

7.20 Freshwater fish seed resources in Viet Nam

Tuan Anh Pham

Research Institute for Aquaculture No. 1

Dinh Bang, Tu Son, Bac Ninh

Viet Nam

patuan@fpt.vn

Pham, T.A. 2007. Freshwater fish seed resources in Viet Nam, pp. 477–490. In: M.G. Bondad-Reantaso, (ed.). Assessment of freshwater fish seed resources for sustainable aquaculture. *FAO Fisheries Technical Paper*. No. 501. Rome, FAO. 2007. 628p.

ABSTRACT

This review provides the current status of freshwater fish seed resources for aquaculture development in Viet Nam. There are a total of nineteen indigenous and exotic fish species commonly cultured in freshwater aquaculture. Chinese and Indian major carps, Mekong catfish and tilapia are the most popularly cultured species. Fish culture based on hatchery seed began in early 1960s. Many of the estimated 420 hatcheries currently in operation in the country produce annually an estimated 15 billion freshwater fish hatchlings. Most of the existing hatcheries are being managed as private business. The Chinese-style circular spawning and incubators are dominant hatchery technologies used throughout the country.

This document also describes a summary of technical parameters for seed production, seed quality management and marketing of the main farmed freshwater fish species in Viet Nam. Finally future prospects and recommendations on several issues related to further development of freshwater fish seed production in the country are provided.

INTRODUCTION

According to the Ministry of Fisheries (MOFI), the total aquaculture area and production in Viet Nam in 2004 were 902 900 ha and 1.15 million tonnes, respectively, of which around 639 700 ha and 0.640 million tonnes came from freshwater aquaculture, respectively (MOFI, 2005). Freshwater fish were estimated as providing nearly 35 percent of the total animal protein intake of the nation. There are nineteen indigenous and exotic fish species commonly cultured in freshwater systems. These are listed in Table 7.20.1. Carps, catfish, and tilapia are the most popularly cultured species. Mekong catfish account for about 40 percent of cultured freshwater fish production followed by major carp species (i.e. grass carp, mrigal, common carp) and tilapia.

SEED RESOURCES AND SUPPLY

Aquaculture in both northern and southern Viet Nam has its roots in the collection and stocking of fish seed caught from the wild. In the north, Vietnamese silver carp, grass carp, mud carp were collected as hatchlings from the Red River. In the south, Mekong catfish, snakehead and silver barb have also been caught as wild fry.

TABLE 7.20.1
List of commonly cultured freshwater fish species in Viet Nam

English name	Local name	Scientific name
Common carp	Ca chep	<i>Cyprinus carpio</i> L.
Chinese Silver carp	Ca Me trang Trung Quoc	<i>Hypophthalmichthys molitrix</i> (C.&V.)
Vietnamese Silver carp	Ca Me trang VietNam	<i>Hypophthalmichthys harmandi</i> Sauvage
Bighead carp	Ca Me hoa	<i>Aristichthys nobilis</i> (Rich)
Grass carp	Ca Tram co	<i>Ctenopharyngodon idellus</i> (C.&V.)
Rohu	Ca Troi An	<i>Labeo rohita</i> Hamilton
Mrigal	Ca Mrigal	<i>Cirrhinus cirrhosus</i> Hamilton
Mud carp	Ca Troi ta	<i>Cirrhinus molitorella</i> (C.&V.)
Black carp	Ca Tram den	<i>Mylopharyngodon piceus</i> (Rich)
Spinibarbus	Ca Bong	<i>Spinibarbus denticulatus</i> Oshima
Gold Fish	Ca Diec	<i>Carassius auratus</i> (L.)
Silver barb	Ca Me Vinh	<i>Barbodes gonionotus</i> Bleeker
Nile Tilapia	Ca Ro Phi van	<i>Oreochromis niloticus</i>
Mekong Stripped Catfish	Ca Tra	<i>Pangasius hypophthalmus</i>
Hybrid Catfish	Ca Tre lai	<i>Clarias macrocephalus</i> x <i>C. gariepinus</i>
Notopterus	Ca That lat	<i>Notopterus notopterus</i>
Climping perch	Ca Ro dong	<i>Anabas testudineus</i> (Bloch)
Sand goby	Ca Bong tuong	<i>Oxyeleotris marmoratus</i> (Rleeker)
Snakehead	Ca loc bong	<i>Ophiocephalus micropeltes</i> C. & V.

