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AQUACULTURE ASIA

Red River Delta aquaculture, Vietnam

Snakehead farming in the Mekong

Small-holder catfish farmers

Small scale prawn culture

Golden mahseer hatchery

Floating hapa technology

NACA

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NACA
An intergovernmental organisation that promotes rural development through sustainable aquaculture. NACA seeks to improve rural income, increase food production and foreign exchange earnings and to diversify farm production. The ultimate beneficiaries of NACA activities are farmers and rural communities.

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Global Conference on Aquaculture 2010

The highlight of our year was the Global Conference on Aquaculture 2010 held in Phuket in September, co-organised by the Thai Department of Fisheries, FAO and NACA. About 500 people attended from all over the world, along with an impressive line up of international expert speakers. The quality of the presentations was excellent and the conference covered a great deal of new ground. A key feature of the event was its interactive nature, based around open expert panel discussions with audience participation.

The conference was the third in a series of aquaculture development conferences that started in 1976 with the FAO Technical Conference on Aquaculture in Kyoto, and the Conference on Aquaculture in the Third Millennium held in Bangkok, 2000. Each conference in turn has produced a series of recommendations to guide policy makers. The main outcome of the 2010 conference is the ‘Phuket Consensus’, a declaration that builds on the Bangkok Declaration and Strategy for Aquaculture Development, adopted by the 2000 conference.

The Phuket Consensus reaffirms commitment to the principles outlined in the Bangkok Declaration, but adds coverage of contemporary issues such as climate change and responses that have evolved such as cluster approaches to management by small-scale farmers. We encourage policy makers (and anyone involved in aquaculture development) to download these documents and consider them when preparing your next work plan.

If you missed the conference, well I have some good news. We recorded the entire proceedings and have published all the presentations, lectures and speeches as MP3 files that you can download from the NACA website at the link below. You can also listen to them online (stream) the files from our server if you prefer. There’s nearly a week’s worth of recordings there. The slides and other conference publications are also available for download.

To single one or two out, David Little’s presentation on “Alleviating poverty through aquaculture: how can we improve” is particularly thought provoking and essential listening for anyone involved in aquaculture development. Patrick Sorgeloos’s talk on “Resources, technologies and services for future aquaculture: a needs assessment for sustainable development” is well worth a listen. And don’t miss M.S. Swaminathan’s keynote presentation on “Aquaculture and Sustainable Nutrition Security in a Warming Planet” which really opens up a whole new raft of issues. You can get these, the rest and the Phuket Consensus from:

http://www.enaca.org/modules/aqua2010/

We hope to make audio recordings a regular feature of all NACA’s technical workshops from now on, to allow global access to the content that is generated. We also have some open source podcasting software in development that will make it easy to track our audio publications. The details will be announced on the NACA website in due course.

Simon Wilkinson

AQUACULTURE ASIA

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Peter Edwards writes on

Rural Aquaculture

Rapidly changing aquaculture scene in the Red River Delta, Vietnam

Major changes are taking place in two traditional integrated aquaculture systems, the VAC and wastewater-fed aquaculture in the Red River Delta, Vietnam, especially in peri-urban Hanoi and adjacent provinces. Traditional aquaculture is integrated with other human activity systems as these provided the only available sources of nutritional inputs for farmed aquatic organisms in the past. However, farmers are intensifying to earn more money through introduction of new or improved higher value species, sometimes raised in monoculture, and increasing integration with feedlot livestock and/or using pelleted feed.

VAC is an acronym for the Vietnamese words vuon (garden), ao (pond) and chuong (livestock quarters) on crop-dominated farms. Traditional integrated small-scale aquaculture (SSA) in the Red River Delta has provided food and some income for generations as most farming households have small ponds located near the house dug for soil for use as fill to raise the level of the land for the homestead and surrounding garden. Ponds are traditionally multipurpose: domestic water; watering vegetables; cultivation of floating aquatic plants for feeding pigs; and harvesting wild fish. Farmers traditionally raise a polyculture of common carp (*Cyprinus carpio*), Chinese carps (grass carp, *Ctenopharyngodon idella* and silver carp, *Hypophthalmichthys molitrix*) and Indian major carps (mrigal, Cirrhinus mrigala and rohu, Labeo rohita) integrated with livestock (pigs and poultry) and crops (fruit and

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Improved VAC in Hai Duong Province. Low yielding rice fields have been converted to fish ponds

Filling in fish ponds in Hai Duong Province.

vegetables). The three main traditional pond nutritional inputs are rice bran, grass and pig manure with pond mud periodically removed to fertilise dike crops.

Research Institute for Aquaculture No. 1 (RIA No. 1) refers to the intensification of VAC as 'improved VAC'. The relatively recent introduction of agro-industrially manufactured pelleted feed which is the main factor in the rapid increase in aquaculture production I define as 'modern' aquaculture. This intensification requires considerably more investment than use of on-farm or local resources such as wastewater but the farm profits are much higher through increased production which is the major driving factor. Intensification is especially taking place in areas near cities with a ready market.

Some fish farms are now rather large and may cover several hectares with all the rice fields being converted into ponds and pond dikes upon which vegetables and fruit trees are planted and /or livestock are housed. Vietnam has a policy of agricultural diversification because rice farming does not provide an adequate household income. Since 1991 the government policy has allowed conversion of poor quality land on which agriculture was not profitable to be converted into fish ponds. Increase in farm size is now possible due to the emergence of a land market with rural households leasing land in or out. Land rental markets allow more productive farming households to gain access to land and increase output; and allow other households to pursue non-farm income opportunities in a rapidly expanding economy.

Two recent visits to Vietnam in April and October 2010 provided an opportunity to witness the rapidly changing face of aquaculture in peri-urban Hanoi and an adjacent province, Hai Duong: the field trip to Hai Duong province followed the FAO Expert Workshop on Enhancing the Contribution of Small-Scale Aquaculture (SSA) to Food Security, Poverty Alleviation and Socio-Economic Development, 21-24 April 2010 in Hanoi for which I was commissioned to prepare background papers on definitions, characterisation and numbers of small-scale aquaculture; and their contribution to economic growth, poverty alleviation and rural development; and reviewing the RIA No.1 component of the EU-funded Asia-Link aquaculture education project in October 2010. I observed improved VAC in Hai Duong Province in April and both improved VAC and declining wastewater-fed aquaculture in Thanh Tri District of Hanoi in April and October.

Improved VAC in Hai Duong Province

Two farms were visited in a previously low-lying area of the province that used to farm mainly rice but have now been converted into fish farms. The farmers used to have such low yields of rice that they could not even pay the local commune tax because the rice fields flooded every year. About 20 years ago the government allowed the farmers to convert their rice farms to fish ponds and this led to major improvements in household welfare as income from fish was reported to be 6-7 times higher than that from rice. An interviewed farmer said that conversion to fish ponds was illegal at first but the commune 'turned a blind eye' to help them improve their livelihoods through farming fish.

Following the conversion of their rice fields to ponds and dikes, the farmers initially used the traditional VAC system, feeding a carp polyculture with grass and rice bran but because of limited on-farm resources the yields were only about 1.5 tonnes/ha. More recently with assistance from RIA No.1, the farmers now practice improved VAC with diversification of fish species and use of pelleted feed to supplement the traditional pond inputs. Pelleted feed is mainly used to fatten fish towards the end of grow-out culture to increase profitability. Nile tilapia (*Oreochromis niloticus*) comprises about 70% of total fish production with climbing perch (*Anabas testudineus*), common carp and a local catfish, Far Eastern catfish (*Parasilurus asotus*) comprising the other 30%. There is a ready market for fish are in Hanoi and surrounding provinces.

