PART 1

PROCEEDINGS AND RECOMMENDATIONS OF THE FAO EXPERT WORKSHOP ON FRESHWATER FISH SEED RESOURCES FOR SUSTAINABLE AQUACULTURE

Officials and experts participating at the FAO Expert Workshop on Freshwater Fish Seed Resources for Sustainable Aquaculture held at the Freshwater Fisheries Research Center in Wuxi, China from 23 to 26 March 2006

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1. Background

Land, water, seed and feed constitute four of the most important resources to aquaculture outside human and technological resources. Efficient use of these resources are necessary to guarantee optimum production from aquaculture. Availability of quality fish seed is a pre-requisite for adoption of sustainable aquaculture especially for smallholders.

A number of regional and international events have highlighted some of the most pressing issues concerning seed in global aquaculture development.

The proceedings of a special session on "Rural Aquaculture" convened during the Fifth Asian Fisheries Forum, International Conference on Fisheries and Food Security Beyond the Year 2000, held in November 1998 in Chiang Mai, Thailand, Edwards *et al.* (2002)[1] identified seed as one of the five major issues affecting rural aquaculture development and considered two aspects: (a) role of the private sector and (b) types of hatcheries (i.e. large, centralized government or small, decentralized hatcheries – which need further consideration in seed production. As part of the same publication, Little *et al*. (2001)[2] reported poor quality seed as a major constraint to the success of fish culture, especially for new entrant farmers and poorer smallholders.

Regional reviews (Asia, Africa and Latin America) from the Conference on Aquaculture in the Third Millemium (NACA/FAO 2001)[3], held in Bangkok, Thailand in February 2000, recognized important issues concerning seed as a significant resource for aquaculture. In the Asian region, Kongkeo (2001)[4] emphasized that one of the technical constraints in Asian aquaculture is the inadequate and unreliable supply of quality fish seed. Machena and Moehl (2001)[5] identified the lack of fish seed as a serious restriction to aquaculture development in sub-Saharan African region. In Latin America, Hernandez-Rodriquez *et al.* (2001)[6] reported that for tilapia culture, maintenance of high genetic quality within the stock as well as development of disease-resistant strains are important issues for consideration as they adversely affect growth, harvest size and profitability. In general terms, broodstock and seed supply have been identified as representing a major constraint to production increases not only in terms of availability but also health management. Several major initiatives are underway to

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[1] Edwards, P., Little, D.C. & Demaine, H. 2002. Rural Aquaculture. UK: CABI Publishing. 385 pp.

[2] Little, D.C., Satapornvanit, A. & Edwards, P. 2002. Freshwater fish seed quality in Asia, pp. 185-195. In P. Edwards, D.C. Little & H. Demaine. Rural Aquaculture. UK: CABI Publishing. 385 pp.

[3] NACA/FAO. 2001. Aquaculture in the Third Millenium. Subasinghe, R.P., Bueno, P., Phillips, M.J., Hough, C., McGladdery, S.E. & Arthur, J.R. (eds). 2001. Technical Proceedings of the Conference on Aquaculture in the Third Millenium, Bangkok, Thailand, 20-25 February 2000. Bangkok, NACA and Rome, FAO. 471 pp.

[4] Kongkeo, H. 2001. Current status and development trends of aquaculture in the Asian Region. In R.P. Subasinghe, P. Bueno, M.J. Phillips, C. Hough, S.E. McGladdery & J.R. Arthur, eds. Aquaculture in the Third Millenium. Technical Proceedings of the Conference on Aquaculture in the Third Millenium, Bangkok, Thailand, 20-25 February 2000. pp. 267-293. Bangkok, NACA, and Rome, FAO.

[5] Machena, C., & Moehl, J. 2001. African Aquaculture: A regional summary with emphasis on Sub-saharan Africa. In R.P. Subasinghe, P. Bueno, M.J. Phillips, C. Hough, S.E. McGladdery & J.R. Arthur, eds. Aquaculture in the Third Millenium. Technical Proceedings of the Conference on Aquaculture in the Third Millenium, Bangkok, Thailand, 20-25 February 2000. pp. 341-356. Bangkok, NACA and Rome, FAO.

[6] Hernandez-Rodriguez, A., Alceste-Oliviero, C., Sanchez, R., Jory, D., Vidal, L. & Constain-Franco, L.-F. 2001. Aquaculture development trends in Latin America and the Caribbean. In R.P. Subasinghe, P. Bueno, M.J. Phillips, C. Hough, S.E. McGladdery & J.R. Arthur, eds. Aquaculture in the Third Millenium. Technical Proceedings of the Conference on Aquaculture in the Third Millenium, Bangkok, Thailand, 20-25 February 2000. pp. 317-340. Bangkok, NACA and Rome, FAO.

develop methods for the use of specific-pathogen-free (SPF) and high-health (HH) seed production. Such strategies involve domestication allowing the development of commercial breeding programmes for the establishment and maintenance of desirable traits. El-Gamal (2001)[7] in a review of the status and development trends of aquaculture in the Near East concluded that availability of seed is a crucial technological constraint to future development of aquaculture in the Near East region. In Egypt, insufficient numbers of tilapia fingerlings are produced in governmental hatcheries and do not match fish farm requirements. He concluded that promotion of aquaculture should not be made unless there is an assured supply of seed from hatchery sources. De Silva (2001)[8], in his global perspective of aquaculture in the new millenium, suggested that in culture-based fisheries one of the major limitations is the lack of suitably sized fingerlings for stocking due to inadequate hatchery technology, inadequate facilities for fry to fingerling rearing and distribution mechanisms.

During the ASEAN-SEAFDEC Conference on "Sustainable Fisheries for Food Security in the New Millenium" held in Bangkok in November 2001, Mair (2002)[9] identified four major elements affecting quality of seed resources for sustainable aquaculture. These are: (a) seasonality and inconsistency of seed supply; (b) inadequate support for seed production; (c) deterioration in quality of seed stocks and (d) impacts of releases of cultured seed stock.

The report of the second session of the Sub-Committee on Aquaculture (Norway, 2003) highlighted the lack of seed as an important issue in culture-based fisheries (Section xxii, para. 53) and which requires further work in order to promote this important sector of aquaculture (FAO, 2003)[10].

Most recently, the thirteenth session of the Committee for Inland Fisheries of Africa (CIFA) held from 27 to 30 October 2004 highlighted two important points: (a) lack of quality seed as one of the important factors limiting the contribution of aquaculture to food security and economic growth and (b) availability of strong and disease-free seed as one of the major constraints to aquaculture development in the region; that seed shortage represents the failure of government hatcheries to meet the expressed demand; noted the progressive involvement of the private sector to revive the seed production industry and the need for more private hatcheries with business orientation.

OUTLOOK AND PROSPECTS

The above-mentioned events have repeatedly highlighted the various issues surrounding seed as an important resource for sustainable aquaculture development. Factors affecting seed availability, seed quality, seed production technologies and support services, seed distribution networks, and etc. need to be understood well if resources are best to be targeted and policy decisions on future investment and management options improved. The development of breeding and hatchery technology, genetic improvement and domestication are additional key objectives for securing the seed supply for major aquaculture species.

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7 El Gamal, A.R. 2001. Status and development trends of aquaculture in the Near East. In R.P. Subasinghe, P. Bueno, M.J. Phillips, C. Hough, S.E. McGladdery & J.R. Arthur, eds. Aquaculture in the Third Millenium. Technical Proceedings of the Conference on Aquaculture in the Third Millenium, Bangkok, Thailand, 20-25 February 2000. pp. 357-376. Bangkok, NACA and Rome, FAO.

8 De Silva, S.S. 2001. A global perspective of aquaculture in the new millenium. In R.P. Subasinghe, P. Bueno, M.J. Phillips, C. Hough, S.E. McGladdery & J.R. Arthur, eds. Aquaculture in the Third Millenium. Technical Proceedings of the Conference on Aquaculture in the Third Millenium, Bangkok, Thailand, 20-25 February 2000. pp. 431-459 Bangkok, NACA and Rome, FAO.

9 Mair, G. 2002. Topical issues in genetic diversity and breeding: genes and fish: supply of good quality fish seed for sustainable aquaculture. Aquaculture Asia, VII(2): 25-27. Bangkok, Thailand, NACA.

