

7.5 Freshwater fish seed resources in China

Hu Honglang

*Aquaculture Seed Development and Management Division
National Fisheries Extension Centre, Ministry of Agriculture
No. 18, Mai Zi Dian Street, Chaoyang District, Beijing 100026, China
aquseed@agri.gov.cn*

Honglang, Hu. 2007. Freshwater fish seed resources in China. pp. 185–199. 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

China, one of the countries with the richest aquatic resources in the world, has more than 800 varieties of freshwater fish species. Based on production, the top 10 cultured species are: (1) grass carp (370 million tonnes); (2) silver carp (346 million tonnes); (3) common carp (236 million tonnes); (4) bighead carp (208 million tonnes); (5) crucian carp (194 million tonnes); (6) tilapia (90 million tonnes); (7) blunt snout bream (52 million tonnes); (8) freshwater eel (48 million tonnes); (9) river crab (41.5 million tonnes); and (10) white-leg shrimp (*Penaeus vannamei*) (40 million tonnes from freshwater culture).

According to an investigation report in 2001, there were 16 435 seed production units (hatcheries) and 8 072 were well equipped for hatching and juvenile rearing. Total production from all hatcheries are estimated at 13 385 billion individuals which meet the needs for grow-out production.

The 16th Item of the “Fisheries Law” requires that hatcheries producing aquatic seed are required to get a license from the local government. According to current statistics, approximately 50 percent of aquatic seed are produced by licensed hatcheries.

With respect to seed quality, the following are major issues of concern: (i) fish species with good strain are not currently the lead producers in aquaculture, (ii) lack of high quality seed and (iii) more emphasis placed on licensing than fish seed quality.

There are a number of services which provide support to China’s freshwater fish seed production sector. The innovation service is responsible for breeding using selective breeding and newly developed breeding techniques. The examination service is responsible for morphological characteristics and farming performance of freshwater fish seed. The extension service provides extension and demonstration activities for both hatchery and grow-out operators on good breeding techniques, evaluation of risks, testing and expansion of introduced or new species.

There are two major problems which need to be addressed: firstly, hatchery techniques for some important species has not yet been established and secondly, seed exchange and transportation between different places lack a valid surveillance.

Future prospects and recommendations for China’s freshwater fish seed sector are: (i) consider the sustainable development of aquaculture, exploit and utilize aquatic genetic resources strategically, (ii) develop genetic breeding programs and improve the quality of aquatic seed, (iii) train farmers how to get good quality seed for farming,

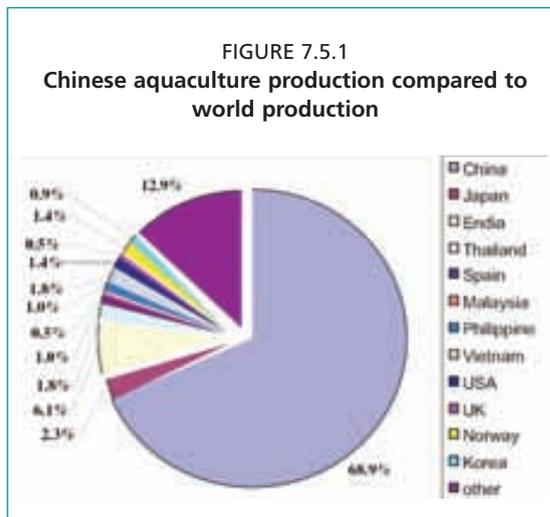
- (iv) reinforce risk assessment on introduced species and minimize their harm to native genetic resources and (v) improve the regulation of seed management and to make it work efficiently.

INTRODUCTION

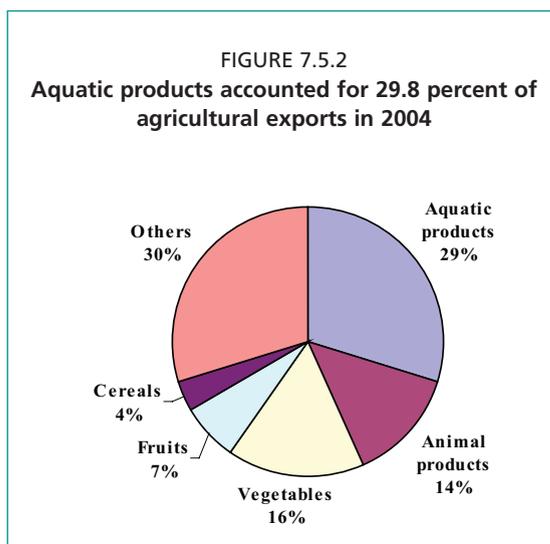
China is one of the countries with rich aquatic resources in the world. According to current statistics, there are more than 800 varieties of freshwater fish species. At present, more than 50 fish species, 20 shellfish species, ten crustacean species and ten algae species are being cultured. Total culture area reached 728 ha producing 3 209 tonnes in 2004. The Chinese government puts strong emphasis on seed improvement, a crucial requirement for the development of the aquaculture industry.

In 2004, China's aquaculture production reached 30.6 million tonnes, accounting for over 68 percent of national fishery production and 68.9 percent of the world's aquaculture production (Figure 7.5.1); aquatic products accounted for 29.8 percent of agricultural exports (Figure 7.5.2). According to an authoritative report in 2002, there were about 16 000 hatcheries in the country, of which about 8 000 are well-equipped for hatching and rearing. This large number of hatcheries meet the growing demand for aquaculture production.

