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Contents

Status and perspective of
culturing catfishes in East and
Southeast Asia 2
Imre Csavas

Prevention and Control of food
borne trematode infections in
cultured fish 11
Carlos A. Lima dos Santos

The legal regime governing
aquaculture in Vietnam 16
W.R. Edeson

Biodiversity conservation and
establishment of Coho salmon
broodstock in Chile 19
Devin M. Bartley

News Items 21

New Publications 23

EDITORIAL

Fish Health Management and Sustainable Aquaculture

It is true that the recent technological advancements have significantly contributed towards the enhancement of global aquaculture production. However, disease continues to act as a major constraint to the sustainable development of the aquaculture industry. Much of the disease problems that are encountered in the present-day-aquaculture are the results of inadequate health management practices stemming from the lack of basic understanding of the intricate balance that must be maintained between the host, pathogen and environment. The economic incentives for producing more and more fish to meet the growing demands have encouraged aquaculturists to intensify their operations. In the process, in many instances, the complex balance between the fish and the environment is disturbed, and the organisms under culture subsequently become stressed and prone to infections. Therefore, it is imperative to design health management programmes which should not only be effective and environmentally sound, but also economically viable.

In order to develop effective health management strategies, it is important to address a number of compelling issues which have direct bearing on aquaculture. They include, reduction of the levels of pollution in water bodies that are important to aquaculture, understanding of the environmental and human health implications of using chemicals and antibiotics in aquaculture, emphasizing the need for integrating new biotechnological developments in disease control and prevention, development of legislation to minimise antibiotic and chemical use in aquaculture, and effective control of live fish movement and exotic species introduction. With this in mind, the Inland Water Resources and Aquaculture Service of the Fisheries Department is now developing a programme on Fish Health Management. This programme envisages to interact closely with the existing programmes on the environment, biodiversity and nutrition. The information generated by this programme will be brought to you through a series of articles beginning from the next issue of the FAN.

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STATUS AND PERSPECTIVES OF CULTURING CATFISHES IN EAST AND SOUTHEAST ASIA

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INTRODUCTION

Aquaculture was the fastest growing branch of fisheries in Asia and the Pacific in the 1980's. Its annual average growth was 7.3 %/year between 1980 and 1990, considerably higher than the 1.8 %/year growth of the population. Out of the 14.1 million tons of aquatic products cultured in 1991 in the region 51.8% was fish, an important commodity group from nutritional point of view. In 1991, Asian finfish culture was dominated by freshwater fishes that provided 87.6% of the total, while in the rest of the world their ratio was only 60.8%.

Fish culture in Asia mainly produces species that are low in the food chain, namely planktivores, herbivores and omnivores (e.g. carps, tilapias and milkfish). These species with relatively low market value consumed by the middle lower income segments of the population. The share of species that are high in the food chain, (carnivorous species) was only 8.3% in 1991 in the region, while in the rest of the world more than half of the cultured finfish volume belonged to this group.

The Asian "carnivores", however, are a highly diverse group, much more so than in the rest of the world, where salmonids dominate production. While in the high-income countries production of yellowtails, seabreams/seabasses, salmonids and eels dominate, the "carnivorous" fish of choice for middle- and low-income countries are catfishes, snakeheads etc. Catfish species provided 12.6% of the total cultured "carnivorous" volume in 1991 in Asia and the Pacific, while their share was twice as high in the rest of the world, due to the volume of channel catfish produced in the U.S.

Due to the leading role of the U.S. in catfish culture, global production is dominated by Ictalurid species, followed by clariids and pangasiids (Figure 1). In 1991, out of the 265,000 tons of production reported by species, 68.1% belonged to ictalurids, while the share of clariids was 25.5%, that of pangasiids 5.9% and other species (e.g. *Chrysichthys*, *Hoplosternum*, *Silurus* sp.) made up the remaining 0.5%. In Asia and the Pacific clariids dominated production, representing nearly 80% of the total 76,000 tons catfish produced in 1991 (Figure 2).

STATUS OF CATFISH CULTURE

The country by country analysis revealed that there are significant volumes of cultured catfish production in Cambodia, China and Vietnam that are either not reported to FAO or are reported under the general "freshwater fish" category. The unreported clariid catfish production is estimated at 22,539 tons, while unreported pangasiid production may be as much as 25,910 tons. The total unreported cultured catfish is therefore estimated at 48,449 tons, thus raising the total volume of cultured catfishes in Asia and the Pacific from the reported 75,476 tons to 123,925 tons (Figure 1).

While catfishes are well known and popular species all over Asia, their share in the cultured freshwater fish volume is not particularly high, except for countries in the Lower Mekong Basin, that is in Cambodia, Thailand and Vietnam (Table 1). Indigenous culture techniques were developed for native species that are preferred by the local population, most important of these are

Table 1: Production of cultured catfishes in Asia and the Pacific in 1991

Country/ Territory	Clariids (t)	Pangasiids (t)	Total (t)	% of cultured freshwater fish	Source of data
Guam	10	-	10	7.7	FAO 1993
Hong Kong	110	-	110	2.1	FAO 1993
India	34,912	-	34,912	3.0	FAO 1993
Indonesia	4,000	*	4,000	1.6	FAO 1993
Malaysia	198	*	198	3.1	FAO 1993
Philippines	100	-	100	0.1	FAO 1993
Taiwan (P.of China)	46	*	46	0.1	FAO 1993
Thailand	20,600	15,500	36,100	36.5	FAO 1993
Reported to FAO	59,976	15,500	75,476		
Cambodia (1993)	3	5,910	5,913	74.9	Tana 1994
China	21,500	*	21,500	0.5	Author 1994
Laos	36	*	36	1.0	Author 1994
Vietnam (1992)	1,000	20,000	21,000	7.1	Author 1994
Estimated	22,539	25,910	48,449		
Total	82,515	41,410	123,925		

(* Insignificant volume of production)

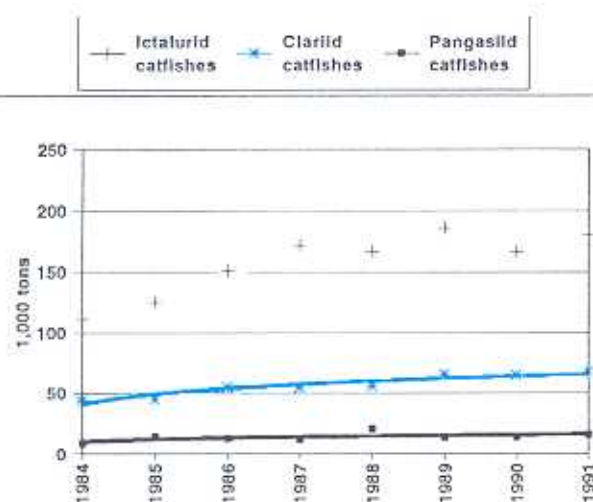


Figure 1: Growth of global cultured catfish production (data from FAO 1993)

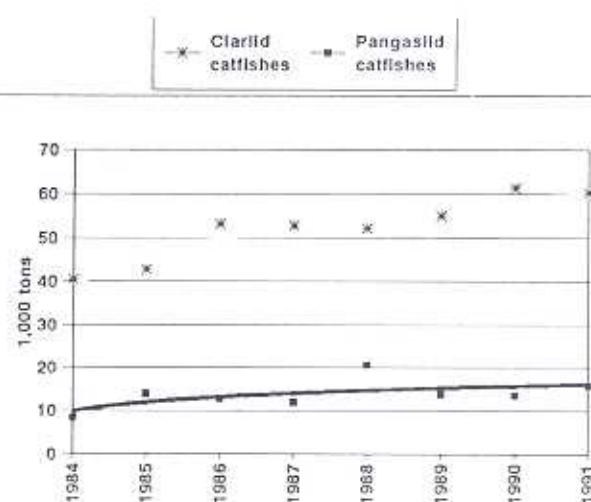


Figure 2: Growth of cultured catfish production in Asia and the Pacific (data from FAO 1993)

Clarias batrachus, *C. macrocephalus*, *C. fuscus*, *Pangasius hypophthalmus*, *P. bocourti* and *P. larnaudii*. Introductions of these species in countries within the region were frequently attempted to boost production, but without much success. Ictalurid species were also introduced from North America to several countries of Asia and the Pacific, most often *Ictalurus punctatus*. This species either did not perform as expected in their new environment or their quality was not readily accepted by the local population.



Feeding catfish cultured in a pond

The only introduced species that had a significant impact on the Asian aquaculture industry is *Clarias gariepinus*. The original introduction was made in 1975 in Vietnam, from where the species spread all over Asia. Although Asians do not prefer its meat quality and its large size, its rapid growth and hardiness made it popular among fish farmers. Quality problems were resolved by producing hybrids of female local clariids (primarily *C. macrocephalus* and *C. fuscus*) and male *C. gariepinus*. For culture purposes, the partially fertile hybrid has replaced the native species almost everywhere in Southeast Asia. While there are legitimate concerns about the negative impact the species or its hybrid may have on natural populations, their culture is still spreading rapidly in South Asia, with or without approval of regulatory agencies.