10 FAO. 2003. Report of the Second Session of the Sub-Committee on Aquaculture, Trondheim, Norway, 7-11 August 2003. FAO Fisheries Report No. 716. Rome, FAO. 91 p.

2. Technical workshop

2.1 OBJECTIVE

The FAO Department of Fisheries and Aquaculture conducted a global analysis of the freshwater seed sector through a number of country case studies, regional syntheses and thematic reviews, the outcomes of which were presented during the FAO Expert Workshop on Freshwater Fish Seed Resources for Sustainable Aquaculture held in Wuxi, China from 23 to 26 March 2006. The objectives of the expert workshop were to analyze the current status of the freshwater seed sector used in aquaculture with special emphasis on rural aquaculture and to evaluate the current constraints and challenges faced by the sector as basis for identifying measures and generating action that will contribute to the sustainable development of this sector.

2.2 STRUCTURE AND PROCESS

The expert workshop was hosted by the Freshwater Fisheries Research Center (FFRC) of the Chinese Academy of Fisheries Sciences (CAFS) in Wuxi, China. The Opening Ceremony was graced by Mrs Wei Shaofen, Director of the Jiangsi Bureau of Marine (Annex 4.1) and Fisheries and Prof Xu Pao, Director of the FFRC/CAFS (Annex 4.2). FFRC Deputy Director Miao Weimin ably chaired the sessions.

Twenty-one experts (Annex 4.3) on freshwater aquaculture, genetics, health, rural aquaculture and aquabusiness from national institutions, universities and private sector from Australia, Bangladesh, Cambodia, China PR, Egypt, India, Indonesia, Mexico, the Philippines, Sri Lanka, Thailand, Viet Nam and the United Kingdom participated in the workshop; co-authors of the different presentations and country case studies participated remotely and provided additional information requirements that were also used during the workshop. The Workshop was facilitated by 3 FAO officers (MB Reantaso, MR Hasan and S FungeSmith).

The four-day Expert Workshop (Annex 4.4) consisted of plenary presentations of six selected country case studies (China, India, Cambodia, Viet Nam, Mexico, Egypt), three regional syntheses (Asia, Africa and Latin America), five thematic reviews (seed quality, genetics and breeding in seed supply for inland aquaculture, seed networks and entrepreneurship, role of seed supply and technology in rural aquaculture and farmer innovations and women involvement in seed production), and four invited presentations (self-recruiting species, decentralised seed networking in Bangladesh, establishment of national broodstock centres in Viet Nam, and private sector involvement in seed production and distribution).

Following the plenary technical presentations, the participants were divided into three Working Groups to deliberate on the following themes based on the Working Group guidelines:

Theme 1: Seed Quality, Genetics, Technology and Certification;
Theme 2: Seed Networking, Distribution, Entrepreneurship and Certification; and
Theme 3: How Rural Fish farmers Can Benefit from the Freshwater Aquaseed Sector.

The outcomes of the Working Group discussions were presented in plenary.

2.3 WORKING GROUP GUIDELINES

The Working Groups were requested to:

- analyse the current status of the freshwater seed sector used in aquaculture, with special emphasis on rural aquaculture;
- evaluate the current constraints and challenges faced by the sector as basis for identifying measures and generating action that will contribute to its further development;
- this will be done in due recognition of variability between regions with respect to farming systems and practices.

Key outputs from the Working Group include:

- several key recommendations to FAO for action;
- appropriate actions to address the following issues affecting the freshwater seed sector:
  - policy guidelines for the national governments/NGOs/international agencies/donors;
  - further studies and research;
  - extension and application/adoption;
  - capacity building;
  - roles of state and private sector, partnerships between private and public sectors.

3. Working Group findings and recommendations

3.1 WORKING GROUP 1: KEY ISSUES CONCERNING SEED QUALITY, GENETICS, TECHNOLOGY AND CERTIFICATION [11]

Working Group 1 Members

Rapporteur/Facilitator: Dr Simon Funge-Smith

- Dr Nguyen Cong Dan
- Dr Kamchai Lawonyawut
- Dr Graham Mair
- Dr C.V. Mohan
- Dr Magdy Saleh
- Dr Md. Rafiqul Islam Sarder
- Mr Miao Weimin

What do we mean by 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. "Seed" can mean eggs, milt fry, fingerlings or nursed animals. 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. There are marked differences in priority and importance of quality criteria according to the systems for which they are intended (e.g. intensive system of small-farmer, extensive systems). There are also specific differences between the major aquaculture groups such as finfish, crustaceans and molluscs, this will inevitably mean that certification system for quality assurance will need to be done with specific relevance to parts of the sector and in consultation with the producers and hatchery operators. The parameters for quality assurance may include the following:

(i) Conforms to market needs, e.g.
- colour
- body shape (meat yield)
- safe (free of human disease causing organisms)

(ii) Meets producers needs and expectations, e.g.
- uniformity of size and age
- fast growing
- consistency
- genetic potential
- purity
- minimizes risk to the farmer, e.g.
  - high survival
  - disease resistance
  - healthy (nutritionally fit and free of disease)

[11] Working Group 1 findings and recommendations were put together by G. Mair.

How do we achieve quality seed?

The Working Group discussed what were the important features of good quality seed and what factors would influence good quality. The group concluded that there were two main categories that were related to seed quality. These were:

(1) Genetic quality which concerns the following aspects: (i) genetic management of domesticated stocks, (ii) development of improved broodstock, (iii) availability of good quality broodstock and (iv) access to good quality broodstock

(2) Good hatchery and/or nursery management which concerns the following aspects: (i) good nutrition of broodstock, larvae and fry, (ii) good record keeping, (iii) bio-security, (iv) financing, (v) disease control, (vi) standardization of protocols, (vii) implementing of technology (e.g. 3n and monosex), (viii) human resource capacity (training, skills development) and (ix) knowledge base/ information resources.

Tables 3.1.1 to 3.1.3 describe different seed quality features as they relate to threat and opportunities Table 3.1.1), scoring and ease of assessment of overall quality (Table 3.1.2) and monitoring points (Table 3.1.3).

Certification of seed quality

A certification system for seed production can cover the following four areas:

- assurance that the genetic status of the seed is correct;
- assurance that the seed has been produced under appropriate husbandry conditions;
- handling and transportation of the seed;
- 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 the broodstock provider. In this case, the seed itself is not certified but the hatchery and/or the broodstock provider is certified or accredited. Certified hatcheries are those hatcheries which adhere 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 or verified quality broodstock. Monitoring for certification can take place during several stages of seed production through third party monitoring, self-monitoring and record keeping).

The quality features that are monitored relate principally to whether the product is to be certified or the production operation is to be certified (or accredited). The quality checks at point of sale (POS) serve as guidelines to the buyers, although they can be used as part of the monitoring process (when used in conjunction with records relating to the production process). This gives some indication of the quality of the production process, but cannot be used to establish the genetic quality features or traits.

Point of sale checks

The final 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 can be divided into those which are possible to be undertaken at POS and those which are possible through light microscopy. These features include:

- regular size (uniform sizes);
- free from fouling or external parasites/fungi, etc.;
- no obvious external damage;
- no obvious deformities;
- full gut (evidence that the animal is feeding);
- body shape (evidence of good feeding, not overlarge head, muscle wasting, etc.);
- free of specific disease (that can be tested using rapid methods, e.g. light microscopy on fresh tissue smears, gene probe or PCR test kit);

TABLE 3.1.1
Table of seed quality features and the issues that relate to them in terms of threat to the operation or opportunity to improve the product (Number of + refers to order of importance)