The field trip participants had an excellent lunch on a relatively large three ha farm with steamed Nile tilapia and grilled giant freshwater prawn (*Macrobrachium rosenbergii*) washed down with ample bottles of local beer. The former rice farmer informed us that his total net income from this and another farm of a similar size is US$26,000/year, mainly from producing monosex tilapia fingerlings to supply local farmers and those in other provinces. Initially he nurses fingerlings in green water produced by fertilisation with pig manure, supplemented by duckweed and chopped water spinach. He also produces two crops of tilapia table fish. Nursed tilapia fingerlings of 30g size are stocked at 3/m^2 with a few giant prawn post-larvae. Grow-out ponds are fed mainly pellets with a protein content of 25%. Tilapia grow to 500-700g in about 6 months with an FCR of about 1.5 and a yield of 10-15 tonnes/ha. Pelleted feed costs $0.6/kg and the farm gate price of tilapia is $1.3-1.6/kg depending on size, leading to a good profit. This is a good example of a former relatively poor rice farmer considerably improving his welfare through aquaculture. Furthermore, farm profitability was considerably increased through producing fingerlings to also sell to other farmers rather than only being involved in grow-out.

Improved VAC in Thanh Tri District, Hanoi. Wide pond dikes are used to grow fruit and vegetables on farms converted from previously low yielding rice fields.

We also visited a cooperative in the same area comprising 52 smaller farm households supported by RIA No.1 with Spanish Government assistance. The total area of the cooperative is 37 ha with each family having a total area of 0.6 ha of ponds, with an average pond size of 0.1 ha. A range of species are farmed: carps (common carp, grass carp and rohu), normal and red tilapia, sea bass (*Lates calcarifer*) , striped catfish (*Pangasianodon hypophthalmus*), Far Eastern catfish, red-bellied pacu (*Piaractus brachypomum*) and giant freshwater prawn (*Macrobrachium rosenbergii*). Chinese carps fetch the lowest price, especially if small: 1 kg grass carp sell for only \$0.3/kg although \$1.4/kg if 2-3kg but \$1.6-1.7 if larger than 3kg; and silver carp only \$0.5/kg for a 3 kg fish. Tilapia sell for a good price at \$1.3/kg for 0.5-0.7 kg fish and \$1.4-1.5/kg for 0.7-0.8 kg fish. Climbing perch fetch a relatively high price of \$1.4/kg for only 100g size fish. Although fish culture has considerably improved their welfare, the interviewed spokesman for the cooperative said that a big problem for the last two years was increasing incidence of fish disease, probably exacerbated by a poor water supply, and low marker price for the fish. The cooperative spokesman said they need investment for a water supply canal.

Improved VAC in Thanh Tri District, Hanoi. Broiler ducks are commonly integrated with fish.

Improved VAC in Thanh Tri District, Hanoi

There is an area of 115 ha of formerly low-lying poorly productive rice fields in Dong My Commune, Thanh Tri District that the government allowed the farmers to convert into more productive improved VAC from the year 2000. Previously only one crop of rice could be successfully grown as a second crop was usually flooded. Now the landscape is one of ponds, with wide dikes created by pond excavation above the usual flood line covered with vegetables and fruit trees and livestock quarters (duck pens on or over the water and pig sties on the dikes).

I interviewed two farmers in depth, who had larger than average farms of 1.7 and 2.2 ha as they had rented and/or purchased additional land to increase the size of their original holding. Both farmers rotate more profitable prawns with a polyculture of fish; neither have livestock as they have more than enough nutrients in the water from use of pelleted feed. The first farmer stocks prawn post-larvae, PL15, 0.7 cm in size, imported from China at 25-20/m^2 in May and raises them until December after which it is too cold for them to survive in the temperate climate. They are fed farm-made pelleted feed and the ponds are aerated from 10pm-6am and additionally from 3-4pm in the winter to prevent temperature stratification. Prawns are harvested at intervals at 10-40 pieces/kg with a total yield of 2-3 tonnes/ha. Common carp and grass carp of 1 cm are nursed at 100/m^2 in a separate pond at the same time that prawns are grown. Nursed fish fingerlings of 200-300 g are stocked at a low density of 0.7/m^2 in winter in all ponds after prawn harvest and are raised from January to April to about 1 kg size. Fish are also fed some grass from pond dikes, and yield about 4 tonnes/ha. Prawns fetch US\$6.4/kg compared to \$1.8-2.3/kg for carps. The farms has very poor water quality with dark green water from a bloom of blue green algae, possibly exacerbated by using home made feed with poor water stability.

Improved VAC in Thanh Tri District Hanoi Pond mud used to fertilise grape fruit trees.

The second farmer interviewed is head of the local fish farmers group, the Binh Minh Farm Club with 26 members, who organised visits to China and Thailand through a local tour group to visit prawn and fish farms. As well as prawns and carps, he also raises tilapia and red bellied pacu although some of the members do not raise prawn, only fish. Most of the club members raise tilapia as well as carps, with tilapia comprising about 70% of the total production although none have only tilapia. Tilapia seed comes from local hatcheries as well as from China and Thailand. He uses commercial formulated feed as do all except two of the club members. The water supply is inadequate as it is provided only through a former rice field irrigation canal. He commented on declining water quantity and quality due to increasing urbanisation and

Improved VAC in Thanh Tri District Hanoi. Farmer using commercial pelleted feed. Duckweed is also cultivated on the pond as duck and fish feed.

industrialisation of the area. The future outlook he though would be stable with an adequate but not high income although tilapia began to get disease about two years ago.

A drive through the area indicated that most of the farms are growing vegetables and fruit trees on the dikes. No rice fields remained on any of the farms. Water spinach is cultivated in drainage ditches as well as some low lying pond areas to feed fish and ducks as well as humans. Some farmers cultivate duckweed on portions of the ponds separated from the main pond area by floating bamboo poles to prevent de-oxygenation of the water which occurs under a complete cover of duckweed. The duckweed is harvested periodically to feed both fish and ducks. Some farmers grow high-value ornamental plants on pond dikes for sale. A farmer reported that he could sell an ornamental fig tree for US$150. Livestock are commonly raised, especially meat ducks on small fence areas of the pond.

Left: Chopping up water spinach raised in drainage ditches to feed ducks and fish.

A few farms raise pigs but most pig sties are empty as the profitability is low. Some farms specialise in sports fishing and other forms of recreation, including a restaurant where my colleagues and I had steamed and grilled tilapia and water spinach fried with garlic for lunch.

Traditional cage culture in Hung Yen Province

The field trip for the Small-scale Aquaculture meeting also took us to see traditional cage culture in the Red River in Hung Yen Province where farming households do not have VAC. The farmer interviewed also has a small farm of 0.15 ha without a fish pond and raises maize, medicinal herbs and fruit but not rice on such a small land holding. He and his wife also raise a few chickens, at the time of the interview 27 birds, and previously they also raised pigs but now they said that they did not have time to do so. Their main income is from raising fish in their cage moored alongside the Red River.

Improved VAC in Thanh Tri District, Hanoi. High-value ornamental fig tree cultivated on a pond dike.

Intensified production on improved VAC in Thanh Tri District Hanoi has lead highly eutrophic water through use of large quantities of pelleted feed.

Some farmers in Thanh Tri District, Hanoi have developed sports fishing and a restaurant on their farms.

Steamed Nile tilapia and stir fried water spinach on an improved VAC pondside restaurant in Thanh Tri District.

Grilled freshwater prawns raised on an improved VAC farm restaurant in Thanh Tri District, Hanoi.

Major highways are being constructed through the wastewater-fed aquaculture area in Thanh Tri District, Hanoi.

Major new urban development in the centre of the wastewater-fed aquaculture area in Thanh Tri District, Hanoi.

Existing settlements also continue to expand at the expense of wastewater-fed aquaculture in Thanh Tri District, Hanoi.