Both the local clariids and pangasiids have several advantageous characters that facilitated the development of indigenous culture systems. Air-breathing clariids are especially suitable for super intensive pond or trough culture; while pangasiids

excel in high-density cage culture, in integrated livestock/fish farming or in human waste utilization. Because of the presence of variety of species and their omnivorous nature, culture techniques can be adapted to the local conditions, especially to the locally available feed ingredients. This keeps their production costs at reasonable levels, placing them at par with or only slightly over the price level of tilapias or cyprinids.

Despite the numerous advantages of clariids and pangasiids, the expansion of their culture has slowed down in Asia and the Pacific. The most important limiting factors are the declining availability and increasing price of trash fish and other suitable animal feed ingredients. Improvements in culture techniques (induced breeding and nursing, health management, pond management) and in feed formulation and manufacturing are essential for the further expansion of the industry.

The most important constraint of catfish culture in Asia and the Pacific is the apparently well defined domestic market niche of these species. Despite their popularity, expansion of their production usually leads to market saturation and declining prices. Traditional marketing structures are not expected to absorb much more live clariids or fresh/chilled pangasiids; development of suitable processing methods and export markets seem to be the prerequisites for a further expansion of production.



Feeding catfish with farm-made feed

Table I (page 3) clearly shows that the main cultured catfish producing countries in East and Southeast Asia are Thailand, People's Republic of China, Vietnam, Cambodia and Indonesia. The status of catfish culture in these five countries are briefly described below.

THAILAND

Clariid catfishes, indigenous air-breathing fishes of the floodplains and swamplands, were abundant and popular food fish in Thailand. However, when their natural habitats were reduced by the construction of dams, rehabilitation of swamps and other human interventions, their availability started to decline rapidly. This created a need for their culture, which started in the early 1960's, at about the same time when shrimp trawling was introduced. By-catch of trawl fisheries, unfit for human consumption, provided plenty and initially cheap food for cultured catfish. Based on the significant market demand and availability of feed, Thailand developed a highly intensive culture technique for clariids that served as a model for other countries of Southeast Asia.

The two native clariid species in Thailand are *C. batrachus* and *C. macrocephalus*. The latter is considered more tasty but the former grows faster, is hardier and is easier to propagate. As the booming catfish culture industry could not be based on collected seed, and as disease appeared as the major constraint to production, *C. batrachus* became the prominent cultured species despite its lower market value. In the mid 1980's about 90% of the production was represented by this species.

The ponds are stocked with 15-25 g fingerlings, in an amazing density of 60-300 fish/m², dependent on the size of the stocking material. Traditional feed consists primarily of trash fish, mixed and minced together with rice bran and cooked broken rice in a ratio of 8:1:1. However, increasing price and decreasing availability of trash fish led to its substitution with offals of slaughterhouses and poultry processing plants. Chicken intestines became especially popular and widely available in the 1980's as the poultry industry expanded in Thailand. Feeding is made by hand until the fish no longer respond to the feed. Factory-made commercial floating pellets are also available. Increasing number of catfish farmers are using commercial feed to avoid the problems associated with the irregular supply, varying quality and increasing price of trash fish.

Because of the very high stocking densities, high feeding rates and inadequate water exchange, the water quality of the ponds deteriorate rapidly and organic wastes accumulate in the water and the mud. Due to the presence of accessory respiratory organs most of the fish can survive in this unfavourable environment, but heavy mortalities do occur. Average losses in the grow-out phase are between 50 and 60 %. As the market size is relatively small (120-200 g), the growing season is 3 to 5 months only. Yields from 3 to 12 kg/m²/crop are achieved that equals to 60 to 240 tons/ha/year as at least two crops are harvested annually. The fish is marketed alive. For transportation and marketing very little water is needed; the fish is just kept wet enough to survive.

The introduction of *Clarias gariepinus* from neighbouring Laos occurred around 1987. The Department of Fisheries encouraged farmers to raise the hybrid because of its better quality, quicker growth and improved resistance to diseases. By now practically the whole industry shifted to the hybrid, which can reach 200-250 g average body weight in 3 months and has much better survival rates than the indigenous species.

Most of the clariid catfishes are cultured in ponds. However, 250-300 tons annually (less than 5% of the total production) reportedly come from fish culture in rice fields and from ditch culture. In 1991, clariid catfish production reached over 20,000 tons.

Pangasiid catfishes are cultured in significant volumes in Thailand. *Pangasius hypophthalmus* (better known synonym: *P. sutchi*) is the most common cultured pangasiid catfish all over Southeast Asia. The species does not spawn spontaneously in captivity. It was successfully induced bred in 1966. Since the mid-1970's several commercial hatcheries have been producing millions of seed every year covering all the demand of culture operations in Thailand.

Although cage culture is the older technique for pangasiids, currently only 5-10% of the annual volume is produced in cages, primarily on the Central Plain, north of Bangkok. The fish are fed with a dough consisting of cooked rice bran, broken rice and trash fish mixed in a ratio of 9:1:1, respectively. Occasionally aquatic plants (*Lemna*, *Ipomoea*), vegetable and soybean wastes are also used as feed ingredients. Mortality in the cages is low and the marketable size of about 1 kg is reached after a 12-15 month growing period. Yields used to be about 40 kg/m³. Broodstock is also reared

in cages; this takes 2 to 3 years, during which period the fish reach 3 to 5 kg bodyweight.

Pond culture of *Pangasius hypophthalmus* is a newer technique and 90-95% of the present production comes from ponds. Ponds can vary widely in shape, size and sophistication but their water depth should be at least 1 m. Stocking density is usually 2 fingerlings/m², although in case of a reliable water supply it may be increased up to a maximum of 4 per m².

A significant portion of the nutritional requirements of the fish is covered by the natural food produced by the pond ecosystem. Because of the omnivorous nature of the fish, an amazing variety of by-products and wastes are given as supplementary feed. These include cooked rice bran, broken rice, oilseed cakes, coconut and vegetable wastes, fish meal, dried fish and wastes from slaughterhouses, bakeries, pastry factories and restaurants.

While *Pangasius hypophthalmus* has become an important cultured species in Thailand, the possibilities of culture of other native pangasiid catfish such as *P. larnaudii*, *P. gigas* etc. are being investigated. In 1991, pangasiid catfish culture production was about 15,000 tons, with 90-95% of which was represented by *P. hypophthalmus*.

PEOPLE'S REPUBLIC OF CHINA

Culturing catfish is not traditional in China, where culture experiments with the local *Clarias fuscus* started only in the mid-1950's along the southern coast. Although induced breeding of the species succeeded already in the 1960's, commercial production did not start until much later. *C. batrachus* was introduced in 1978 and *C. macrocephalus* in 1982 from Thailand; these "exotic" species have proven better for intensive culture than the local species. Production started to increase after 1978, primarily in Guangdong, Guangxi and Fujian provinces. In 1981, *C. gariepinus* was introduced to Guangdong, where group-spawning and high density nursery methods were developed for this species. Hybrids of *C. fuscus* female and *C. gariepinus* male were produced first in 1984. The hybrids grew rapidly with good survival rates and had good public acceptance because of their superior quality.

Consumers consider the meat of *C. fuscus* the most delicious, consequently the price of this species is the highest. The quality of the hybrid catfish is also

considered good. However, the taste of *C. batrachus* is regarded inferior and this species has the lowest market value. On the other hand, culture period from fingerling to market size is only 3 months for *C. gariepinus*, 3 to 4 months for *C. batrachus* and 4 to 5 months for *C. fuscus*. In recent years, popularity of catfish culture has increased rapidly as it is considered more productive and profitable than traditional carp culture. With high density monoculture yields up to 120 tons/ha have been achieved with relatively low investments and production costs.



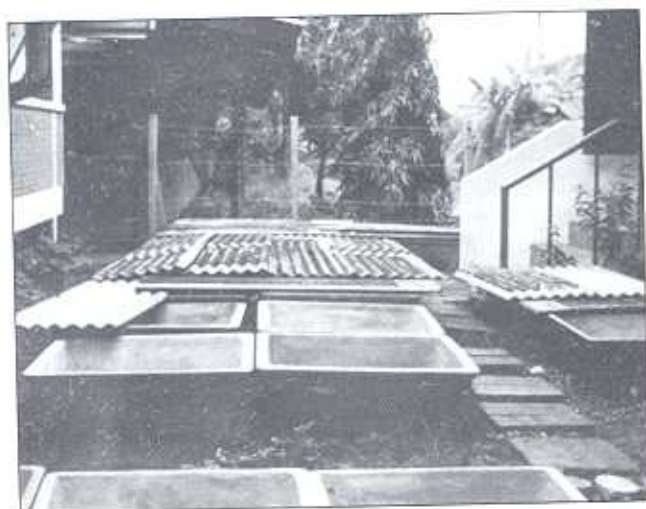
Artificial breeding of catfish

Catfish fingerlings are sometimes added to traditional polyculture of carps and tilapias, 3 to 4 months after the initial stocking. The additional 3,000 to 5,000 catfish per hectare do not need additional feeding but increase the yield by some 75 kg/ha. They are harvested at the end of the season, together with the other fish. Most common practice is to culture catfish in 1.5-2.0 m deep ordinary ponds with a stocking density of 20-25 fingerlings/m². The size of the ponds range from 0.03 to 0.3 ha, stocking starts in June and the season lasts until November. Small family ponds, ditches or concrete tanks are increasingly popular among rural families for home production of catfish, using agricultural by-products for feeding. Stocking densities are extremely high (50-100 fingerlings/m²), resulting in yields of 10-20 kg/m². Biggest constraint of catfish culture is the generally low survival rate, which is countered by stocking bigger (more than 5 cm long) fingerlings. Proper water quality is maintained by frequent water exchanges. Occurrence of diseases is

also reduced by thorough sterilization of the ponds before restocking. The fingerlings themselves are sterilized by immersion in 10% common salt solution.