Quality factor (of seed)	Genetic Factors	Seed husbandry/ process including transport	Threat to producer	Opportunity to producer	Strategy to ensure/mitigate against result
Features that are mainly related to the genetic quality of the stock or genetic management of the stock					
Colour	++++++			Exploit colour preference in market	Use correct species or strain or breed for desired colour
Genetic purity[12]	++++++		Introgression, poor performance, reduced yields		Good broodstock management; Control hybridisation
Shape (conformity)	+++++	+		Exploit shape preference in market	Use correct species, strain or breed for desired shape
Sterility	+++++	+	Unwanted reproduction and environmental impact	Enhanced growth, environmental safety, better meat yield	Develop and apply triploidy by direct induction or 4n x 2n, also hormonal sterilization in common carp
Growth potential	++++	++	Poor performance = higher costs (e.g. high FCR), lower value, late harvest	Good performance = lower costs (e.g. lower FCR), higher value, early harvest	Responds well to strain selection & selective breeding
Disease resistance and/or immunity	++++	++	Poor survival, poor quality, need for treatment (use of chemicals)		Breed for disease resistance and utilize immune-prophylactic practices (e.g. disease challenges, vaccination, immunostimulation)
Advanced maturation	++++	++	Reduced growth after maturation, unwanted reproduction and recruitment	Early availability of over-wintered seed	Selection for late maturation, early or late season spawning of broodstock, stunting of seed by overstocking
Features that more or less equally influenced by genetic quality and management of the hatchery production process (depending upon species or method)					
Deformity	+++	+++	Poor performance, low marketability		Use good lines, avoid inbreeding. Good husbandry, nutrition, DO, etc.
Environmental tolerances	+++	+++	Mortality at stocking or later	Can culture in different environments	Selection for increased environmental tolerance and appropriate acclimation (e.g. temp, DO, salinity)
Monosex	+++	+++	Not monosex = variable growth, recruitment etc.		e.g. hormones, temperature treatments, breeding
Features which are principally influenced by the hatchery production process					
Uniformity of size and age	+	+++++	Cannibalism, differential growth, regular grading	Reduced management costs and improved efficiency & more marketable product	Grading, avoid mixing batches, good feeding, maintain optimum temperature
Disease status	+	+++++	Poor survival, poor growth, disease transmission, need for treatment (use of chemicals)		Provide better biosecurity (e.g. broodstock, seed , hatchery free of notifiable pathogens, hygienic practices)
Nutritional health	+	+++++	Poor survival, poor growth, deformities		Ensure/provide good larval and juvenile nutrition
Weaning off live feed onto artificial diet	+	+++++	Mortality of unweaned stock or costs of live feeds, poor marketability		Good management
Transportation and handling stress	+	+++++	Transit mortality, reduced survival at stocking and poor disease resistance		Optimize transportation condition (conditioning, packing, density, temperature, DO, etc.)
Species/strain purity/hybrids		++++++	Poor or unexpected performance, predation, lower stocking densities, reduced yields		Good broodstock management, screening of hatchery ponds, etc.

[12] To ensure that stock is genetically pure, i.e. for pure species/stocks that they are not introgressed with other species/stocks or that hybrids are indeed F1 hybrids between target parental species

– fish weaned onto pellet feeds (this can usually be observed in the hatchery);
– swimming behaviour.

Scoring of quality features for ease of monitoring and degree of importance on overall seed quality

Table 3.1.2 shows possible scoring to determine the relative ease of assessment for a number of quality features of seed at two levels, i.e. hatchery and point of sale.

Hatchery production process monitoring

A second 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. These would be more comprehensive and cover issues such as health and internal physical characteristics, e.g.:

– freedom from specific diseases (through microscopy, gene probe, etc.);
– normal pathology of major organs (gut, liver, etc.);
– evidence from records of appropriate genetic management of broodstock;
– evidence from records that the broodstock originated from a certified supplier;
– records that the hatchery activities follow a code of practice or better management protocols (BMPs) (particularly if a specific technical intervention is used such as sex reversal or vaccination).

For process monitoring of hatchery production, the existence of protocols or BMPs can be used as basis for hatchery certification. Hatcheries that source their broodstock from accredited suppliers are also easier to certify in terms of the genetic quality of their animals. The requirement for record keeping is important in this situation, since this would be an important part of the monitoring process that would enable the renewal of certificates.

TABLE 3.1.2

Possible scoring for quality features, ease of assessment of overall seed quality (Number of + relate to relative ease of assessment of quality traits via process monitoring or monitoring seed at the point of sale)

Quality features (of seed)	Relative ease of assessment		Main control point
	Process/ monitoring of hatchery	Seed at point of sale (POS)	Either Point of sale (POS) or Monitoring hatchery production process
Principally monitored during production and difficult to check at point of sale			
Monosex	+++	+	Monitoring hatchery production process
Sterility	+++	+	Monitoring hatchery production process
Weaning off live feed onto artificial diet	+++++	++	Monitoring hatchery production process
Species/strain purity[13]	++++	+	Monitoring hatchery production process
Genetic purity	+++	+	Monitoring hatchery production process
Growth potential	+++	+	Monitoring hatchery production process
Disease resistance/immunity	++++	+	Monitoring hatchery production process
Environmental tolerances	++	+	Monitoring hatchery production process
Advanced maturation	+++	+	Monitoring hatchery production process
Can be checked during production and also rechecked at point of sale			
Disease status	+++	+++	Both
Colour	++++	+++++	Both
Nutritional health	+++	+++	Both
Transportation and handling stress	++	++++	Both
Easily checked at point of sale			
Uniformity of size & age	+++++	++++++	POS
Deformity	++	++++	POS
Shape (conformity)	+	+++++	POS
Swimming behaviour			POS

[13] To ensure that species/stocks are not contaminated with individuals of other species/stocks

TABLE 3.1.3
Seed quality features and the critical monitoring points at which they could be applied

Quality feature	Critical process point within hatchery	Point of sale check?
Mainly related to broodstock genetics		
Species/strain purity	Evidence of broodstock source or broodstock certification. Feedback from buyers	Contaminants from fish that are visibly different can be detected
Sterility*	Feedback from buyers Verification of triploidy protocols	
Genetic purity*	Evidence of broodstock source OR Broodstock certification	
Colour*	Feedback from buyers	POS checklist. Readily detected in many cases
Shape (conformity)*	Feedback from buyers	POS checklist. Detectable in some cases
Growth potential*	Feedback from buyers	
Advanced maturation*	Feedback from buyers	
Broodstock genetics and hatchery production process		
Monosex*	Feedback from buyers Evidence of broodstock source OR Broodstock certification OR BMP of sex reversal.	
Environmental tolerances*	Record of acclimation process OR Evidence of broodstock source or broodstock certification	
Deformity*	Evidence of broodstock source OR Broodstock certification	POS checklist. Detectable in some cases
Disease resistance/ immunity*	Record of vaccination and/or use of immuno-stimulation	
Disease status	Records of monitoring of batch health	POS checklist External inspection detectable in some cases.
Nutritional health	Feed quality & feeding regime	POS checklist
Weaning off live feed onto artificial diet	Records on feeding	POS checklist. Detectable soon after POS.
Uniformity of size & age	Records on management and grading	POS checklist. Readily detectable.
Transportation & handling stress	Adherence to protocol	POS checklist

* indicates those quality features which could potentially be certified at the level of the broodstock if they were traits from breeding programs.

There are several quality features which are desired by the grow-out producer, but which can only be indicated by the genetic source and quality of the stock and cannot be monitored at the hatchery level. These features would only become apparent after the grow-out period.

There are a number of specific technical interventions which can be applied during the hatchery production process which are also difficult to monitor. Fish vaccination and the use of hormonal sex reversal techniques are two such examples.

In this case, the buyer has to trust that the hatchery has produced the seed with the desired quality features and this can be partly guaranteed by the hatchery being certified as adhering to specific good practices. The monitoring point for whether the hatchery has adhered to these protocols or practices is problematic. Typically, farmer feedback or monitoring at the grow-out level is the only way to determine if the product has reached the expected performance.

Farmer feedback may be in the form of complaints to the hatchery or to local government offices responsible for monitoring. The inevitable result of the supply of seed that does not perform as expected or advertised is subsequent purchase of seed from other hatcheries. Monitoring the genetics related performance of the stock is a critical aspect of the certification process for broodstock.

A few examples are presented below.

Monosex fish produced by hormone reversal. If the process is not undertaken properly, there will be an unacceptably high proportion of non-sex reversed animals. In this case, it is too late for the producer to do anything about it but would either seek compensation from the hatchery for the mistake or change to a different supplier.

Good genetic stock with good growth potential. This would only become apparent during grow-out. The farmer has little recourse to the hatchery if strain performance is unsatisfactory. The solution is usually to seek hatcheries that have a particular strain (branded strain) or purchase from a hatchery that is certified as having good genetic quality stock (or which is purchasing broodstock from an accredited supplier).

Vaccination of stock against specific disease. Typically this could be tested using gene probes but may be expensive and impractical. If the stock was affected by the disease against which it was supposed to have been vaccinated, this would be a strong indication that that there is a problem with that hatchery's vaccination process.