Raising grass carp in wooden cages started here about 20 years ago and the number of household level cages has increased in recent years with 35 cages now in this commune alone. The farmer interviewed stocks 600 grass carp fingerlings of 300g size in a single wooden cage of 3.5 x 7.0 x 1.5 m deep dimensions, or about 20 fish/m^3, and they reach 4-5 kg in two years. The cage lasts for three years and costs $260-320. The fish are fed grass at 20-30% body weight/day collected by the family from various sources such as their farm and locally. In the dry season when grass is limited they travel 10-15 km to collect discarded vegetable leaves removed prior to marketing. The production ranges from 1.5-1.8 tonnes/cage with fish sold at $.6-1.7/kg to middlemen who come to the cage site to purchase fish. Red spot disease is a problem in the rainy season.

Traditional wooden cages stocked with grass carp on the Red River in Hung Yen Province.

Wastewater-fed aquaculture

Wastewater-fed aquaculture occurs in peri-urban Hanoi, in a low-lying area that receives the bulk of the city's wastewater and urban run-off. However, the practice is declining due to urban expansion of the rapidly growing capital city of Vietnam, Hanoi. I reported on this trend in an earlier column (Decline of wastewater-fed aquaculture in Hanoi. Aquaculture Asia 9(4):13-14, 2004) but the process is now accelerating. Major roads are being constructed through the centre of the wastewater-fed pond complex with associated construction of housing and industrial complexes. Furthermore, existing villages in the area are expanding through filling in ponds.

Wastewater-fed aquaculture appears to be a transient phenomenon as I've written elsewhere several times. Reuse of wastewater used to made sense in countries with limited sources to feed fish but once an economy starts to expand rapidly, several factors constrain wastewater-fed aquaculture: increasing shortage and value of peri-urban land; declining quality of wastewater as a nutrient source due to increasing contamination

with industrial effluents and associated declining quality of produce; increasing demands of more affluent consumers for larger fish and often for species that cannot be raised profitably in fertilised ponds; and the increasing ability of farmers to meet the demand for alternative farmed species because of the availability of seed and pelleted feed through R & D and agro-industry.

Current situtation and challenges for the farming of snakehead fish (*Channa micropeltes* and *Channa striatus*) in the Mekong Delta, Vietnam

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Fish culture in ponds and cages is very common in freshwater areas of the Mekong Delta of Vietnam, where aquaculture plays a very important role in national fisheries production. The farming of giant snakehead began in the 1960s while the culture of common snakehead occurred since the mid 1990s. There are two groups of snakehead, that is, *Parachanna* and *Channa*. The *Channa* group is recorded to have 27 species and distributed in most of the Asian countries while *Parachanna* are mainly distributed in Africa, with three species, only. There are four species of Channidae in the Mekong Delta: *Channa gachua* (Ca Chanh duc), *Channa lucius* (Ca Day), *Channa striata* (Ca loc den), *Channa micropeltes* (Ca loc bong) (Khoa & Huong, 1993). However, two species - Ca loc den or Common snakehead (*C. striata*), and Ca loc bong (*C. micropeltes*) - are the main species of snakehead farmed in the delta.

In Asian countries snakehead is cultured in semi-intensive or intensive systems in earthen ponds, cages, garden ditches and rice fields (Ling, 1997; Xuan et al., 1994). Long et al. (2004) estimated the production of cultured snakehead in the MKD in 2002 to be about 5,300 tonnes, mainly from An Giang, Dong Thap, Can Tho and Kien Giang provinces. Our estimated production of snakehead from the provinces in 2009 was about 30,000 tones, of which 7,500 tones was giant snakehead. All of the snakehead fish farmers surveyed in this study practiced aquaculture spontaneously at a small scale without any planning or sector management. However, the information on snakeheads is not much available (Huan, 2007) while there are many issues which need to be solved, in particular, dependence on the supply of small fish which are used for snakehead feed is an important source of animal protein for a significant proportion of population in the delta. It should be noted that there are three typical geographical conditions in freshwater areas of the delta by annual flood

level, that is, deep flooded areas (more than 2 m depth in the peak of floods), medium flooded area (1-2 m depth), and shallow flooded area (less than 2 m depth). The wild fish stocks and fishing activities may differ in these areas.

Objectives

This study was aimed to describe the status of snakehead farming in the MKD. The study helps to provide a set of suggestions for appropriate development of the snakehead farming sector in the MKD in relation to the protection and development of natural aquatic resources, as well as food safety.

Approach

This study was carried out from January 2009 to March 2010 by interviewing a total of 71 giant snakehead and 544 common snakehead farmers respectively from eight provinces of the Mekong Delta (Long An, Tien Giang, Dong Thap, Vinh Long, Can Tho, Hau Giang, An Giang and Kien Giang), through interviews and questionnaires. Some poor samples were discarded during the entry and checking of data. Descriptive and multiple choice analyses were applied for the analysis of farmers' perceptions after processing of collected data. Linear multiple regression analysis was used for the analysis of relationships between a set of independent variables (Xn) and Y, dependent variable (Y, yield of fish in kg/m^3/crop). Simple regression analysis was applied to independent variables which had significant relation to Y in the multiple regression model. Xn were independent variables which tentatively assumed to influence the yield of fish, and ε was the error term, the multiple regression can be written as follows:

$$Y = A + B_1.X_1 + B_2.X_2 + \ldots + B_n.X_n + \varepsilon$$

Findings

Description of snakehead farmers

Snakeheads are easy to culture using simple farming methods. The age of sampled farmers varied from 17 to 82 with an average of 44 (±11). However, experience in farming snakehead was fairly short, mostly about 5-7 years. Some farmers had experience of about 30 years because they have cultured giant snakehead in cages for a long time, especially in Chau Doc town (An Giang province) and Hong Ngu district (Dong Thap province).

The educational level of fish farmers were very low, 46.4% of them had elementary/primary level education, and 10.1% were illiterate. About 0.6% of farmers with large farms had vocational college level education. Therefore, their perception and knowledge on snakehead farming was limited mainly based on their own experience and the use of wild small wild fish as feed.

Snakehead farming practices were mainly and spontaneously carried out by small-scale farmers using family labour, up to a of maximum eight family members. Males were dominant in fish farming activities (78.4% of interviewees), but the participation of women in the farming these species was good in comparison to other cultured fish species (21.6% of farmers). About 9.8% of farmers used hired-labors, mainly in the case of large-scale farms, and about 5.5% of farmers hired temporary labors, particularly for pond preparation and harvesting.

Farm design

About 43.5-66.7% of farms had only one pond, cage or tank. This figure varied by farming type. Earthen ponds tended to have a large average culture area (621.4 m^2/pond) meaning that the number of ponds per farm was low. Because of limited area available for culture along rivers, fish cages were quite small (38.4 m^3/hapa) and the average total cultured area per cage farm was 64.0 m^3. Farmers with nylon or cement tanks (floating ponds) often were small farms because of the high costs of construction, and therefore, 64.5% of tank-based farms owned only one tank, with an average volume of just 21.0 m^3. For farms where fish were stocked in hapas, numbers of hapas were higher if located in ponds rather than in rivers (Table 1). Note that the first four system are for common snakehead while the fifth one is for giant snakehead, only.

Table 1: Design of snakehead culture area.