The fish are fed with a mixture of suitable ingredients of animal and plant origin. Farmers along the Pearl River delta use 40-50% of animal ingredients and 50-60% of vegetable ingredients in the mixture. Where available, trash fish, low-value molluscs, animal viscera and blood, silkworm pupae, mosquito or fly larvae, earthworms are preferred; otherwise, fish meal or bone meal are used. As vegetable ingredients, soybean meal, wheat or rice bran, meal of pulses, oilcakes are popular. High-value ingredients are used primarily in the initial period of the grow-out phase.

Unfortunately, China does not report catfish production separately in her official aquaculture production statistics. This makes it extremely difficult to assess the volume of cultured catfishes in a country which produces almost 60% of cultured finfish in the Asia/Pacific region. A good guesstimate is that, in 1991, China produced about 21,500 tons of catfish which represented 0.5% of the total aquaculture production in the country.



Rearing catfish fry/fingerlings in trays

In Taiwan (Province of China), the native clariid catfishes are *C. fuscus* and *P. asotus*, both were first induced bred in 1970. In 1972, *C. batrachus* was introduced from Thailand. This "exotic" species achieved considerable popularity because of its fast growth. Soon it was hybridized with the local clariid species in order to improve its meat quality. The

resulting hybrid successfully combined the advantages of the two species and spread rapidly all over Taiwan. The native species is now in danger of extinction.

An earlier introduction (1969) of *Pangasius hypophthalmus* from Thailand was a failure. Although the species was successfully propagated since 1976 by induced breeding, the climate proved to be too cold for it and public acceptance was also unfavourable. Currently it is used as an ornamental fish rather than for food.

The introduction of channel catfish (*Ictalurus punctatus*) from the U.S. in the mid 1970's was not successful either. The climate was too warm for the species. Moreover, the meat quality was not well accepted by the local population.

Since the mid-1980's catfish culture has been declining in Taiwan. Production peaked in 1985 with 119 tons, that represented only 0.15% of the total cultured freshwater fish volume. In 1991, only 46 tons of catfish was cultured, 0.06% of the total freshwater fish output. Inland fish culture in Taiwan continues to be dominated by tilapias and carps, that provided 64.2% and 32.0% of the total respectively, in 1991.

VIETNAM

There are three economically important indigenous clariid catfish species in Vietnam: *C. fuscus* in the cooler North, *C. batrachus* and *C. macrocephalus* in the warmer South. Induced breeding and commercial seed production techniques for all three species have been developed. Pond culture techniques are also known and practised to some extent. However, the production of these species is not significant.

Clarias gariepinus was introduced to Vietnam in early 1975. The first hybridization of a female *C. macrocephalus* and male *C. gariepinus* was performed in 1983 at the Research Institute for Aquaculture No. 2 in Ho Chi Minh City and it proved to be a success. Consumers liked the appearance and taste of the hybrid that resembled the preferred local species. Currently only this hybrid is cultured commercially in the southern part of the country. In the cooler North, however, the hybrid of *C. gariepinus* and *C. fuscus* shows better growth and environmental tolerance.

Clariid catfishes, however popular and widespread, are still not cultured in volumes in Vietnam. Pangasiid species, on the contrary, play a significant role in aquaculture of the Mekong Delta. Their culture in small, household ponds which are outfitted with overhung latrines, is traditional, probably several centuries old. In the rural areas of the Mekong Delta it evolved to be the main method for human waste disposal, which may not be without public health hazards. The species cultured in ponds is *P. hypophthalmus*.

The latrine ponds are usually small, 200 to 500 m² clay pits which were dug out to provide filling for houses, vegetable gardens and/or dikes. They may be used by a single family or shared by several families, although communal ponds adjacent to schools and markets are also common. The ponds are usually situated next to watercourses in order to provide some water exchange. Traditional stocking density is about 5 fish/m². Together with *P. hypophthalmus* some clariid catfish, giant gourami, silver carp are also stocked. Fish are harvested year round but at the end of the dry season the ponds are usually drained. *P. hypophthalmus* attains about 700-800 g in one year.

Unlike pond culture, cage culture is considered a new technology in the Mekong Delta, introduced by ethnic Vietnamese fishermen escaping from Cambodia in 1968. Some floated their boat-cages down the river, others brought only their accumulated experiences. By the mid-1970's the cage culture method became well established with several thousand cages in operation. The war, however, disrupted the expansion of cage fish culture. After the fighting ended in 1975, the recovery has been slow; and in 1986, the total production from 2,400 cages was estimated at 6,450 tons and in 1992 at 7,000-8,000 tons.

The species cultured in cages is *P. bocourti*. This species requires better water quality than *P. hypophthalmus*, the species cultured in cages in Cambodia or in the latrine ponds of Vietnam. For stocking cages, 100 million fry/fingerlings of *Pangasius*, caught from the natural waters, are imported from Cambodia. The dependence on captured wild seed is a cause of concern in both Cambodia and Vietnam. Curbing the capture and export of seed is already under consideration in Cambodia, where protection of the natural resources receiving increased attention. A ban introduced abruptly would devastate the cage culture system in the Mekong Delta; because while induced breeding of *Pangasius hypophthalmus* has been resolved, reliable methods for the mass production of *P. bocourti* seed are not yet available.



Culturing catfish in tanks

In the grow-out cages *Pangasius* is fed with fresh, low-grade fish (when it is abundant and available at reasonable prices) or with a wet dough prepared from dried fish, cooked rice bran and water spinach. Stocking densities vary from 100 to about 200 fish/m². Because of the high densities disease problems are on the rise, although mortalities are still below 10% over the growout period. The 100-150 g fingerlings reach marketable size of

0.8-1.0 kg in about 10 months. In recent years, yields of 70-150 kg/m²/year have been reported.

Originally the cage-cultured fish used to be transported alive to urban areas and marketed fresh; however, since the mid-1980's processing and exporting *Pangasius* became dominant. Most of the cage cultured fish are now filleted and exported to Australia, Hong Kong, Japan, Singapore and France.

As the cultured freshwater fish volume is not broken down by species in the official statistics, the volume of cultured catfishes in Vietnam could only be estimated.

From various reports it is estimated that Vietnam in 1992 produced 21,000 tons of cultured catfish out of which only 1000 tons were represented by clariid species and the remainder 20,000 tons were represented by pangasiid species.

CAMBODIA

Cambodia is probably the richest country in terms of freshwater fish resources in the region due to the unique system of the Mekong River and the Great Lake that serves as a natural buffer reservoir for the river during its annual floods. Still, as fish catch is highly seasonal, a special form of aquaculture developed here. The origin of which goes back to the 10th century. In an attempt to keep the most valuable part of their catch alive and to be able to sell in the off-season, when the glut in the market is over, fishermen stock live fish in baskets attached to the floating houses of the fishermen. Kitchen refuse and other by-products are fed to them and as a result some species show considerable growth during the holding period. This system has evolved into one of the most efficient and productive aquaculture systems of Southeast Asia.

Cultured species are primarily pangasiid catfishes, with *Pangasius hypophthalmus* as the dominant species representing 98% of cultured catfishes in 1993; *P. bocourti* and *P. larnaudii* made up the rest with 1.5% and 0.5%, respectively. Seed supply is entirely dependent on captured wild fry or fingerlings. Most of the fry is caught in June in a distinct 3-4 days long migratory period in the Mekong River by 10-15 m long bag nets. Beside satisfying the domestic demand, each year not less than 100 million 1.5-2.0 cm fry are exported to Vietnam. The majority of the export is fry of *P. bocourti*. About 4-8 cm long fingerlings for the domestic cage culture operations are caught around the Great Lake and along the Tonle Sap River, mainly in December and January.

Size, shape and material of the cages vary greatly in Cambodia according to the culture site, fish species and age group and also to the affluence of the owner. Smaller cages of 5-15 m³ are used for raising fingerlings and for rearing snakehead; while bigger ones, with volumes of 25 to 100 m³, for pangasiid catfish growout. Cages in rivers tend to be smaller, while those in the Great Lake are bigger. Very large "cages" with volumes from several hundred to several thousand m³ are used to transport live fish from the Great Lake to the major fish landing places. The most typical cages in Cambodia

are relatively large, boat-shaped, with the house of the owner/operator built over it. Many of these boat-cages have also pigsties on their deck. These floating households tend to group together in floating villages along the riverside or in the Great Lake and may be towed to the fish landing places of Phnom Penh. Stocking densities vary from 10-60 kg/m³. Over the grow-out period 10% loss due to mortalities is considered normal.