Certifying seed traders

The effect of traders on the quality of a product needs to be considered as transportation and handling issues. This relates to the actual POS with respect to the certification of seed. For some systems, this will be when the animal leaves the hatchery, but in other cases, hatcheries will deliver the seed to the farm or to the growers. Thus, the transport method is another part of the production and management chain that can be certified and subject to a "code of practice" or "better management practice" and would be certifiable. Either the hatchery is certified if it is transporting or seed traders are certified.

Other issues related to quality of hatchery produce seed

Stocking of open waters

This issue can be divided into two main concerns: (a) stocking of waters with species that are unable to breed in the environment in which they are placed and (b) stocking of species which are able to breed in the environment inn which they are placed.

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

For those species which are able to breed, there are three sub-issues relating to the likely impact of that breeding activity. These are:

- if the species stocked are able to breed but not with wild fish, there may be an issue of competition for niches (this is not an issue of seed quality but relates to the choice of species to be released);
- if the species are exotic, there maybe an issue with hybridization with indigenous species and subsequent loss of genetic diversity;
- 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.

There are clear examples where the genetic diversity of wild populations has been modified. Although the genetic effects of the release of hatchery-bred animals to the wild can be demonstrated in some cases where very large-scale releases have taken place, the actual effects on the populations and the fisheries for these animals are less clear.

A cautionary note here is that in the case where there is a programme of large-scale release of fish to the wild, then it is important to take the precaution that the genetic diversity of the fish to be stocked should reflect that of the wild population into which it is to be stocked. The stocking of open waters with domesticated stock or stock with

narrow genetic diversity should be discouraged if there is a likelihood that they will breed with local populations.

The costs of ensuring 'wild type diversity' for stocks to be released to open waters can be quite high. Therefore, stocking with a less diverse stock can be considered in the case where the diversity of the wild population has already been severely compromised as a result of loss of habitats or other environmental factors (or even due to long-term restocking programmes).

Recommendations on the identified issues

1. Broodstock genetics and broodstock supply are fundamental and need to be addressed at various levels including the promotion of basic genetic management of broodstock in all aquaculture systems and the conservation of wild genetic resources.
2. At national level, governments should promote public and private selective breeding as the core of genetic improvement programs of species for which sustainable aquaculture industries have developed (see fuller recommendation in Section 8.2 (Mair, 2007, this volume).
3. There is value in reviewing the models used for certification in the livestock sector (and possibly agriculture sector generally), for processes of developing certification systems for seed quality.
4. The benefits of hybridization are minimal and risks of introgression and contamination of domesticated and wild stocks are significant and hybridization should be avoided in seed production with specific exceptions (e.g. tilapia and *Clarias*).
5. Emerging genetic technologies such as transgenic fish, genetic use restriction technologies (GURTs) and marker assisted selection/quantitative trait loci (MAS/QTL) were not considered to be of current significance with respect to quality assurance but developments should be monitored. The use of these technologies would be covered under any certification or labelling system if they were introduced.
6. There is a need to continue investigation on indigenous species for their potential to be used in aquaculture or to be further domesticated. The closing of life cycles, maintenance of broodstock and development of economic hatchery systems for these species is a technical constraint.
7. Caution should be made in reintroducing broodstock from the wild due to potential loss of benefits of domestication selection and disease transmission.
8. There is a strong need for certification or accreditation of practices to validate seed quality at various levels:
   i. at the broodstock/genetic level
   ii. level of production
   iii. during transportation
   iv. point of sale
9. There is a need for assistance in the development of national broodstock certification programs (at national level) including provision of guidelines on development of national broodstock certification systems for public and/or private sector seed suppliers.
10. There is a need for the development of policies and legislation governing the production and supply of quality fish seed including incentives for private hatcheries (see also outcomes of Working Group 2).
11. There is a need for assistance on the development of guidelines for establishing standardized protocols for optimizing seed quality and hatchery certification at the national level. Certifying hatcheries for international trade may be necessary in cases where broodstock or seed are shipped between countries.

12. There is a need for regional multidisciplinary reviews of broodstock quality of key freshwater aquaculture species that have a high likelihood of international/regional transfer.
13. There is value in reviewing the potential impact of past and current culture-based fisheries on genetic diversity in wild stocks in major regional watersheds such as:
    i. risks of disease transmission
    ii. hybridization with indigenous species
    iii. genetic diversity of wild populations
14. Hatchery-based breeding for release to enhance fisheries should utilize indigenous (local) stock with large effective population sizes, to minimize potential negative impacts on wild populations.
15. There is a need for species and/or system-specific checklists for seed quality for use by purchasers at the point of sale.
16. It is necessary to investigate the potential for regional level sharing of knowledge on national broodstock management and genetic improvement schemes and the potential for improving these through intergovernmental organisations such as the International Network of Genetics in Aquaculture (INGA) or the Network of Aquaculture Centres in Asia-Pacific (NACA). Many national initiatives are not well known outside of the country and this information could also be made available through a web-based resource.

Recommendations to FAO

1. Assist member countries in the development of national broodstock certification programs (at national level) including provision of guidelines on development of national broodstock certification systems for public and/or private sector seed suppliers.
2. Support the development of guidelines for establishing standardization of protocols for optimizing seed quality and certifying hatcheries at national level.
3. Review the models used for certification in the livestock sector (and possibly agriculture sector generally), for processes of developing certification systems for seed quality.
4. Support the development of guidelines for establishing standardization of protocols for optimizing seed quality and certifying hatcheries at a national level.
5. Support regional multidisciplinary reviews of broodstock quality of key freshwater aquaculture species.
6. Develop species and/or systems specific checklists for seed quality for use by purchasers at the point of sale.
7. Review the potential impact of past and current culture based fisheries on genetic diversity in wild stocks in major regional watersheds.

3.2 WORKING GROUP 2: KEY ISSUES CONCERNING SEED NETWORKING, DISTRIBUTION, ENTREPRENEURSHIP (AND CERTIFICATION) [14]

Working Group 2 Members:

Rapporteur/Facilitator: Dr Mohammad Hasan

- Dr Benoy Kumar Berman
- Mr Agus Budhiman
- Ms Hu Honglang

[14] Working Group 2 findings and recommendations were put together by B. Rodriguez and A. Nietes-Satapornvanit

- Mr Basilio Rodriguez, Jr.
- Ms Arlene Nietes Satapornvanit
- Mr Melchor Tayamen
- Mr Zhou Xiaowei

In order to be effective and efficient, aquaculture seed production and distribution, especially when undertaken by the private sector, depend on a number of key factors. These key factors can be classified according to the following categories: basic infrastructure, production support, business and marketing support, financial support and the policy environment. These are the basic elements of an enabling environment for agriculture.

Basic infrastructure includes roads and transportation, communications, electricity, water access and regulation and products from agricultural research. In the case of aquaculture seed distribution, the most important research products include genetically improved breed, hatchery technologies and other information for efficient production. Production support providers include input (feed, seed, etc.) suppliers, equipment manufacturers and suppliers, extension services providers and others. Market and business support services include information, market intelligence, market promotion and technical and business training services. Such services can be provided by consultants, traders, chambers of commerce/industry associations, cooperatives and other support groups. Financial support services include credit, insurance and banking services. The policy environment consists of the body of laws and regulations that support the aquaculture and aquaculture seed enterprises. The lack of certain services and other factors may be common among the different parties involved in seed production and distribution. However, not all needs and concerns across the parties are the same.

The parties involved in seed production and distribution can be described according to the functions they fulfill in the supply chain. These include the following:

1. The breeder – the individual or the enterprise that develops and produces broodstock for use in the further production of broodstocks or in the production of seedtock (animals that will be grown for eventual use as food). In the livestock industry, broodstock that are used to produce animals for growing are called parent stock. Broodstock that are used to produce such parent stocks are called grandparent stocks. Animals bred to produce grandparent stocks are called great-grandparent stocks and onward up (or down) the breeding chain. The breeder's main line of business is to produce parent stocks which are sold/distributed to hatchery operators.
2. The hatchery operator – the individual or the enterprise that produces seedstocks for sale/ distribution to growers. Seedtock can be in the form of eggs, fry or fingerlings.
3. The nursery operator – the individual or the enterprise that purchases seedtock from the hatchery and grows the seedtock for a certain period and sells/distributes more advanced seedtocks to growers.
4. The trader – the individual or the enterprise that purchases seedtock from the breeder, the hatchery or the nursery and sells these to growers. Very often traders sell seed along with other inputs such as feeds. Traders may also provide these inputs to growers on credit terms.
5. The grower – the individual or the enterprise that raises the seed to market size. The grower is the end-customer of the aquaculture seed supply chain.