Description	Unit	Earth pond (n1=132)	Hapa in pond (n2=260)	Hapa in river (n3=115)	Tank (n5=62)	Cage (n4=66)
Number of ponds, cages, hapas/ farm						
1	%	66.7	43.5	48.7	64.5	53.0
2	%	19.7	33.5	36.5	21.0	27.3
≥ 3	%	13.7	23.1	14.7	14.6	19.7
Culture area/farm						
Mean	m^2	1,406.3	55.0	29.3	34.3	67.6
± (Standard deviation)	m^2	4,864.8	77.2	25.5	30.6	100.5
Culture volume						
Mean	m^3	2,925.9	126.0	64.0	31.8	260.6
±	m^3	6,800.3	215.8	66.2	32.3	466.7
Water volume	n					
Mean	m	2.1	1.8	1.5	0.8	2.8
±	m	0.7	0.6	0.3	0.2	1

Seasonality of fish culture

Ca loc den or common snakeheads have a reasonable growth rate and can be harvested in about 4-5 months after stocking enabling two crops/year (51.2-53.1% of the farms), and 5.5% of them practiced three crops/year. Giant snakeheads require a longer time (about 8 months), and therefore, 85.9% of giant snakehead farmers obtain only one crop/ year. The seasonality in snakehead culture is not clear, but the farmers often begin to stock from March to May in Lunar months (or May to July in Western calendar months) in order to utilise the small fish available during the flooding season. Fish are usually harvested from July to November (Lunar months) or from September to the next January (Western calendar).

Seedlings and sources of seeds

Giant snakehead were mainly cultured in cages in rivers (87.9% of the farms practicing cage culture), common snakehead fish or Ca loc den consisted of several species such as rectangular head and sharp head. The rectangular head fish were mostly stocked in river hapas (53.9%). Clean water and flows are suitable for these two types of snakehead farming. The sharp head fish were stocked in all of the systems, but they were dominant in nylon tanks (88.7% of farmers with tanks stocked sharp head fish), pond hapas (77.3%) and earthen ponds (64.4%). Three quarters of farmers had to buy fingerlings for stocking (the lowest rate was 57.6% in the case of earth pond farms). The remainder of fingerlings came from farmers who had facilities for nursing fry which they purchased from others (20.3% overall, but the highest rate was observed with earthen pond farms at 33.3%), or were produced by farmers who had induced snakehead to spawn by creating appropriate environmental conditions and had retained the seed for themselves spawn (4.3% of all farmers in the same produced seed in this way not clear, equaling 9.1% of the pond farmers due to the suitability of ponds for this activity). Several farmers also obtained seed from wild stocks but use of artificially propagated fingerlings were completely dominant.

The average stocking density of snakehead in ponds was 21.5 fingerlings/m^2 (± 45.2). The highest density (236.5 fingerlings/m3) was in nylon tanks, followed by cages (147.6 fingerlings/m^3) and hapas placed in ponds (109.0 fingerlings/ m^3). Water level in the nylon/cement tanks was lower in comparison to that of other models, but water exchange rate in this model was more than that of the others. Snakehead farming in cages and hapas placed in the rivers with water current were stocked higher densities than hapas placed in the ponds.

Feed and feeding

The amount of feed used for snakehead farming in cages and nylon tanks were 374.9 and 305.9 kg/m^3/crop, respectively due to higher stocking densities employed than the other systems. However, food conversion ratio in pond culture was lowest (FCR=4.17) perhaps due to the availability of natural food in ponds. The FCR of snakehead cultured in cages was highest (4.58). There were many types of feeds for snakehead farming including freshwater and marine small size fish/ low valued fish, heads and bones of ca tra (*Pangasianodon hypophthalmus*) from processing companies, field crabs, golden snail meat, and pellets or home-made feeds (Table 3).

Small freshwater fish were used by almost all of the farmers and comprised 31.3 – 59.2% of total feeds used for snakehead farming. Small marine fish was used by 34.0 – 63.9% households. The farmers farming snakeheads in ponds and cages used a larger amount of small marine fish (more than 60% of total amount of feed). Most households caught small freshwater fish to feed the stock which shared 9.5-34.8% of total used small freshwater fish. Therefore, in order to harvest 30,000 tonnes of cultured snakehead fish, about 50,000 tonnes of small freshwater fish and 75,000 tonnes of small marine fish respectively are required per year. These cover 30% and 12% of total annual catch of wild freshwater fish and marine fish catch in the Mekong Delta, respectively.

If the amount of self-captured small freshwater fish was not sufficient for feeding the cultured fish, then the farmers often bought them from local fishers (18.2 – 50.1%/total amount of feed) or fish traders (16.2 – 55.6%). The cost of small fish ranged from VND 4,600 to VND 5,400/kg (USD 1 = VND 17,000 in 2009). Some households fed their stocked fish with golden snail meat. Farmers' experience showed that 4 – 4.5 kg of golden snail meat could give 1 kg of snakehead (1.0 kg golden snail meat required about 3.5-4 kg of on-shell golden snails which had the price of VND 500/kg). This may be a suitable solution for both economic and environment aspects to replace small size fish. Note that, a big amount of heads and bones of Pangasius catfish (ca tra) are released as by-products by processing companies, but mostly bought and used for Pangasius catfish or hybrid catfish in terms of home-made feed.

Water and fish health management

The mean water depth of the farming systems was 1.8 ± 0.8 m. The deepest and lowest water depths were in cages (2.8 m) and nylon tanks (0.8 m), respectively. Farmers exchanged water every fifth day at the rate of 50% of water volume. In nylon tanks, water was exchanged daily and the rate was up to 90%. 53.5% households exchanged water by pumping, and of these, most practiced snakehead culture in nylon

Table 2: Information on fish seed for snakehead farming.

Description	Pond culture (n1=132)	Hapa in pond (n2=260)	Hapa in river (n3=115)	Nylon tank (n5=62)	Cage (n4=66)	Total (N=635)
Species (% of the farms)						
+ Sharp head	64.4	77.3	46.1	88.7	12.1	63.3
+ Rectangular head	25.8	22.7	53.9	11.3		25.5
+ Giant snakehead	9.8				87.9	11.2
Sources of seed (%)						
- Self produced/captured	9.1	3.8	1.7	0.0	4.5	4.3
- Nursed	33.3	20.4	15.7	8.1	13.6	20.3
- Bought	57.6	75.8	82.6	91.9	81.8	75.4
Stocking density (fish/m^3)						
Mean**	21.5^a	109.0^b	133.5^{bc}	236.5^d	147.6^c	111.7
± (Standard deviation, SD)	45.2	141.2	118.8	176.6	104.6	136.7

*** Values in the same row are significantly different at α = 5%.*

Table 3: Amount of feed and feed sources of snakehead faming in different culture systems.

Item	Pond culture (n1=132)	Hapa in pond (n2=260)	Hapa in river (n3=115)	Nylon tank (n5=62)	Cage (n4=66)	Total (N=635)
Total amount of feed / farm / crop						
Mean (t)	43.2	9.1	6.3	7.1	73.4	22.2
±SD	117.5	14.5	7.8	8.5	94.4	66.1
Amount of feed/m^3/crop						
Mean(kg)**	24.2^a	120.0^b	129.7^b	305.9^c	374.9^d	146.5
±SD	30.4	146.5	125.1	373.4	228.4	204.7
Feed composition (%)	100.00	100.00	100.00	100.00	100.00	100.00
+ Marine fish	60.57	42.80	34.02	40.38	63.91	56.73
+ Freshwater fish	31.34	50.14	59.19	45.45	36.02	37.99
+ Head/bones of Tra fish	7.35	5.60	1.55	10.46	0.02	4.33
+ Golden snail meat	0.45	1.35	5.07	3.70	0.04	0.80
+ Pellet	0.21	0.03	0.00	0.00	0.00	0.09
+ Others (crab etc)	0.08	0.07	0.17	0.00	0.00	0.05
FCR (kg of feed/kg of fish)						
Mean*	4.17^a	4.33^{ab}	4.33^{ab}	4.26^{ab}	4.58^b	4.31
±	1.24	1,46	1.48	1.52	1.25	1.41

*For the value at the same row: * significant at α = 10%; ** significant at α = 5%.*

tanks. 32.9% households (mainly pond farmers) exchanged water by tides, and 6.2% households with hapas in ponds did not exchange the water.