An unmatched combination of pen and cage culture developed around the Great Lake, where the water level rises 7 to 8 meters during the flood of the Mekong River. Large fingerlings of *Pangasius hypophthalmus* are raised inside 500-5,000 m² bamboo pens constructed in the lake during the dry season. They are transferred to floating cages when the water starts to rise. After the water recede, the pens are re-established and the fish spend another dry season in them. By the next rainy season they reach 1.5-2.0 kg and are transported to the market in giant floating cages.

Feed is the most important input in cage or pen culture of pangasiid catfishes, representing some 70% of the total production costs. Fish are fed with fresh, low-grade fish in the fishing season. Once in every two or three days a thick layer of small fish is spread on the surface of the cage. Fish farmers' rule of thumb is that for the production of one kg cultured fish four kg of fresh fish has to be used as feed. When fresh fish is not available, cooked rice bran is used, sometimes mixed with some broken rice and/or sun-dried small fish or fish heads. When these also run out, aquatic plants (like *Lemna*, *Azolla*, *Ipomoea*) are fed to the fish as a last resort, although feeding these plants over prolonged periods results in retarded growth.

Pond culture is a relatively new technique in Cambodia, its contribution to the total cultured fish production was only about 780 tons or 10% of the total in 1993. Half of the volume produced in ponds was also *Pangasius*, primarily *P. hypophthalmus* and some *P. larnaudii*.

Aquaculture activities were banned under the reign of the Khmer Rouge and had stopped completely between 1975 and 1979. Production recovered rapidly in the 1980's and by the end of the decade reached pre-war levels. The peak was reached in 1982 with 7,900 tons, a substantial part of which was exported, mainly to Vietnam. Production is dominated by catfishes that provided 5913 tons, 75% of the total cultured freshwater fish production in 1993.

Clarias batrachus, the most important cultured catfish species in Southeast Asia, is native in Sumatra, Java and Kalimantan; however, it was introduced to Sulawesi and Irian Jaya. Government agencies actively promoted the adoption of induced breeding and intensive pond culture of catfish since the early 1980's, but until the second half of the decade production of cultured *Clarias* remained below 1,000 tons or 0.5% of the total cultured freshwater fish volume in Indonesia. The major constraints were the limited supply of fry and traditional culture techniques with low profitability. With the introduction of *C. gariepinus* in mid-1980's and the development of hybrid (*C. gariepinus* and *C. batrachus*), cultured catfish production reached 4000 tons in 1991.

Catfishes are not regarded as particularly high-value fishes in Indonesia. In 1991, the price of clariid catfish in Jakarta was above the price level of tilapia and silver

carp, but it was only marginally higher than that of common carp and giant gourami. This may be the reason why the expansion of catfish culture stalled in the 1990's.

Out of the 19 species of the genus *Pangasius*, ten are indigenous and four of which are endemic to Kalimantan. Despite such a wealth of species, culturing pangasiid catfishes is rarely practised.

A local species misidentified as *P. pangasius* (most likely *P. micronema*) was successfully propagated by induced breeding in South Sumatra in order to provide seed for commercial cage culture. Another indigenous species, *P. djambal*, is also reported to be cultured in Indonesia, particularly in Java. However, none of these pangasiid species are produced in significant commercial quantities, most likely because of scarcity of seed and relatively low economic returns.

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PREVENTION AND CONTROL OF FOOD BORNE TREMATODE INFECTIONS IN CULTURED FISH

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INTRODUCTION

Fishborne Trematode (FBT) infections pose a major public health problem, with over 50 million people affected throughout the world, mainly in Eastern and Southern Asia. In all cases, infection takes place through the consumption of raw, under-cooked or otherwise under-processed fish or shellfish containing infective stages of these parasites. Infection from contaminated drinking water is rare.

The World Health Organization (WHO) Study Group on the Control of Foodborne Trematode Infections held in Manila, Philippines, from 18 to 26 October 1993, recognized the serious, yet neglected, problems associated with trematodes infecting humans. The Study Group carried out in depth discussions on the most important trematodes by considering its hosts, epidemiology, geographic distribution, impact on public health, clinical aspects, and treatment and control strategies.

Prevention and control could be implemented by food safety procedures based on the concept of Hazard Analysis and Critical Control Point (HACCP). This involves a completely new strategy of FBT control based on a comprehensive coverage starting from the origin of fish/shellfish up to its consumption. This approach will only be successful if there is collaboration amongst public health, fisheries, aquaculture, food industries, food safety, and education sectors.

This paper outlines the HACCP-based concept of prevention and control of FBT infections in cultured fish.

THE PROBLEM

Aquatic food, raw or inadequately processed, are major sources of FBT infection. Many factors such as traditional methods of food preparation, increased international trade in fishery products originating from endemic areas, increased trend of tourism, use of human and animal excreta in pond culture of fish/shellfish, pollution, etc. exert direct or indirect impacts on the spread of FBT infection.

The parasites and epidemiology

Trematodes are leaf-shape flatworms (flukes). They have a very complicated life-cycle which involves one or two intermediate hosts. Fish may serve as the final host, and adult trematodes are commonly found in the digestive tract. However, it is as the intermediate host to the larvae (cercariae or metacercariae) that fish can transfer the parasite to man. Man's habit of eating raw or insufficiently cooked fish is quite often the cause for infection. Promiscuous or deliberate defecation in ponds, lakes or streams furnishes a constant supply of parasite eggs that, together with suitable intermediate hosts, continue the life cycle.

For liver fluke species such as *Clonorchis sinensis*, *Opisthorchis felinus* and *O. viverrini*, the intermediate hosts are snails and freshwater fish while dogs, cats, pigs, wild animals and humans are the final hosts where the fluke lives and develops in the bile-ducts of liver. These flukes are endemic in southeast Asian countries and in China, Korea, Japan and former USSR.

The symptoms of infections vary according to the species of the liver fluke. However, in general, chronic infections cause damage to the bile-ducts, gastro-intestinal problems, jaundice, fever, fatigue, pneumonia and various respiratory problems.

For various *Paragonimus* species, snails serve as first intermediate host and some species of crabs and crayfish are reported to be the second intermediate host. In China, about 20 million people were estimated to be infected with *Paragonimus* species.

Intestinal flukes are regarded as less public importance than flukes inhabiting the liver or other vital organs; and infection is rare, accidental and often asymptomatic. Nevertheless, 28 countries, mostly in Asia, reported over 70 species of intestinal flukes infecting over one million people.

The costs associated with FBT infections can be estimated in terms of absenteeism, hospitalization, treatments, disability and agricultural/aquacultural economic losses. The direct cost of health care in developing countries is enormous. The costs of treatment and often repeated treatment for liver, lung and intestinal fluke infections are a burden to most endemic countries. The costs of control measures are currently associated with health costs, diagnosis and treatment. The costs involved in food safety and other sectors are yet to be established. In Thailand, the cost to control opisthorchiasis in 3 million people was approximately US\$8.3 million, mostly for medicines, training, and education.

CONTROL OF FBT INFECTIONS

Present control methodology in endemic countries

Models for the control of FBT have been established in China, Japan, Thailand and the former USSR, by the use of case detection and patient treatment, health education, excreta disposal legislation and community participation.

The national programme of liver fluke infection control in the former USSR is integrated into the primary health care systems in major endemic areas. The main goal of this programme is to reduce the prevalence of the disease. Major control measures are the following: (1) detection and treatment of patients; (2) health education; (3) deep freezing and salting of cyprinid fish; (4) protection of environment from contamination by eggs of parasite; (5) treatment of cats and dogs; and (6) snail control. In China, human and animal excreta is extensively used in pond fish culture.

The strategy for reducing the transmission of liverfluke includes: (1) putting stress on health education; (2) treating cases with symptoms in time; and (3) improving faecal disposal system.

In Thailand, FBT infections are considered to be a consequence of the food habits. Therefore, the aim of principal control measures is to modify the health risk behaviour among the target population i.e., discourage the consumption of raw or improperly cooked fish dishes and promote well-cooked dishes. Other important control measures are the detection and treatment of infected persons, the interruption of disease transmission, and the development of self-reliance and community participation. Recently, the Ministry of Public Health has changed its strategy of trematode infection control from a passive to a more active approach. The main policy and guidelines are the following: (1) integrating the liver fluke infection control programme into a primary health care approach with community participation; (2) providing health education and public health information to the communities - the goal is to change the habit of eating raw fish to eating cooked fish; (3) strengthening efficiency of stool examination both qualitatively and quantitatively and, following this, proper treatment of liver fluke infection; (4) improving environmental sanitation through the construction of latrines and sewage/refuse disposals; (5) organizing seminar and training courses on liver fluke control programmes for health care workers, community leaders and village health volunteers; (6) supporting all levels of health care service centres with sufficient budgetary provisions, supplies and medicines; and (7) encouraging and cooperating with other Governmental Organizations (GOs) and Non-Governmental Organizations (NGOs) to participate in the control programmes.