The predominant species cultured in China are black carp, grass carp, silver carp and bighead carp (also called the "four major domesticated fish"), common carp



and crucian carp. The production of the "four major domesticated fish" amounts to 57.7 percent of the total freshwater production followed by common carp and crucian carp which produced 22.4 percent of the total freshwater production and few other species including blunt snout bream contributing 3.4 percent and tilapia contributing 4 percent to total production. Some species such as sturgeon, trout, etc. are cultured in a small-scale with limited production (Table 7.5.1).



Most of the freshwater products are supplied live to the market with very little processing. Only about 7.75 percent of the total production were processed in 2003. According to a study conducted by the Shanghai Fishery University, domestic consumption is the main target of the commonly produced freshwater fish species. In more economically developed areas, for e.g. Shanghai, people still prefer low-priced fish. Culture of medium-priced fish such as tilapia and the giant Malaysian prawn is expanding because of good profit. The consumption of giant Malaysian prawn also increased by 50 percent in the late-1990s.

TABLE 7.5.1
The main freshwater species cultured in China

	Name	Wild	Imported	Breeding
1	Silver carp	▲		
2	Bighead carp	▲		
3	Grass carp	▲		
4	Black carp	▲		
5	Common Carp (lens <i>Cyprinus carpio</i> , <i>Cyprinus carpio var.jian</i> , <i>Cyprinus carpio wuyanensis</i>)	▲		<input type="checkbox"/>
6	Crucian Carp (Pengze crucian, Silver Prussian, Daban crucian)	▲		<input type="checkbox"/>
7	Mud carp	▲		
8	Chinese perch	▲		
9	Japan eel	▲		
10	European eel		<input type="checkbox"/>	
11	American eel		<input type="checkbox"/>	
12	Nile tilapia		<input type="checkbox"/>	<input type="checkbox"/>
13	Blue tilapia		<input type="checkbox"/>	
14	Red tilapia		<input type="checkbox"/>	<input type="checkbox"/>
15	Hybrid tilapia	▲		<input type="checkbox"/>
16	Rainbow trout (Dao's rainbow trout, gold rainbow trout)		<input type="checkbox"/>	<input type="checkbox"/>
17	Channel catfish		<input type="checkbox"/>	<input type="checkbox"/>
18	<i>Ictalurus nebulosus</i>		<input type="checkbox"/>	
19	Pacu		<input type="checkbox"/>	
20	Chinese sturgeon	▲		
21	Dabry's sturgeon	▲		
22	<i>Acipenser schrenckii</i>	▲		
23	Chinese paddlefish		<input type="checkbox"/>	
24	Great sturgeon		<input type="checkbox"/>	
25	Siberian sturgeon		<input type="checkbox"/>	
26	<i>Distoechodon tumirostris</i>	▲		
27	<i>Xenocypris argentea</i>	▲		
28	<i>Plagiognathops microlepis</i>	▲		
29	Blunt snout bream (Pujiang No.1)	▲		<input type="checkbox"/>
30	<i>Megalobrama hoffmanni</i>	▲		
31	<i>Megalobrama terminalis</i>	▲		
32	<i>Myxocyprinus</i> sp.	▲		
33	Ratmouth barbel	▲		
34	Armorhead catfish	▲		
35	Longsnout catfish	▲		
36	Yellow catfish	▲		
37	<i>Cranoglanis boudierius</i>	▲		
38	<i>Clarias lazera</i>		<input type="checkbox"/>	
39	Catla catla		<input type="checkbox"/>	
40	<i>Labeo rohita</i>		<input type="checkbox"/>	
41	<i>Cirrhina mrigala</i>		<input type="checkbox"/>	
42	Striped Catfish		<input type="checkbox"/>	
43	Chum salmon		<input type="checkbox"/>	
44	<i>Micropterus salmoides</i>		<input type="checkbox"/>	
45	<i>Lepomis macrochirus</i>		<input type="checkbox"/>	
46	Stripedbass		<input type="checkbox"/>	<input type="checkbox"/>
47	Red fish		<input type="checkbox"/>	
48	Walleye		<input type="checkbox"/>	
49	Shad		<input type="checkbox"/>	
50	Big Mouth Buffalo		<input type="checkbox"/>	
51	<i>Takifugu flavidus</i>	▲		
52	<i>Fugu obscurus</i>	▲		
53	<i>Fugu xanthopterus</i>	▲		
54	Amur pike	▲		
55	River perch	▲		
56	<i>Erythroculter ilishaeformis</i>	▲		
57	<i>Spinibarbus sinensis</i>	▲		
58	Snakehead	▲		
59	<i>Channa asiatica</i>	▲		
60	flowergu fish	▲		
61	Rice field eel	▲		
62	Chinese mitten-handed crab	▲		
63	river prawn	▲		
64	Giant Malaysian prawn (<i>Macrobrachium rosenbergii</i>)		<input type="checkbox"/>	
65	<i>Cherax quadricarinatus</i>		<input type="checkbox"/>	
66	Chinese turtle	▲		
67	Reeves' Turtle	▲		
68	<i>Hyriopsis cumingii</i>	▲		
69	<i>Cristaria plicata</i>	▲		

SEED RESOURCES AND SUPPLY

Freshwater fish seed production in China can be classified into three categories. The first is the wild seed. Since hatchery technologies for some species have not yet been established, fish seed come from fishing from natural ground. At present, there are still few species, such as eel and some new cultured species, being captured from the wild. The second is from wild stocks. With the study of propagation physiology and fertilization technology, after catching broodstocks from natural waters, fish seed of black carp, grass carp, silver carp, bighead carp and river crabs can be manually reproduced. Most aquatic seed are produced this way. According to the survey, 86 percent of freshwater fish species rely on using natural parents for seed production. The third category is domestic seed production. Artificially-bred parents are adopted for seed production using current technologies and the number of fish species completely artificially reproduced is increasing (e.g. common carp, crucian carp, bream, salmon trout, tilapia, etc.). So far, most seed are supplied by hatcheries. Seed production technology for 88 percent freshwater fish species are developed and 66 percent of freshwater seed are produced at the industrial level. By 2000, the total number of hatcheries (freshwater and marine water) reached 16 435. Of these, about two thirds (2/3) are private and the rest (1/3) are government or a combination of private/government operation. Fish seed output has already met the basic needs in aquaculture and the seed production industry has thus become an important part of aquaculture (Figure 7.5.3).