Most snakehead farms are located near big rivers or canals (83.3% households), so inlet water was generally available. Some farms located far from rivers, obtain water from small irrigation canals (14.6%) or paddy fields and garden canals (0.9% households). 1.2% of households used groundwater. Inlet and outlet water were not treated by 59.8% and 94.3% households, respectively. In ponds, hapa placed in ponds, and nylon tank systems, 4.6% of farms used chemicals for water treatment and 1.1% of farms used settlement ponds to treat effluents before discharge them into public water bodies. However 38.0% of farmers used lime or salt, and 2.2% had settlement ponds to treat inlet water. This was a way to limit fish pathogens spreading out during cultured cycles.

The results showed that parasite infections of snakeheads were reported by 85.9% of farmers. Snakeheads also got hemorrhage disease (55.9%), mucus loss/columnaris (11.8%), while gill disease affected 8.5% and liver and kidney diseases 7.8%. According to fish farmers, it was very difficult to treat liver and kidney diseases as well as hemorrhage disease. Presently, there are no special medicines to treat liver and kidney diseases. Farmers just mixed antibiotic with feed for treatment, but did not know the efficacy of their cure.

Harvest, production and fish yield

Survival rates of snakeheads in different farming systems were similar and ranged from 46.1-56.0%. Highest and lowest survival rates were in cage culture (56.0%) and nylon tank systems (46.1%). Production of snakeheads cultured in ponds and cages was higher than that of other systems due to large area or volume. However, yields from cages and nylon tanks were higher than those of other systems because of the high stocking densities used. The largest size of harvested fish was for giant snakehead (*Channa micropeltes*) about 1.1 kg/fish while the popular for common snakeheads (*Channa striatus*) was 0.6 – 0.7 kg/fish (Table 6).

Figure 1: Fish diseases occurring in snakehead farming.

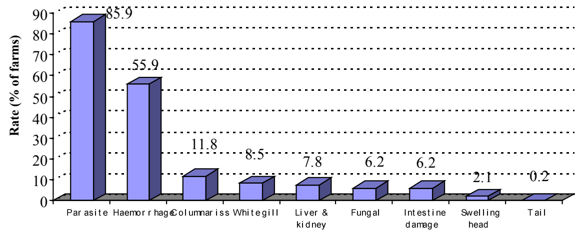
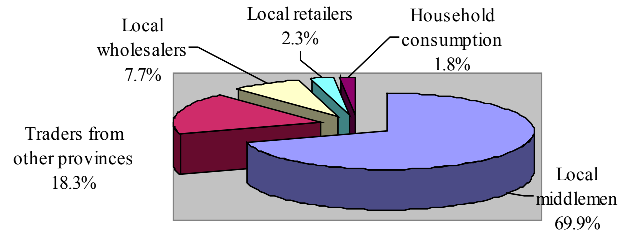


Figure 2: Distribution of harvested snakeheads.



Post-harvest distribution of snakehead

Harvested snakehead were sold by farmers to many buyers including local middlemen (69.8%), traders from other provinces (17.7%), and local wholesalers (7.7%). Some small farms (2.3%) sold their fish themselves at local markets, and 1.8% households consume their fish as fresh or in fermented forms. In addition, some households in Hong Ngu district of Dong Thap province and Tan Chau district of An Giang province, sold snakeheads to Cambodia via the traders from other provinces (0.6%).

Economics of snakehead farming systems

Table 7 shows that total operating cost for snakehead farming in cages was highest of all the systems (2.3 million VND/m^3/crop), while the costs of production in nylon tanks and ponds were lower (VND 1.9 and 0.7 million/m^3/crop, respectively).

Table 4: Small freshwater fish used for snakehead in different farming systems.

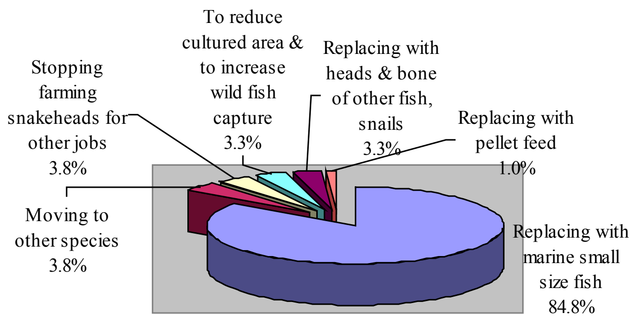
Items	Ponds (n1=84)	Hapas in pond (n2=232)	Hapas in river (n3=110)	Nylon tank (n5=51)	Cage (n4=53)
Amount of small freshwater fish/ farm/crop					
Mean (t)	21.3	5.1	3.9	3.9	32.9
±	81.2	6.8	6.7	5.5	67.0
Composition of feed amount by sources (%)	100.0	100.0	100.0	100.0	100.0
+ Traders	55.6	34.9	16.2	50.8	36.3
+ Local fishermen	18.2	30.3	50.1	39.7	40.3
+ Self exploitation	26.2	34.8	33.7	9.5	23.4

Table 5: Water management in different snakehead farming systems.

Item	Unit	Ponds	Pond hapa	Nylon tank	Total
Exchange water frequency					
Number of farms	n	123	194	62	395
Mean	Times/day	4.6	5.6	1.1	4.6
±		6.7	6.5	0.6	6.2
Water exchange rate					
Number of household	n	111	180	62	362
Mean	% / time	43.7	46.6	90.0	53.2
±	% / time	17.9	17.5	19.3	24.6

Some households caught Small size fish to feed their snakehead, so the amount of captured small size fish is also factored into total feed costs. Based on this accounting, gross return (VND 2.4 million), and profit (VND 0.2 million) per cubic meter were highest for cages. Variable costs took high percentage to total operation cost and ranged from 97.0 – 98.3%. Gross profits from other systems were low. On average farmers returned a negative profit (-30,600 VND/m^3/crop) on hapas placed in ponds. The percentage of farmers who lost money was high, and fluctuated from 40.9 – 61.7% of households interviewed. However, if the cost for self-exploitation of small size fish is not accounted, the profits from all snakehead farming systems are higher, and depend on the amount of small feed fish captured. The number of households having negative profits is reduced if the cost of self-harvesting of small size fish is excluded, and ranges from 15.2 – 40.0%. Benefit cost ratio (BCR = total returns/ total operating costs) was also higher. BCR per production cycle was highest (92%) in cage culture and lowest in nylon tank culture (14%). In general, if farmers had to supply all the inputs for snakehead farming, profit was low and percentage of financial losses incurred was high. However, many households cultured snakeheads on a small scale, using natural small freshwater fish during the flood season, and available free labour. This strategy allowed them to obtain high profits. Issues of economic efficiency and the risk of exhausting natural aquatic resources which have a negative effect on the availability of cheap food for local people need to be solved when conducting the research on replacing freshwater small size fish with other feed sources.

Figure 3: Solutions suggested by the farmers for the lack of freshwater small size fish to culture snakehead fish (% of farms).



The results of multiple regression analysis showed that there were 5 independent variables affecting to fish yield (Y) at the same time at $p<0.05$, as follows:

Table 6: Survival rates, harvested sizes, production and yields of cultured snakeheads.

Item	Ponds (n1=132)	Hapas in pond (n2=260)	Hapas in river (n3=115)	Nylon tank (n5=62)	Cage (n4=66)
Survival rate, 1st crop (%)					
Mean	47.8	47.6	46.5	46.1	56.0
±	14.9	16.4	18.9	23.6	14.7
Production/farm/crop (t)					
Mean	10.6	2.1	1.6	1.6	17.1
±	32.2	3.0	1.9	1.7	24.6
Yield/m^3/1st crop** (kg)					
Mean	5.9[a]	28.3[b]	31.6[b]	74.9[c]	83.6[c]
±	7.6	36.1	31.2	96.1	47.5
Harvest weight (kg/fish)					
Mean	0.7	0.6	0.6	0.6	1.1
±	0.3	0.2	0.2	0.2	0.3

*** Significant at α = 5%.*

Table 7: Major financial indicators of different snakehead farming systems.