In most of the countries where FBT infections are endemic, the food inspection and safety services are weak; and, in general, are not particularly interested in fish and shellfish. Some countries have separate arrangements for hygienic handling of fish & shellfish produced for the international market; but local or national markets are generally neglected.

THE POSSIBLE USE OF THE HACCP-CONCEPT FOR THE CONTROL OF FBT INFECTIONS IN CULTURED FISH

General approach to parasite control in fish as food

As far as fish as food is concerned, up until recently (1989) WHO's recommended strategy for controlling parasite infections - limited to nematode control - was based on three objectives, namely:

1. Avoidance of capture of nematode-infected fish by selecting specific fishing grounds, specific species or specific age groups.
2. Sorting and removal of nematode-infected fish or removal of nematodes from fish, e.g., by hand over a candling table.
3. Application of techniques to kill nematodes in the fish flesh.

For the US Food and Drug Administration (1994), the best available control measures, only for nematode and cestodes, are visual examination and physical removal of the parasites. This method, termed candling, may only be used for white translucent fleshed fish and can reduce, but does not eliminate, the parasite.

During the WHO Study Group on the Control of Foodborne Trematode Infections held in Manila, Philippines, October 1993, an attempt was made to design a new strategy of prevention and control of FBT based on the HACCP-concept. With this approach, the prevention and control of FBT infections should have the following two main objectives:

1. Prevention of contamination of fish with infective stages of the parasite (metacercariae).
2. Inactivation of the parasite which contaminated the fish (killing the parasite).

CULTURED FISH

It is claimed that in properly managed culture systems there is no conclusive epidemiological evidence linking aquaculture to the transmission of trematode infections. About 80% of freshwater fish production in China comes from managed aquaculture systems, yet there are at least 4 million persons infected with Trematodes. In fact, in Taiwan today the incidence of FBT infection is higher in farmers due to the fact that they culture freshwater fish near pigsties and eat contaminated raw

fish. In the absence of data the situation in the Mekong delta cannot be properly evaluated. However, liver fluke infection is a major health problem in these countries.

The possible use of the HACCP-concept in the prevention and control of FBTs in cultured fish is based on the assumption that the farmer must design and apply a HACCP plan for the production and marketing of fish free from FBT infection. The farmer will be assisted by the local public health officers and fish-inspection officers. The whole process should involve the local community and reach the village and retail market, processing plants, restaurants and the housewives, and should have the support of a well-coordinated health education and public information programme.

Based on the working sequence for the application of HACCP recommended by the CODEX Committee on Food Hygiene (FAO/WHO, 1993), a basic flow diagram for cultured fish is shown in Figure 1.

Also, the Critical Control Points (CCPs) have been identified and for each one of the CCPs the potential hazards of FBT infection have been identified and analyzed. Control measures, critical limits, monitoring procedures and corrective measures necessary under the HACCP-plan are summarized in Table 1.

CONCLUSIONS AND RECOMMENDATIONS

Practical experiments on the possible use of the HACCP-based measures mentioned here must be carried out in order to check their feasibility and efficiency in the prevention and control of foodborne trematode infections. Its success would depend on collaboration between the agencies responsible for public health, fisheries, aquaculture, food industries, food safety (inspection and quality assurance) and public education.

To meet the challenge, fish inspection programme in endemic areas must be strengthened. Fish inspectors must be informed about the hazards of FBT infections and trained on how to prevent their occurrence and monitor all critical control points in production, handling, processing and marketing operations.

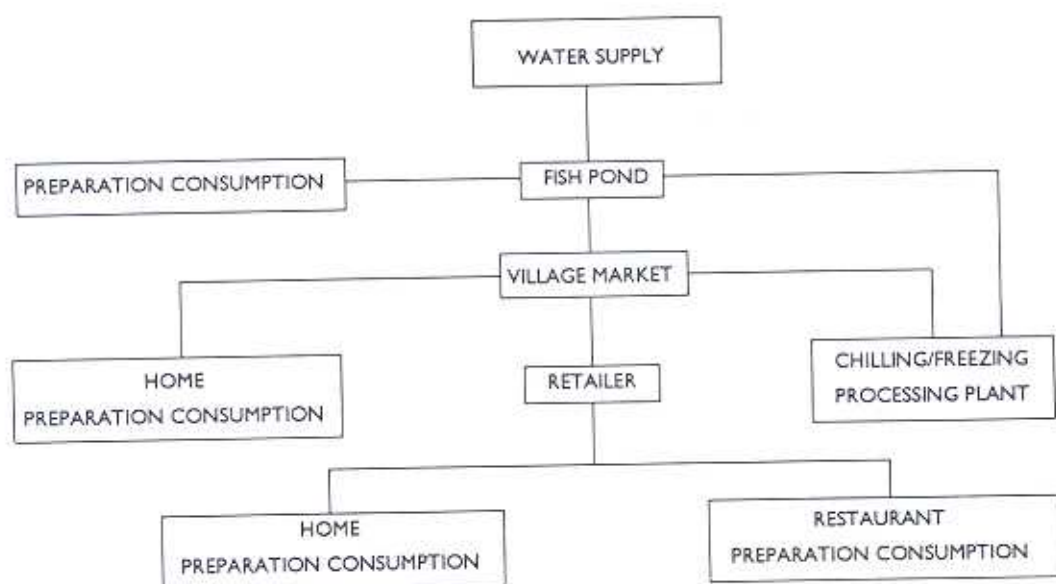


Figure 1: Flow diagram for cultured fish, for the application of HACCP

OPERATION/ CRITICAL CONTROL POINT	HAZARD	PREVENTIVE/ CONTROL MEASURES	CRITICAL LIMITS	MONITORING PROCEDURES	CORRECTIVE MEASURES
WATER SOURCE	FBT egg present	Select egg free water supply; water treatment	No FBT eggs	Visual inspection of site; water analysis for FBT	Identify/eliminate source of contamination
	Snail present	Prevent snail entry	No snail	Visual inspection of site	Eliminate snail
	FBT infected fish present	Eliminate infected fish/select water supply free of infected fish	No infected fish present	Visual inspection of fish	Cook infected fish; ensure efficiency preventive/control measures
FISH POND	FBT eggs present	Avoid contamination from excreta	No FBT eggs	Visual inspection of pond; water analysis	Identify/eliminate source of contamination
	Snail present	Prevent snail entry	No snail	Visual inspection of pond	Eliminate snail
	Infected fish present	Eliminate infected fish. Obtain fingerlings from safe source	No fingerlings infected	Physical inspection of fingerlings for FBT	Ensure that fingerlings are obtained from safe source
VILLAGE MARKET & RETAILER	Infected fish present	Obtain fish from safe sources	No fish infected	Regular check of raw material sources; visual inspection of fish	Ensure that fish are obtained from safe ponds
PROCESSING PLANT	Infected fish and fish products	Obtain fish from safe sources; when necessary apply proper FBT killing process	No end product infected with viable FBT metacercariae	Regular check of raw material sources; visual inspection of raw material	Separate infected fish lots and apply proper FBT killing process; ensure fish are obtained from safe ponds
HOME & RESTAURANT	Eat infected fish	Cook fish properly before eating	Do not eat raw or improperly cooked fish	Check time and temperature of cooking; visual inspection of food handling area/practices	Stool examinations and treatment; make necessary adjustments to time/temperature of cooking

Table 1: Application of HACCP-concept for the prevention and control of food borne trematodes in cultured fish

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THE LEGAL REGIME GOVERNING AQUACULTURE IN VIETNAM

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In an earlier issue of this newsletter (August 1994, Number 7), it was mentioned that subsequent papers would be written on an occasional basis dealing with reviews of legal regimes for environmental management of aquaculture, as well as some case studies under the existing legal regimes in some countries.

In this paper, the legal aspects of the management of aquaculture in Vietnam are considered.

BACKGROUND

Vietnam is a country with 64.4 million inhabitants, who draw from the country's inland and marine waters a high percentage of their animal protein and substantial foreign exchange earnings.

The country is long, about 1,800 km, and shaped like an S, broader in the North and in the South, and very narrow in the middle. It is bordered on the East by the South China Sea, and has a coastline of about 3,200 km with 112 estuaries and 3,000 islands. The latter are divided in two categories: in the coastal waters, there is a chain of islands, most of which were once part of the mainland and those farther out are coral islands. The inland water areas in Vietnam are estimated to cover 1,379,038 ha, and the living environment of fresh and brackish aquatic species consists of: rivers, streams, lakes, ponds, floodplains, rice fields, lagoons, reservoirs, etc. The area of salt and brackish swamps covers 51,000 ha and ponds cover 58,088 ha.

Vietnam shows a diversity in climatic conditions which vary from humid tropical conditions in the Southern lowlands to bracing temperature conditions in the northern hills.

The population is still basically rural (79% in 1987 compared with 85% in 1960) and is concentrated in the two main deltas (the Red River and the Mekong River).

Vietnam is one of the most, if not the most, densely populated countries in mainland South-Eastern Asia. Rural population densities average 194 persons/sq km, but vary regionally. Indeed, in some provinces in the North, such as Thai Binh, population densities are among the highest in the world, ranging from 839 to 1,029 persons/sq km. The Mekong delta, which is over twice as large as the Red River delta, has a far lower population density (200-250 per sq km in Hau Giang Province) and for this reason alone, plays a key role in supplying food and other agricultural commodities to the North.