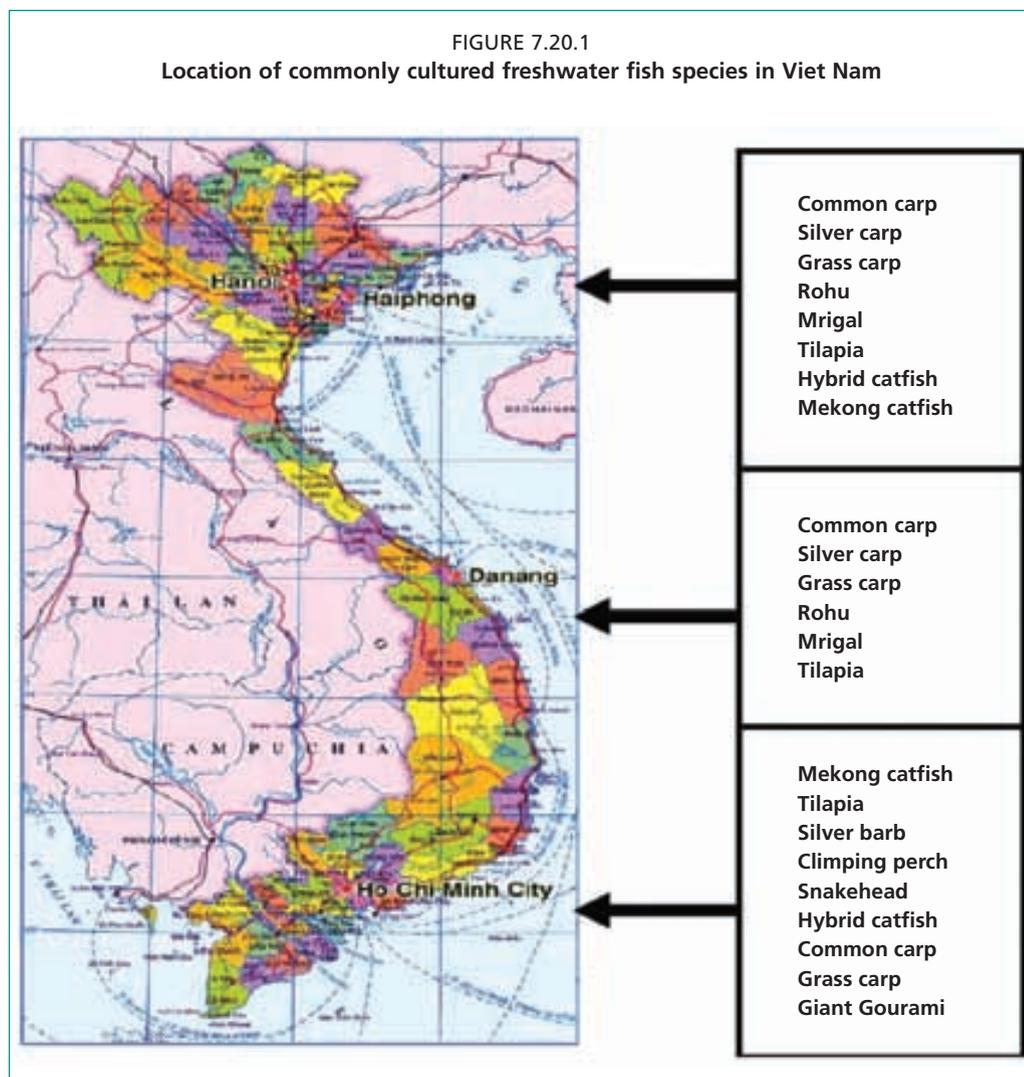
Fish culture based on hatchery seed began in early 1960s. The introduction of induced breeding of fish can be traced to a group of technicians from north Viet Nam who travelled to the People's Republic of China between 1957 and 1960 to learn the techniques. Government hatcheries were subsequently built all over north Viet Nam between 1965 and 1975, and thereafter technicians were sent to the central highlands and south between 1975 and 1990.

Almost all of the commonly cultured freshwater fish seed are currently produced from hatcheries. Large variations in aquaculture environment, particularly in minimum temperatures between north and south Viet Nam are largely responsible for the differences in popularly cultured species in the two regions. Significance of aquaculture importance and existing hatchery seed production of different major freshwater fish in northern and southern provinces of the country are presented in Table 7.20.2.

Plate 7.20.1 illustrates the different freshwater fish species produced in hatcheries in Viet Nam.

TABLE 7.20.2
Hatchery seed production of freshwater fish species in Viet Nam

Species	Northern Provinces	Southern Provinces
Silver carp	+++	++
Bighead carp	++	+
Mud Carp	+	
Common carp	++++	+++
Grass carp	++++	+++
Rohu	++++	++
Mrigal	++++	+++
Black carp	+	
Spinibarbus	+	
Nile tilapia	++	+++
Silver barb	+	+++
Hybrid catfish	++	+++
Mekong stripped catfish	+	++++
Climbing perch	+	+++
Aquaculture importance and hatchery seed production: + +++++		



SEED PRODUCTION FACILITIES AND SEED TECHNOLOGY

Many of the estimated 420 hatcheries are currently in operation in the country. According to MOFI, in 2004 there were a total of 15 billion freshwater fish hatchlings produced from hatcheries. Out of these, 3 billion were Mekong striped catfish hatchlings. Hatcheries used to be nominally under the Central Government, provincial administration or commune control. But most of existing hatcheries are now effectively being managed as private businesses. Private entrepreneurs are active in hatchery development and dominate the nursing and trading sectors in both north and south Viet Nam. Currently, only 43 hatcheries are government supported, although the level of support is variable and low. Financial support for government hatcheries are limited to management salaries and occasional investment in infrastructure. Most of the hatchery operation costs are met from seed sales and revenues are retained after payment of tax. Private hatcheries have evolved from farmer cooperatives and local government operations, but many started after implementation of the market reform policy. Most government hatcheries have larger pond areas than that of private operations.