SEED PRODUCTION FACILITIES AND TECHNOLOGY

According to an investigation report in 2001, there were 16 435 fish seed production units and of these, about 8 072 were well equipped for hatching and juvenile rearing. Total production of all the hatchery is 13 385 billion individuals which meet the need for grow-out production. There are 8 171 hatcheries of the “four major domesticated fish”, 6 700 hatcheries for common carp and crucian carp and 499 for tilapia. The rest of the hatcheries are for river crab (515), reptile (203) and shellfish (1 017). Total investment for all fish hatcheries is about 149.6 billion yuan and employs about 275 539 persons (Plate 7.5.1).

From the 1970s to the 1980s, cross-breeding technology has brought encouraging results as exemplified by common carp (Figures 7.5.4 and 7.5.5). New fish strains such as Heyuan carp and Tri-cross-bred carp were selected and bred. Strains such as Jian carp (Figure 7.5.6), Songpu carp, Prussian carp, etc. were bred through a combination of conventional and gynogenesis technologies. Then a series of new aquatics, such as Xiangyun crucian and Xiangyun carp were reared as a result of polyploid breeding. Blunt snout bream “Pu River No.1” was acquired through conventional breeding method. Meanwhile, there were significant accomplishments on research on transgenic fishes. According to the authorization by the National Certification Committee of Aquatic Wild and Bred Varieties (NCCA-WBV), until the end of 2004, there had been 32 strains, among which were 16 selective strains and 16 cross-breeding strains. Most of them are carp (Table 7.5.2).

Many of cultured species in China are introduced exotic species. According to incomplete statistics, since the 1950s more than 140 species have been introduced to

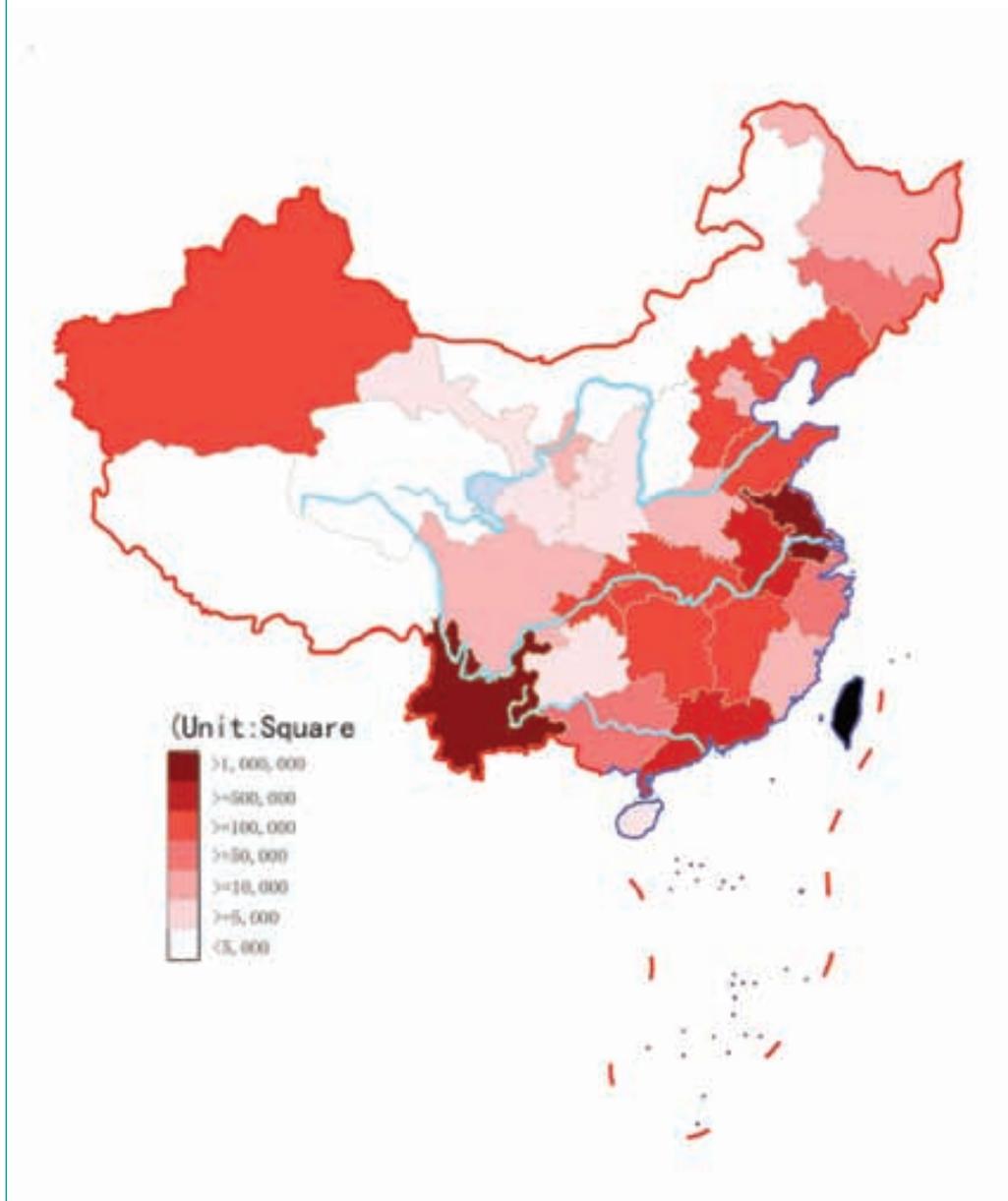
TABLE 7.5.2

Introduced exotic species having obvious economical benefits (in thousand tonnes)