The fishery sector is highly diversified and includes inland and marine capture fisheries as well as freshwater, brackish water and marine aquaculture.

THE LEGAL REGIME APPLYING TO AQUACULTURE

It is not intended here to canvass the entire legal regime that can impinge on an activity as diverse as aquaculture, which is a surprisingly vast area of study, as was demonstrated in the first paper in this series (p10 FAN, August, 1994 Number 7). In this respect, the Constitution states (in Article 17) an important principle regarding the ownership of natural resources in the country. It reads:

"The lands, forests, rivers and lakes, water supplies, wealth lying underground or coming from the sea, the continental shelf and the air, the funds and property invested by the State in enterprises and works in all branches and fields - the economy, culture, society, science, technology, external relations, national defence, security - and all other property determined by law as belonging to the State, come under the ownership of the entire people".

As well as the constitution, it is important to refer to passing to the fisheries laws, which will of course

impinge on aquaculture activities. More importantly also, in Vietnam, it has to be remembered that many activities are subject to control at the local level, and the information regarding this is not easy to obtain. For more details, see The Legal Framework governing aquaculture in Vietnam, a paper presented to the National Workshop on Environment and Aquaculture Development held in Haiphong from 17 to 19 May, 1994. Important though all these laws are, it is on the laws governing the access to and use of land and the environmental laws in their impact on aquaculture on which it is proposed to focus in this paper.

Access to and use of land

Vietnam is a country which has paid some attention to the use and access to land for aquaculture purposes. Appropriate government bodies are entitled to allocate land for aquaculture purposes. Under Article 5 of the Land Law, "The State encourages the land users to invest labour, material, capital and apply scientific and technical achievements to reclaim virgin land, upturn uncultivated land, encroach land upon the sea, green the waste land and bare hills and coastal sandy land in order to expand areas of land for the production of agriculture, forestry, aquatic culture and salt-making."

The fundamental principle of Vietnamese land tenure is stated in article 1 of the Land Law as being: "Land is the property of the whole people, uniformly managed by the State". In other words, the land is owned by the entire people of Vietnam, and the State is designated as its manager. The government organizations, from the National Assembly to the People's Committees at different levels have the responsibility for land management. The People's Committee at the provincial level is responsible for activities concerning surveying and classification and demarcation of land. The practical work is the responsibility of the People's Committee in the District or in the Village (Article 8, Land Law).

Under Article 1 also, any person or group in Vietnamese society can receive land for aquaculture purposes, including foreigners. However, in respect of the latter, special rules are applicable (see Chapter 5 of the Land Law).

There are six categories of land recognised under the Land Law:

- agricultural land;
- forest land;
- residential land in rural areas;

- urban land;
- land for specialised use;
- unused land.

Land suitable for aquaculture is embraced by agricultural land.

Land is allocated for a limited period of time. Under the Land Law, allocation occurs for 20 years for annual crops and aquatic culture, 50 years for perennial crops, with a provision for renewal if the person to whom the allocation was made still needs it and has complied with the Law.

The new Law also states clearly that the land may be allocated subject to "right to exchange, transfer, lease, inherit, mortgage the land use rights" - [Article 3(2)]; while in Article 5, the State is to encourage the land users to invest labour, material, capital and apply scientific and technical achievements to "increase the value of the land in its utilization" and "intensify farming, increase crops, and the economic effectiveness of land utilization".

Since 1994, a land utilization tax is applied, which is determined on the following basis. There are six grades of agricultural land, which are determined by the productivity of the land:

550 kg	rice	per ha	pa
460 kg	"	"	"
370 kg	"	"	"
280 kg	"	"	"
180 kg	"	"	"
50 kg	"	"	"

Even though the land is used for aquaculture, it is still subject to the same rate of tax. The tax is about 6 to 7% of total output.

The procedure for the classification of the land for this purpose is set out in the Land Tax law which is dated 14.7.93. A further decree dated 25.10.93 (No 73) explains how the land use classification is to be made for the purpose of this tax. No copy of this was available in English.

A particular regime is provided for foreign companies under the "Regulation on rents of land, water and sea surfaces to be applied to foreign investment firms in Vietnam" - (Decision No 210A - TC/VP of 1.3.1990). Foreign companies, i.e. all joint ventures, enterprises with 100% foreign invested capital and parties to

business cooperation contracts, hereinafter called "foreign invested capital enterprises" are subject to following obligations:

1. they must be allowed by the state to lease "land, water and sea surface"; and
2. they must pay rents. These are calculated on the annual base of one unit of acreage or on the whole of acreage in accordance with the lease contract. The yearly rent for land averages from 200 to 1000 USD/ha; for waters such as river, lake and gulf from 100 to 700 USD/ha; and for sea surface from 200-800 USD/km², except for the cases where there are acreages under unspecified use from 2.000 to 10.000 USD/km². These rents are reduced occasionally in special cases subject to approval of the State Committee for Cooperation and Investment. The "foreign invested capital enterprise" shall be exempted from paying these rents when they are considered as part of the contribution of the Vietnamese shareholder to the legal capital of the company" - (Article 9). Offences are punished with fines.

However, under the new Land Law, it is possible that there could be an international agreement to which Vietnam is a party which might provide for different conditions governing the use of land by a foreigner (See Ch V of the Land Law, especially Article 82).

The land user's tenure is not unconditional during the term of allocation. General obligations are set out in Chapter III (Utilization system for the Land Categories), the most important of which to note regarding aquaculture is the need to comply with land use planning requirements imposed, and with environmental laws (Articles 47 and 48).

Infringements of these obligations can lead to the recovery of land by the State. These are set out in Article 20 of the Law. However, particular reference can be made to recovery where the land is used for 12 continuous months without a permit, the land user intentionally tries not to fulfil his responsibility, the land is not used according to the purpose for which it was allocated, or the land was not allocated by the right authority as defined under the Law.

It is difficult to judge whether this land policy in coastal and marine areas provides for the optimization of various activities located there as well as resolving problems of compatibility between different uses.

ENVIRONMENTAL ASPECTS

Recent changes in the law have introduced greater awareness of the environmental aspects of aquaculture activity, though these are dealt with in laws which impinge upon aquaculture rather than deal with it separately. First, the Land Law itself, in Article 47 stipulates that "the use of the water surface of lakes, ponds, rivers, and canals must comply with the regulations of the environmental protection and cause no hindrance to the transportation"; while Article 48 further stipulates that "the user of land with water surface on the coastline for agricultural, forestry production, aquatic culture must conform to" amongst others, regulations which "protect the ecosystem and the environment". Further, Article 79 imposes on the land user the obligation to "comply with the regulations on environmental protection, do no harm to legitimate interests of the neighbouring land users."

The Land Law also provides for land use planning which could impact on aquaculture activities, but it is not known at this stage whether there are any specific provisions governing aquaculture.

The new Law on Environment Protection provides the basis for a more comprehensive regulation of activities that could harm the environment, and although aquaculture is not specifically mentioned, it is obvious that many of the provisions will apply. In Article 2, for example, it is stated that "Environment components include air, water resources, land, land-bed, sea, forests, plants and animals, ecosystems, living areas, production areas, national parks and landscapes." Some specific prohibitions in the law would apply to aquaculture activity, for example Article 29(2) which prohibits amongst other things the discharge of animal and plant corpses, disease viruses into water resources, lakes, ponds, rivers, streams, canals and sea. The Law also provides penalties for breaches of the Law (Articles 50 - 53).

It is not possible at this stage to state how effectively this new law is operating, nor whether it is being used or is intended to be used in the regulation of aquaculture. However, it is evident that its provisions are capable of having a considerable impact on aquaculture activity. Increased recognition of the importance of the environmental aspects of aquaculture may well lead to a greater reliance on the provisions of this law in bringing about a greater level of environmental protection.

BIODIVERSITY CONSERVATION AND ESTABLISHMENT OF COHO SALMON BROODSTOCK IN CHILE

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In early 1994, FAO started implementation of a TCP (Technical cooperation Programme) project on "Genetic Improvement of Salmon in Chile" - TCP/CHI/2354A. This project concentrates only on coho salmon, *Oncorhynchus kisutch*, and utilizes selective breeding based on family performance as the means toward genetic improvement. Salmon are selected for fast growth and for early spawning time to take advantage of good seasonal markets. Details of this genetic improvement programme will be included in the future issues of the FAN, but in this article I wish to elaborate some of the biodiversity concerns that are associated with aquaculture development of an exotic salmonid in Chile.

Several species of salmonids have been introduced into Chilean waters in attempts to establish sea ranching programmes, closed system aquaculture programmes, as well as both commercial and sport fisheries. Although there are a few instances where introduced salmonids have established small, self sustaining populations, in general, the attempts at sea ranching and the establishment of new fisheries in Chile were unsuccessful.