The dominant hatchery technology throughout the country is the Chinese-style circular spawning and incubation systems (Figure 7.20.2) introduced from the People's Republic of China 40 years ago. Using low water head and large flow rates, these systems are eminently suitable for the water-rich delta areas of north and south Viet Nam where they are concentrated.

PLATE 7.20.1

Illustration of freshwater fish species produced in hatcheries in Viet Nam



Common carp



Vietnamese Silver carp



Chinese Silver carp



Rohu



Mrigal



Grass carp



Nile Tilapia



Black carp

Careful broodfish management and natural spawning, rather than stripping is the normal practice (Figure 7.20.3). Two types of hormone are commonly used in induced breeding of fish under hatchery conditions. These are preserved pituitary gland (PG) and gonadotropic releasing hormone (LH-RH). Most hatcheries spawn broodfish more than once in a season depending on species and seed demand. Major carp broodfish spawn two to three times in a season as is commonly practiced in hatcheries.

Chinese-style hatcheries suit Chinese and Indian major carps (grass carp, silver carp, bighead carp, rohu, and mrigal) including the *Spinibarbus* and silver barb. Common carp is an important species in both north and south Viet Nam, but appears to suffer significant hatchery constraints. Spawning naturally in hatchery cisterns, fertilized eggs attached to water hyacinth roots can be incubated out of water early in the season or in water as the temperatures increase. Stripping and 'dry' fertilization followed by removal of the egg stickiness before incubation in the normal way has also been found to improve hatchery efficiency of this fish considerably.

These techniques were practised in producing common carp seed in a few hatcheries of the Research Institute for Aquaculture No. I (RIA 1), National Broodstock Centres (NBCs) and some provincial fish seed centres. The stripping technique and 'dry' fertilization are also commonly applied in production of hybrid catfish (*Clarias macrocephalus* x *C. gariepinus*) and Mekong stripped catfish.

Plate 7.20.2 shows some examples of the different types of incubation systems for different species used in Viet Nam.

Five to seven day old hatchlings are the main seed produced in hatcheries. Most hatcheries nurse some fry but the majority of hatchlings are sold to nursing operators. There are several concentrated areas of specialized nursery operators. Nursery operations are based on stocking a single species of hatchlings in fertilized earthen ponds at high densities. The fish are raised as a batch for a few weeks or months before harvesting.

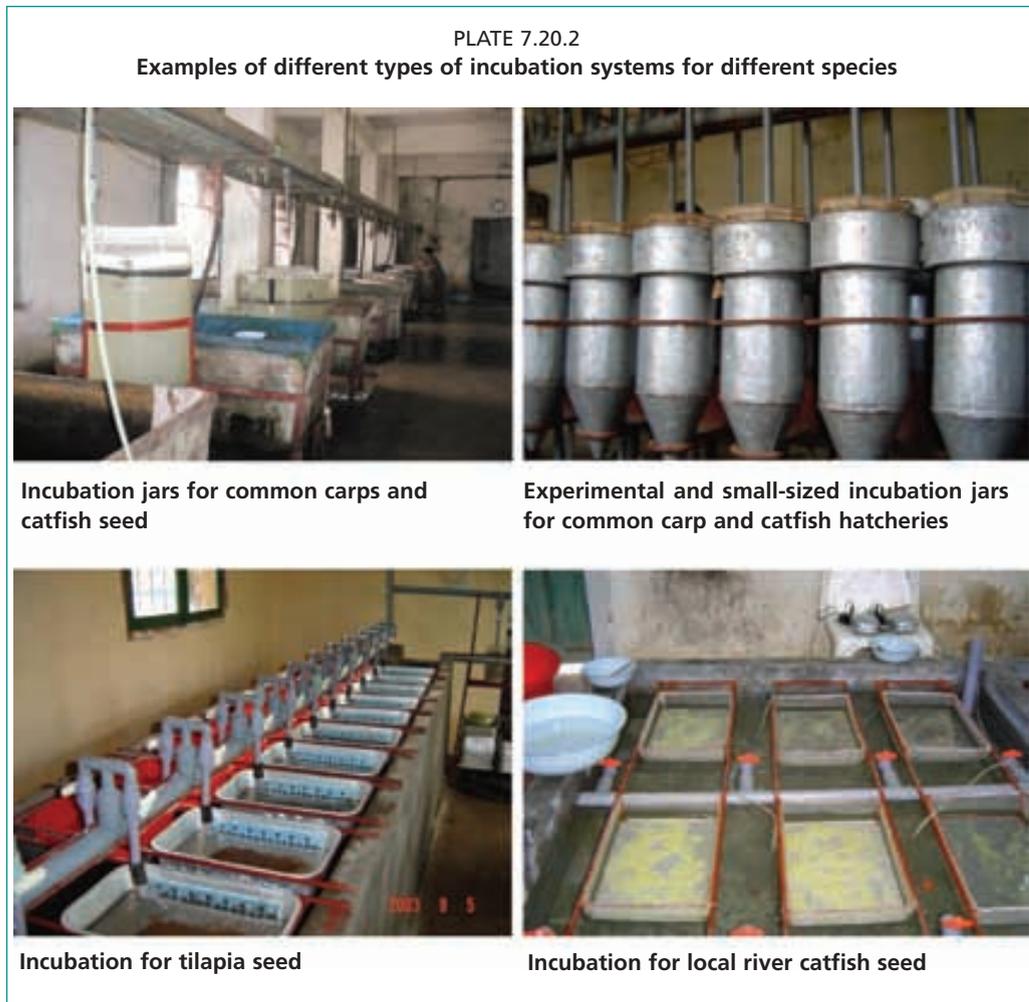
Live gene banking of freshwater fish species was initiated at the three Research Institute for Aquaculture (RIAs), priority given to commonly cultured species/strains and seriously threatened indigenous freshwater species. Three NBCs have been built in the northern, central and southern regions providing *ex-situ* gene banking of commonly