500-1000	100-500	10-100	Below 10
scallop	giant Malaysian prawn	Channel catfish	Rainbow trout
tilapia		<i>Micropterus salmoides</i>	Rohu carp <i>Clarias lazera</i>
<i>Penaeus vanmamei</i>		<i>Colossoma brachypomum</i>	Turbot
		<i>Penaeus monodon</i>	American red fish

Source: Li Sifa (pers. comm.)

FIGURE 7.5.3
Map of China showing the distribution of freshwater fish seed production in different provinces



China. More than ten species show obvious economic value and produce 10 percent of total aquatic production (including marine species) (Table 7.5.3). Because they are very good species, their production accounts for about 20 percent of the total aquatic production value.

SEED MANAGEMENT

The 16th item of the “Fisheries Law” requires that hatcheries producing aquatic seed are required to get a license from the local government. According to current statistics, approximately 50 percent of aquatic seed are produced by licensed hatcheries.

The “aquatic seed management” also defined that the introduction of exotic or foreign seed requires a quarantine license from the local government fishery bureau. Only those without pathogens can be transported and sold. Unfortunately, this regulation has not been seriously implemented.

PLATE 7.5.1
The main freshwater fish species in China



Jian carp



Huanghai Chinese shrimp



Common carp



Triploid carp



Triploid crucian carp



Triploid common carp



Cyprinus carpio singuomensis



Cyprinus carpio wananensis



Bluntnout bream

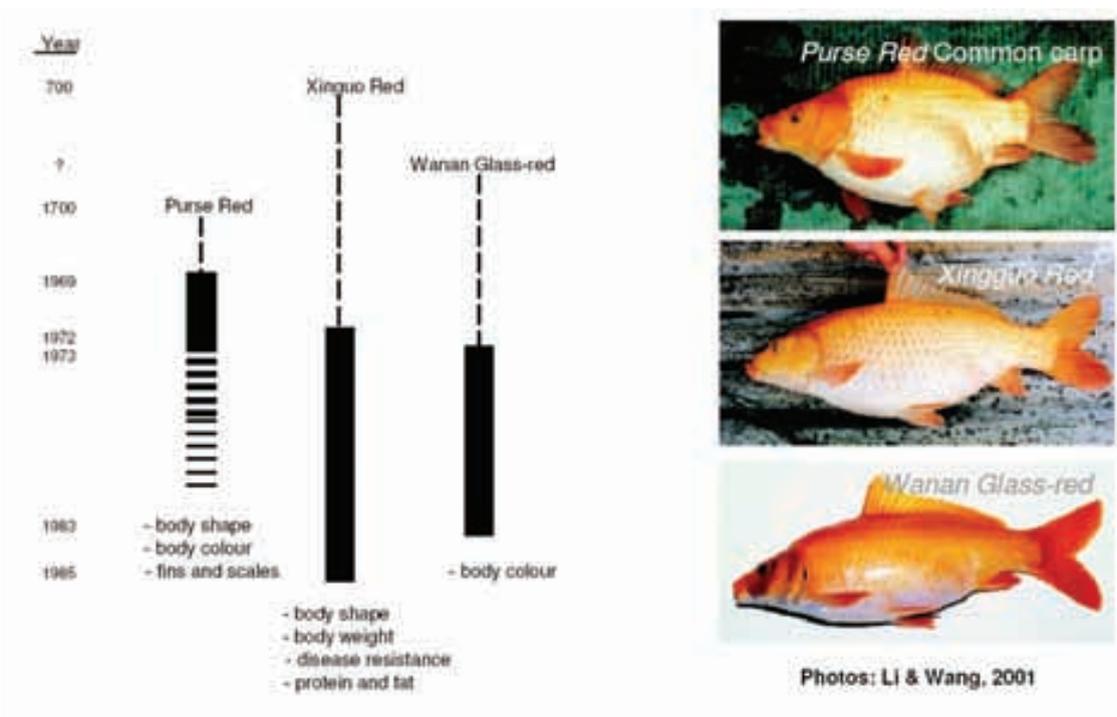


Triploid hybrid of common carp and crucian carp



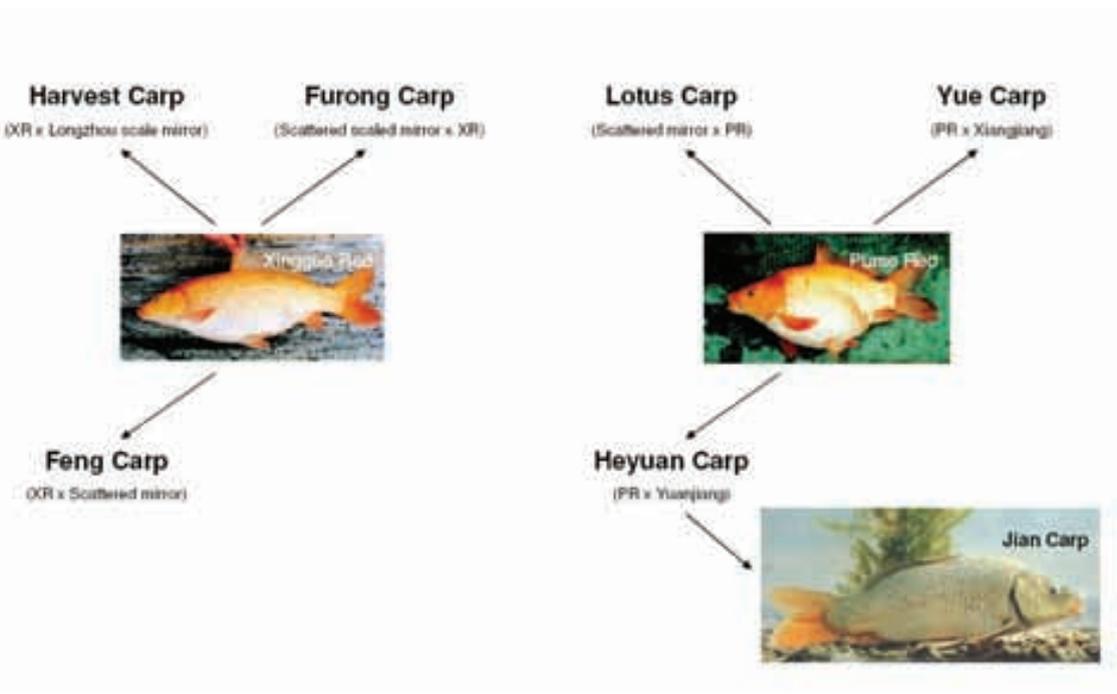
Transgenic common carp in China

FIGURE 7.5.4
Selective breeding of common carp

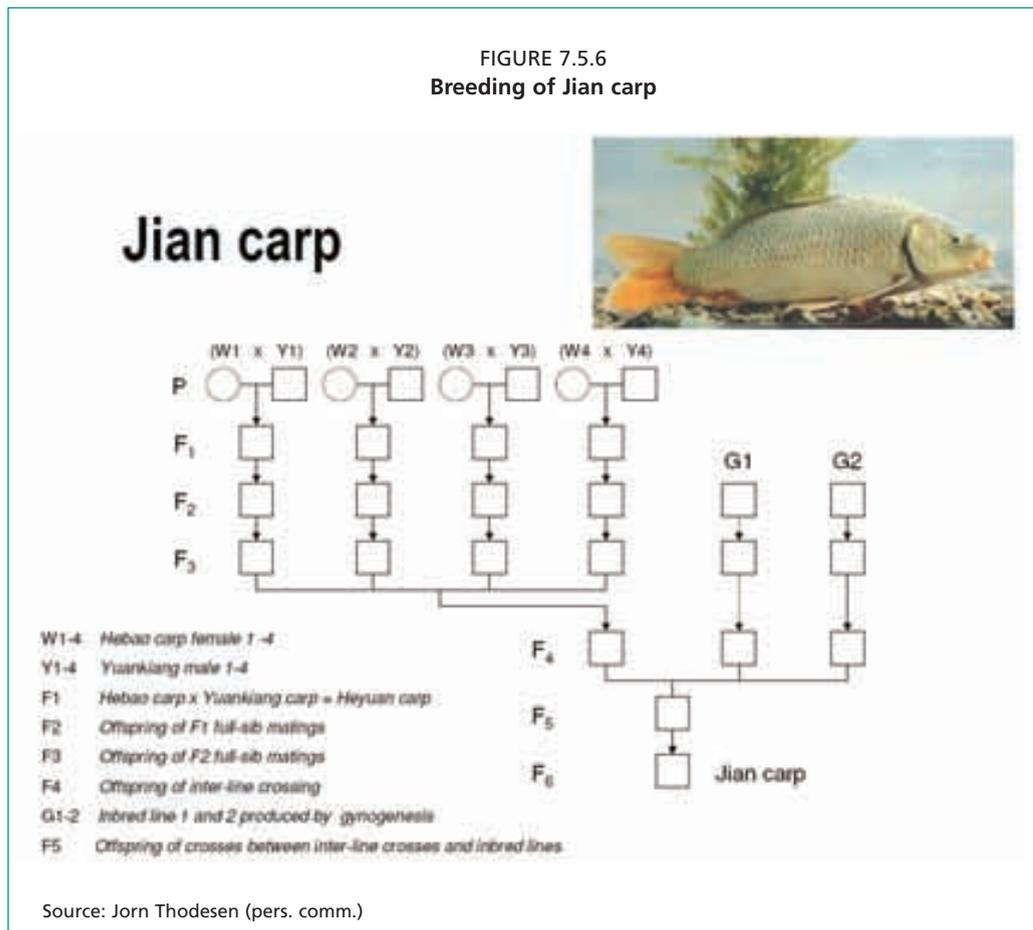


Source: Jorn Thodesen (pers. comm.)

FIGURE 7.5.5
Cross breeding of common carp



Source: Jorn Thodesen (pers. comm.)



Since 1990, national and local governments of China have increased investment on the establishment of the National Aquatic Bred and Wild Seed System (NABWSS) which includes the Genetic Breeding Center (GBC), the Wild Variety Collection Center (WVCC), the Wild/Bred Variety Amplifier (WBVA), the Exotic Species Centers (ESC) and the Seed Quality Inspection Centers (SQIC).

In order to match with NABWSS construction, the Ministry of Agriculture, Fishery Bureau successively issued several documents, including “management norms for WBVA”, “guide for WBVA construction”, etc. which standardized the procedure and operation of WBVA.

