

# Developments In Freshwater Fish Culture In Southeast Asia

**Fuad Cholik**

Central Research Institute for Fisheries  
Agency for Agricultural Research and Development  
P.O. Box 6650, Slipi  
Jakarta, Indonesia

## **Abstract**

Aquaculture has been practiced for more than a century in a few countries of Southeast Asia (Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Papua New Guinea, Philippines, and Singapore). Currently, the industry is carried out in various ecosystems such as ponds, paddy fields, raceways, fish pen and cages in freshwater, brackishwater, and marine environments. Developments in freshwater finfish culture in Southeast Asia are becoming prominent. Currently, the industry is carried out in various ecosystems such as ponds, paddy fields, raceways, fish pen and cages in freshwater, brackishwater, and marine environments. With respect to finfish culture in freshwater, Southeast Asia is showing prominent development. Freshwater fish culture production in the region accounted for 4.4% of the total world freshwater fish and shellfish culture production. In 1997, world freshwater fish culture production amounted to 16,212,730 mt. An indicator of development is the increasing number of the cultured species. In 1988, the number of freshwater fish species cultured in the region was not more than 34 species, but a decade later the list has become longer, attaining more than 36 species. The major ones are common carp and Nile tilapia. These two species are widely cultured in the region. Eight of 10 Southeast Asian countries culture common carp and Nile tilapia. Further diversification of cultured species is still widely open since there are more than a dozen freshwater fish species available in rivers and lakes in the region that are potential candidates for aquaculture. The success in mass production of fry in the hatchery in some Southeast Asian countries has contributed much to these developments in freshwater fish aquaculture in the region, owing to the application of advances in science and technology. Supports from ancillary industries such as feed mill plants, cold and ice storage, etc. and the development of networking that rapidly disseminates information and aquaculture technologies within and outside the region have also contributed to the development of freshwater fish culture in Southeast Asia. Nonetheless, there are constraints to further development and these are discussed in this paper.

## **Introduction**

In some Asian countries, freshwater fish culture has been practiced for centuries, resulting in the bulk of world aquaculture production being derived from this region. Presently, mainland China together with India and Japan leads the world in fish aquaculture production. Mainland China alone produced 11.94 million mt of fresh water fish in 1997 (FAO, 1999). With Hongkong and Taiwan,

altogether China produced more than 12 million mt of freshwater fish.

Freshwater aquaculture in Asia contributed significantly to world aquaculture production. In 1997, Asia produced 16.21 million mt of freshwater fish, which is equal to 45% of the total world aquaculture production or 56% of the total world fish and shellfish culture production. The said statistics indicate the importance of freshwater fish culture as an economic activity, providing protein food for the world's population.

This paper attempts to identify the development of freshwater finfish culture in Southeast Asia during the last decade (1988-1997). The approach utilized was analysis of data from available sources on some development indicators such as production growth, number of species cultured, application of science and technology, transfer of aquaculture information and technology, and support from ancillary industries, specifically fry and feed industries.

Data and information presented in this paper were derived from references rarely available in the countries under study. In countries where freshwater finfish culture has developed, such as Indonesia and Thailand, the references are plentiful, whereas in countries where the industry is developing like in Vietnam and the Philippines references on freshwater fish culture are rather scarce. In other countries of Southeast Asia where freshwater fish culture has just started, references are hardly found.

### **Southeast Asian Countries**

Countries in Southeast Asia include Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam. This sub region of Asia lies mainly in the basins of the Irrawady and the Mekong river systems with peninsular or archipelagic countries influenced by high ambient temperature and high rainfall. These countries possess rich freshwater resources provided by their river systems and associated floodplains.

At present, Southeast Asia is populated by almost half billion people and around 40% live in Indonesia, the largest country in the region. The GDP of the Asean nations (minus Myanmar) amounted to US\$838 billion and total exports of US\$338 billion in 1996 (Severino, 1998).

The per capita supply of fish in this region averaged about 23 kg per year and contributed about 51% of the total animal protein supply (Shang ,1992 in Shang ,1994). The consumption rate most likely has been influenced lately by an increase in disposable incomes of the people in the region. For example, Duangsawasdi (1998) reported that the average annual per capita consumption of fish in Thailand is approximately 30 kg. Guerrero (1998) stated that average products from fisheries account for 70% of the total animal protein intake among Filipinos. In Indonesia, the average supply of fish in 1997 was 28 kg per capita per year.

### **Global and Regional Trends of Aquaculture Production**

Aquaculture expanded continuously during the last decade (1988 - 1997) as indicated by FAO (1997). During the said period, aquaculture production increased at the rate of 13.20% per year from 15.54 million mt in 1988 to 36.05 million mt in 1997. Production was valued at US\$50.37 billion.