FIGURE 7.20.2
Chinese-style spawning and incubation system



FIGURE 7.20.3
Careful selection of broodfish for spawning





cultured freshwater fish species/strains and are responsible for dissemination and maintenance of genetic quality of existing and improved aquaculture breeds. They also have a role in genetic improvement for different stocks of major cultured freshwater fish. Recently, frozen gene bank have been developed, starting with the cryopreservation of common carp, grass carp, silver carp and Mekong striped catfish.

SEED MANAGEMENT

A summary of technical parameters for seed production of some common freshwater fish species in Viet Nam is given in Table 7.20.3.

Most of the major carps (i.e. grass carp, silver carp, rohu, mrigal) with very high fecundity have the advantage for mass production of seed using the Chinese-style hatcheries with low head supply tank, supplied by water pumped from an irrigation canal.

The relatively low fecundity of common carp is a fundamental constraint to mass production of seed but production is further restricted by reliance on natural spawning in tanks or hapas with egg collection and incubation on aquatic weeds.

Despite the very recent history of hatchery development, hatchery operators have rapidly gained experience in managing broodfish and adapted quickly to the high demand for their products. Year-round spawning rapidly developed once it was realized that fish could be maintained in mature condition year round. Demand for seed exceeding supply has further stimulated output and operators have overcome constraints of small land areas by specialization into hatchling or fingerling production. Intensification of broodfish management through intensive feeding and multiple spawning became essential.

TABLE 7.20.3
 Technical parameters of fish seed production in Viet Nam

Species	Age of maturity (year)	Average weight of spawner (kg)	Number of spawning per year	Introduction	Effective interval (hour)	Fecundity (1 000/kg Female)	Hatching time (hour)	Hatching rate (%)
Silver barb	1	0.15-0.2	4	1.5-3 doses of pituitary gland Water current	4-6	500-700	6-9	50-90
Silver carp	2	1-2	2	1 000-3 000 I.U. HCG/kg female	8-10	80-200	12-18	50-80
Indian carp	1-2	1-3	3	2.5-3 doses of pituitary glands 0.1 mg RLH/kg 500 I.U. HCG/kg	8-10	120-300	15-20	65-90
Common carp	1	0.3-1	6	1 dose of pituitary glands Water current	6-12	80-100	36-48	70-90
Hybrid catfish	1	0.1-0.25	3-4	3.5 mg of pituitary glands/kg 2 500-3 000 I.U. HCG/kg	14-18	50-70	22-26	60-90
Tilapia	3-6 mo	0.03-0.1	5-6	Natural spawning		6.3-18.5		

