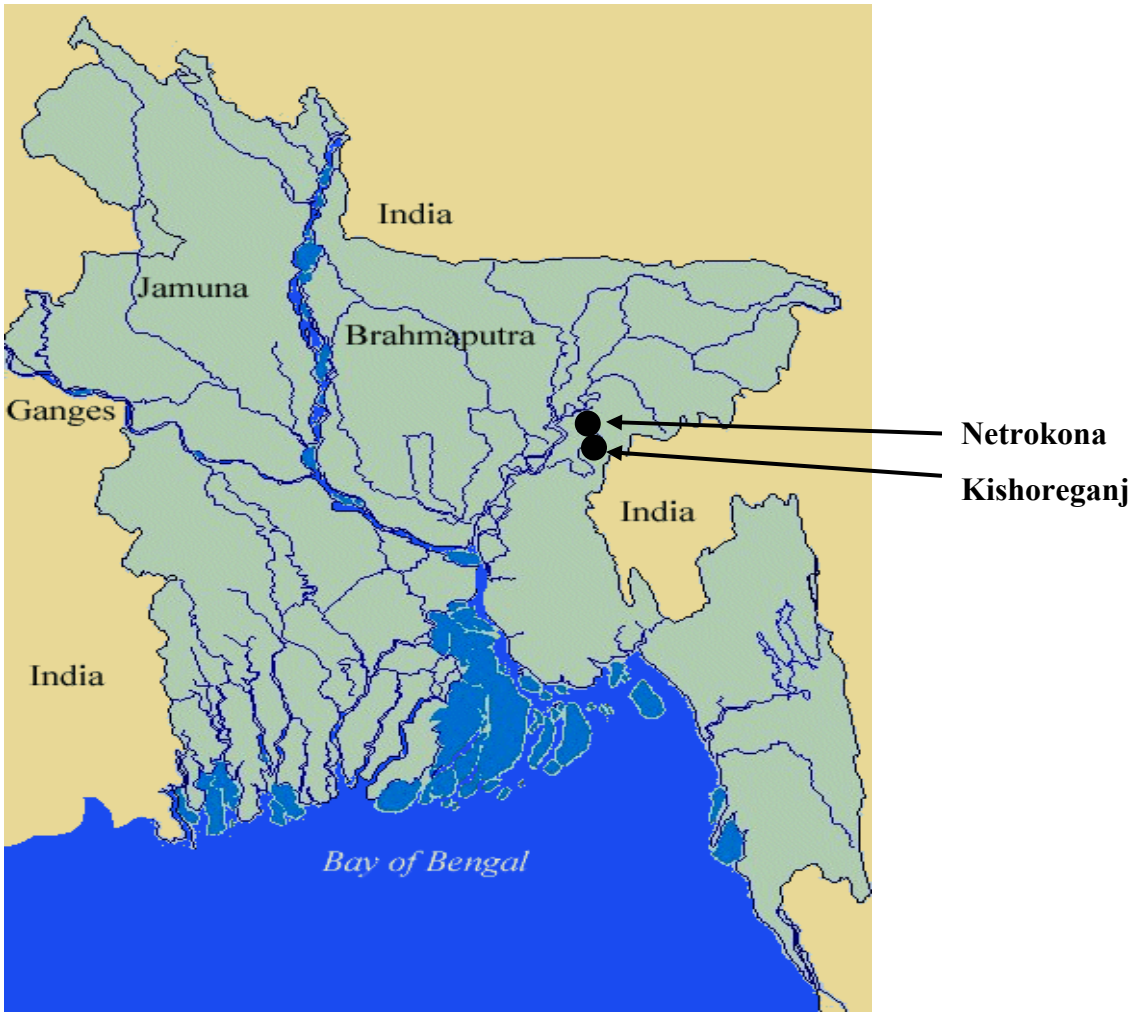


Fig. 21. Map showing the location of selected hatcheries (●) for brood banking.

B. Methodology of quality (genetic) IMCs seed production and brood bank management

1st year (2009)

Before starting brood bank activities a clear decision from the DoF authority will be necessary that these FSMF farm and the existing facilities including regular logistic supports would be provided. Also it is recommended that the activities jointly undertaken by the SICD project and Brood Bank Establishment Project will be implemented.

i) Activities:

The following activities will be conducted for quality IMCs seed development in each of two selected farm/hatcheries:

1) **Pond selection & renovation:** Nine ponds of 15-20 decimal sizes each will be selected in each farm for separately stocking of natural seeds collected from the Halda river. Renovation work such as dike/monk repair and re-excavation will be done accordingly.

2) **Pond preparation:**

a. Removal of weed fish/drying, fertilization: The selected ponds will be cleaned from undesired fish by repeated netting, applying piscicide, and if it does not work complete drying will be done. Lime @ 1.0 kg/decimal will be applied to all the experimental ponds. Ten days after liming, cow-dung @ 20.0 kg/decimal will be applied to all the experimental ponds. Ponds will then be fertilized with urea and triple super phosphate (T.S.P) @ 120.0 g/decimal and 240 g/decimal respectively prior to 10 days of stocking.

b. Fencing of ponds: The pond bank will be fenced by nylon net to a certain height with the help of bamboo sticks to ensure the survival of experimental fishes in their respective ponds even if the ponds get inundated due to over raining. Netting will be done to remove small frog and water bug from the experimental ponds 03 days prior to stocking of spawn from the Halda stock.

3) **Visit to spawning ground:** For the collection of natural stocks of IMCs spawns/fertilized eggs, the Madhuna Ghat for the Halda spawn will be visited and the actual breeding time will be monitored with contact to the relevant personnel (DFO/TFO) so that the purity of spawns can be ensured. Then the collected spawn will be transported to the farm with proper precautions for nursing and quality brood development.

4) **Collection of spawns:** Approximately, 1 kg fertilized eggs of the IMC species from Madhuna Ghat for the Halda source will be collected and be transported to Hathazari Mini Hatchery. Then the fertilized eggs will be nursed there and larvae will be hatched out after the completion of incubation period. The spawns will be transported to the farm using water in double polythene bags with sufficient oxygen packed within a carton box.

5) **Nursing and rearing of spawns:** After one month of rearing spawns will become fry/fingerlings and they will be graded based on their growth and health conditions. Then the selected fry will be stocked in three different ponds and the ponds will be numbered

together with the river name and year (viz. for the Halda river source HR-01/2009, HR-02/2009 etc). Sufficient amount of wheat flour (1.0 kg/decimal) will be used for the production of zooplankton prior to 03 days of spawn stocking.

a. Feeding: Boiled-egg yolk will be supplied to the 2-3 days old spawns during nursing. Then the wet mustard oil cake with fishmeal (at a rate of 50:50) will be supplied for next 7 days. After 07 days a common supplemental feed consisting of 30% fishmeal, 20% wheat bran, 20% rice bran, 10% soybean meal and 20% mustard oil cake will be administered @ 5% of body weight to all the fries. The above mentioned feed ingredients will be procured from the market and made into small wet balls. The feed will be administered in two splits once at 09.30 h and again at 17.30 h through putting the balls directly into the ponds. The quantity of feed to be administered will be adjusted after every 10 days on the basis of increase in the average body weight of the stocked fishes through proper sampling.

b. Water quality checking: For the proper management of stocked fishes water quality will be monitored once in a fortnight. For this one Techno-kit having monitoring facility of water pH, dissolved oxygen (DO), total alkalinity and total hardness will be provided to each farm.

c. Research students/workers: Two research students will perform and monitor all the activities in coordination with the farm manager and they will receive on daily allowance. While the DoF officer at the Netrokona Fish Seed Multiplication Farm and at the Kishorganj Fish Seed Multiplication Farm, Mymensingh will get no daily allowance.