As mentioned earlier, the bulk of aquaculture production came from developing countries in Asia. In 1997 the region produced 32.77 million mt, which is equal to around 91% of the total world aquaculture production. China (including Hongkong) and India as the leading countries produced 24.04 million mt and 1.78 million mt, respectively. Along with these two countries, there were 12

other countries, which were classified as principal producers of world aquaculture. Eight of them were Asian countries: Japan, Indonesia, Thailand, Bangladesh, Vietnam, Republic of Korea, Philippines, and Taiwan. The other four were USA, Norway, France and Chile. In 1997, these countries individually produced over 250 thousand metric tons. During the last decade, mainland China, India and Japan have maintained their first, second and third positions among the 14 principal producers, respectively. Indonesia, whose position in 1988 was fifth, ranked fourth in 1997. Thailand progressed significantly, from being tenth rank in 1988 to fifth in 1997. Likewise, Vietnam also progressed from twelfth in 1988 to seventh rank in 1997. However, the Philippines dropped from seventh in 1988 to twelfth in 1997 (Table 1).

**Table 1. Rankings of principal producers in fish aquaculture (FAO, 1999)**

Country	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Mainland China	1	1	1	1	1	1	1	1	1	1
India	2	2	2	2	2	2	2	2	2	2
Japan	3	3	3	3	3	3	3	3	3	3
Indonesia	5	4	4	4	4	4	4	4	4	4
Thailand	10	8	9	7	8	5	5	5	5	5
Bangladesh	11	11	11	11	9	9	9	8	6	6
Vietnam	12	12	12	12	12	12	13	7	7	7
USA	6	6	8	6	5	6	6	6	8	8
Korea, Republic of	4	5	6	8	7	7	8	9	9	9
Norway	13	13	13	13	13	13	12	13	10	10
Philippines	7	7	5	5	6	8	7	10	11	11
France	9	10	10	10	11	9	11	11	12	12
Chile	14	14	14	14	14	14	14	14	14	13
China Taiwan	8	9	7	9	10	10	10	13	13	1

Aquaculture production of Southeast Asian countries in 1997 amounted to 3.2 million mt, which is equivalent to only around 13% of China's production (Table 2).

**Table 2. Aquaculture production (mt) by country in Southeast Asia (FAO, 1999)**

Country	Freshwater Fish			Total aquaculture		
	1988	1997	Annual increase (%)	1988	1997	Annual increase (%)
Brunei Darussalam	1	30	290	2	156	770
Cambodia	4600	11534	15	4600	11800	16
Indonesia	209266	407990	9	499597	911610	8
Laos	7000	14000	10	7000	14000	10
Malaysia	7761	20303	16	46957	103360	12
Myanmar	5668	87306	144	5673	87320	144
Philippines	81232	97189	2	430374	957548	12
Singapore	0	115	-	1969	4088	11
Thailand	91542	257371	18	220416	575901	16
Vietnam	111157	369000	23	154317	492000	22
Total	518,27	1,264,838		1,370,905	3,159,780	

Aquaculture in Southeast Asia may be in freshwater, brackishwater, and marine environments. Historically, the former has been practiced since centuries ago. In the past, freshwater fish culture was meant to fulfill daily fish demand of rural households. In such a case, the freshwater ponds generally were located at the backyard. As the demand for fish increased, fish culture became a commercial activity and special ponds were constructed in suitable areas. Other culture systems and facilities were utilized such as paddy fields, cages, pens, etc. Production increased yearly at 14.4% since 1988, amounting to 1,264,838 mt freshwater fish produced in Southeast Asia (Table 1).

### Cultured Freshwater Finfish Species

More than 43 species of freshwater fish are cultured in Asia at present. Thirty six species are cultured in Southeast Asia alone, 13 species in mainland China, 9 species in South Asia (mainly India), 9 species in East Asia (in Japan and Republic of Korea), and only 6 species in West Asia (mainly Iran, Table 2). Most of the cultured species are indigenous to Asia. The only species exotic to the region are fishes of the genus *Oreochromis* and carps.

Out of the 43 cultured finfish species, the common carp is cultured in many countries in Asia and Europe. This species is exotic to Southeast Asia, however. Their tolerance of wide differences in pond temperature and chemistry, their ease of management, and their high growth rates have made them a favorite of fishery development programs worldwide. The wide acceptance of the species by people of various social status in many countries may likely be due to the taste of its meat, few bones, and the ease of propagating and culturing the common carp. Eighty percent of Southeast Asian countries have cultured common carp. The other dominant exotic species that are being cultured in 5 to 6 Southeast Asian countries are grass carp, silver carp and tilapias, especially *Oreochromis niloticus*.