SEED CERTIFICATION

The 16th Item of the “Fisheries Law” states that “any new cultured aquatic species can’t be produced and extended until obtaining certification by NCCAV followed by approval by the MOA”.

The documentation required for certification of good species, include: (i) application report which is the main document which contains original sources of seed, breeding process, major characteristics, extension and evaluation; (ii) other supporting documents consisted of research report, reproduction and seed production technical reports, genetic characterization, inspection report concerning disease resistance by an authority designated by NCCAV, on farm testing report during the last two years.

The government established NCCAV in 1991 under the MOA of China. The NCCAV is responsible for certificating three kinds of cultured species which includes genetic improved varieties (strains), hybrids and exotic species.

The NCCAV consists of scientists with genetics background, who are from research institutes and universities; aquaculture administrators, who are from the

TABLE 7.5.3
List of new varieties and strains approved by national government from 1996 to 2004)

Year	Variety			Total
	New variety	Hybrid	Imported	
1996	<i>Cyprinus carpio singuomensis</i> , <i>Cyprinus carpio</i> var. <i>wuyanensis</i> , <i>Carassius auratus</i> <i>pengzesis</i> , <i>Cyprinus carpio</i> var. <i>jian</i> , <i>Songpu crucian carp</i> , <i>Cyprinus</i> <i>carpio</i> var. <i>wuyanensis</i> , <i>German mirror carp</i> (7)	Blue tilapia, <i>Oreochromis</i> sp., Ying hybrid carp, Feng carp, Heyuan carp, Yue carp, three-hybrid carp, Furong carp, Allogynogenetic Silver crucian Carp (9)	<i>Tilapia nilotica</i> , <i>Tilapia</i> <i>aurea</i> , <i>Micropterus</i> <i>salmoides</i> , <i>Colossoma</i> <i>chypomum</i> , Channel catfish, rainbow trout, Donelson rainbow trout, <i>Clarias lazera</i> , <i>Cyprinus</i> <i>carpio</i> var. <i>specularis</i> , Scatter scaled mirror carp, <i>Labeo rohita</i> , Giant river shrimp, bullfrog (<i>Rana</i> <i>heckstheri</i>), <i>Patinopecten</i> (<i>Mizuhopecten</i>) <i>yessoensis</i> , Pacific oysters (17)	33
1997	"901" kelp, Songpu carp (2)	Gift tilapia (1)	-	3
2000	Bluntnout bream (Pujiang No.1), <i>Cyprinus carpio</i> var. <i>wananensis</i> (2)	Big Mouth Buffalo, turbot (2)	-	4
2001	-	<i>Cyprinus carpio</i> Triploid, <i>Carassius auratus</i> Triploid (2)	-	
2002	-	Red white crucian with long tail, Blue flower crucian with long tail (2)	SPF White Prawn (1)	3
2003	<i>Fenneropenaeus chinensis</i> ("Yellow Sea 1"), Songhe carp, Molong carp, <i>Xiphophorus</i> <i>helleri</i> (4)			
2004	Huanghe carp	"DalianNo.1" hybrid abalone, "East No.2" hybrid kelp, "Rongfu" kelp(3)	Alligator snapping turtle, <i>Pangasius sutchi</i> , <i>Hyriopsis schlegelii</i> (3)	7
Total	16	16	24	56

Bureau of Fisheries, the National Fisheries Technology Extension Center and the Academy of Fishery Science of China, under the MOA. In China, only NCCAV has been authorized by the central government to certify those genetic improved varieties extending to all of the country.

According to NCCA authorization, until end of 2004, there had been a total 32 bred varieties consisting of 16 selective breeding varieties and 16 crossbreeding varieties (Table 7.5.3).

LEGAL AND POLICY FRAMEWORKS

The legal documents in China concerned with aquatic seed are the "Fisheries Law" and "Aquatic Seed Management Measure". The 16th item of the "Fisheries Law" is about the management of aquatic varieties and seed. Details of this can be found in the section on Seed Management.

As the seed is a very important foundation of aquaculture, Chinese central and local governments pay more attention to this field through supporting policies. Since 1998, the national and local governments of China have increased investments continually in the establishment of National Aquatic Seed Production System (NASPS) (Plate 7.5.2), which includes Genetic Breeding Center, Breed Amplifier and Key Hatchery. The first project of NASPS was carried out from 1998 to 2004; a second project is on-going (2005-2010).

SEED QUALITY

The "aquatic seed management" provision of the "Fisheries Law" from MOA defined that the breeders for seed production must be introduced from WBVA or WVCC and

GBC in order to ensure the quality of the broodstock. However, in practical operation there are three problems. The first is the limitation of wild or bred variety production ability. The WBVA cannot produce enough breeders to satisfy the needs of hatcheries in both quantity and varieties. Good strain does not play a leading role quantitatively in aquaculture production. The second problem is seed evaluation techniques. An effective and scientific technique is needed. The third problem is that more emphasis is placed on the license and little on the quality of the seed itself.

SEED MARKETING

Aquatic seed are sold and circulated mainly from the hatchery to independent farmers, hatcheries generally produce seed according to the customer's order. Seed from some large farms in the southern region of the country are transported to farms mainly via air or land transportation. Seed of the northwest and the northeast regions mainly come from southern region. Because farming in these regions are made by small farmers, seed are not easily accessible locally. Therefore, some seed distribution companies emerged and are involved in the seed trade. Exotic seed are distributed by companies who purchase seed abroad, sell them to the farmers through their networks or branches such as those practiced in the eel seed business.