Tilapia seed production is part of a diversified sub-urban agriculture system concentrated in the peri-urban areas of Hanoi and Ho Chi Minh cities where the main sewage canal drains through these areas and mixed-sex tilapia are produced in shallow earthen ponds fertilized with sewage. Pond preparation involves draining, sun drying (one day) and application of pesticide before refilling. Quicklime is used at a rate of 7-10 kg/100 m² and pig dung or ammonium nitrate-based NPK fertilizers as basal fertilizers. Sewage varies in strength seasonally where dry season sewage is stronger and needs settlement before use. Approximately three weeks after stocking, young fry are evident and the brooders are removed by seining. The seed are then nursed on in the same pond for a further 10-30 days after which all the seed are harvested by seining, draining of the ponds and final fish harvest. The pond is then re-prepared over a ten day period. Seed are graded at harvest and the ratio of seed sizes harvested depends on the nursery period. The duration of the cycles varies with demand. If demand is low, the operator tends to lengthen the nursery period resulting in larger seed. A total of four to five cycles per year are normal. The system is efficient with respect to broodfish use because fish removed from one pond can be stocked in another. Usually, sewage is added during a culture cycle by gravity and pumping. Broodfish are also fed supplementarily with rice bran. The earthen pond hatcheries around Hanoi and Ho Chi Minh cities that have long produced poorly documented tilapia hybrids are now in decline because of urban development and there is a widening demand by public and private hatcheries for pure strains of Nile tilapia, with certified breeding histories.

Recently, demand of all-male tilapia seed is increasing in Viet Nam. Most of all-male tilapia are normally produced by sex-reversal treatment using hormone diets. Oral administration of hormone-treated diets, with a dosage of 17 α -methyltestosterone ranging from 45 to 60 mg/kg⁻¹ diet, starts from first feeding and continues for a duration of four weeks. Details of hatcheries and production of sex-reversed tilapia in Viet Nam in 2003 are shown in Table 7.20.4.

There are two methods of spawning catfish: natural spawning and artificial spawning. But now, artificial spawning is popular and necessary for catfish. Simply stated, artificial spawning involves administering the potential breeders with two shots of gonadotrophic hormones and then manually spawning the fish. Broodstocks are separated by sex three to four mos in advance of breeding. Females will have a soft belly and an enlarged, red genital pore. Males will display a small genital pore and flat belly. Broodstock are fed with a mixture of animal and vegetable protein at about 5 percent of their body weight per day.

TABLE 7.20.4
Production of sex-reversed tilapia fry (millions) in 2003

Hatchery and Province	Production by strain, where known		
	GIFT	Thailand	Total
Research Institute for Aquaculture No. 1, Bac Ninh	4.8	1.2	6.0
AG Aquacultural Research and Hatchery Production Center, An Giang	3.5	1	3.5
Do Luong Hatchery, Nghe An	—	—	2.0
Yen Ly Hatchery, Nghe An	1.9	—	1.9
Fish Seed Center, ThuaThien, Hue	—	—	0.7
Dong Son Hatchery/ Thanh Hoa	—	0.7	0.7
Fish Seed Center, Hung Yen	0.2	0.2	0.4
Fish Seed Company, Son La	—	—	0.2
Fish Seed Center, Hai Phong	1.8	1.2	3.0
Hai Thanh Company, Ho Chi Minh City	25.0	—	25.0
Phu Huu Company, Ho Chi Minh City	1.2	10.8 ^a	12.0
Vinh Hung Company, Vinh Long	—	—	8.0
Fish Seed Center, DongThap	1.5	—	1.5
Total (where strains are known)	39.9	14.1	64.9

— = no data available by strain

The final stages of maturation of the female's eggs are induced by injection of hormones, a combination of dried pituitary glands and HCG. The hormones are grinded, dissolved in distilled water and administered as a single injection in the evening which allows the ripe eggs to be manually stripped from the fish the following morning. Sperms are obtained from testes removed from a male African catfish by dissection and the eggs are fertilized by carefully mixing eggs and sperm together in a bowl. The number of eggs produced per female depends on the time of year. In the early part of the season (February - April), 1 kg of females will produce around 5 000-7 000 hatchlings but this rises to over 20 000 later in the season. A single male will produce enough sperms to fertilize 0.5 kg of eggs.

SEED QUALITY

MOFI (2000) has issued criteria for seed quality of the most commonly cultured fish species. These include specific requirements for size and age of brooders and growth performance and health status of fish seed such as growth rate, survival, uniformity of size at harvesting. However, the government guidelines for standard broodfish age and weight are not clearly observed in many hatcheries. And there are no clear criteria for selection of quality broodfish.

Fish seed quality is an important concern by different aquaculture stakeholders. Little and Tuan (1998) reported more than 60 percent of fish farmers in the north perceived fish seed quality to be "good" or "very good", only a minority (< 7 percent) thought they were "bad". However, there presently is a widespread opinion that seed quality of most of commonly cultured fish species such as Chinese and Indian major carps, tilapias, etc. is poor. There are several reasons that can explain the existing poor quality of fish seed in Viet Nam. These are: (i) most hatcheries's broodstocks came from same sources, i.e. one founder stock and (ii) hatcheries have retained their own fish, only a few purchased extra from different sources, suggesting inbreeding is likely a problem and (iii) poor management of broodfish due to limited pond area and intensively multiple spawning.