Of 36 fish species cultured in Southeast Asia, 25 species are indigenous. Among them are java carp, nilm carp, catfish, and one diadromous species, namely sea bass. These species are cultured in 5 to 6 countries in the sub region. Although these species have been cultured for quite some time, data on their biology is still scarce. Only a few of these species have been fully domesticated.

Compared to 1988, six additional species were cultured in 1997. Attempts to culture more species have been conducted in several countries, especially those considered indigenous such as two spot-glass catfish (*Ompok maculatus*), red-tail mystus (*Mystus wyckiodes*), giant catfish (*Pangasius gigas*), red cheek barb (*Puntius orphoides*), brook carp (*Tor soro*), *Catlocarpio siamensis*, which can attain a size of 2.5 m, *Cyclocheilichthys enoplos*, *Probarbus jullieni*, and some hybrids of tilapias, catfishes, etc. To some extent, some countries have also grown some exotic species for aquaculture, such as *Colossoma sp.* in Indonesia. In Malaysia, the breeding and culture of this species is done small-scale.

### Culture Systems

Aquatic resource systems for aquaculture in Southeast Asia are ponds, rice paddy fields, disused mining pools, lakes, reservoirs, streams and rivers, and land-based tanks. The types of culture facilities in these resource systems are embankments and excavated structures (pond and paddy field), irrigated or rain-fed, floating net cages, bamboo cages, fish pens, raceways, and concrete or fiberglass tanks. Utilization of the latter is limited to mass production of fish fry and grow out of high-value fish products such as eel.

Southeast Asia has considerable potentials for further developments of freshwater fish culture. Around 1.4 million ha of inland water area are suitable for aquaculture development in Vietnam (Son,

1998). Thailand also has high potential for aquaculture (Duangsawasdi, 1998). Although Malaysia does not have natural lakes, it has man-made reservoirs with a total area of 160,000 ha (Yusoff *et al.*, 1994). Indonesia has around 2.1 million hectares of lakes and man-made reservoirs and more than one million hectares of irrigated paddy fields. In the Philippines, more than 356,000 ha area of inland open waters are present (Guerrero, 1998).

Fish culture in ponds is the most popular activity of freshwater aquaculture in the region, being practiced in all countries in Southeast Asia. The fish selected for culture depends on the pond system, whether these are irrigated or rain-fed ponds, or disused mining pools. In irrigated ponds, the water flows through continuously, making the pond suitable for the culture of fish species, such as common carp, java carp, silver carp, and the like, which require waters with high dissolved oxygen content. Such ponds may produce 1.6 mt to 3.9 mt per ha per year (Huat and Tan, 1980). On the contrary, species cultured in rain-fed pond are fishes, such as the air-breathing gouramy, the clariid catfishes, snakehead, etc., which can tolerate low dissolved oxygen. In Malaysia and to certain extent also in Indonesia, disused mining pools have been converted for fish farming. These ponds from dredged excavation, gravel extraction, and hydraulic mining range in size from 0.2 to 35 ha and in depth from 3 to 15 m, producing from 0.3 mt to 3.9 mt fish per ha per year (Huat and Tan, 1980).

Pond productivity may be improved through a polyculture system and supplemental feeding. This culture technique is adopted in ponds, disused mining pools, cages, and rice paddy fields. Constraints to further development of fish culture in pond are competition for land use with other sectors, environmental degradation, and pollution.

Fish culture in paddy fields began in China 2000 years ago (Chapman, 1996) and, more recently, practiced in Indonesia, Laos, Philippines, Thailand, and Vietnam. This culture system has very high potential in Southeast Asia, due to vast areas of irrigated rice field in the region. At present, the area of rice cum fish culture in Indonesia amounts to 140,000 ha. In Vietnam, out of 400,000 ha of irrigated paddy fields suitable for rice cum fish culture, only 35,000 ha have been utilised (Nhan, 1997). With the addition of potential areas of paddy fields in Malaysia, Philippines, Thailand, and other countries in Southeast Asia, the area for rice cum fish culture in the region is estimated to be around one million hectares. Assuming fish production of paddy field is 250 kg per ha per crop or 500 kg per ha per year, the existing paddy fields in Southeast Asia potentially may produce around one million metric ton fish per year. Fish cum rice culture not only produce fish, but also increase paddy production by up to 14% (Sabri *et al.* in Oka *et al.*, 1992).