6) **Genetic analysis:** The allozyme electrophoresis protocol will be used to analyze the genetic variation of both developed fries/fingerlings of virgin sources for brood bank and the hatchery produced sources. The starch gel electrophoresis system will be followed with 5-6 enzymes for getting allelic variation. At least 30 individuals of each species for each stock (virgin source and hatchery sources) will be selected for allozyme study and the protocol is shown in Table 5.

Table 5. Number of individuals from Halda river stock will be used for allozyme analysis

Sl. No.	River sources	Species	No. of individuals	Date of collection
1	Halda	Rohu (*Labeo rohita*) Catla (*Catla catla*) Mrigal (*Cirrhinus mrigala*) Kalibaush (*L. calbasu*)	30 30 30 30	June, 2009
Total			120	

A list of buffer systems, electrophoretic process and enzymes to be used are shown in Tables 6 and 7.

Table 6. Composition of buffer system and electrophoretic process

Buffer system	Gel buffer	Running time	Voltage	References
CA 6.0 Electrode buffer 0.04 M Citric acid pH adjusted to 6.0 with NaOH	1:20 dilution of electrode buffer	Thick gel (0.5 cm) Initial: 30 min Final: 5-6 h	100 V 150 V	Clayton and Tretiak, 1972
CA 7.0 Electrode buffer 0.04 M Citric acid pH adjusted to 7.0 with NaOH	1:20 dilution of electrode buffer	Thick gel (0.5 cm) Initial: 30 min Final: 5-6 h	100 V 150 V	Clayton and Tretiak, 1972

Table 7. Enzymes to be examined and tissues used for electrophoresis.

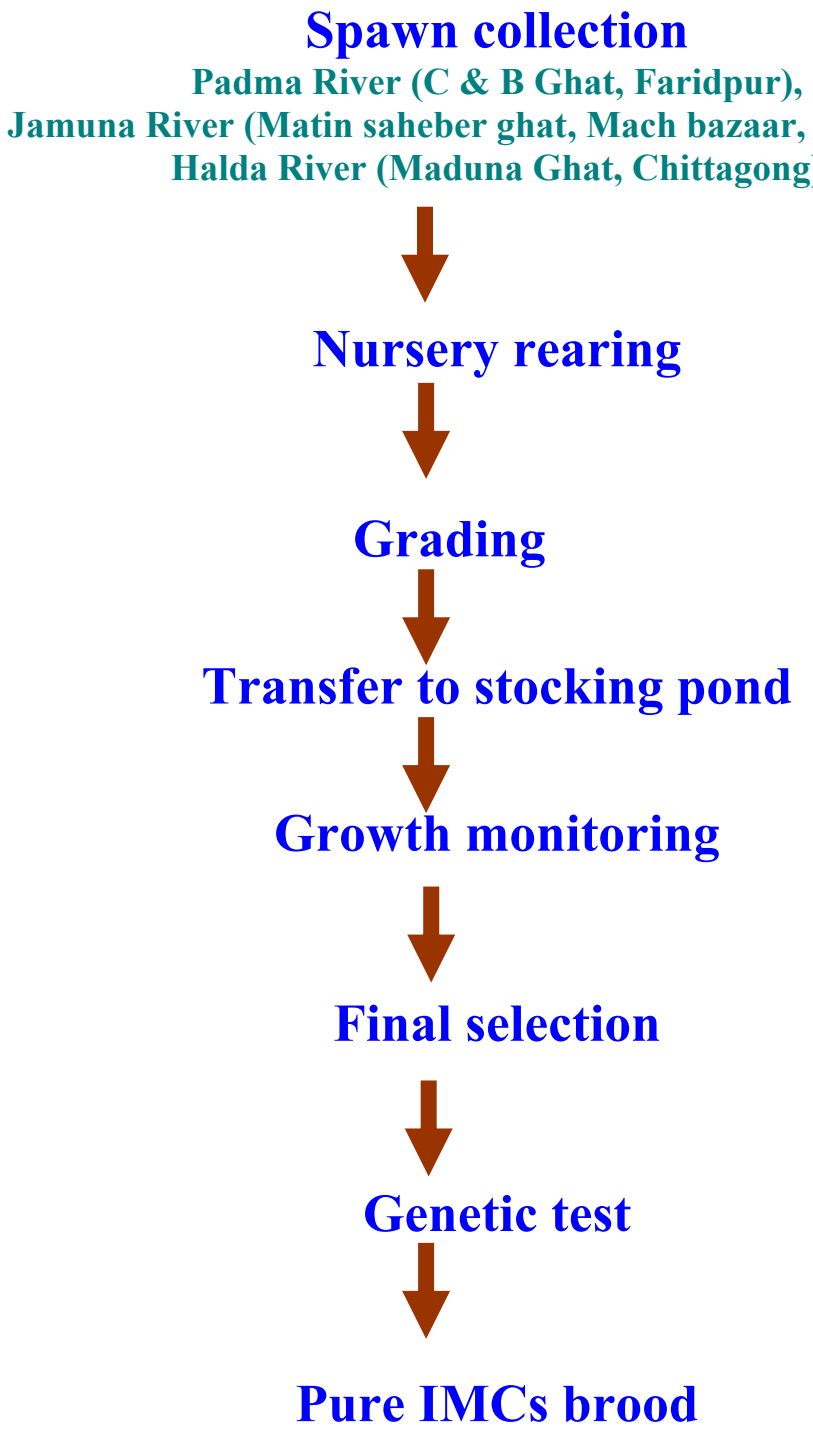
Enzymes	Enzyme abbreviations	Enzyme patterns	E.C. Number	Tissue*[1]	Buffer system*[2]
Esterase	EST	Monomer	3.1.1. -	M\L	CA 6.0/7.0
Glycerol-3-phosphate dehydrogenase	G3PDH	Dimer	1.1.1.8	M	CA 6.0/7.0
Glucose-6- phosphate isomerase	GPI	Dimer	5.3.1.9	M\L	CA 6.0
Lactate dehydrogenase	LDH	Tetramer	1.1.1.27	M	CA 6.0
Malate dehydrogenase	MDH	Dimer	1.1.1.37	M	CA 6.0
Phosphoglucomutase	PGM	Monomer	5.4.2.2	M	CA 6.0

*[1] M: muscle; L: liver
*[2] CA 6/7, amine-citrate buffer (pH = 6.0/7.0) (Clayton and Tretiak, 1972)

7) Growth performance:

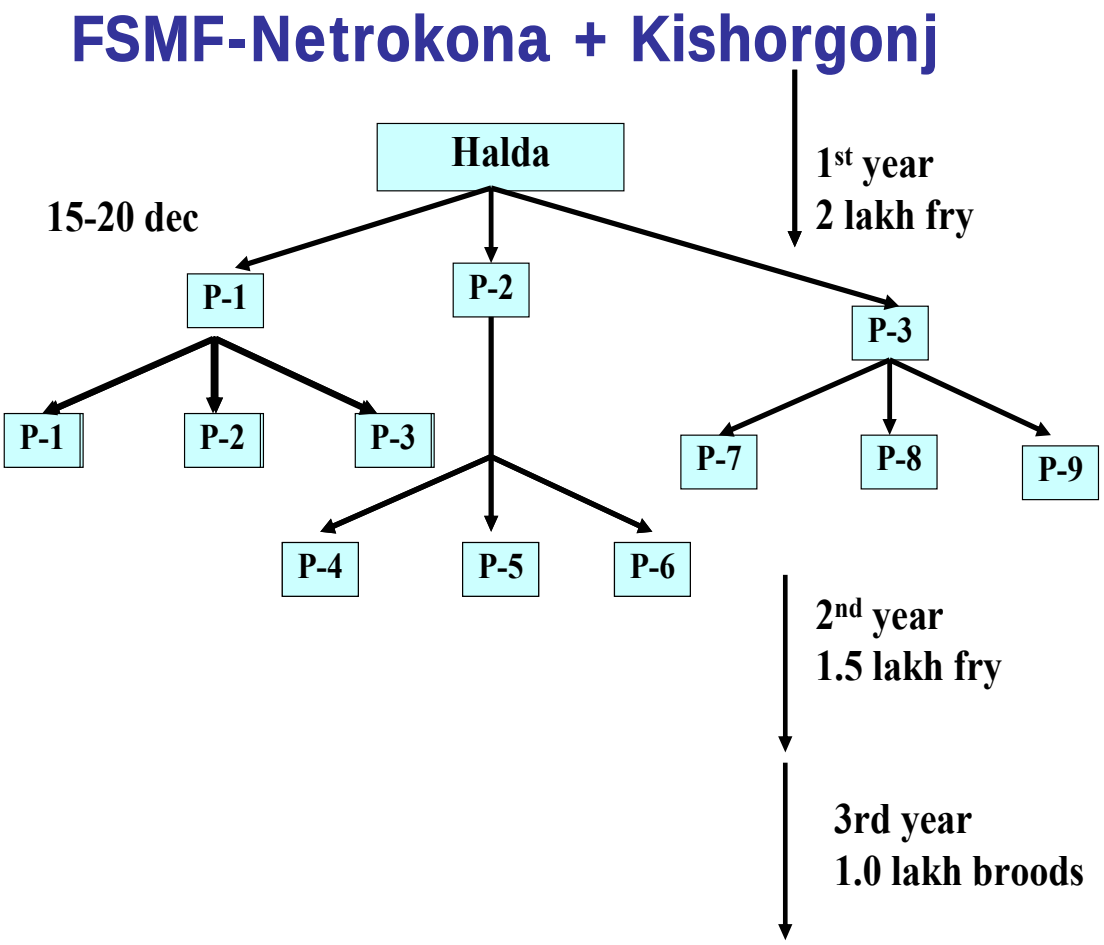
The growth performance (length and weight) of all fries will be recorded and the fries those have standard growth pattern and health will be graded and transferred to the three replicated ponds with low stocking density for 2nd year rearing. The total 2 lakh fry of three species (rohu, catla and mrigal) will be selected during 1st year experimentation following the standard protocol (Protocol 1).

Development of pure Major Carps (IMCs) brood using spawn of natural sources



Protocol 1. Standard system to develop quality IMCs seed using wild spawns.

Pond distribution



- Based on growth chart and genetic variation the total of 2 lakh fish will be selected during 1st year (2009) experimentation.
- In 2010, the growth trial will be continued following the standard stocking density and about 50,000 fish will be removed from this activity. This fish will be transferred to the other Govt. farms for demonstration activity.
- In 2011, tentative 1 lakh broods will be developed and the broods will be used for 1st generation offspring production.

8) Training required for Fish Farm/Hatchery Managers and Technicians: On-farm demonstration and training on quality seed production

After completion of genetic analysis a comprehensive report will be prepared and submitted to the Project Director, SICD for examination and approval by the DoF prior to distribution to the selected farms. This report having the protocol of producing quality broods, carp seeds and seed certification process will be prepared in the form of a Training Module so that training could be provided to the hatchery operators of both the public and private sectors in future. The report will help the hatchery operators to easily understand the genetic variation of seed originating from natural sources and hatchery produced sources.

9) Demonstration

After the completion of 1st year activities the protocol followed for IMCs seed production, developed fry and the ponds distribution maintaining pedigreed will be presented to private hatchery owners/farmers. The extension material will be prepared using the growth performance chart having genetic profile.

7.5.2. Budget: Budget estimate for the two FSMFs are shown in Tables 8 & 9.

i. **Budget estimate** for April-August, 2009 period.

Table 8. Budget estimate for April-August, 2009

Amount in Taka

Sl. No.	Line items	Farms		Total (Tk.)
		Govt. Farms		
		Netrokona	Kishorganj	
1.	**Pond renovation** (dike/monk repair)-9 ponds for each farm	20,000/-	20,000/-	**40,000/-**
2.	**Pond preparation** i. Removal of weed fish/drying, liming/fertilization	10,000/-	10,000/-	**20,000/-**
	ii. Fencing of ponds	20,000/-	20,000/-	**40,,000/-**
3.	**Travel to spawning grounds**	12,000/-	12,000/-	**24,000/-**
4.	**Collection of spawns** (including poly bags & cartons, 3-4 days staying)			
	i. Halda stock	30,000/-	30,000/-	**60,000/-**
5.	**Nursing & rearing of spawns**			
	i. Spawn transportation	6,000/-	6,000/-	**12,000/-**
	ii. Stocking	2,000/-	2,000/-	**4,000/-**
	iii. Feeding and management	20,000/-	20,000/-	**40,000/-**
	iv. Research students*	35,000/-	35,000/-	**70,000/-**
	v. Water quality checking kits	72,000/-	72,000/-	**1,44,000/-**
	Total	**2,27,000/-**	**2,27,000/-**	**4,54,000/-**

ii. **Budget estimate** for September-December, 2009.

Table 9. Budget estimate for September-December, 2009

Amount in Taka

Sl. No.	Line items	Farms		Total (Tk.)
		Govt. Farms		
		Netrokona	Mymensingh	
1.	**Pond management** (pond drying/repair) - 09 ponds for each farm	12,000/-	12,000/-	**24,000/-**
2.				
	i. Chemicals (Lime, Rotenon, KMno4, Urea, TSP etc)	5,000/-	5,000/-	**10,000/-**
	ii. Fertilizers (Cowdung)	5,000/-	5,000/-	**10,000/-**
	iii. Nets & hapas	10,000/-	10,000/-	**20,000/-**
	iv. Ropes & Bamboo poles	10,000/-	10,000/-	**20,000/-**
	v. Buckets & chives	3,000/-	3,000/-	**6,000/-**
	vi. Feeds	30,000/-	30,000/-	**60,000/-**
	vii. Water quality checking kits	40,000/-	40,000/-	**80,000/-**
3.	**Genetic analysis**			
	i. Research students*	-	-	**30,000/-**
	ii. Chemicals, starch gel, enzymes etc.**	300,000/-		**300,000/-**
	iii. Documentation	10,000/-		**10,000/-**
	iv. Contingency	20,000/-		**20,000/-**
	iv. Report preparation	20,000/-		**20,000/-**
	Total =	**3,05,000/-**	**3,05,000/-**	**6,10,000/-**

* Two research students will be assigned to monitor the hatchery activities including seed collection from natural rivers, nursing, rearing, fry stocking, genetic analysis in the laboratory and will get a lump sum allowance of Tk. 5,000/-per month

** Cost for genetic analysis (Table 10)

Table 10. Cost for genetic analysis of 120 samples collected from the Halda river