It is important to note that there are other actors in the seed networks but they do not handle seed directly. Depending on the country, these actors include water providers for traders in fish seed markets, transport providers, sellers of hormones, supplies and equipments related to seed production, nightsoil traders, extensionists and project staff. Some of their issues may be similar to the seed traders especially for those in the trading business.

In countries where species for which the aquaculture seed industry is not yet fully developed, government agencies may be the only provider of the above services. A single party, government or private, may also be responsible for carrying out two or more of the above functions. For example, a government agency may serve as breeder, hatchery/nursery operators and distributor while it is promoting a specific type of aquaculture. In addition, this government agency will also be responsible for providing extension and other services until the number of farmers who adopt the technology reaches critical mass. When such critical mass is reached, private individuals or enterprises may recognize a potential market and begin to provide the needed products and services. Aside from the market situation, technology also serves as a factor in determining how the above functions are carried out. As an example, the transport and distribution of tilapia eggs to nurseries only became possible with the advancement of artificial incubation technologies.

Each party involved in carrying out a specific function in the aquaculture seed supply chain will have issues and concerns along the key factors described above. Such a matrix of issues and concerns is presented in Table 3.2.1 .

Summary of issues and recommendations

This section summarizes five major issues followed by general recommendations and specific recommendations to FAO and governments to address the issues identified.

Issue 1: Poor quality and accessibility of breeding materials, parent stock and seed stock

Many countries do not have regulations governing aquaculture seed production, distribution, monitoring and surveillance.

General recommendations:

Governments should be encouraged to develop, with the participation of stakeholders, appropriate regulations, including registration, licensing and/or certification schemes for

a) aquaculture breed/strain development and quality improvement,
b) aquaculture seed production (hatcheries and nurseries),
c) aquaculture seed distribution,and
d) collection and distribution of wild-caught brood and seed stock for aquaculture.

Recommendations to FAO:

- International organizations such as FAO can develop technical guidelines for such registration, licensing and/or certification and provide assistance in the implementation of such guidelines.

Issue 2: Poor capacity in terms of technology, facilities, infrastructure, human resources, extension, information, business environment and government support/ incentives, including weak linkages between public and private sectors related to seed production, distribution and networking

Despite recent advances in fish seed production technologies, there are still gaps in the capacity of stakeholders in the seed sector, specifically:

- inadequate or lack of know-how/technology, facilities, trained staff and resources for breeding centers and hatcheries, infrastructure, extension services;
- quality, availability, and cost of inputs other than seed;
- absence of production and market information;
- lack of or inability to access business services, including business and entrepreneurship training;

- lack of government incentives/support/weak linkages with private sector (producers, traders, other interested entities).

General recommendations:

- Governments are encouraged to carry out a careful system-level assessment of the seed sector's capacity to provide the volume and quality of seed needed by the entire aquaculture industry of their respective country. Such a system-level capacity assessment is expected to highlight strategic interventions (policies, institutional strengthening, infrastructure development, investments, etc.) to improve seed production and distribution.
- Governments are encouraged to seriously consider options for collaboration with the private sector in broodstock development, seed production and seed distribution.
- Governments are encouraged to establish national networks for genetic improvement, seed production and seed distribution. Such networks should be tasked with initiating programs and projects that promote the development of the aquaculture seed sector.
- Governments, especially in countries where there are numerous institutions involved in seed production and distribution, are encouraged to develop a national inventory or directory of institutions involved in seed production and distribution to guide hatchery and nursery operators (and even growers) in the procurement of quality broodstock, seedtock and technical advisory services.
- Governments are encouraged to strengthen extension services and to develop, whenever and wherever appropriate, new channels (e.g. through private sector participants) for more effective delivery of such services. In addition, training and extension materials related to broodstock management, seed quality management and assurance and distribution should be developed, updated and disseminated.
- Parties involved in genetic improvement, seed production and seed distribution should organize themselves into networks/clusters/clubs to share information/technology and other resources, to undertake appropriate collective action and, for greater efficiency and effectiveness, consider alliances and collaboration to vertically integrate seed production and distribution functions.
- Governments are encouraged to promote, facilitate and provide incentives for the formation of such networks/clusters/clubs, including the setting up of local information centers or one-stop aqua shops.

Recommendations to FAO

- There will be value in conducting an international review on the experiences and status of aquaculture seed production and distribution and the effectiveness of strategies (including seed networking and public-private sector partnerships) implemented in various countries in order to come up with a set of best practices, including models and options for networking and partnerships, based on lessons learned.
- Encourage establishment of international networks for collaboration in genetic improvement, information sharing and sharing of genetic materials.
- Support for the development and/or updating of training and extension materials related to seed production and distribution, incorporating development issues with technical inputs.

Issue 3. Negative perceptions on the role of traders in seed distribution and small-scale seed producers (e.g. local or decentralized seed production systems)

Seed traders are important conduits between seed producers/wholesalers and the growers, not only for seed distribution but also for information on seed market

TABLE 3.2.1
Issues and concerns in aquaculture seed production and distribution

	Breeder	Hatchery	Nursery	Seed trader	Grower
Basic Infrastructure	• Inadequate infrastructure (roads, communications, water, electricity, etc.) • Lack of breeding know-how/ technology, facilities, trained staff and resources • Inability to obtain or have access to breeding materials • Poor quality of breeding materials	• Inadequate infrastructure (roads, communications, water, electricity, etc.) • Lack of hatchery knowhow/ technology, facilities, trained staff and resources. • Inability to obtain or have access to parent stock • Poor quality of parent stock	• Inadequate infrastructure (roads, communications, water, electricity, etc.)	• Inadequate infrastructure (roads, communications, water, electricity, etc.)	• Inadequate infrastructure (roads, communications, water, electricity, etc.)
Production/ Technical Support	• Quality, availability and cost of other inputs (feeds, tags, etc.) and equipment	• Quality, availability and cost of other inputs (feeds, etc.) and equipment • Lack/absence of extension services	• Inability to obtain seed • Poor quality seed • Quality, availability and cost of other inputs (feeds, etc.) and equipment • Lack/absence of extension services	• Inability to obtain seed • Poor quality seed • Lack of skills specific to their roles	• Inability to obtain seed • Poor quality seed • Quality, availability and cost of other inputs (feeds, etc.) and equipment • Lack/absence of extension services
Business and Marketing Support	• Absence of production and market information • Lack of or inability to access business services, including business and entrepreneurship training	• Absence of production and market information • Lack of or inability to access business services, including business and entrepreneurship training	• Absence of production and market information • Lack of or inability to access business services, including business and entrepreneurship training	• Absence of production and market information • Negative perceptions on the role of traders in seed distribution • Lack of or inability to access business services, including business and entrepreneurship training • Lack of stability due to seasonality of trade/other alternative livelihood	• Absence of production and market information • Lack of or inability to access business services, including business and entrepreneurship training
Financial Support		• Unavailability of credit.	• Unavailability of credit	• Informal status not recognized by lending institutions limiting their access to credit	• Unavailability of credit
Policy Environment	• Lack of government incentives (i.e. tax holidays, exemptions, credit, etc.) • Absence of technology transfer policies, particularly for products of genetic improvement programs. • Actual or perceived competition of government with the private sector.	• Lack of government incentives (i.e. tax holidays, exemptions, credit, etc.) • Actual or perceived competition of government with the private sector • Lack of policies/incentives for group formation and participatory learning	• Lack of government incentives (i.e. tax holidays, exemptions, credit, etc.) • Lack of policies/incentives for group formation and participatory learning	• Lack of government incentives for traders/negative perception of public sector • Lack of policies/incentives for group formation and participatory learning	• Lack of government incentives (i.e. tax holidays, exemptions, credit, etc.)
Public Sector/ Social	• Lack of or weak linkages with public sector especially on technical issues	• Competition with government producers especially on prices • Lack of or weak linkages with public sector • Lack of venues for information sharing • Lack of initiatives related to maintenance and upgrade of broodstock quality	• Lack of or weak linkages with public sector • Lack of venues for information sharing	• Lack of understanding of field situation of actors esp the involvement of poor • Lack of support in forming advocacy groups • Lack of or weak linkages with public sector • Lack of venues for information sharing	• Lack of venues for information sharing

demand and supply. In areas where centralized seed production is the norm, the only way for growers to have access to seed is through traders, who travel long distances carrying fish seed. These informal networks involving seed traders and other business and service providers have developed because of the growing demand for seed and the development of aquaculture in remote rural areas. Public institutions in some countries have ignored the existence and the important role these traders play in seed distribution and indirectly in aquaculture development. The same is true with small-scale seed producers, who are perceived to produce low quality seed by government and large private hatcheries. In reality, these small-scale seed producers in the rural areas are producing better seed and their proximity to growers enable them to sell larger sized seed as well as reducing transportation time. It is imperative that their existence and their needs are recognized to achieve the seed sector's goal of delivering quality fish seed. Considering that most of these people are poor, their involvement in such activities should be encouraged so their livelihoods will be improved.