In order to improve quality of fish seed, there have been several selective breeding programmes of freshwater fish. These genetic improvement programmes involved common carp (Thien *et al.*, 1993), tilapia (Dan, Luan and Quy, 2001), Mekong striped catfish (Hao *et al.*, 2004), grass carp and mrigal (Tuan *et al.*, 2003, 2005). Awareness of genetic issues has also increased among hatchery operators during the last decade, largely due to training programmes and extension conducted in the country. These have

lead to many hatchery operators changing their broodstock management practices and broodstock. The impacts of these are hard to measure but likely to be fairly widespread.

The Ministry of Fisheries promulgates and implements fish quarantine regulations in Viet Nam, the responsibility for disease screening is allocated to the National Office for Fisheries Quality and Aquatic Health. The RIAs have responsibilities for assessment of environmental and economic impacts of fish introductions and transfers. However, these institutes currently lack sufficient resources to implement biosecurity measures effectively. Illegal and unquarantined introductions of alien aquatic species are continuing, posing threats to biodiversity and to aquaculture and fisheries.

SEED MARKETING

Seed traders are obviously playing important roles in freshwater fish seed marketing and distribution in Viet Nam. The specialized nature of the hatchery, nursery and food fish operations have resulted in the emergence of traders or middlemen as key actors in fish seed marketing. However, many farmers buy fish seed directly from hatchery and nursing operators. Most farmers buy and stock fish seed in early part of the year when seed are considered as being “good quality” and having a longer period to grow.

Recently, tilapia aquaculture is expanding in Viet Nam. Demand for tilapia seed, particularly all-male tilapia in the northern provinces during the early months of the year is very high. Large numbers of tilapia seed produced in the south and China are imported to the north during February-May.

Trading fry and fingerlings is a seasonal activity peaking between February and May. Nursed seed are purchased and distributed mainly by young, otherwise underemployed, men in the village. Working in pairs, they travel long distances by bicycle with the fish seed carried in basket panniers lined with plastic sheeting. Typically only two baskets will be carried and the traders alternate the load between them. Seed may be traded locally but longer distance marketing, where fry are carried for several days, is also common.

Traders may extend their range by using a bus or truck for part of the journey to reach the furthest destinations which are often areas with few hatcheries and where there is a high demand for fish seed. Fish are conditioned in hapas prior to moving them and mortalities are generally very low during transportation. Water is regularly exchanged from ponds, rivers and the ricefields *en route* and the movement of the bicycle aids in aeration. The numbers of seed varies with the size rather than the season. Table 7.20.5 presents live transportation details of some freshwater fish seed in northern Viet Nam.

In order to promote sales, the nursing operators and traders often provide accommodation, and other services including provision of credit, guaranteed replacement of fish mortalities to seed buyers. The nursing operators also attract and maintain customers by ensuring that a variety of fish seed species are available during the sales season and guaranteeing both quality and quantity of the fish seed sold.

SEED INDUSTRY

Most of freshwater fish seed producers and suppliers in the country are small-scale operators. Fish hatcheries often have a total of pond water areas from 1 to 10 ha, with annual seed production capacity varying from 5 to 200 million hatchlings. Household nursing operators with limited pond areas ranging from 500 m² to 5 000 m² per household are common. They nursed fry and fingerlings to sell the majority of seed to nearby growers.

There are differences in weather conditions between the north and the south. Warm temperature all-round year in the southern provinces are favourable for fish seed production; the cold winter during December-March in the north is unfavourable weather for fish seed production. Fish seed have to be overwintered in ponds with

TABLE 7.20.5
Trading of freshwater fish seed in northern Viet Nam

Species	Size (cm)	Price (VND/fish)		Transportation			Notes
		Buy	Sell	Container	Containers/trip	Fish/container	
Grass carp	hatchling	2	3	Plastic bag	2	0.6 million	Bottled oxygen Motorbike
Rohu	hatchling	2		Plastic bag	1	50-70 000	Local nursery operator Air-inflated, bicycle, bottled oxygen, motorbike
	hatchling	2		Plastic bag	1	1.0 million	Up to 6 hrs
Mrigal	1-2			basket	2	8 000	Bicycle, 2.5-4 kg weight, 80 km journey
Grass carp	2	15	18	Basket	2	7 500	Bicycle
Mrigal	2-3			Basket	2	2 700	Bicycle, on ferry
Common carp	2-3			Canvans	1	200-300 000	By truck to northwest highlands; nurse themselves
	4			Tank	1	150 000	
Common carp	4	20	40-100	Basket	2	750	Bicycle < 100 Km 10 kg weight (depends on distance)
Rohu	8	36	50-100	Basket	2	300	Bicycle Nursing for 1 mo before sale (depends on season)

high water depth, even in green house facilities. There are often shortages of fish seed at early months of every year. Shortage and high demand of seed at early months lead to higher price of fish seed during these months.

Most seed suppliers are close to the markets. However, there is less development of hatcheries and nursing operations in the northern mountains, thus, a huge number of fish seed particularly fry and small fingerlings are being transported long distances from the suppliers located in the delta to markets in the mountainous areas.