The type of fish culture systems in paddy fields has not changed since 50 years ago, wherein fish are concurrently cultured with the growing rice, and follows a rotation system where the fish is reared as a single annual crop of rice (Huat and Tan, 1980).

The fish species cultured in paddy fields differs from one country to another. Huat and Tan (1980) listed 19 fish species harvested in rice fields in Asia. However, in many countries, *Cyprinus carpio* is most common. In Indonesia, aside from the common carp, fish species cultured in paddy fields are Nile tilapia and giant gouramy. In the past, polyculture of kissing gouramy, Java carp or "tawes", *Osteichthyes hasseltii*, common carp and Mossambique tilapia (Ardiwinata, 1957) was common. At present, fish culture in rice field in Indonesia is focused more on fingerling production, rather than fish for consumption. In Vietnam, the farmers also stock rice paddy fields with silver barb (*P. gonionotus*) and Nile tilapia (Nhan, 1997). In the Philippines, common carp, Mossambique and Nile tilapia are cultured. In Thailand, farmers grow the following species: snakeskin gouramy, java carp, and common carp. In Laos, the species grown in paddy fields are common carp, tilapia, *Puntius spp.*, *Trichogaster spp.*, and various local species (Singh, 1994).

Fish culture in rice field has some advantages and disadvantages. Fish cum rice culture is a means to increase fish production and to improve the paddy field's ecology. The system has been proven to be advantageous in fingerling production in floating net cages. Fish cum rice culture may also be suitable as a subsistence-type activity, which provide fish for family consumption (Bocek, 1992).

Floating net cages and fish pens can be found in lakes or man-made reservoirs in Indonesia, Philippines, Malaysia, and Vietnam. Floating or submerged bamboo cages are also common in rivers or streams in Indonesia. The most common species cultured in floating net cages in Southeast Asia is *C. carpio*, and milkfish in fish pens. Other species are Nile tilapia, red tilapia, pangasiid catfishes, and milkfish. Common carp and carnivorous fish such as *Channa spp.* are grown in bamboo cages.

Recently, a double-cage culture technique has been developed in Indonesia and already adopted by fish farmers. In this technique, the inner cage is stocked with common carp, while the outer one with Nile tilapia, which feed on the leftover food of common carp, thus contributing to efficiency in food conversion. Such practice also reduces the amount of uneaten feed released to the surrounding environment.

Tanks, concrete or fibreglass, are used in hatchery and in indoor culture of *Anguilla* sp. This technology is capital intensive.

### **Contribution of Science and Technology to Aquaculture**

Aquaculture technology can contribute significantly to fish supply to meet the increasing demand for fish protein. The increase of freshwater aquaculture production in China during the last decade was perhaps the result of the application of research on breeding and biotechnology, and the diversification of cultured organisms (Yingren, 1998). Although research in various institutions in Southeast Asia is active, innovative research remains lacking. In order to cope with the rapid pace of expansion, aquaculture must be backed up by scientific principles and relevant technologies. Since aquaculture is a commercial activity, it requires economic and sociological inputs. Thus, innovative research to back up aquaculture should be extended also to relevant economic and social aspects.

There are three major interrelated aspects concerning aquaculture technology, i.e. the cultured organism, the culture environment, and feed. Application of science and technology to aquaculture should be focused on these aspects. With respect to the cultured organism, knowledge of its biology should be well recognized. Unfortunately, data and information concerning the biology of individual cultured species is still very scarce. Information is scarce on many aspects of taxonomy, anatomy and morphology of organs, reproduction and life cycles, genetics, growth, food and feeding habits, nutrition and metabolism of both non-traditional and indigenous species. Except for the transfer of diseases and parasites, there are several advantages of using native species such as preserving the genetic integrity of wild native stocks. Likewise, local markets are more familiar with native species, precluding the need to develop a market for new products, thus reducing total operational cost (Heggberget, 1994).

Regarding the culture environment, science and technology application could explain the dynamics of aquatic ecosystems to help improve the environment of the cultured organisms, thus reducing pollution. Likewise, science and technology should also be directed towards the conservation of water resources. Boyd *et al.* (1998) stated that freshwater aquaculture ponds should be operated without water exchange, and that they be drained every few years for pond repairs and inventory adjustment. In this regard, precise definition of water quality requirements of traditional and non-

traditional species should be established.

Aquaculture requires various inputs such as feed, both natural and artificial. The type of natural food varies depending on the feeding habit of the fish species. Natural food for herbivorous/omnivorous may be grown by water or bottom soil fertilization. Unfortunately, the existing knowledge on natural food fertilization does not provide specific procedures to stimulate the growth of the desired plankton, so that applying the same fertilization protocol may stimulate the growth of different types of phytoplankton and zooplankton.