General recommendations:

- Governments are encouraged to consider the role and contribution of traders in their assessment of and recommendations for the strengthening of the seed sector's capacity, including providing training to develop/strengthen technical and entrepreneurial skills and programmes to meet their social/economic/health needs.
- Social marketing activities to change public perception, thereby encouraging seed producers and traders to improve the quality of their products and services.

Issue 4. Financial issues

Seed production costs money, especially for infrastructure, equipment and inputs for producers. Traders need financing of seed money for products and transport. Credit is often not available as formal financial institutions require collateral and other guarantees which being in the aquaculture and seed production and trading business may not be able to fulfill.

General recommendations:

Aside from clustering and networking, parties in the aquaculture seed sector should be encouraged to establish linkages with micro, small, medium enterprises (MSME) and microfinance development programmes.

Issue 5. Policy issues

The absence of technology transfer policies, particularly for products of genetic improvement programs has been found to limit production of good quality seed. Government hatcheries producing seed for sale to farmers is perceived by the private sector as competitor especially in terms of selling price and market.

General recommendations:

- Governments are encouraged to review their policies on technology transfer from government research institutions to the private sector.
- Governments are encouraged to establish a policy to create an environment that would encourage the participation of the private sector in broodstock development, seed production and seed distribution.
- Governments are encouraged to review their role in seed production and distribution, i.e. to support private sector seed production and not to compete by selling seed to the same group of customers but to provide seed for stock

enhancement of public waters, for charity and for public sector fish production programmes.

Recommendation to FAO:

- Conduct a livelihoods analysis of people in rural communities involved in various activities of seed production and distribution to generate information for policy development

3.3 WORKING GROUP 3: KEY ISSUES PERTAINING TO DEVELOPMENT OF THE FRESHWATER FISH SEED PRODUCTION SECTOR THAT WILL BENEFIT RURAL FISH FARMERS

Members of Working Group 3
Rapporteur/Facilitator: Dr Melba Reantaso

- Dr Alejandro Flores Nava
- Dr Mudnakudu Channabasappa Nandeesha
- Dr So Nam
- Mr Ernesto Morales
- Dr Tuan Anh Pham
- Mr Yuan Xinhua
- Dr Sunil Siriwardena

Major recommendations resulting from the deliberations of Working Group 3 on issues pertaining to benefits that will accrue rural fish farmers from development of the freshwater fish seed production sector, many of which are directed to FAO (as indicated) are briefly elaborated below.

Policy/guidelines

National programmes such as rural aquaculture development within the broader framework of poverty reduction and food security should recognize that the seed production sector is a primary pre-requisite and an integral part of sustainable aquatic food production. Governments should play a facilitating and monitoring role and ensure that appropriate policies and/or mechanisms are in place and effectively implemented that will address the needs of the rural fish farmers concerning issues such as:

- suitable species, particularly harnessing indigenous species (e.g. self-recruiting species) and using exotic species after careful assessment, appropriate for rural aquaculture development
- quality control in seed production through certification;
- improved collection and dissemination of information and statistics for better development planning;
- viable market;
- better integration of all inputs and services;
- intersectoral cooperation and other essential stakeholder consultations.

Risk communication

Typically small-scale fish farmers are risk-averse and vulnerable to losses in their systems due to a number of potential risks. These include asset, market and production/management risks which may originate from irresponsible trans-boundary movements, negative interaction between cultured and wild fisheries, use of pesticides and other chemicals, poor quality seed, unstable supply of seed and other inputs, natural disasters and other emergencies, loan diversion and non-payment, market fluctuation, etc. This can mean that transfer or start up of aquaculture technologies can be constrained by farmers' negative perceptions of the risks involved or examples of failed activities.

Communicating these risks to all stakeholders especially fish farmers is significantly essential. Suggested key actions include:

- raising fish farmers' awareness of the various forms of risk;
- evaluating the various risks faced by rural fish farmers and developing support system focussing on mitigating such risks;
- identifying and implementing risk management measures by concerned stakeholders;
- developing guidelines on risk assessments in aquaculture and making them available in simple terms for rural fish farmers.

Monitoring and evaluation of the sector

Monitoring and evaluation of the seed production sector, based on reliable statistics and information are essential for successful planning and further development of rural aquaculture. Suggested key actions include:

- improving collection and sharing of statistics and information on freshwater fish seed production sector within rural aquaculture with emphasis on the following information: number of households/individuals involved, volume of fish produced by species and contribution to household income;
- assessing and standardizing of fishfarmer's data collection methods;
- providing training for data collectors;
- appropriate analysis and management o such data/information.

Capacity building and extension

- Recognizing that small scale rural hatcheries are often located near the homes and can be managed by women, special attention shall be given to women as target recipients for capacity building especially in the areas of seed nursing, entrepreneurship and credit and savings management (FAO).
- Provision of simple hands-on and practical training on various aspects of seed production (e.g. breeding; nursing; stress tests; simple seed quality test, basic health checks; condition, packaging and transporting; record keeping and basic accounting or simple bookkeeping; and simple understanding and managing of risks) will benefit the rural fishfarmer through better decision making (FAO).
- Hatchery/nursery operators and traders as target recipients of training so they could effectively function as primary guides/service providers/extensionists for fish growers.
- Community-based capacity building on managing aquatic resources, e.g. culture-based fisheries and fish refuge pond management in floodplains (FAO).
- Relevant institutions involved in supplying services should have the necessary knowledge and skills to work with fish farmers using adaptive approaches and technologies.
- Applying important lessons learned from culture-based fisheries and stock enhancement programmes (e.g. comparative socio-economic analysis of different water bodies in Bangladesh, stocking in small lakes, commune canals, reservoir in Cambodia).

Making accessible appropriate rural microfinancing programmes for rural fishfarmers

The general benefits and varying levels of successes and failures of microfinance in aquaculture are recognized. Suggested key actions include:

- provision of access to feasible credit and microfinance services based on local needs and requirements, prudent and flexible enough (in terms of intended purpose, collateral requirements, interest rates, lending procedures and repayment period) to meet rural fish farmers' ability to effectively participate in such financial schemes;

- available guidelines as well as lessons learned from past microfinance systems be considered by such service providers in designing pertinent schemes;
- where appropriate, initial seed funds can be provided as a start up basis;
- a system of voluntary savings component may also be considered to be integrated in such programmes.

Gender issues – enhancing women's role in seed production

It is generally known that women play an important role in seed production (e.g. seed nursing and common carp breeding in Bangladesh; all stages of seed production in China and Viet Nam). However, their access to opportunities such as training, empowerment, involvement in decision-making, etc. are missing. The following key action is recommended:

- supporting a regional project to focus on enhancing the role and empowerment of women in aquatic food production with emphasis on the organization of women into self-help groups (SHG) and skills development in breeding, nursing, entrepreneurship and credit/microfinance management (FAO).

Farmer-field schools (FFS) and Farmer participatory research (FPR)

The 'farmer-field school' (FFS) concept has been successfully applied within the framework of Integrated Pesticide Management (IPM). For this concept to be applied effectively in rural aquaculture, it is important to use the systems approach and to integrate fish production as part of the rice-production system, wherever possible. A suggested key action is:

- Conducting sustainability studies using FPR in places where FFS has been practiced in rural aquaculture (e.g. Bangladesh, Indonesia, and Viet Nam), taking lessons learned and experiences and particularly incorporating seed production in the system (FAO).