SEED INDUSTRY

The seed industry is composed of many small private seed producers. In order to make progress in seed quality improvement, the government invests substantially in the sector therefore making its role in seed production very significant.

The government has already set up 36 national classes and 100 provincial classes of WVCC and WBVA which have been checked and accepted in 2004. Some of them are equipped with advanced technology and known as demonstration base. WVCC is responsible for the collection, conservation and supply of the good wild stock. The selected wild stock is mainly supplied to WBVA. Fourteen national classes of WVCC have been checked and accepted. WBVA is responsible for the acclimatization, selective breeding of good wild varieties, exotic species, as well as bred varieties approved officially. They provide government and private hatcheries and farms with broodstock or seed. Twenty-three WBVAs have been checked and accepted. The ESPC is responsible for the introduction, risk evaluation, quarantine, production testing and extension of exotic species. Twenty-two ESPCs have been checked and accepted.

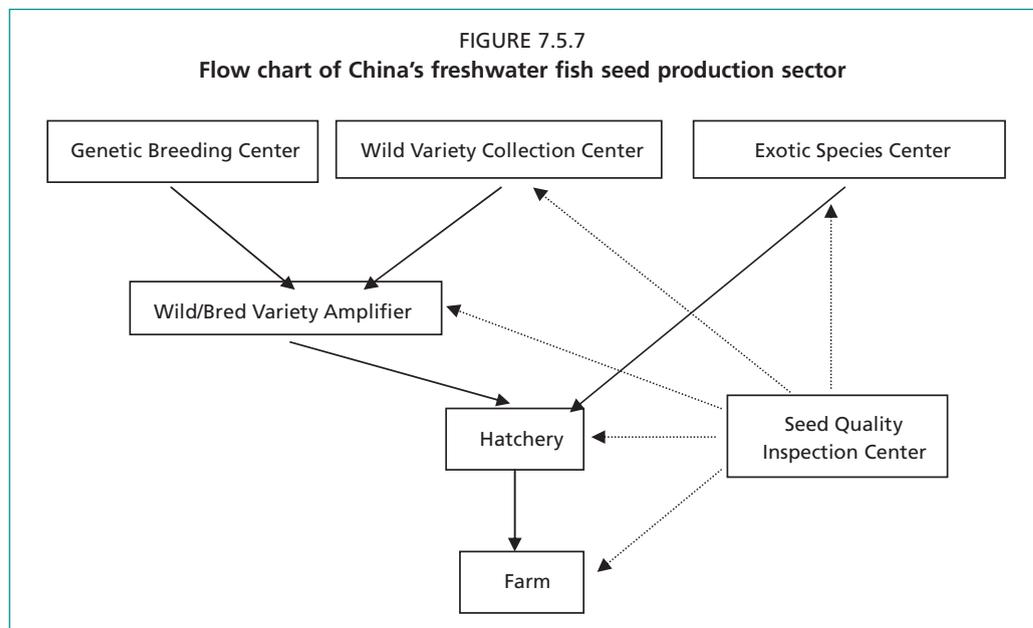


PLATE 7.5.2
Facilities at the National Aquatic Seed Production System (NASPS)



Genetic breeding center indoor tanks



Genetic breeding center indoor tanks



Wild breed variety amplifier



Larviculture tank



Tilapia hatchery in Qingdao



Larviculture tank

Government hatcheries fetching broodstock from WVCC or WBVA, are responsible for demonstrating hatchery techniques and supplying seed to farmers (Figure 7.5.7).

SUPPORT SERVICES

According to functions, support services are divided as follows:

- (i) Innovation service is provided by the GBC who is responsible for breeding (both through selective breeding and other newly developed techniques such as genetic engineering) in order to keep up with industry development demand as well as marketing demand. The first GBC, located at Heilongjiang Fisheries Research Institute (Harbin) was an investment by the central government in 2004.

- (ii) The examination service is provided by the SQIC who is responsible for the establishment and improvement of rapid and accurate evaluation techniques to strengthen the germplasm examination. The examination service is concerned with the morphological characteristics, farming performance and other cellular and molecular authentication requirements. Standards for more than 20 species (e.g. grass carp, silver carp, Nile tilapia, etc.) have been issued. The

PLATE 7.5.2 (CONTINUED)
Facilities at the National Aquatic Seed Production System (NASPS)



Wild variety collection center for "major four family carp"



Tilapia stock farm in Guangdong



Man-made lake for preserving breeder



Cement ponds for rearing seeds



Exotic species rearing center

germplasm authentication techniques as well as standard research methods are also in the process of being established. Four centers have already passed the national examination. These are the: (i) Chinese Academy of Fishery Sciences, Yangtze River Fisheries Research Institute (Hubei Jingzhou); (ii) Chinese Academy of Fishery Sciences, Yellow Sea Fisheries Research Institute (Qingdao); (iii) Chinese Academy of Fishery Sciences, Pearl River Fisheries Research Institute (Guangzhou) and (iv) Chinese Academy of Fishery Sciences, Heilongjiang Fisheries Research Institute (Harbin).

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

ECONOMICS

So far, there is no specialized organization or individual studying the economics of aquatic seed production in China. However, the aquatic seed market generally follows the market trends, i.e. profits mainly decide the relationship between supply and demand. When a certain fish seed is in shortage, the price will go high and the hatchery will make high profit. On other hand, when a certain fish seed is more than the demand, hatcheries will probably lose money.

In general terms, the main species used in freshwater farming do not change greatly and the seed market is relatively stable. The price is also steady. Whichever the case, the seed production sector is the highest profit making activity of the aquaculture business.