Sl. No.	Line item	Quantity/Amount	Unit cost	Total cost
1.	**Chemicals:** Alcohol, Acetic acid, HCl, Glycerol, Formalin	1 L for each item		**30,000/-**
2.	**Powder/satls:** NaCl, Trisma base, Boric acid powder, Hydrolyzed starch powder	1 kg per item		**90,000/-**
3.	**Enzymes and co-enzymes:** MTT, NAD, NADP, ATP, NBT, Na-isocitrate, AAT, G6PDH, PMS, Creatin, Sorbitol, GDA, GIP etc	5 g per item		**1,75,000/-**
4.	Paper/filter: Toyo paper, Cellophane paper etc			**5,000/-**
Total				**3,00,000/-**

C. Long-term activities (up to 2011)

Based on the above mentioned protocol it is expected that at least 50,000 brood fish will be produced from each river source from each farm. Each hatchery will rear those 50,000 fishes and take proper management up to their maturation. It will take at least two years up to 2011 and then these broods will be distributed among the registered hatcheries for mass scale seed production.

i) Activities for 2009

The produced brood fish consisting of four species i.e. rohu, catla, mrigal and calbasu will be reared intensively. The growth performance and health conditions will be monitored by monthly sampling. The stock of the Halda source will be spread over in 9 ponds of about same sizes for easy handling and monitoring (Table 11).

Table 11. Stock spread over plan in three separate ponds for brood banking

Sources	Pond title	Rohu	Catla	Mrigal
Halda	1. H1-10	1. HR1-10	1. HC1-10	1. HM1-10
	2. H2-10	2. HR2-10	2. HC2-10	2. HM2-10
	3. H3-10	3. HR3-10	3. HC3-10	3. HM3-10

ii) Activities for 2010

The same procedure will be followed for this year and brood fish will become mature and their age will be 2+ years and they will be considered for selective breeding. During breeding the di-allelic mating system will be followed for each pond stock of each source (linebreeding) for sustainable quality seed production and maintain the genetic quality i.e. free from inbreeding/genetic drift (Table 12).

Table 12. Breeding system of 5 rohu stocks from H1-09 pond of the Halda source for pedigreed mating

Stocks	**1**	**2**	**3**	**4**	**5**
1	-	X	X	X	X
2		-	X	X	X
3	X	X	-	X	X
4	X	X	X	-	X
5	X	X	X	X	-

iii) Activities for 2011

Each IMCs brood station/center will produce seed based on pedigreed mating of each species stock from the Halda River and spawn will be distributed among the pond fish farmers for sustainable aquaculture production. Moreover, these brood banks will as well distribute broods to the registered hatcheries following proper guidelines and registration and regulation.

7.5.3 Future guidelines for Govt. & private hatcheries

(A) For Government hatcheries

(a) Avoid inbreeding

To avoid or control inbreeding it is suggested that at first breeding should be started with wild stocks where the fish are inbreed free (*F*=0%). If the fish used for breeding are not pedigreed or unknown then it is very difficult to control inbreeding and often impossible. So, if the same stock is used for next generation then the considerable factor is only the effective breeding number (*Ne*) but inbreeding rate (*F*-value) is commercially accepted up to 12.5% (not more than that) (Table 12)..

Table 13. Effective breeding number (*Ne*) in each generation to control inbreeding.

No. of generation	Effective number of breeding (Ne)	
	F=5%	F=10%
1	10	5
2	20	10
3	30	15
4	40	20

How to avoid inbreeding depression?

For exotic species and improved strains of indigenous fishes, the breeders should be selected from fingerlings parented by a large number of breeders, preferably not less than 25 pairs. Their genetic diversity can be maintained by rotational cross-breeding of different hatchery stocks.

(b) Inbreeding and maintenance of genetic quality

It is as important to prevent production losses due to inbreeding as it is to increase production from genetic enhancement. This applies especially to species with high fecundity, e.g. Indian and Chinese carps, where few broodstock are necessary to meet demands for fry and broodstock replacement. The detrimental effects of inbreeding are well documented and can result in decreases of 30 percent or greater in growth production, survival and reproduction (Kincaid, 1976a, b, 1983; Dunham, 1996b).

(i) Maintain stock integrity by not hybridizing different stocks, strains or species

Hybridization

Hybrids may be used as broodstock in backcrosses or in the production of F_2 crosses. Over generations there is a general mixing and segregation of genes from the original parental species,

which is known as i**ntrogression**. Due to the segregation of genes the phenotypes resulting are highly variable and some of the fish carrying the introgressed genes cannot be easily distinguished from the original pure species. Hybrid introgression is thought to have occurred in some major carp populations, e.g. in Chinese carp in Bangladesh (Mia *et al*., 2005; Simonsen *et al*., 2005) where hybrids were originally produced, either for scientific interest or through reasons of shortage of broodstock.

Why is the present hybridization in commercial hatcheries devastating to biodiversity and to aquaculture?

Species hybridization at different levels –including backcrossing in commercial hatcheries is extremely harmful to genetic diversity of the involved species and may irreversibly damage the genetic pool of indigenous species in the wild too. Aquaculture production is negatively affected by using hybridized fingerlings, for the following reasons:

i) The feeding habit of a hybridized fish is not known, thus planned composite-culture to utilize all niches is not possible.
ii) Hybridized fish generally do not grow well, because they may not be able to digest what they eat, as they may have the feeding preference of one parent and the gut with its digestive enzymes of the other parent.
iii) Mortality of hybridized fry is generally high.

What to do to save genetic resources from hybridization and to improve aquaculture production?

i) Only pure species, having documented origin (pedigree), should be reproduced in commercial hatcheries
ii) Hybridization should be restricted exclusively to scientific institutions and only for research purposes
iii) Illegal production, sale or possession of hybridized fish should be reported to the Fisheries Department for necessary action

Intraspecific crossbreeding

The Vietnamese x Hungarian common carp crossbreed is particularly popular, due to fast growth and high survival rates under different production conditions (J. Bakos, unpublished data). Under various rice-field conditions, growth rates of different strains of Nile tilapia and their crosses showed that the crosses were superior to pure Senegal strains (Circa *et al*., 1994). Breeding programmes are also under development in several countries for the Java or silver barb, *Barbonymus* (formerly *Puntius gonionotus*), another economically important fish species in Southeast Asia (Bentsen *et a*l., 1996; Hussain and Islam, 1999). The Bangladesh programme used three strains: “Bangladesh”, “Thailand” and “Indonesian”. The growth rate of females from six crosses was 23% higher than the average growth rate of the parent strains. Even higher growth rates (35% improvement) were found in the three crosses using the Thailand strain as either the sire or dam. In the Vietnamese breeding programme, six different strains were used to produce a population ideally suited for culture (Bentsen *et al*., 1996).

Interspecific hybridization

Hybridization between some species, such as *Nile tilapia* and blue tilapia, *Oreochromis aureus*, result in predominantly male offspring (Rosenstein and Hulata, 1994). Other tilapia crosses, which produce mainly male offspring, include *Nile tilapia x O. urolepis honorum* or *O. macrochir*, and *O. mossambicus* x *O. urolepis honorum* (Wohlfarth, 1994). Conversely, the cross between striped bass and yellow bass (*M. mississipiensis*) produced 100 percent females (Wolters and DeMay, 1996). This can be desirable for culture purposes where

i) there are growth differences between the sexes;
ii) sex-specific products (such as *caviar*) are wanted; or
iii) reproduction needs to be controlled (e.g. overpopulation and stunting in tilapia production ponds).
(ii) Minimize transfer of genetically different stocks
(iii)Periodically assess their genetic diversity (i.e. by laboratory genetic analysis)

(B) For private hatcheries

(i) Pedigreed record need to be ensured
(ii) Male : female ratio should be equal
(iii)Full-sib mating should be omitted
(iv)Mass spawning of fish species and the use of fingerlings produced as future broodstock

In general guidelines

(i) Controlled breeding and seed production

Controlled reproduction of a number of species is yet not achieved. Rising of spawner and brood stock management would need major research support for the study of reproductive physiology. Investigations are needed on factors controlling maturation and spawning, acceleration of sexual development, etc. to maintain greater control over breeding. Ecophysiological aspects of breeding needs further study for the creation of conditions conducive for spawning.