Enhancing human capital through documenting indigenous knowledge and farmer innovation

Innovation is a necessary strategy which rural fishfarmers have adopted in order to meet their livelihood necessities. In the seed production sector, farmers have developed innovations on hatchery technology (e.g. bamboo/wood based circular technology), breeding techniques (e.g. Bundh breeding in India), nursing techniques (e.g. removal of egg stickiness by washing with milk prior to nursing in jars, application of fermented manure including oil cakes, stunting fish technology), local methods for fish collection and transportation and others. Even as farmers have practiced many such innovations, these remain undocumented. Suggested key actions include:

- reviewing and compiling all relevant published materials on indigenous knowledge and farmer innovations and documenting other unpublished practices (FAO);
- creating databases of farmer innovations and making it accessible to all (FAO);
- replicating and promoting fully tested innovations in other countries/regions;
- recognizing and honouring successful farmer innovators.

Farmers' indigenous knowledge and farmers' practical experiences are important and can significantly contribute to research and development. Suggested key actions include:

- implementing research in a participatory manner, involving farmers, where possible, at every stage of the process;
- making every effort be made to identify research areas based on farmer needs. Specific areas of research which are thought to benefit rural fishfarmers include: (a) improved seed (genetics and growth rates); (b) disease risk and management; (c) feed formulation using locally available materials; (d) breeding of indigenous species; (e) management of aquatic resources (for wild caught seed);

- translating research results in practical terms and wide dissemination for efficient field application by actors involved in the seed production sector;
- recognizing that there are many currently practiced farmer innovations in many countries, such practices can be further verified through appropriate research and improve such innovations for further dissemination.

Availability and affordability of suitable species of high quality and sufficient quantity

Rural fish farmers involved in the fish seed production sector as well as those engaged in culture-based fisheries will greatly benefit from suitable and locally produced seed, fry and fingerlings of high quality, in sufficient quantity and affordable price. These will not only enhance fish production but will also promote fish consumption. Suggested key actions to address this issue include:

- conducting proper diagnostics of the seed production sector in terms of suitable species and potential market;
- providing support to the initial establishment of hatcheries in strategic rural/remote areas
- promoting decentralized seed distribution after an evaluation of the need for such system in target communities;
- establishing national broodstock centres to ensure continuous supply of high quality broodstock at subsidized costs;
- promoting price regulation through government intervention in order to protect rural farmers
- promoting the use of indigenous species, where they exist, that is supported by proper broodstock management programmes;
- forming networks of small-scale hatcheries to provide necessary service support (e.g. information sharing, marketing, etc.).

Encouraging formation of self-help groups (SHG) and other forms of farmer associations

Self-help groups and other forms of farmer association (seed clubs/network, producer club, farmer association, etc.) have effectively worked in many food production systems. They serve as important entry points for cluster management, implementation of development strategies and conservation efforts, empowerment, sharing and dissemination of information, can be key partners in delivery of services, venue for learning and skills development, serve as guarantors of loan, etc. Special attention should be given to support the organization of women SHGs. A number of key actions are recommended, such as:

- identifying social groups/networks, providing access to such networks through Information, Communication and Technology (ICT);
- providing functional linkages with financial and technology providers;
- providing a forum for interaction and consultation of all players;
- providing financial support to undertake these activities.

Private and public sector partnership

Rural fish farmers will benefit from improved integration and linkage of inputs and efficient delivery of services in the broad spectrum of the freshwater fish production sector from hatchery to seed trader to nursery operators to aquaculturists including all other services provided by various stakeholders from government and non-government. Suggested key actions include:

- taking lessons learned from the China model of contract growing for fingerling production (i.e. contracting local small farms to produce fingerlings for use of larger fish farms and for open water fisheries); such contracting systems ensure that

there is continuous supply of high quality fingerlings, good return on investment and reduced risk). Practicability of contract growing to other countries should be determined;

- encouraging large-scale hatchery operators to support small scale hatcheries for training, information sharing, broodstock exchange, provision of high quality seed;
- promoting government-private sector (large hatcheries) partnership for broodstock development and supply.

4. Annexes

ANNEX 4.1
Expert workshop programme

TIME	ACTIVITY
22 March 2006 Arrival of Participants	
23 March 2006, Thursday (Day 1)	
08.30–09.00	Opening and Welcome Remarks Madam Wei Shaofen, Director of Bureau of Fisheries and Marine Affairs of Jiangsu Province Prof Xu Pao, Director, Freshwater Fisheries Research Center, Chinese Academy of Fishery Sciences Election of Chair
09.00–09.15	Introduction to and Rationale for the FAO Expert Workshop on Analysis of Status of Freshwater Fish Seed as Global Resource for Aquaculture - Dr Melba B. Reantaso (FAO)
09.15–10.15	Selected Country Case Study Presentations
09.15–10:15	Presentations of Selected Country Case Studies • China (Mrs Hu Honglang) • India (Dr N. Basavaraja) • Cambodia (Dr So Nam) • Viet Nam (Dr Pham Anh Tuan)
10.15–10.30	Coffee Break
10.30–11.00	Presentations of Selected Country Case Studies • Mexico (Dr Alejandro Nava) • Egypt (Dr Magdy Saleh)
11.00–12.30	Regional Syntheses Presentations
11.00–11.30	Regional Synthesis: Asia (Dr Sunil Siriwardena)
11:30–12.00	Regional Synthesis: Latin America (Dr Alejandro Flores Nava)
12.00–12.30	Regional Synthesis: Africa (D. Randy Brumett) – presented by Dr Melba B. Reantaso
12.30–14.00	Lunch Break
14.00–15.00	General Discussions on Country Case Studies and Regional Synthesis
15.00–18.00	Thematic Review Presentations
15.00–15.30	Thematic Review 1: Seed quality (Dr C.V. Mohan)
15:30–16.00	Thematic Review 2: Genetic resources (Dr Graham Mair)
16.00–16:30	Coffee Break
16:30–17.00	Thematic Review 3: Seed network and entrepreneurship (Ms Arlene Nietes)
17.00–17:30	Thematic Review 4: Seed supply and technology in rural aquaculture (Dr Sunil Siriwardena)
17.30–18.00	Thematic Review 5: Farmer innovation and role of women in seed production (Dr M.C. Nandeesha)

24 March 2006, Friday (Day 2)	
08.30–09.00	General Discussions on Thematic Reviews
09:00–11:30	Invited Presentations
09.00–09.30	Invited presentation: Self-recruiting species (SRS) from farmer-managed aquatic systems (FMAS) – the contribution of non-stocked species to household livelihoods (Mr Ernesto Morales)
09.30–10.00	Coffee Break
10.00–10.30	Invited Presentation: Decentralized seed – poorer farmers producing large size fingerlings in irrigated rice fields in Bangladesh – Benoy Kumar Berman (Bangladesh)
10.30–11.00	Invited presentation: Highlights of DANIDA's Support to Freshwater Aquaculture (SUFA) Project on Establishing National Broodstock Centres in Viet Nam –Dr Nguyen Cong Dan (Viet Nam)
11.00–11.30	Invited presentation: Philippine experience on Genetically Improved Freshwater Tilapia (GIFT) Foundation – Mr Basilio Rodriquez, Jr. (Philippines)
11.30–12.30	General Discussions on Invited Presentations
12.30–14.00	Lunch Break
14.00–14.15	Mechanics and Guidelines for Working Group Discussions – Dr Simon Funge-Smith (FAO)
14:15–18.30	Working Group Discussions
15.30–16.00	Coffee Break
25 March 2006, Saturday (Day 3)	
08.30–12.30	Continue Working Group discussions and preparation for plenary presentation
10.00–10.30	Coffee Break
12.30–18.30	Lunch/Field Trip/Free Time
26 March, Sunday (Day 4)	
	Working Group (WG) Presentations in Plenary (30 minutes each)
08.30–09.00	WG 1
09.00–09.30	WG 2
09.30–10.00	WG 3
10.00–10.30	Coffee Break
10.30–11.00	WG 4
11.00–11.30	WG 5
11.30–12.30	General Discussion of Working Group Presentations
12.30–14.00	Lunch Break
14.00–16.00	Working Groups Chairpersons, Rapporteur and Technical Secretariat finalise Workshop Recommendations
16.00–17.00	Presentation of Final Workshop Recommendations in Plenary
17.00–17.30	Closing

ANNEX 4.2
Participants to the FAO Expert Workshop on FAO Expert Workshop on Freshwater Fish Seed as Resource for Global Aquaculture, Wuxi, Jiangsu Province, China, 23-26 March 2006

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ANNEX 4.3
Welcome remarks of Professor Xu Pao, Director of the Freshwater Fisheries Research Center, Chinese Academy of Fishery Sciences at the FAO Expert Workshop on Freshwater Fish Seed as Resources for Global Aquaculture, 22 March 2006, Wuxi, China

Ladies and Gentlemen, Good morning. The FAO Expert Workshop on Freshwater Fish Seed as Resources for Global Aquaculture is now commencing at the Freshwater Fisheries Research Center (FFRC), Chinese Academy of Fishery Sciences (CAFS), Wuxi, China. On behalf of the Freshwater Fisheries Research Center (FFRC), I would like to extend a warm welcome to all the experts from FAO and other countries.