In contrast, the closed-system culture of three species (rainbow trout, Atlantic salmon, and coho salmon) have been fairly successful in Chile. In 1992, Chile ranked second only to Norway in world production of farmed salmonids with a production of about 60,000 tonnes. However, the majority of this culture depends on eggs imported from the northern hemisphere. 62 million eggs imported in 1992 yielded over 60 tonnes of salmonids (24 tonnes Atlantic salmon, 17 tonnes coho, 20 tonnes rainbow trout).

For a variety of reasons Chilean dependence on eggs from the northern hemisphere is dangerous for the stability of the salmonid aquaculture industry. Therefore, the Instituto de Fomento de Pesquero (IFOP), the University of Chile, and the Chilean Salmon Growers Association desire to establish a local brood stock of coho salmon well adapted to the culture conditions and environment of Chile.

There are two main aspects of biodiversity conservation that need to be addressed with the development of coho aquaculture in Chile. First, because this fish is being reproduced in hatcheries, care must be taken to protect the genetic resources of the farmed coho salmon. That is, farmers must use adequate numbers of adult spawners to get a large reservoir of genetic diversity (resources), farmers should know how their stocks relate to other stocks to avoid outbreeding depression (when two dissimilar types breed subsequent generations may perform poorly even if initial hybrids perform well), and should strive to avoid inbreeding depression. Second, because this fish is an exotic salmon from the northern hemisphere, it may impact on the local aquatic resources through predation, competition, or spread of exotic diseases.

GENETIC RESOURCES OF FARMED COHO SALMON

The international community and Member States of FAO are emphasizing the value and importance of the genetic diversity in both wild and domesticated species in sustainable fisheries and aquaculture. However, this diversity is undescribed for the coho salmon in Chile. This project seeks to provide a baseline description of the genetic resources of coho salmon to better understand their relationship with farmed and natural stocks in the Northern Hemisphere and to discover how the genetic improvement programme may change the genetic resources.

Coho salmon were first introduced into Chile from the USA in the 1930's. Japanese started the culture of coho salmon in Llanquihue Lake, north of Puerto Montt in 1979. In the period 1980-1981, about 150,000 fish escaped into the Lake, thus establishing a naturalized run of coho salmon. The stock used in the genetic improvement programme (CMG stock) originated from the naturalized run in Llanquihue lake in 1983. It is unclear what the exact source of the Llanquihue stock was, but the composition is thought to have involved stocks from Oregon Aquafarms (Puget Sound and Oregon coho), Fish Pro and Kitamat (Canada), and

Aquamar (Chile). Perhaps it is more likely that the Oregon fish were from Alsea or another state hatchery as private farms were not well established in early 80's in Oregon. Eggs and smolts from the CMG stock at present are sold to local salmon farmers; the stock performs well and is highly regarded by the industry.

Analyses of isozymes (isozymes are the products of genes, so isozyme variation is considered a reflection of gene variation) by Chilean researchers (Nelson Diaz, Ricardo Guinez, Alfredo Torres, and Fredericko Winkler) have found variation at two loci (locations of genes on a chromosome). Coho salmon have some of the lowest levels of variation of the salmon and these results are the first documented genetic variability of coho in Chile. Work is continuing on this genetic description. Once levels of variation have been established, this information can be used to assess how the Chilean coho relates to Northern stocks and how the continued selection programme affects the genetic diversity. This information may help interpret production trends. For example, Dr Valerio Sbordoni and associates in Italy found that genetic diversity and percent hatch in *Penaeus japonicus* decreased over 7 generations in a hatchery. These scientists showed that this was due to inbreeding depression. The genetic data helped interpret the cause for decreased hatch rate in the shrimp.



Graham Gall (Mission Leader) and Eduardo Bustos (National Coordinator) at a salmon culture site on Chiloe Island, Chile.

USE OF EXOTIC SALMON IN CHILE

It has proven to be nearly impossible to contain completely aquaculture stock in cages, escapes are inevitable and feral salmon can adapt to a variety of habitats and consume zooplankton as juveniles, and switch to fishes as they grow. Little is known of how these salmon will affect the aquatic resources around Chile. In the Northern Hemisphere exotic salmon have seriously impacted related salmon species through predation, competition for food and mates, disease transmission and hybridization. Although Chile had no naturally occurring populations of salmon before several species were introduced for sport fishing, fisheries and aquaculture, Chile does have several species of Galaxids that are related to salmon. Galaxids of the Southern Ocean have been shown to be very susceptible to exotic salmon because the two groups did not evolve together, but have similar ecological niches. One Galaxid is endemic to Chile, that is, it is found nowhere else and therefore care should be taken that introduced salmon do not cause this unique resource to go extinct.

One threat to coho salmon in Chile is the spread of disease. Bacterial Kidney Disease (BKD) was introduced to Chile presumably from the USA with infected salmon and now infects numerous farms. The movement of coho salmon among regions in Chile is now prohibited to help control the spread of this pathogen. With the

continued importation of salmonids, other diseases such as rickettsia and IHN (Infectious Hematopoietic Necrosis) may find their way into Chilean culture systems.

It is important to realize that coho salmon, although exotic, are now a valuable resource of Chile. Chilean coho salmon are adapted to the environmental conditions of the Southern Hemisphere, they spawn 6 months out of synchrony with their relatives in the North. A few naturalized runs have changed not only their spawning times, but also their migration patterns, and possibly their navigation cues in order to orient themselves in the Southern Ocean. These "man-assisted" changes, which are partially associated with genetic changes and domestication, now represent a valuable resource that should be conserved and utilized.

[Thanks to FAO mission members G. Gall, R. Pascha and Chilean experts M. Arredonda, E. Bustoz, R. Neira, J. Ruiz and the researchers listed in text.]

Broadening the Mandate of the FAO Commission on Plant Genetic Resources

The 170th FAO Council, 15-24 November, 1994, was presented with a proposal (Council Document CL 107/18) to expand the Commission on Plant Genetic Resources into a Commission on Genetic Resources for Food and Agriculture. Obviously such a Commission would include aquatic species and would be a significant development for FAO Fisheries Department. The proposal was well received by the delegates, however certain questions remain and concern was expressed over possible negative financial aspects of such an expansion. Council Document CL 107/18 recommended that a detailed paper on this issue be prepared for the March 1995 meeting of COFI. This recommendation is being acted upon by the Fisheries Department.

Here, only some of the considerations that must be taken into account when expansion occurs. The first sector to be included in the expansion will be terrestrial animals, i.e. livestock. Therefore, the Fisheries sector can watch and learn for a while, but we should be ready and prepared when our time comes.

The expanded Commission must be prepared to deal with an increased awareness of the value of biological diversity and especially genetic diversity. The most visible sign of this new awareness is the signing and entry into force of the Convention on Biological Diversity. This Convention is significant in that it recognizes the importance of biological diversity, mandates that developing countries manage their resources within national priorities and obligates developed countries to share in the increased costs of conservation and sustainable development. Therefore, international coordination and action will be necessary to fulfil the spirit of the Convention. Clearly, new intergovernmental mechanisms will be needed to address adequately the concerns of the sustainable use and conservation of aquatic genetic resources.

The Convention also calls for the creation of a "subsidiary body" to act on technical matters related to conservation and use of biological diversity. An expanded Commission on all genetic resources would

be well positioned to provide input and guidance to the subsidiary body.

Although the underlying principles of genetics and gene action are similar for aquatic and terrestrial organisms, there are substantial differences between the sectors involved in food production that must be considered in order for the expanded Commission to deal effectively with aquatic resources. The major difference between plant and aquatic animal genetic resources lies in their level of domestication; the majority of aquatic genetic resources reside in the wild or in near-wild relatives, whereas plant and most terrestrial genetic resources are highly modified or domesticated. This primary difference leads to a suite of related differences, such as location and ownership of resources, level of endangerment from introduction and genetic contamination, ease of containment, existence of wild relatives and knowledge on basic biology, taxonomy and ecology. Even the aquatic sector itself is extremely diverse with aquaculture striving to domesticate aquatic resources in controlled or semi-controlled environments and capture fisheries striving to harvest and maintain natural aquatic communities. An expanded Commission must be prepared to deal with these differences and not simply treat aquatic resources as wet plants.

The aquatic sector must become a full partner in the Commission. Presently the mechanisms of the Commission to assist with the Global programme on Plant Genetic resources include Panel of Experts of Forest Genetic Resources, International Undertaking on Plant Genetic Resources, World Information and Early Warning System on Plant Genetic Resources and an International Code of Conduct on Collecting and Transfer of Plant Genetic Resources. These instruments would need to be created for the aquatic sector. There would be technical difficulties with simply expanding those that exist to cover fisheries.

Some of these instruments exist for fisheries and aquaculture in various stages of development. For example codes of practice on the use of introduced species exist, as do databases on aquatic resources (FISHBASE with FAO/ICLARM, SpeciesDab with FAO, Registry of North American Strains of rainbow trout

with the US Fish and Wildlife Service). However, these instruments would need to be refined, coordinated and coalesced into a global programme.

Council Document CL 107/18 strongly emphasises agrobiodiversity. Thus, there is an explicit focus on domesticated resources. Therefore, in accordance with a step-by-step integration of additional sectors into the expanded Commission as suggested in the document, aquaculture should be the first discipline from the aquatic sector incorporated.