(ii) Genetic research.

The research methodology for genetic improvement of stocks of cultivated finfish, shellfish and molluscs need development. Assessment of available genetic resources would be a primary requirement for the development of stock improvement programmes. Methods for the assay of manipulatory techniques for stock improvement such as gynogenesis, polyploidy, etc. would be needed.

(iii) Nutrition and feed formulation

Research is needed to study the nutritional value of feeds in nursery and growout systems. Nutritional requirements will need to be assessed for various life stages of different cultivated commodities for proper feed formulation. Research is necessary for the assessment of the nutritional values of locally available ingredients for the formulation of cost-effective supplementary and balanced feeds for different life stages of cultivated species. Standard methods need to be developed for nutritional analysis.

(iv) Fish health management

Systematic research is needed on diseases and their causative factors for different commodities. Diagnostic procedures along with preventive and immunoprophylactic measures for the control

of diseases need to be developed. All these would need similar methodology and approach although their application may be commodity or site specific. Research is necessary to standardize health monitoring methodology and management techniques especially for intensive production systems.

(v) Social and economic aspects

Many of the major issues are social and economic in nature. The problems of conflict resulting from privatization have already been mentioned. In order to deal with these, research is required to develop programs that will facilitate improved aquaculture while protecting or enhancing the welfare of the weaker sections of the community. With regard to prawn culture, research is required on global market conditions; the net benefits to the economy of investments in culture programs; the distribution of benefits among farmers, the community and society as a whole; and the effects of prawn culture development on production of fish for low income consumers.

7.5.4. Stocking of open waters

This issue can be considered into two ways:

A) Stocking of open waters with species that are unable to breed in the environment in which they are positioned;

For those species which are unable to breed in the environment to which they are released, the quality assurance aspect is related to the health of those animals and the need to avoid introducing diseased fish that may impact wild populations.

B) Stocking of species that are able to breed in the environment in which they are placed.
For those species which are able to breed, there are three sub-issues relating to the impact of that breeding activity. Theoe are:

i) if the species stocked are able to breed but not with wild fish, there may be an issue of competition for niches;
ii) if the species are exotic, there may be an issue with hybridization with indigenous species and susequent loss of genetic diversity;
iii) if the species released are indigenous, then there is a direct competition with the wild relatives; if the genetic diversity of the stocked species is narrow (as a result of captive broodstock or using domesticated broodstock), this may also impact the genetic diversity of the wild stock.

The stocking of open waters with domesticated stock or stock with narrow genetic diversity should be discouraged if there is a possibility that they will breed with local populations. Guidelines for seed production for open water stocking are given in Table 14.

Table 14. Minimum age and weight of broods for open water stocking

Species	Minimum age (Year)	Minimum weight (Kg)
Catla	3	4+
Rohu	2	1.5+
Mrigal	2	1.5+
Kalibaus	2	1.0+
Silver carp	2	2+
Grass carp	2	2+
Thai Pangas	3	3+
Common carp (scale)	1	1.5+
Common carp (mirror)	1	2.0+
Silver barb (Female)	1	0.2+
Silver barb (Male)	1	0.5+

7.5.5. General recommendations

Genetic improvement of cultured fish and shellfish that increases productivity and turnover rate, results in better use of resources and reduces production costs, should be given higher priority by government, NGOs and commercial organizations. Such improvement methods include:

- multiple trait selection programmes;
- efficient breeding plans, in which selection is combined with other genetic technologies;
- better genetic controls for monitoring the progress of breeding programmes;
- more education and training programmes for aquaculture geneticists,
- the establishment of national genetic controls, including homozygous and heterozygous clonal populations for key species to help in comparing genetic results and genetic material from different research institutions, and
- domestication of cultured organisms such as shrimp and molluscs that still rely on wild seed.

7.5.6 Researchable issues

Specific development issues

1. Study of broodstock genetics and broodstock supply for the promotion of basic genetic management of broodstock and the conservation of wild genetic resources.
2. Study to continous investigation on indegenous species for their potential to be used in aquaculture.
3. Genetic variation analysis of wild and hatchery stocks of Indian major carps using molecular technologies (marker assisted selection/quantitative trait loci-MAS/QTL).
4. Study on growth performance of wild and generation maintained IMCs
5. Study the impact of development and dissemination of genetically improved stocks

Biodiversity issues

- Aquatic biodiversity needs to be characterized and protected.
- Population genetics of many key species require closer examination.

- Interactions of wild and domesticated species need more detailed study, including modelling.
- There should be an intensification of live, frozen and molecular gene banking efforts strongly linked to in-situ conservation.
- More research is needed in the area of effective sterilization techniques for domesticated and genetically improved aquatic organisms.
- There is a need for greater controls of transboundary movements of aquatic genetic material, and development of more efficient containment systems.
- Research on genetically improved aquatic organisms should continue because of their potential benefits; however, much greater understanding of potential environmental impacts is necessary.
- Linkages should be formed among the general public, organizations, scientists, industry and governments to address genetic issues and to support the development of practical regulation and sound policy.
- Dissemination of genetically improved aquatic organisms for aquaculture should only be carried out within the framework of adequate regulations and policy.
- National breeding plan should be implemented with periodical review.

7.5.7 References

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Annexure 1: Terms of References (ToR)

DEPARTMENT OF FISHERIES

AGRICULTURE SECTOR PROGRAMME SUPPORT –II

Regional Fisheries and Livestock Development Component

Strengthening Institutional Capacity of DoF Project

Terms of Reference:

Fish Genetics Specialist

1. Background

The Government of Bangladesh implemented and Danida-supported Agricultural Sector Support Programme (ASPS II) was initiated in October 2006 with a timeframe of five years. The programme covers the crops, fisheries, livestock and rural road sub-sectors, with extensive field activities implemented through relevant line departments and coordinated by three institutional support units located in the Ministry of Planning, the Ministry of Agriculture, and the Ministry of Fisheries and Livestock. The development objective of ASPS II is "Improved living conditions of poor marginal and small farmer households through enhanced, integrated and sustainable agricultural productivity".

The Regional Fisheries and Livestock Development Component of the programme has four outputs to achieve the immediate objective:

> *Improved and sustainable productivity of and returns from fisheries and livestock systems of resource-poor households*

The component has Support Units in Department of Fisheries and Department of Livestock Services, and Technical Support Units located in Noakhali and Patuakhali for field based activities.

The Support Unit at the Department of Fisheries supports the department in implementing activities under Output 5 of the Programme:

> *Capacity of Department of Fisheries and Department of Livestock Services to deliver public goods (supporting legislative and regulatory framework, quality control of inputs and products, disease control, relevant research, monitoring) enhanced*

The main activities are: rehabilitation and extension of the department's management information system; human resources development; improvement of seed quality, certification and traceability in the shrimp culture sector; community based fisheries management, review of the National Fisheries Policy, implementation of the National Fisheries Strategy, studies and research.