The FFRC of the Chinese Academy of Fishery Sciences (CAFS) is one of the major comprehensive fisheries institutions for research, education/training and information exchange. In the research activities, FFRC has the main functions oriented toward basic and applied research. The key research emphasis are laid on fishery breeding biology and genetics, conservation of biodiversity and fishery stock resources, monitoring and protection of fishery environment, evaluation and management of fishery resources, fish disease prevention and control, carrying capacity and healthy aquaculture, fish nutrition and information exchanges.

The Asia-Pacific Regional Research and Training Center for Integrated Fish Farming is an important component of FFRC, has continuously undertaken China-TCDC training courses for 25 years. Over 30 courses have been successfully conducted for more than 1 000 participants from 80 countries. Besides, there have been also a great number of international academic workshops, visiting scholar exchanges and research collaborations taking place at the center.

The present FAO workshop is focused on freshwater fish seed development. It is generally recognized as the hottest issue for global aquaculture and essential basis for the farmers. In the 1950s, Chinese fishery specialists successfully conducted induced breeding of the Chinese carps, it is a milestone for mass seed production and a termination of wild collection from natural waters. However, greater efforts are expected in order to have better, steady and healthy supply of quality seed for farmers where aquaculture technologies are less developed.

The present FAO Expert Workshop on Freshwater Fish Seed as Resources for Global Aquaculture is highly anticipated for an appropriate orientation and practical approaches for both research people and farmers and the FFRC is pleased to carry out collaboration in any form regarding this subject for greater contribution to the aquaculture development of global freshwater fish seed resources apart from fisheries research, technical training, human resource development with all the specialists present at the workshop.

Finally, I wish in advance the successful completion of the workshop and good health to all the guests present at the workshop

Thank you .

ANNEX 4.4
Welcome remarks of Mrs Wei Shaofeng, Bureau Director, Jiangsu Provincial Marine and Fishery Bureau at the FAO Expert Workshop on Freshwater Fish Seed as Resources for Global Aquaculture, 22 March 2006, Wuxi, China

Ladies and Gentlemen, Good morning.

The FAO Expert Workshop on Freshwater Fish Seed as Resources for Global Aquaculture is now open at the Freshwater Fisheries Research Center, Chinese Academy of Fishery Sciences, Wuxi China. On behalf of the Jiangsu Provincial Marine and Fishery Bureau, I would like to extend a warm welcome to all the participants from FAO representatives and specialists from the other participating countries.

Aquaculture products are the important components for food security provision, while seed is the essential basis for aquaculture activities and assurance of sustainable development. The growth of production and the fisheries like crop production mostly demand quality seed.

Aquaculture in China is well-developed and largely dependent upon quality seed production and extension. China has laid a strong emphasis on capacity building and infrastructures for the seed development, greater efforts are made to the quality, size, standard operating procedures and scientific principles and even the quality monitoring and evaluation. Now there have been over 30 farms serving as gene banks for native and quality stocks for the whole country. The Ministry of Agriculture in China officially declares that there are about 60 quality species in China suitable for the Chinese context of aquaculture and extension. In 2004, the seed production reached 711.6 billion fry. Common carp, tilapia and shrimps are the most popular for production which largely promotes healthy aquaculture practices.

However, there have been serious degradation of the traditional fish species with limited number of quality species seed for replacement, poor use of the quality seed

and even the un-effective extension systems which are the bottleneck of the national aquaculture development and demand further efforts.

Jiangsu province is a large province for aquaculture in China. In 2004, the total area reached 800 000 ha. The total production reached 3.6 million tonnes. There is a general consensus that greater efforts are needed to develop quality seed and species with higher efficiency. This province has worked hard on seed action for aquaculture as the key project particularly in the field of seed production systems. Successful results have been achieved. We would like to share this experience and carry out collaboration with all the specialists present at the workshops. Welcome to visit Jiangsu Province.

I strongly believe that the present workshop will greatly promote the aquaculture seed production in China and push forward the seed production into a new phase with mass scale and better quality.

I wish in advance that the workshop will achieve a fruitful result and wish you good health and happy stay for all the guests present in this workshop.

Thank you.

5. Country case study template

Objective:
The objective of the country case study is to collect information on the status of freshwater fish seed resources in selected countries in three aquaculture regions.

Methodology:
Country case studies (to be conducted through various ways such as literature search, actual interviews or field visits) will be commissioned through an author's contract to selected country nationals.

The following information will be collected:

(a) **Introduction.** This section contains basic information about the country in terms of : Freshwater aquaculture resources (e.g. tilapia, carps, catfish, milkfish, other important freshwater aquacultured species), contribution to aquaculture production, consumption, consumer acceptance.
(b) **Seed resources/supply.** This section includes information on resources available in terms of seed supply from hatcheries (private and government) or from wild sources.
(c) **Seed production facilities and seed technology.** This section includes information on existing number of hatcheries for freshwater fish seed production, available production figures, the number of species, available technologies (e.g. breeding, hatching, rearing), gene banks.
(d) **Seed management**. This section includes information on husbandry management of broodstock and larvae, feed management, etc.
(e) **Seed quality**. This section includes information on performance, health/diseases, hygienic procedures in hatcheries, available set criteria for seed quality (e.g. growth rate, survival, uniformity of size at harvest, etc.)
(f) **Seed marketing.** This section includes information on supply and distribution mechanisms, types of distribution networks (e.g. organized or disorganized), flow chart or channels of distribution, people involved in the process (i.e. selling, exchange, purchase, marketing agents, etc.), market, accessibility, transportation (e.g. delivery or pick-up, what means of transportation, etc.), available financing, sales promotion.
(g) **Seed industry.** This section includes information on the scale or level of industry (i.e., small, medium or large scale (producers and suppliers) and may include a description for each level, etc., risks (socio-economic, technical and environmental risks, e.g. seed or broodstock mortality, seasonality of market, low seed price, unfavourable weather conditions, distance between seed suppliers and market, non-payment among seed buyers, impacts of naturala disasters, etc.), and other information, for example, such as women involvement, traditional knowledge of farmers.
(h) **Support services**. This section includes information on support services at the country level (extension, technical training, technology transfer, manuals, others)
(i) **Seed certification.** Does this exist in the country? For which species? If so, describe the processes and organizations involved, any recognizable impact/s?

(j) **Legal and policy framework.** This section includes information on legal and policy framework supporting the seed sector, e.g. STREAM initiative, governance, trade, etc.

(k) **Economics.** This section includes information which will determine profitability, i.e., supply and demand, prices, seasonality; what factors determine the price of seed?; contribution to household income? return of investments?

(l) **Information or knowledge gaps.** May also include other limitations or problems not covered in this outline.

(m) **Stakeholder**. Identify the various stakeholders involved in seed production, describe the number and scope and extent of activities. May include such groups 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. small hatcheries – to develop local market;
d. larger hatcheries – for development of new varieties/strains or innovations;
e. associations – to represent industry interest;
f. government institutions – to provide legal and policy framework for the seed industry (producers, etc.), extension services, training, start off seed;
g. researchers – information, knowledge and technology (e.g. universities, fisheries colleges, research institutes, etc.);
h. donors (funding agencies). Please provide information on existing donor-funded projects;
i. others.

(n) Future prospects and recommendations.