Ho Chi Minh City is a concentrated area for tilapia seed production, most of its production are supplied to seed markets in the Mekong Delta and in the central highlands and even to northern provinces during February-May.

Women have actively involved in freshwater fish seed production. They are working in fish hatcheries, fry and fingerling nursing, i.e conditioning broodfish, pond preparation, feeding, and managing incubators. Only a few women are involved in fish seed trading.

A number of traditional knowledge of farmers exists in the freshwater fish seed industry in the country. Fish nursing farmers believe that preparation of seed prior to sale is very important and that which affects the quality of fish seed. Various techniques are commonly used including stopping feeding for one or two days before packing. Fish fry and fingerlings are trained in pond before harvest by seining or other forms of disturbance to acclimatize them to stress and eliminate weaker individuals. Hatchery operators report that well-fed and fully-mature broodfish produced high quality eggs and inappropriate use of hormones was also implicated in the production of poor quality seed in early breeding season.

SUPPORT SERVICES

There are good support services to freshwater fish seed industry in Viet Nam. Every year MOFI have aquaculture extension and technical training programmes, many of them related to freshwater fish seed production. These included:

- short-term training courses on hatchery and broodstock management of Chinese and Indian major carps, common carp, tilapia; sex-reversal tilapia techniques; improved common carp seed production and broodstock management;

- distribution of improved tilapia and common carp to different local hatcheries; and
- production of technical extension manuals on fish seed production, fish nursing, live fish transportation and others.

In order to promote aquaculture development in remote regions, there are annual budgetary allocations from local governments to subsidize fish seed transportation to fish farmers in the remote mountainous areas. Funds for each mountainous province usually range between VND50-200 million/year.

There are credit schemes available for farmers. Fish seed producers (hatchery, nursing operators) have access to credit from different banks where they can have a loan of VND50 million maximum for their seed business with very low interest.

SEED CERTIFICATION

There is no seed certification system existing in the country.

ECONOMICS

There are several factors that determine the price of freshwater fish seed. These depend on the balance between supply and demand, seasonality, species and quality of seed.

Seed production of most Chinese and Indian major carps are beyond the demand therefore these seed often are relatively cheap. However, the seed produced during the early months of the breeding seasons can be sold at higher price due to high demand of fish seed as fish producers are very keen in getting early seed for longer period of growth.

The price of the improved quality seed is normally high. The improved tilapia and the selected common carp can normally sell at 50 percent higher than that of normal ones.

STAKEHOLDERS

There are various stakeholders involved in freshwater fish seed production. These are as follows:

Producers/Farmers. There are a total of 420 freshwater fish hatchery operators and thousands of fish nursing farmers.

Fishery extension services. There are national networks of fishery extension services in the country. The National Fishery Extension Centre (NAFEC) under MOFI is responsible for fishery extension services at the national level. In every coastal province, there is a Provincial Centre for Fishery Extension Services under the Provincial Department

PLATE 7.20.3
Freshwater fish seed transportation methods used in Viet Nam



of Fisheries, whereas in each inland province, fishery extension services are included in the activities of the Provincial Centre for Agriculture Extension Services under the Provincial Department of Agriculture and Rural Development.

Research Institute for Aquaculture (RIA) and National Broodstock Centres (NBC). There are three RIAs in the country (RIA No. 1, RIA No. 2 and RIA No. 3) who are responsible for aquaculture research and development in the north, south and the central regions of the country, respectively. Recently, three NBCs have been established under these RIAs. The RIAs and NBCs are responsible for development of new varieties/strains or innovations in freshwater fish seed production.

Government Institutions. The Department of Aquaculture under MOFI is responsible for providing the legal and policy frameworks for the seed industry.

Education and Training Institutions. There are seven universities in the country providing a degree on Bachelor of Science in Aquaculture. Aquaculture technicians have also been trained from three Fisheries Colleges.

Donors. There are a several existing donor-funded projects on freshwater fish seed research, development. These are:

- DANIDA: provided Support to Freshwater Aquaculture (SUFA).
- MOFI: provided support to the following research projects and activities:
 - Investigation into genetic improvement of grass carp and mrigal
 - Selective breeding for growth improvement of Mekong striped catfish
 - Induced breeding and hatchery technique of *Hemibagrus elongatus* (Grinther)
 - Gene bank of freshwater fish species
 - Induced breeding and hatchery technique of *Semilabeo notabilis* Peters
 - Seed dissemination and technology transfer projects:
 - dissemination of improved common carp and tilapia strains
 - technology transfer of all-male tilapia production
- AUSAID: improved breeding of common carp for small-scale farmers (002/04VIE). A research project under the Collaboration for Agriculture & Rural Development Program (CARD).
- NORAD: selective breeding for growth improvement of tilapia, a component under the NORAD-funded project on Building up Research, Education and Extension Capacity of RIA-I.
- ADB: achieving greater food security and eliminating poverty by dissemination of improved carp strains to fish farmers (ADB-RETA 6136).