Item	Unit	Earth pond (n1=132)	Hapa in pond (n2=260)	Hapa in river (n3=115)	Cages (n4=66)	Nylon tank (N=62)
1. Including cost of catch small fish						
1.1 Total cost/m^3/crop*	VND'000	144.0	731.1	736.1	2,252.1	1,856.3
±	VND'000	186.1	1,182.0	617.2	1,365.9	2,129.2
Percentage of total variable cost	%	98.1	97.2	97.0	98.3	98.2
1.2 Gross return/m^3/crop**	VND'000	154.3	700.6	738.5	2,430.3	1,893.7
±	VND'000	210.5	1,115.1	841.3	1,404.7	2,647.1
1.3 Mean, profit/m^3/crop*	VND'000	10.3	-30.6	2.4	178.1	37.4
±	VND'000	79.8	896.8	443.2	886.9	1,020.3
1.4 BCR (profit/total cost)**	%	10.3	1.0	-3.2	17.1	3.4
±	%	42.6	34.4	44.4	53.6	36.0
1.5 Rate of successful farms	%	57.6	45.4	38.3	59.1	56.5
2. Without small fish catch cost						
2.1 Profit/m^3/crop**	VND'000	26.4	121.7	150.3	632.2	154.2
±	VND'000	84.0	856.7	444.7	933.8	1,052.0
2.2 BCR (Profit/total cost)*	%	43.2	87.6	54.3	92.5	14.0
±	%	84.7	174.5	144.9	214.3	49.9
2.3 Rate of successful farms	%	68.9	72.3	60.0	84.8	62.9

* Significant at α = 10%; ** significant at α = 5%.

$$Y = 2.73 + 28.61 X_1 + 13.5 X_2 + 0.24 X_3 + 0.08 X_4 + 9.05 X_5$$

Of which:

- X_1 = Species (1 = Giant snakeheads; 0 = Others).
- X_2 = Geographical condition (1 = Deep flooded area; 0= Others).
- X_3 = Stocking density of fish seed (fingerlings/m^3/crop).
- X_4 = Costs of medicines/chemicals (VND/m^3/crop).
- X_5 = Training on snakehead farming (1 = Yes; 0 = No).

Short explanations of the regression model are:

- Snakehead species: the yields of giant snakeheads (*C. micropeltes*) was higher than that of common ones (*C. striatus*).
- Geographical condition: the fish yields in deeper flooded areas were higher than that of other areas because of better supply of water and small size fish.
- Stocking density: In order to increase fish yield, density of snakeheads could be increased above comparison the mean value reported in this survey. However, although profit was highest at 120-160 fingerlings/m^3, the benefit : cost ratios were highest at stocking densities of 40-80 fingerlings/m^3

The costs of medicines and chemicals to prevent and treat snakehead diseases could be increased against the mean value reported in this survey in order to increase fish yield. But a cost of VND 25,000-40,000/m^3/crop offered the best benefit : cost ratios.

Snakehead culture techniques: farmers who have been trained on culture techniques could gain higher benefits than those who cultured fish based only on their own experience.

Snakehead farmers' perception

There were some advantages for snakehead farming in flood-prone areas of the Mekong Delta. During the flood season there were plenty of small freshwater fish suitable for farmers to exploit or buy as snakehead feed (28.0% households). Farmers used their own ponds, and rivers nearby their houses for small-scale snakehead culture (22.4%). In the flood areas without a surrounding dike, farmers can not cultivate rice, so fish farming can help to make use of the free time during the flood season (12.9%). This helps to diversify the activities or agricultural products in order to increase farmer incomes (17.4%) as well as supply more high value food to the community.

Practicing snakehead farming also had a number disadvantages. The lack of capital for fish culture was the first difficulty (49.7% of respondents). They also needed more credit support from the government (50.5%). After many years of snakehead farming, fish diseases seem to be appearing more and more and are very difficult to treat, leading to high mortality (38.5%). Technical knowledge of farmers on snakehead farming was limited, and found it difficult to prevent and to treat the diseases (17.3%). The farmers needed to be trained on fish farming techniques, prevention and treatment of fish diseases, as well as the treatment/management of water inlet and outlet (34.1%). In addition, snakeheads were mainly for domestic consumption, the price fluctuated seasonally, with the lowest price occurring during peak harvest season (20.8%). Depletion of natural aquatic resources has increased the cost of small size fish for cultured fish, therefore, some snakehead farmers tried to find alternative sources of feed for cultured fish (10.3%). Over-exploitation of aquatic resources for snakehead fish culture were also considered to have negative effects on the supply of high nutrition and cheap food (59.1%) and the quality of public water (29.0%) for local community.

Aquatic resources in the Mekong Delta become more exhausted day by day due to over exploitation (Sinh, 2005), so the production of small freshwater fish used as feed for carnivorous species has become scarce. Many solutions were suggested by respondents, of which the most common one was to replace freshwater small size fish with marine fish (84.8% of households suggested), moving to other culture species (3.8%), stopping culturing snakeheads and moving to other jobs (3.8%), reducing culture areas and culture following the planning and management of capture fisheries in order to meet the feed needs of this species (3.3%). However, these solutions should be considered in relation to the competition of feed for other cultured species such as Pangasius catfish, hybrid catfish, giant freshwater prawns, and swamp eels (Figure 3).

Conclusions and recommendations

C. micropeltes farming has been practiced for a long time in the Mekong Delta. Recently, some species of *C. striatus* have been introduced into a variety of culture systems. The area under snakehead culture was largest in ponds. Stocking density was highest in nylon/cement tanks. In cages and tanks, more feed was used for snakehead than in other systems, but FCR in earthen ponds was lowest. Many farmers captured wild freshwater small size fish for snakehead feed, but wild fish stock has been rapidly depleted. Survival rates of fish in the different systems were similar. Fish yields in cages and tanks were higher than that of other systems. There were five variables significantly affecting the fish yield (at $p < 0.05$), including: (i) species of fish stocked (*C. micropeltes* or *C. striatus*); (ii) water level of cultured areas in the flood season; (iii) stocking density of fingerlings; (iv) cost for medicines/chemicals to prevent and treat fish diseases; and (v) the farmers were trained on culture techniques or not. Total operating costs per cubic metre per crop were highest in cages and lowest in hapas. If farmers had to buy all feed for snakehead farming, the profit was low and the percentage of farmers obtained negative profit was high. It is more reasonable and profitable to culture snakehead fish at small-scale by utilising the free family labours and to capture wild fish in flooding season. Fish farmers recognised that the price of fish increased in the dry season and that the overuse of small size fish for snakehead culture had negative effect on natural aquatic resources.

In order to have a better development of snakehead farming in the delta, wild freshwater small feed fish should be replaced by (i) marine fish and/or (ii) other alternative sources of feed. Research on replacing freshwater small size fish with other feed source is very important. Better planning and management of snakehead culture should be in hand with an appropriate management of exploitation and protection of natural aquatic resources, capital and technical supports, and the marketing of harvested fish.

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Is there a business case for small-holders in Vietnamese Pangasius?

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Vietnamese pangasius has emerged as one of the most successful globally traded aquaculture products. The diversification of international markets has led to the rapid growth of the industry in the Mekong Delta, which has in turn led to concerns over what remains largely unplanned, uncoordinated, and unregulated development.

Concerns have also been raised over whether and how small holders (farmers with a total area of ponds less than 0.1 ha) can maintain their position in the industry. Since 2007 decreasing marginal returns have left small holders vulnerable to a range of regulatory and economic changes. The impact to this group of farmers is clearly evident with a 37% decline in participation from 2006 to 2008 (see Figure

Harvesting the poind of a small holder in An Giang province.

Pangasius farm located next to the Mekong at Can Tho.

1). Although farms with an area greater than 10 ha make up only 11% in An Giang province, they increased by 123% over these three years.