Natural food is of utmost importance in the operation of a hatchery. In certain cases, facilities required to grow plankton are several times larger than those required for larval rearing. The growth of certain plankton species may be a problem during certain seasons. However, this problem may be solved by cryopreservation of natural food.

The artificial feed used in herbivorous or omnivorous freshwater fish culture may involve a single raw material such as rice bran, colocacia leaves, etc., simple mixtures of ingredients, or complex formulated compound feed. For carnivorous fish like *Channa spp.*, the feed may consist of a single ingredient such as trash fish or a compound feed, i.e. pellet or moist feeds. At present, no formulated feed has ever been produced for freshwater carnivorous fish, probably because of a lack of data on the nutrient requirements, feeding habits, and other nutrition aspects of this species.

As aquaculture production systems become more intensive, their dependency on the external provision of manufactured compound aquafeeds becomes great. In fresh water fish culture, intensive feeding is practiced in cages, pens, running water ponds, and raceways. Such practice will sooner or later accelerate eutrophication, especially in closed water bodies where cage and pen structures are installed. Moreover, there have been serious mortalities in heavily stocked cages in Cirata and Saguling reservoirs in West Java, Indonesia as reported by Zerner (1992). The problem actually may be avoided by limiting the number of cages so that it will not exceed the carrying capacity of the water bodies. Unfortunately, no data are available on the carrying capacity of any water bodies in the region. Periodic monitoring of water quality has also been neglected even as culture intensity in cages has been increasing by the introduction of double net cage technology.

FAO (1995) estimated that aquaculture used 15% of the global fishmeal supply in 1995. It is imperative, therefore, that research to find substitutes (partly or completely) for fish meal in the diet of some species be pursued. For aquaculture to be sustainable in the long term, it is also imperative that donors, development agencies, and government promote the culture of species with herbivorous and omnivorous feeding habits, or species which are not dependent on the use of high quality protein-rich feed inputs, and which are able to make maximum benefits from naturally available food organisms and farm-made supplementary inputs (Tacon (1994) in FAO, 1995).

### **Development of Related Ancillary Industry**

Freshwater finfish culture is important in providing food and in providing employment opportunities, especially for rural people in the region. Development of the industry, therefore, warrants proper attention from all parties concerned. To develop fish culture requires a sufficient supply of quality fry and fingerling, which can be fulfilled by the establishment of a sufficient number of hatcheries. A significant development in freshwater fish culture during the last decade has been the availability of hatchery-produced fry and the establishment of feed plants. The hatcheries are mostly owned by private entrepreneurs.

## Aquaculture Information and Technology Transfer

The level of fish culture technology applied throughout the region differs from one country to another. The most progressive countries are Indonesia and Thailand, followed by Malaysia, Philippines, and Vietnam. In Indonesia, the dissemination of aquaculture technologies is done by extension services in collaboration with scientists from the newly established Institute for Agricultural Technology. The laboratories of the Institute are available in every province in Indonesia (Cholik *et al.*, 1997). The promotion of fish culture in Thailand includes the transfer of improved seed and production technique directly to private hatcheries, quality testing and endorsement of fish seed at hatcheries, and technology dissemination through hatcheries and traders (Ingthamjitr *et al.*, 1997).

The development of freshwater fish culture in Southeast Asia maybe accelerated through the establishment of research networking. Through this, the exchange of information among scientists concerned will be facilitated. Research collaboration among network members can be accommodated to benefit all. An example of a research network is INGA of ICLARM.

## Constraints to Freshwater Fish Culture Development

Several constraints associated with further development of freshwater fish culture in Southeast Asia include resource-use conflicts, habitat destruction, water quality deterioration, and unequitable distribution of benefits (Chua, 1994). Another common constraint is low market price and high costs of production. Ja Cho (1997) reported seven issues and constraints to aquaculture development that have been identified from her survey in Asia, which included five Southeast Asian countries (Indonesia, Malaysia, Philippines, Thailand, and Vietnam). The most common constraints to those countries are related to weak institutional and organizational linkages and coordination among related agencies and program. Other common issues are ineffective transfer of technologies, including lack of technology packages, pollution and environmental degradation. Heggberget (1994) summarized limiting factors to aquaculture development which may also be applicable to Southeast Asia as follows: 1) coordination and marketing, 2) aquaculture economy (cost reduction), 3) technological standards, 4) water resources, 5) information and information flow, 6) biological knowledge of cultivated species, 7) diseases and parasites, and 8) environmental effects. Absence of legal aspects and poor law enforcement are other constraints to aquaculture development in the region.

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