Seed quality has been recognized as a major problem for increased production and profitability in aquaculture in Bangladesh. Fourth Fisheries Project and other interventions by the Department of Fisheries, have addressed the issue. A brood stock management plan was developed and is under implementation. However, additional support is required, which is a major activity of the support unit of the Department of Fisheries. The unit will support the department in the implementation of its brood stock management plan and improvement of quality seed production from registered and certified hatcheries, which are identified in the National Fisheries Strategy. Support will be proved to piloting of a certification system. Training will be provided both for government staff and private hatchery operators. The immediate actions are the selection of three hatcheries for initial support, preparation of a plan for support, including training needs.

2. Objective

Improved seed quality in three hatcheries and a plan for extension of improved seed quality and certification of hatcheries

3. Outputs

1. An inception note describing the consultant's understanding of the assignment, approach and work plan with time and reporting schedules;
2. Long-term plan for seed quality improvement drafted and adopted by the Department of Fisheries;
3. Assisted improvement of seed quality at three selected hatcheries according to plan;
4. Guidelines for hatchery registration and certification;
5. Training plan formulation and implementation initiated; and
6. A detailed final report on the assignment.

4. Activities

The short term consultant will report to the Project Director of the Support Unit and work in close collaboration with the National and International Advisers and Department of Fisheries' Staff:

1. Review and document experiences from earlier and ongoing interventions for seed quality improvement and prepare training materials (texts, leaflets, posters, lecture notes etc.);
2. Preparation of a plan for support to three selected hatcheries, including training needs;
3. Prepare a draft longer term plan for seed quality improvement, including inputs to the human resources development plan;
4. Assist in organization of and reporting from a stakeholder workshop on the draft plan;
5. Finalization of the plan through small focus group consultations;
6. Initiate support to selected hatcheries;
7. Initiate training activities as per the plan;
8. Prepare audio-visuals for the training workshops and courses;
9. Deliver lectures to different training groups on genetic improvement methodologies;
10. Develop guidelines to establish fish seed certification system for private hatcheries; and
11. Develop protocols for maintaining genetic integrity (for best performance) of farm species.

5. Staffing and budget inputs

The short term consultant (either from a consultancy company or an independent consultant) will be contracted for a maximum of 6 months by the project Strengthening Institutional Capacity of DOF. Remuneration and other benefits will follow ASPS-II guidelines.

The Consultant will be paid monthly remuneration against an invoice after approved monthly activity by the appropriate authority.

As per Government of Bangladesh' procedures, VAT and Income tax will be deducted form the consultancy fee.

6. Timing frame

The assignment is for maximum 6 months staring from March 2008.

7. Qualifications

The incumbent shall have at least a post graduate degree in fisheries with specialization in fish genetics from a recognized university. He/she shall have extensive hand-on experience (at least 10 years) from work in the sectors. He/she shall be fluent in English and have solid analytical, writing and communication skills, be computer literate and be a positive team player with a high level of integrity. He/she shall have documented ability to take initiatives and work independently. Experiences from working with international organizations and/or donor funded projects and the organization of and reporting from workshops/conferences are definite advantages.

9. AUTHORIZATION

Prepared by:

_____	_____
(Nasiruddin Md. Humayun)	Arne C I Andreasson
Project Director	Senior Adviser

Date:_____

Annexure 2.

Format for baseline information survey for improvement of quality seed production and broodstock management

1. Name of the District:

2. Name of the hatchery (Carp/Shrimp):

3. Name of the personnel:

(DFO/TFO/Farm Manager/Owner)

4. Location:

Thana: Post office: Union/Village:

5. Information of hatchery stocks (rearing fish):

Species (Carp/Shrimp-Galda)	Sources of spawns/broods	No. of matured broods	Size of broods		Spawn production (kg)/ year		
			Weight	Age	2006	2007	2008 (Target)
Rohu, Catla & Mrigal, Kalibaush, etc							
Exotic carps (Silver, Bighead etc.)							
Common carps							
Others							

6. Pond information:

Species (Carp/Shrimp)	No. of brood ponds	Size of ponds/area (dec.)	Age of ponds (year)	Duration of brood fish rearing per year		
				12 months	6 months	4 months
Rohu, Catla & Mrigal, Kalibaush, etc						
Exotic carps (Silver, Bighead etc.)						
Common carps						
Others						

7. Breeding system practicing:

(Among stock/between stocks/selective breeding)

i)

ii)

iii)

8. Existing problems in your hatchery:

i)

ii)

iii)

iv)

9. Problems facing for quality seeds/broods:

i)

ii)

iii)

iv)

10. Suggestions for improvement of quality seeds/broods:

i)

ii)

iii)

iv)

11. Suggestions for brood bank (Government/Private) establishment:

i)

ii)

iii)

iv)

12. Comments (if any):

Annexure 3

The Aquaculture Products Export Development Authority
(Ministry of Fisheries & Livestock, Government of Bangladesh)

SEED SPECIFICATIONS

Sl. No.	Parameter	Standard
1	Colour	Silvery colour
2	Activity	Actively swimming
3	Feeding	Readily accept and eat feeds
4	Gut.	Full gut
5	Stress test survival	Above 80 %.
6	Fouling organisms	Less than 20 %.

Annexure 4

6.1. Dhaka Division
6.1. A. Program Routine

Routine

Date and Time	Subject	Trainer
Day-1: 28 April, 2008 8:45-9:00	Registration	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project, DoF
9:00-10:00	Course Instruction & Pre-assessment test	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project, DoF
10:00-11:00	Introduction to Fish Genetics in context to our cultured species and hatchery practices	Dr. M. G. Hussain, Director, BFRI, Mymensingh
11:00-11:15	**Tea Break**	
11:15-12:15	Main cultured fish species of Bangladesh and their genetic status	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
12:15-13:15	Carp breeding grounds and spawn collection centers of Bangladesh	Dr. A. K. Yousuf Haroon, National Adviser, SICD Project
13:15-14:15	**Prayer & Lunch Break**	
14:15-15:15	Existing practices in the carp hatcheries	Mr. M. A. Khaleque, Principal Scientific Officer, Matshya Bhaban, Ramna, Dhaka
15:15-16:15	Brood selection criteria and choice of various inducing agents	Prof. Dr. M. F. A. Mollah, Dept. of Fisheries Biology & Genetics, BAU
16:15-16:30	**Tea Break**	
16:30-17:30	Group work & Presentation	i. Mr. Nasiruddin Md. Humayun, Project Director, SICD Project ii. Dr. A. K. Yousuf Haroon, National Adviser, SICD Project
Day-2: 29 April, 2008 8:45-9:00	Review	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
9:00-10:00	Genetic deterioration (Inbreeding, Genetic drift)	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
10:00-11:00	Genetic deterioration (Negative selection, Hazardous hybridization & others)	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
11:00-11:15	**Tea Break**	
11:15-12:15	Improvement of genetic diversity of cultured stocks (Linebreeding & Generation maintaining)	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
12:15-13:15	Pedigree recording	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
13:15-14:15	**Prayer & Lunch Break**	
14:15-15:15	Recent developments (Sex reversal & Monosex tilapia)	Dr. M. G. Hussain, Director, BFRI, Mymensingh
15:15-16:15	Recent developments (Gynogenesis, Androgenesis & Chromosomal manipulation)	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
16:15-16:30	**Tea Break**	
16:30-17:30	Group work & Presentation	Dr. A. K. Yousuf Haroon, National Adviser, SICD Project