This article outlines the findings of an action-oriented research project between 2007 and 2010 that what business case exists for small-holder pangasius farmers to maintain their position in global export markets.[1] We focus on the challenges faced by small-holders in maintaining or moving out of the industry in Vietnam.

Approach

Using an action oriented research approach the project assisted small-holder pangasius farmers to respond to economic uncertainties around variable input costs and farm gate prices. These responses, generally termed 'upgrading', were then followed in order to understand whether and how producers can increase the functions they perform, as well as negotiate the terms and conditions of incorporation in the global value chains.[2] This include both vertical contracts with feed or processing companies, or horizontal contracts between farmers in forming a cooperative. Alternatively, farmers may choose to downgrade, reducing the functions and contractualisation, or 'outgrade' by exiting the value chain by shifting to alternative production systems.

The project supported three groups of small-holder farmers in Chau Phu district of An Giang province in the Mekong Delta to combine various strategies to upgrade, downgrade and/or outgrade:

- A group of thirty grow-out farmers were supported to upgrade their production process by increasing their collective area and output to a more commercially viable scale; coordinate improved supply and demand through improved contracts between farmers and processing companies; and finally, comply with the SQF1000 food quality and safety standards.
- After downgrading from grow-out production, a group of nine nursing farmers were supported to upgrading to collective production to more commercially viable scale; improve production practices through compliance with SQF1000 certification; and reduce production risks through vertical contractualisation with the state run An Giang Seed Centre.
- A trial of seven 'micro' farmers with a pond area of less than 0.01 ha, and representing the nucleus for a wider network of farmers, were supported to outgrade away from pangasius farming to a number of alternative species including tilapia, eel, snakehead and snakeskin gourami.

Outcomes of upgrading strategies

Grow-out farmers

The results of upgrading strategies for grow-out farmers illustrate key challenges for small holders aquaculture producers in Vietnam. From 2008 to 2010 the farmers experienced a 24% turnaround in their return on investment, from -11% to 13%. As illustrated in Figure 2, this indicates the variability of profits, but it also shows the incentive of what might be termed a 'boom cycle'. However, despite the high profits in the final cycle, farmers made an average cumulative net loss of US$1,821 per ha (Figure 3).

The formation of a cooperative production group also had mixed results. The 'Phu Tan Clean Pangasius Club' was successfully formed in 2008 with 32 members. Over the two year period there was evidence that the group increased the reputation of the farmers in the market place. The group also facilitated shared compliance with SQF 1000 certification, and in doing so led to a collective water management system in Hoa Lac commune – the first of its kind for small holder pangasius producers.[3] However, after each production cycle farmers exited the group until by 2010 only nine remained. Reasons for leaving varied, but the two most cited reasons were the poor economic performance of the industry in 2008 and, consequently, the inability of the group to negotiate improved contract conditions with processing companies.

The failure of improved contractual relations with processing companies severely limited the activities of the cooperative group. None of the three companies involved in the project were willing to provide production contracts, setting for example, floor prices. However, they did agree to improve payment conditions. This was a major benefit for the farmers who had been subjected to long delays in payment which led to added interest payments that reduced profit margins by up to 50%.

While farmers were successful in complying with SQF1000, they lacked market recognition of being certified and benefits of coming under this scheme. Without explicit rewards for compliance, either through market access or price premium, farmers are less likely to expend effort, in upgrading their production. Nevertheless, the project was able to demonstrate improved production efficiencies of between 1 and 2%. Making such returns clear to farmers, through reflection on the production statistics recorded, are an important 'learning dividend'. However, it remains unclear whether this margin is enough to warrant the added effort, no matter how minimal, required for compliance with even relatively simple HACCP based standards such as SQF.

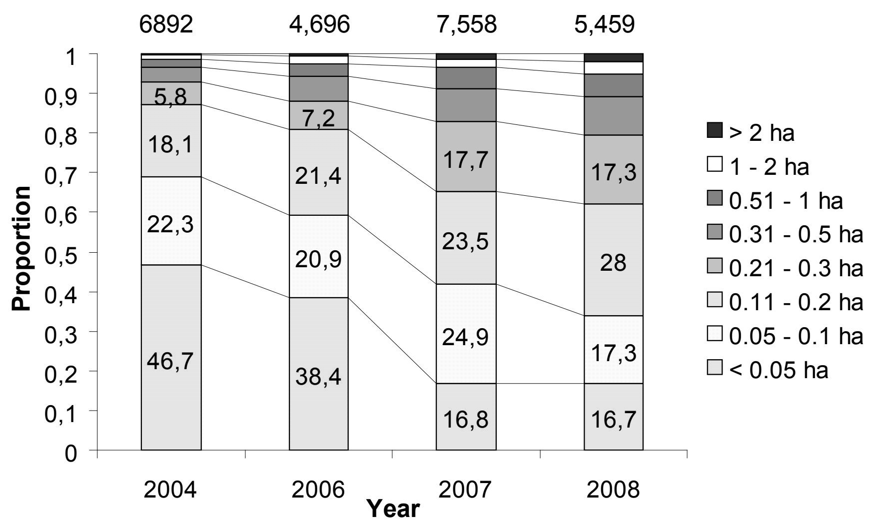
Nursing farmers

The upgrading activities for nursing farmers returned very mixed results. The formation of a cooperative group was fraught with conflicting interests between a group of seven farmers. The problems experienced stress the dilemma many producers face in balancing higher efficiencies through collective action with maintaining their independence to capture upswings in market prices.

To overcome the hesitations of producers, a two tiered model of incorporation – which was labeled a satellite model – provided an alternative that differentiates roles and expectations. Having a more stable

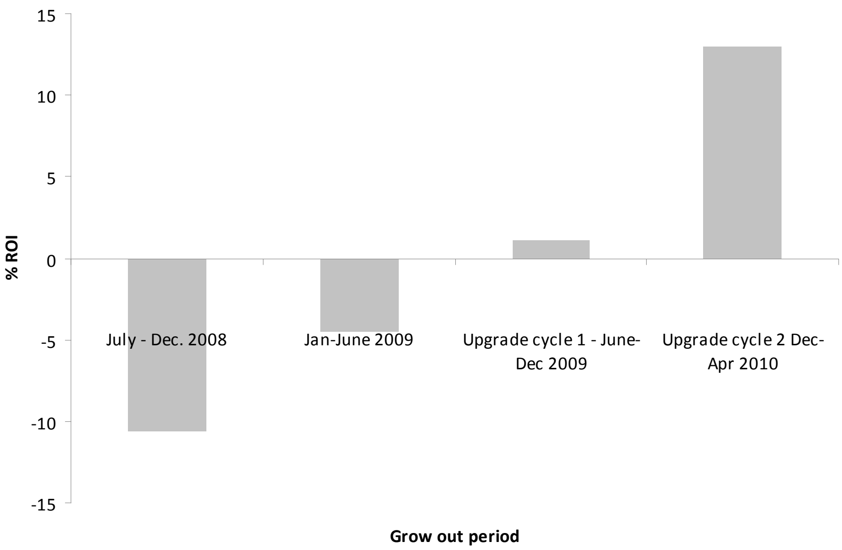
Pangasius nursing farmer in An Giang.

Figure 1. Industry composition of farms by size class in An Giang Province, 2006-2008. Based on data from DARD and DoS (2008).



Pangasius being offloaded from a transport boat in Dong Thap.

Figure 2. Comparison of return on investment from 2008 to 2010.



individual leading the group, with poorer and/or risk averse farmers attached to this individual, led to successful incorporation. It also allowed for significantly lower costs of SQF1000 certification while also enabling farmers to maintain a degree of independence from each other.