FUTURE PROSPECTS AND RECOMMENDATIONS

The Government of Viet Nam has considered freshwater aquaculture as an important means to ensure food security of the Vietnamese people in the future. Production of enough quantity of quality fish seed is an essential factor to sustain development of freshwater aquaculture in the country. The government had approved a national program of aquaculture development for the period of 1999-2010 which projected 2 million of aquaculture products by the year 2010, of which 0.87 million tonnes will come from freshwater aquaculture. It has also estimated that a total of 9 200 million freshwater fish seed of major cultured species (Major chinese and Indian carps, Mekong striped catfish, tilapia) are needed.

There are several issues related to freshwater fish seed production in Viet Nam, these are:

- development of appropriate methods for field-level identification of fish seed quality is obviously needed;

- improving quality of fish seed is essential, plans for developing improved genetic quality of fish seed should involve private hatcheries, as well as appropriate approaches of improved seed dissemination;
- further training in both technical and management of seed production for stakeholder's are needed; and
- certification of seed quality should be developed.

REFERENCES

- Brenden Mc.A., Penman, D. & Guy, D.** 2005. Report on Fourth Genetic Improvement Consultancy, February 24th –March 15th 2005. 65 pp.
- Dan, N.C., Thien, T.M., & Tuan, P.A.** 2001. Review of fish genetics and breeding research in Vietnam. *In* Fish Genetics Research in Member Countries and Institutions of the International Network on Genetics in Aquaculture. *ICLARM Proceedings*, 64: 91-96.
- Dan, N.C., Luan, T.D., & Quy N.V.** 2001. Selective breeding of *Tilapia Oreochromis niloticus* for improvement of growth performance and cold tolerance. Final Technical Report of MOFI-funded Research project. 76 pp.
- Government of Vietnam**, 1999. National program for aquaculture development in period of 1999-2010. Prime Minister's decision No. 224 QD-TTg, Dec. 8th, 1999. Hanoi. 7 pp.
- Government of Vietnam**, 2004. National program for fisheries seed development by the year 2010. Prime Minister's decision No. 112 QD-TTg, Jun. 23rd, 2004. Hanoi. 8 pp.
- Hao, N.V., Sang, N.V. & Khanh, P.V.** 2004. Selective breeding of Mekong striped catfish *Pangasius hypophthalmus*. Final Technical Report of MOFI-funded Research project. 82 pp.
- Little, D.C. & Tuan, P.A.** 1995. Overview of freshwater fish seed production and distribution in Vietnam. AIT Aquaculture Outreach Programme. Working paper No. NV6. 123 pp.
- Little, D.C. & Tuan, P.A.** 1998. Fish seed quality in Northern Vietnam. Report of DFID-funded research project on fish seed quality in Asia. 23 pp.
- Little D.C.** 2003. Seed Quality Management and Evaluation for freshwater aquaculture Development in Vietnam covering. The 2nd Consultancy report, August 20-30th, 2003. 75 pp.
- Mair, G.C.** 2002. Genetic management and improvement of broodstock for freshwater aquaculture development in Vietnam. The Initial Consultancy report, November 2002. 56 pp.
- Mair, G.C. & Pante, M.J.** 2003. Genetic management and improvement of broodstock for freshwater aquaculture development in Vietnam. The 3rd Consultancy report, July 9-14th, 2003. 73 pp.
- MOFI.** 2000. Criteria of Vietnam Fisheries. Hanoi, Agriculture Publishing House. 372 pp.
- MOFI.** 2002. Development of Tilapia Culture in the Period 2003-2010. Hanoi: Ministry of Fisheries. 15 pp.
- MOFI.** 2005. Review of Vietnam Fisheries in 2004. *Journal of Fisheries*, 1: 4-6. Hanoi: Ministry of Fisheries.
- Thien, T.M.** 1993. Review of fish breeding research and practices in Vietnam. Proc. of the workshop on selective breeding of fishes in Asia and the United States. May 3-7, 1993. Honolulu, Hawaii. 7 pp.
- Thien, T.M., Thang, N.C., Tien, P.H. and Tuan P.A.** 1995. Selective breeding of common carp *Cyprinus carpio* L. Final Technical Report of MOFI-funded Research project. 45 pp.
- Tuan, N.A.** 1991. The status of finfish hatcheries in the Mekong delta, Vietnam. Paper given at the conference "Finfish Hatcheries in Asia 91".
- Tuan, P.A., Hung, L.Q., Diep, H.T. & Tan, N.T.** 2003. Investigation into genetic improvement of grass carp and mrigal. Final Technical Report-Phase 1 of MOFI-funded Research Project. 76 pp.

Tuan, P.A., Hung, L.Q., Diep, H.T. & Tan, N.T. 2005. Investigation into genetic improvement of Grass carp and Mrigal. Final Technical Report-Phase 2 of MOFI-funded Research project. 64 pp.