INFORMATION OR KNOWLEDGE GAPS

There are two main problems.

First is that hatchery techniques for some important farmed species has not been established yet. An example is eel aquaculture which is a major and profitable industry. It has an export value of US\$860 million in 2004 contributing to 12.2 percent of the total national aquatic product exports and the top position for a single-item agricultural export product. Since the eel hatchery technique has not been developed yet, the seed for grow-out production depend on wild sources. Wild-caught seed have continuously declined during the successive last few years. Eel seed imports amounted to 51.4 tonnes in 2004 valued at US\$ 7.8 million. Because the cost of imported seed have increase, seed cost accounts for 30 percent of the total farming cost.

The second problem is that seed exchange and transportation between different places lack a valid surveillance system. China is a huge country and as such, transfers and movements of many fish species from region to region (e.g. introduction of fish from Yangtze River to Erqishi River in Xingiang Province or vice-versa) within the country has been going on. The biological significance is almost similar to the introduction of a species from one country to another. Such transfers has lead to great damages. An example is the proliferation of the Chinese turtle from Taiwan Province of China impacting the fine genetic resources of China mainland turtle and which also brought new pathogens. Risks exist from nation-wide distribution, repeated introduction and escapees (e.g. rainbow trout).

Although introduction of fish seed is regulated by the “Office Procedure for Fish Seed in Aquaculture” which requires that quarantine procedures be carried out by the local administrative department in charge of fishery and release, transport and sale of seed authorized only after certification – this regulation has not been put into practice rigorously.

FUTURE PROSPECTS AND RECOMMENDATIONS

Future prospects and recommendations for China's freshwater fish seed sector are:

(i) consider the sustainable development of aquaculture, exploit and utilize aquatic genetic resources strategically, (ii) develop genetic breeding programs and improve the quality of aquatic seed, (iii) train farmers how to get good quality seed for farming, (iv) reinforce risk assessment on introduced species and minimize their harm to native genetic resources and (v) improve the regulation of seed management and to make it work efficiently.

Some of these recommendations are elaborated below.

Sustainable development of aquaculture, exploitation and utilization of aquatic genetic resources strategically. The following aspects should be considered: (i) selection of genetic resources should be based on geographic characteristics and suitable local species, (ii) market needs and (iii) production needs and trends in international aquaculture development.

Development of breeding programs and improvement of quality of aquatic seed. Compared with crop or livestock industry, the number of good species for aquaculture in the country is very limited. Every year, about 150 new species are approved for the crop industry; in aquaculture, only 2-3 new species are approved. Thus, the next step is to develop good new species. The country will continue to develop new species/variants of the "four major family fish species", crucian carp, common carp, tilapia and others. Innovation in breeding will involve development of species that are high-producing, of high quality, disease resistant, etc.

Determining the appropriate and leading species for China. In determining the most appropriate and leading species of fish to be bred in China, the following needs to be considered: (i) it should be the main species, (ii) it should be consumed by large population in China and (iii) it should also be popular in the international market.

Reinforce risk assessment on introduced species and minimize their harm to native genetic resources. This can be achieved through the following:

- Establish national management and information systems for newly introduced species in aquaculture. This will ensure healthy and systematic production. Such system will be able to trace and manage the introduced species and will allow the formulation of mid-term and long-term plan for such introduced species according to the development of the industry. Reasonable standards based on local conditions, integrated planning and classified guidance will be required. Well-planned introduction of new species in accordance with available resources (in terms of water area, technology, economic conditions) will prevent duplication of efforts.
- Quarantine measures should be strictly implemented to avoid diseases and parasites from introduced species. Introduced species have played a significant role in the country's fishery and aquaculture industries; nevertheless, quarantine should not be neglected as it is one of the most important steps in any species introduction. There are lessons from the past where numerous parasites and diseases have been introduced because of the lack of quarantine enforcement and losses were significant.
- Understanding the ecology of the receiving environment for the introduced species through investigation and research should be carried out. Promotion of such introduced species should be made only when it is assured that the new species will not destroy the environment.
- Introduction of good breeding species and technologies plays an extremely

significant role in increasing genetic resources and improving aquaculture production as well as increasing the economic benefits for the country. Biotechnology can be used to conserve and innovate new genetic resources and in combination with supply of new parents, can be a safe and economic way to promote and utilize foreign species.

REFERENCES

- BOF.** 1998. The National Construction Plan for Aquatic Bred and Seed Production System (1998-2002). Beijing, China, Bureau of Fisheries, Ministry of Agriculture. 30 pp.
- BOF.** 2004. China Fishery Statistical Yearbook. Beijing, China, Bureau of Fisheries, Ministry of Agriculture.
- BOF.** 2004. The Compilation of National Fisheries Survey Data in China (2000-2002). Beijing, China, Bureau of Fisheries, Ministry of Agriculture. pp. 61-104.
- BOF.** 2006. China Fishery Statistical Yearbook. Beijing, China, Bureau of Fisheries, Ministry of Agriculture.
- Honglang, Hu.** 2003. Development of Selective Breeding of Atlantic Salmon in Norway. Fisheries of China, Beijing, China. 64 pp.
- Honglang, Hu.** 2004. Review of Checking of State-Class Aquatic Bred and Seed Farms. Beijing, China, Bureau of Fisheries, Ministry of Agriculture.
- Honglang, Hu.** 2005/2006. Research on Development of Aquatic Breed and Seed for Aquaculture in China . Fisheries of China. Beijing, China.
- Honglang, Hu.** 2005. Research on the National Aquatic Bred and Seed Production System in China. China Fishery News (8/29/2005). Beijing, China. 4 pp.