Day-3: **30 April, 2008** 8:45-9:00	Review	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
9:00-10:45	Genetic resource conservation (Ex-situ & In-situ conservation) and Cryopreservation (Fish gene banking)	Prof. Dr. M. R. I. Sarder, Dept. of Fish. Biology & Genetics, BAU
10:45-11:00	**Tea Break**	
11:00-13:00	Post-assessment test and Course Evaluation	a. Dr. A. K. Yousuf Haroon, National Adviser, SICD Project b. Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
13:00-14:15	**Prayer & Lunch Break**	
14:15-16:00	Certificate distribution & Closing	i. Dr. A. K. Yousuf Haroon, National Adviser, SICD Project ii. Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project

6.2. Rajshahi Division

6.2. A. Program Routine

Routine

Date and Time	Subject	Trainer
Day-1: **06 May, 2008** 8:45-9:00	Registration	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project, DoF
9:00-10:00	Course Instruction & Pre-assessment test	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project, DoF
10:00-11:00	Introduction to Fish Genetics in context to our cultured species and hatchery practices	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project, DoF
11:00-11:15	**Tea Break**	
11:15-12:15	Main cultured fish species of Bangladesh and their genetic status	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
12:15-13:15	Carp breeding grounds and spawn collection centers of Bangladesh	Dr. A. K. Yousuf Haroon, National Adviser, SICD Project
13:15-14:15	**Prayer & Lunch Break**	
14:15-15:15	Existing practices in the carp hatcheries	Mr. Ruhul Amin, Farm Manager, Fish Seed Multiplication Farm, Puthia, Rajshahi
15:15-16:15	Brood selection criteria and choice of various inducing agents	Dr. A. K. Yousuf Haroon, National Adviser, SICD Project
16:15-16:30	**Tea Break**	
16:30-17:30	Group work & Presentation	i. Mr. Nasiruddin Md. Humayun, Project Director, SICD Project ii. Dr. A. K. Yousuf Haroon, National Adviser, SICD Project
Day-2: **07 May, 2008** 8:45-9:00	Review	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
9:00-10:00	Genetic deterioration (Inbreeding, Genetic drift)	Dr. Abul Hasanat, Project Director, Brood Bank Establishment Project, DoF

11:00-11:15	**Tea Break**	
11:15-12:15	Improvement of genetic diversity of cultured stocks (Linebreeding & Generation maintaining)	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
12:15-13:15	Pedigree recording	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
13:15-14:15	**Prayer & Lunch Break**	
14:15-15:15	Recent developments (Sex reversal & Monosex tilapia)	Mr. Md. Showkat Ali, Deputi Director, Department of Fisheries, Rajshahi Division, Rajshahi
15:15-16:15	Recent developments (Gynogenesis, Androgenesis & Chromosomal manipulation)	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
16:15-16:30	**Tea Break**	
16:30-17:30	Group work & Presentation	Dr. A. K. Yousuf Haroon, National Adviser, SICD Project
Day-3: 08 May, 2008 8:45-9:00	Review	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
9:00-10:45	Genetic resource conservation (Ex-situ & In-situ conservation) and Cryopreservation (Fish gene banking)	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
10:45-11:00	**Tea Break**	
11:00-13:00	Post-assessment test and Course Evaluation	a. Dr. A. K. Yousuf Haroon, National Adviser, SICD Project b. Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
13:00-14:15	**Prayer & Lunch Break**	
14:15-16:00	Certificate distribution & Closing	a. Dr. A. K. Yousuf Haroon, National Adviser, SICD Project b.Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project

6.3. Khulna Division

6.3. A. Program Routine

Routine

Date and Time	Subject	Trainer
Day-1: 13 May, 2008 8:45-9:00	Registration	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project, DoF
9:00-10:00	Course Instruction & Pre-assessment test	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project, DoF
10:00-11:00	Introduction to Fish Genetics in context to our cultured species and hatchery practices	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project, DoF
11:00-11:15	**Tea Break**	
11:15-12:15	Main cultured fish species of Bangladesh and their genetic status	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
12:15-13:15	Carp breeding grounds and spawn collection centers of Bangladesh	Dr. A. K. Yousuf Haroon, National Adviser, SICD Project
13:15-14:15	**Prayer & Lunch Break**	

14:15-15:15	Existing practices in the carp hatcheries	Mr. Mohammad Shahidul Islam, HRD Specialist, SICD project, DoF
15:15-16:15	Brood selection criteria and choice of various inducing agents	Dr. A. K. Yousuf Haroon, National Adviser, SICD Project
16:15-16:30	**Tea Break**	
16:30-17:30	Group work & Presentation	i. Mr. Nasiruddin Md. Humayun, Project Director, SICD Project ii. Dr. A. K. Yousuf Haroon, National Adviser, SICD Project
Day-2: 14 May, 2008 8:45-9:00	Review	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
9:00-10:00	Genetic deterioration (Inbreeding, Genetic drift)	Dr. Abul Hasanat, Project Director, Brood Bank Establishment Project, DoF
10:00-11:00	Genetic deterioration (Negative selection, Hazardous hybridization & others)	Dr. Abul Hasanat, Project Director, Brood Bank Establishment Project, DoF
11:00-11:15	**Tea Break**	
11:15-12:15	Improvement of genetic diversity of cultured stocks (Linebreeding & Generation maintaining)	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
12:15-13:15	Pedigree recording	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
13:15-14:15	**Prayer & Lunch Break**	
14:15-15:15	Recent developments (Sex reversal & Monosex tilapia)	Mr. Joydeb Kumar Biswas, Deputi Director, Department of Fisheries, Khulna Division, Khulna
15:15-16:15	Recent developments (Gynogenesis, Androgenesis & Chromosomal manipulation)	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
16:15-16:30	**Tea Break**	
16:30-17:30	Group work & Presentation	Dr. A. K. Yousuf Haroon, National Adviser, SICD Project
Day-3: 15 May, 2008 8:45-9:00	Review	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
9:00-10:45	Genetic resource conservation (Ex-situ & In-situ conservation) and Cryopreservation (Fish gene banking)	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
10:45-11:00	**Tea Break**	
11:00-13:00	Post-assessment test and Course Evaluation	b. Dr. A. K. Yousuf Haroon, National Adviser, SICD Project b. Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
13:00-14:15	**Prayer & Lunch Break**	
14:15-16:00	Certificate distribution & Closing	a. Dr. A. K. Yousuf Haroon, National Adviser, SICD Project b.Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project