The aquatic sector, and in the first instance aquaculturists, must give immediate consideration to how the expansion of the Commission will be practically implemented. It may be wise to create, as a first step in this process, a group of experts on aquatic genetic resources similar to the panel of experts that advise the forestry sector. It should be noted that the Consultative Group on International Agriculture Research (CGIAR) is also developing a system wide strategy for the utilization and conservation of genetic resources and may wish to participate in the creation and consultation of such a panel of experts.

The two year project AQUILA II (Support to Regional Aquaculture Activities in the Latin America and the Caribbean - GCP/RLA/102/ITA) was completed in June 1994. Like its predecessor (AQUILA I), the project was financed by the Government of Italy and executed by FAO. AQUILA II, with its headquarters based at the National Fisheries Institute in Mexico City, assisted 33 countries in the region, including the English speaking Caribbean nations. The project carried out many activities related to aquaculture development, including planning, development of information system, promotion of research, etc. The project assisted SIFR (Strategy for International Fisheries Research) in carrying out the study on "Aquaculture Research in Latin America and the Caribbean - Needs and priorities for short and medium term development". Expert consultations on aquaculture research needs, organized by the project, have resulted in the formulation of several project proposals for external funding. Recently, the project performance was evaluated and the evaluation mission recommended, among other things, the continuation of the project focusing on the subject of aquaculture in coastal lagoons in a limited number of countries in the region. Funding for such a follow-up project is being sought.

In Madagascar, UNDP funded project "Promotion of aquaculture and privatization of fingerling production - (FI/DEP/MAG/88/005)" has been successfully completed. The main strategy used in the first phase of the project was the promotion of fingerling production by private producers who integrated this activity with other traditional agricultural practices. In the second phase these farmers were trained to become extension workers (privatization of extension services). As a result, there has been a significant growth of fish (*Cyprinus carpio*) culture in ponds and rice fields. At present, an estimated 125,223 farmers are involved in aquaculture and producing 1585 tons/yr of fish of which 1085 tons/yr are from 13,381 ha of rice fields and 500 tons/yr from ponds.

Mr. P.C. Choudhury presented a paper entitled "Integrated rice-fish culture in Asia with special reference to deepwater rice", in the 18th session of the International Rice Commission, held in FAO Headquarters in Rome, from 5-9 September 1994. The paper points out that in Asia, with the introduction of HYV of rice, fish production from the traditional rice-fish culture systems, with the exception of a few countries such as China, Indonesia, etc., has been steadily decreasing.

The agronomic conditions needed for HYV rice cultivation are not very suitable for fish life, and, as a result, integration of the two systems is not always profitable to the farmers. However, some of the inherent problems could be resolved through research and development support and the improved traditional rice-fish culture systems could be maintained at a subsistence level playing an important role in rural development. Traditional rice-fish culture is carried out in ricefields with water depth of less than 50 cm. Fish culture integrated with deepwater rice, cultivars which grow in water of over 50 cm for at least one month during the growing season, has not yet been tried in large scale. However, results obtained from field trials of fish culture integrated with deepwater rice cultivation are very promising. Every effort should therefore be made to develop appropriate deepwater rice-fish culture technologies and to encourage farmers to adopt such technologies. It is estimated that if only 5% of the irrigated ricefields with production target of 300 kg/ha/yr and 15% of the deepwater ricefields with 600 kg/ha/yr were brought under integrated rice-fish culture, 3.2 million tons of fish could be produced.

Ad hoc Working Group on Responsible Stock Enhancement

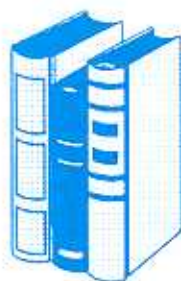
Members of the World Aquaculture Society, under the direction of Dr Ken Leber of the Oceanic Institute in Hawaii, formed an ad hoc working group on Responsible Stock Enhancement following the Society's 1993 meeting in Torremolinos, Spain. FAO Fisheries Department has significantly contributed to the group through a variety of means such as presentations of papers, rapporteuring, and promotion.

One of the goals of the group is to promote scientific debate that will lead to the development of guidelines, recommendations and codes of practice for Responsible Stock Enhancement. Toward that end the following guidelines have been proposed for further considerations.

Guidelines for a "Responsible Approach" to Stock Enhancement

- Establish priorities and methodologies for selecting species to be ranched or enhanced.
- Create a species management plan with long and short term goals, harvest regimes and genetic conservation objectives.
- Incorporate life history and ecological attributes into enhancement strategies and tactics.
- Create a genetic resource management plan to minimize inbreeding/outbreeding depression and to conserve genetic resources.
- Create a disease and health management plan.
- Define an empirical process for defining optimal release strategies.
- Define and implement means to identify hatchery-produced fish.
- Assess the enhancement project in terms of stated objectives in management plan. Include quantitative measures of success and socio-economic evaluation.

Another goal of the group is to develop a global network of professionals interested in stock enhancement. If you would like to become involved with the global network and have questions or input that would be appropriate for the group please contact Dr Devin Bartley care of FAN. Formal membership in the group is open to all interested members of the World Aquaculture Society (WAS). However, non WAS members are encouraged to participate through FAO. A detailed description of this group will appear in a future issue of FAN.



Coche, A.G., B. Haight and M. Vincke

Aquaculture development and research in sub-Saharan Africa. Synthesis of national reviews and indicative action plan for research.

CIFA Technical Paper. No. 23. Rome, FAO. 1994. 151 p.

This document is based on twelve national reports of the most important aquaculture countries in Africa south of the Sahara. It analyses the present situation of aquaculture development in terms of: its historical development, public sector involvement, support activities for development of the subsector and planning experiences, and briefly reviews the external assistance received for development projects. The research subsector is then analyzed to verify the correspondence between its structure, programmes and plans and the identified needs for aquaculture development. Through a logical process for priority-ranking and for correspondence with the development objectives an indicative action plan emerges, including nine regional programmes which would assist in fostering aquaculture development in the short and medium terms through support to research. These research programmes, involving centres of the five agro-ecological regions of Africa South of the Sahara working as activity networks, include a project for aquaculture information centres in support of all other eight proposals. Other programmes include socio-economics, aquaculture production indicators, pond fertilization and feeding strategies, fish broodstock improvement and management, small water bodies fisheries enhancement, aquaculture in irrigation schemes, indigenous fish culture and marine aquaculture.

NEW PUBLICATIONS

Tacon, A.G.J. Feed ingredients for carnivorous fish species: Alternatives to fishmeal and other fishery resources.

FAO Fisheries Circular No. 881. Rome, FAO. 1994. 35 p.

This paper reviews the major studies conducted to date concerning the partial or total replacement of fishmeal within aquafeeds for carnivorous fish species with alternative protein sources or "fishmeal replacers", including terrestrial animal by-products, single-cell proteins (SCP), oilseeds, grain legumes, cereal grains, and miscellaneous plant products. Information is presented concerning the nutritional value and chemical composition of the individual protein sources, together with their normal and suggested maximum dietary inclusion levels. Emphasis is placed on the important role played by feed technology and biotechnology in the development and nutritional success of individual fishmeal replacers, either through 1) the use of appropriate feed processing techniques for the deactivation/removal of endogenous anti-nutritional factors and/or for increasing nutrient availability and digestibility, 2) the use of dietary enzyme supplements to aid digestion within the gastro-intestinal tract and so increase nutrient availability and digestibility, 3) the use of dietary amino acid/mineral supplements, either in crystalline/purified form or coated/protected from, to overcome inherent amino acid and/or mineral imbalances, 4) the use of dietary feeding stimulants so as to enhance feed palatability and maximize feed intake, 5) the use of fermentation technology and genetic manipulation to produce single-cell proteins from waste streams with the desired dietary nutrient profile for the cultured specie, or 6) the use of plant breeding programmes to produce genetically selected varieties low in specific anti-nutritional factors or high in specific essential nutrients.

Calamari, D., Naeve, H.

Review of pollution in the African aquatic environment.

CIFA Technical Paper No 25. Rome, FAO. 1994. 118 p. Available in English and French.

This document summarizes the findings of the CIFA Working Party on Pollution and Fisheries. It gives advice on strategies for aquatic pollution control, including the establishment of environment quality standards, emphasizing the use of risk assessment methodologies for arriving at site-specific environmental protection measures. The document further reviews the state of the African aquatic environment in respect of pollution by organic loads, by heavy metals and by organochlorine substances. It concludes that contamination of African inland waters, with the exception of some hot-spot areas, is still relatively low. Pollution by organic matter, causing eutrophication and anoxia, however, is identified as a major threat to fisheries. Although contamination with metals and organochlorines is still low, with the expected increases in urbanization and socio-economic activities, it is imperative to identify the sources and quantify the discharges of such material into the aquatic environment. The occurrence of synthetic micropollutants like organochlorine substances in different compartments of the aquatic environment, even at trace and ultra-trace levels is of ecological and environmental health concern. Pollution control strategies should be formulated in all countries, covering legislation, environmental standards and criteria, waste minimization, effluent treatment, pollution monitoring, training, education and public awareness campaigns.