6.4. Barisal Division

6.4. A. Training Routine

Routine

Date and Time	Subject	Trainer
Day-1: 26 May, 2008 8:45-9:00	Registration	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project, DoF
9:00-10:00	Course Instruction & Pre-assessment test	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project, DoF
10:00-11:00	Introduction to Fish Genetics in context to our cultured species and hatchery practices	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project, DoF
11:00-11:15	**Tea Break**	
11:15-12:15	Main cultured fish species of Bangladesh and their genetic status	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
12:15-13:15	Carp breeding grounds and spawn collection centers of Bangladesh	Mr. Mohammad Shahidul Islam, HRD Specialist, SICD project, DoF
13:15-14:15	**Prayer & Lunch Break**	
14:15-15:15	Existing practices in the carp hatcheries	Mr. Ramesh Chandra Mandal, Principal, Fisheries Training Institute, DoF, Faridpur
15:15-16:15	Brood selection criteria and choice of various inducing agents	Mr. Mohammad Shahidul Islam, HRD Specialist, SICD project, DoF
16:15-16:30	**Tea Break**	
Date and Time	**Subject**	**Trainer**
16:30-17:30	Group work & Presentation	i. Mr. Nasiruddin Md. Humayun, Project Director, SICD Project ii. Dr. A. K. Yousuf Haroon, National Adviser, SICD Project
Day-2: 27 May, 2008 8:45-9:00	Review	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
9:00-10:00	Genetic deterioration (Inbreeding, Genetic drift)	Dr. Abul Hasanat, Project Director, Brood Bank Establishment Project, DoF
10:00-11:00	Genetic deterioration (Negative selection, Hazardous hybridization & others)	Dr. Abul Hasanat, Project Director, Brood Bank Establishment Project, DoF
11:00-11:15	**Tea Break**	
11:15-12:15	Improvement of genetic diversity of cultured stocks (Linebreeding & Generation maintaining)	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
12:15-13:15	Pedigree recording	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
13:15-14:15	**Prayer & Lunch Break**	
14:15-15:15	Recent developments (Sex reversal & Monosex tilapia)	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
15:15-16:15	Recent developments (Gynogenesis, Androgenesis & Chromosomal manipulation)	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
16:15-16:30	**Tea Break**	
16:30-17:30	Group work & Presentation	Mr. Mohammad Shahidul Islam, HRD Specialist, SICD project, DoF

Day-3: **28 May, 2008** 8:45-9:00	Review	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
9:00-10:45	Genetic resource conservation (Ex-situ & In-situ conservation) and Cryopreservation (Fish gene banking)	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
10:45-11:00	**Tea Break**	
11:00-13:00	Post-assessment test and Course Evaluation	a.Mr. Mohammad Shahidul Islam, HRD Specialist, SICD project, DoF b. Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
13:00-14:15	**Prayer & Lunch Break**	
14:15-16:00	Certificate distribution & Closing	a Mr. Mohammad Shahidul Islam, HRD Specialist, SICD project, DoF b.Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project

6.5. Sylhet Division
6.5. A. Training Routine

Routine

Date and Time	Subject	Trainer
Day-1: **04 June, 2008** 8:45-9:00	Registration	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project, DoF
9:00-10:00	Course Instruction & Pre-assessment test	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project, DoF
10:00-11:00	Introduction to Fish Genetics in context to our cultured species and hatchery practices	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project, DoF
11:00-11:15	**Tea Break**	
11:15-12:15	Main cultured fish species of Bangladesh and their genetic status	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
12:15-13:15	Carp breeding grounds and spawn collection centers of Bangladesh	Mr. Mohammad Shahidul Islam HRD Specialist, SICD Project DoF
13:15-14:15	**Prayer & Lunch Break**	
14:15-15:15	Existing practices in the carp hatcheries	Mr. Md. Serajuddin District Fisheries Officer DoF, Sylhet
15:15-16:15	Brood selection criteria and choice of various inducing agents	Mr. Mohammad Shahidul Islam HRD Specialist, SICD Project DoF
16:15-16:30	**Tea Break**	
16:30-17:30	Group work & Presentation	i. Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project, DoF ii. Mr. Mohammad Shahidul Islam HRD Specialist, SICD Project DoF
Day-2: **05 June, 2008** 8:45-9:00	Review	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
9:00-10:00	Genetic deterioration (Inbreeding, Genetic drift)	Dr. Abul Hasnat, Project Director, Brood Bank Establishment Project, DoF

Date and Time	Subject	Trainer
10:00-11:00	Genetic deterioration (Negative selection, Hazardous hybridization & others)	Dr. Abul Hasnat, Project Director, Brood Bank Establishment Project, DoF
11:00-11:15	**Tea Break**	
11:15-12:15	Improvement of genetic diversity of cultured stocks (Line breeding & Generation maintaining)	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
12:15-13:15	Pedigree recording	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
13:15-14:15	**Prayer & Lunch Break**	
14:15-15:15	Recent developments (Sex reversal & Monosex tilapia)	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
15:15-16:15	Recent developments (Gynogenesis, Androgenesis & Chromosomal manipulation)	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
16:15-16:30	**Tea Break**	
16:30-17:30	Group work & Presentation	Mr. Mohammad Shahidul Islam HRD Specialist, SICD Project DoF
Day-3: 06 June, 2008 8:45-9:00	Review	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
9:00-10:45	Genetic resource conservation (Ex-situ & In-situ conservation) and Cryopreservation (Fish gene banking)	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
10:45-11:00	**Tea Break**	
11:00-13:00	Post-assessment test and Course Evaluation	Mr. Mohammad Shahidul Islam HRD Specialist, SICD Project DoF Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
13:00-14:15	**Prayer & Lunch Break**	
14:15-16:00	Certificate distribution & Closing	i. Mr. Mohammad Shahidul Islam HRD Specialist, SICD Project DoF ii. Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project

6.6. Chittagong Division

6.6. A. Training Routine

Routine

Date and Time	Subject	Trainer
Day-1: 22 June, 2008 8:45-9:00	Registration	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project, DoF
9:00-10:00	Course Instruction & Pre-assessment test	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project, DoF
10:00-11:00	Introduction to Fish Genetics in context to our cultured species and hatchery practices	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project, DoF
11:00-11:15	**Tea Break**	
11:15-12:15	Main cultured fish species of Bangladesh and their genetic status	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
12:15-13:15	Carp breeding grounds and spawn collection centers of Bangladesh	Dr. A. K. Yousuf Haroon, National Adviser, SICD Project

13:15-14:15	**Prayer & Lunch Break**	
14:15-15:15	Existing practices in the carp hatcheries	Mr. Md. Yeasin, Farm Manager, Fisg seed Multiplication Farm, Jangalia, Comilla
15:15-16:15	Brood selection criteria and choice of various inducing agents	Dr. A. K. Yousuf Haroon, National Adviser, SICD Project
16:15-16:30	**Tea Break**	
16:30-17:30	Group work & Presentation	i. Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project ii. Dr. A. K. Yousuf Haroon, National Adviser, SICD Project
Day-2: 23 June, 2008 8:45-9:00	Review	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
9:00-10:00	Genetic deterioration (Inbreeding, Genetic drift)	Dr. Abul Hasanat, Project Director, Brood Bank Establishment Project, DoF
10:00-11:00	Genetic deterioration (Negative selection, Hazardous hybridization & others)	Dr. Abul Hasanat, Project Director, Brood Bank Establishment Project, DoF
11:00-11:15	**Tea Break**	
11:15-12:15	Improvement of genetic diversity of cultured stocks (Linebreeding & Generation maintaining)	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
12:15-13:15	Pedigree recording	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
13:15-14:15	**Prayer & Lunch Break**	
14:15-15:15	Recent developments (Sex reversal & Monosex tilapia)	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
15:15-16:15	Recent developments (Gynogenesis, Androgenesis & Chromosomal manipulation)	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
16:15-16:30	**Tea Break**	
16:30-17:30	Group work & Presentation	Dr. A. K. Yousuf Haroon, National Adviser, SICD Project
Day-3: 28 May, 2008 8:45-9:00	Review	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
9:00-10:45	Genetic resource conservation (Ex-situ & In-situ conservation) and Cryopreservation (Fish gene banking)	Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
10:45-11:00	**Tea Break**	
11:00-13:00	Post-assessment test and Course Evaluation	a.Mr. Mohammad Shahidul Islam, HRD Specialist, SICD project, DoF b. Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project
13:00-14:15	**Prayer & Lunch Break**	
14:15-16:00	Certificate distribution & Closing	a Dr. A. K. Yousuf Haroon, National Adviser, SICD Project b.Dr. M. M. R. Khan, Fish Genetics Specialist, SICD Project