The outcome may provide a model to allow smaller producers to maintain their position in the pangasius industry. Nevertheless, the initial small number of farmers enrolled indicates the difficulty of finding suitable and willing farmers for nursing. The exit of the smallest of these farmers also indicates there is a critical size of approximately 0.5 ha for participation in nursing – a threshold already identified by the An Giang Seed Centre. The main constraint to these farmers is the size of land and considerable costs needed to purchase the extra land needed to build sedimentation ponds.

Nursing 40-day fry returns a modest income of only 5.2 million VND (US$327) per crop they earned. However, if the farmers are able to maintain profitability they would earn nearly two times more than those remaining in grow-out farming over the course of the project. This indicates the lower overall risk associated with downgrading to nursing farming. Greater certainty of demand may also be provided by the growing demand for certified fingerlings. As this demand grows, farmers may well see a benefit in a lower, but more steady return in comparison to the boom and bust cycles experienced in grow-out farming.

Exiting ‘micro’ farmers

So called ‘micro’ farmers were the first to leave the pangasius industry. Most subsequently shifted to alternative species such as snakehead, tilapia, walking perch and gourami. All of these species have a lower return per grow-out cycle, but overall provide a more stable, and relatively lower risk production system for small-holders.

The results from the pilot farmers in the project demonstrate a clear trade off. For those exiting the industry the opportunity cost during the 2010 boom cycle is estimated at least 80.4 million VND (US$5,023). However, our results also show that those pangasius grow-out farmers who benefited during this grow-out cycle had a net average loss of 17.2 million VND (US$1,075) over the two years of the project, or 29.1 million VND/ha/year (US$1,821) (Figure 3). In contrast, the outgraded farmers showed a more stable income ranging from 18 million VND (US$1,163) to 100 million VND (US$6,263) per hectare per year.

The results indicate that grow-out farmers exiting production would be better off in the long term by switching to alternative species. However, this depends on whether these farmers would be willing to forgo the potential high returns of a boom cycle. In other words, would they remain ‘outgraded’ if they saw an opportunity to also capitalise on higher demand for pangasius. The latent capacity of these farmers for the industry, and the impact this capacity has on the cyclical nature of production, makes the development of profitable alternative production systems, with alternative market channels increasingly important.

A buyer from a processing company checks the colour of the meat to determine the contract value during a harvest.

Looking for a way forward

Maintaining the position of pangasius in international markets has become a clear challenge for the Vietnamese government and private sector alike. The case of pangasius also represents a wider set of challenges facing small holders in aquaculture across Asia as industries move further into regional and global markets. Will consolidation and integration of industries continue, or is there a ongoing business case for small-holders?

Cooperative production

Despite the challenges observed in this study, the scale of farming alone does not appear to pose a barrier for entry into the industry. Smallholder aquaculture farmers can to organise into cooperative groups, or 'clusters', to gain production efficiencies. Where changes to infrastructure are not prohibitive, cooperative groups also provide opportunities for improved environmental outcomes such as water management. to enable cooperative groups to develop the necessary skills required to develop these management systems support is needed by both the government, in a more traditional capacity building role, as well as by the private sector to ensure a successful business model can be developed.

Contract conditions

For cooperative groups to succeed they require explicit benefits. Such benefits might come through improved contract arrangements that recognise the reduced risk from internal quality control systems. Improved payment schedules for farmers is one area that significantly reduce exposure to prolonged interest payments may be one example of such an improvement. For this to happen government intervention is needed to create and enforce contracts and agreements between groups and processing companies. In addition, buyers in international markets could pressure processors to ensure fairer payment schedules for small-holders; as already attempted in other global value chains such as cocao and coffee. A representative body with the specific aim of representing small holder producers and cooperative groups in contract negotiations would create greater leverage for improved contract arrangements. Again, for such models to be successful both political and private sector support is needed.

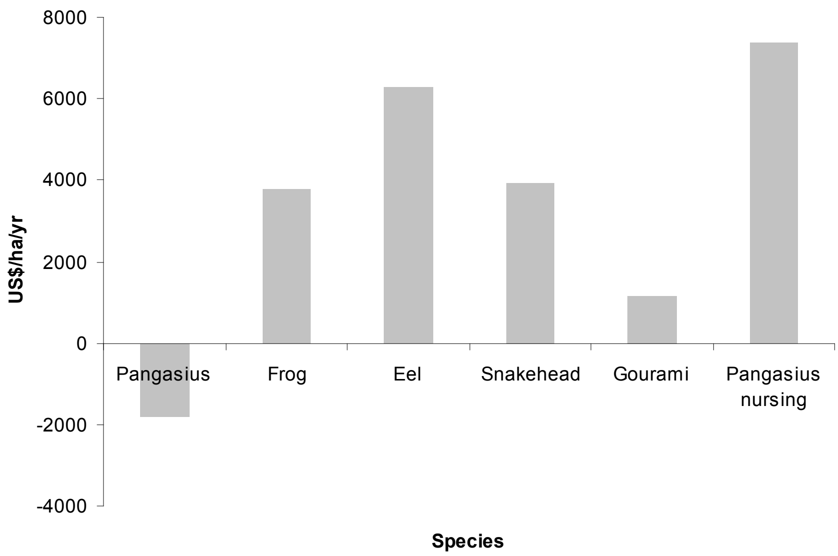
Role of standards

Farmers are increasingly having to respond to food quality and safety standards, in particular those relating to production process, to gain or maintain their position in export markets. Lower entry level standards such as SQF1000 or government led BMPs, provide a strong basis for on farm capacity building in reporting and standard compliance. These standards do provide a capacity building function, but they are not recognised by the market, meaning that processing companies are less willing to provide better contract conditions, including a price premium in the short-term. Future standards such as GlobalG.A.P. or the forthcoming ASC have market recognition and therefore scope for improved benefits. However, it is yet to be seen whether these two schemes, which also carry much higher compliance costs, will support certification of small-holders.

The business case for small holders

For farmers who choose to exit grow-out production, both nursing and shifting to alternative species are viable options. However, the choice of producers to move into either form of production will be largely determined by the trade-off between relatively lower but more stable returns, with the higher risk and higher return opportunities associated with boom cycles in grow out production. As certified production becomes increasingly common demand for certified seed will also increase providing a remaining place within the global pangasius value chain. For alternative production to remain an viable option for small-holders improved market access and value-adding for domestic markets have once again come on to the agenda. If incentives to remain in these more stable market chains are not addressed then small holders will remain as a latent capacity for the industry which will continue to be a factor in the highly cyclical nature of supply and therefore returns to farmers.

Figure 3. Comparison of cumulative profit of Pangasius and alternative species from July 2008 to April 2010.



Processing companies the verify value of a harvest in Dong Thap.

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Small scale prawn culture practices towards sustainable development in Chittagong region, Bangladesh

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Bangladesh is one of the most suitable countries in the world for freshwater prawn *Macrobrachium rosenbergii* farming, because of its favourable resources and agro-climatic conditions. The expansion of *M. rosenbergii* farming depends on availability of prawn fry, the supply of which is currently the main bottleneck for further expansion of prawn culture, as the prawn culture sector in Bangladesh still relies on wild postlarvae (PL). Farmers prefer to stock wild PL rather than hatchery produced fry as production of the hatchery PL is limited and farmers consider them to be of lower quality. However, there is a growing acceptance of hatchery fry by producers[1]. There are 1.2 million people employed in prawn and shrimp production and a further 4.8 million household members are associated with the sector[2]. In addition, the livelihoods of around 400,000 people, many of them women and children, are associated with prawn and shrimp fry fishing in coastal Bangladesh[3]. It is estimated that around 600,000 people are directly involved in prawn farming, marketing and associated activities[4]. Among them, around 120,000 farmers engage in small-scale prawn farming and employing nearly 200,000 on-farm labourers. In fact, prawn marketing also potentially provides economic returns, social benefits and livelihood opportunities to thousands of rural poor4. The freshwater prawn and shrimp are highly valued products for international markets; almost all are therefore exported particularly to the USA, Europe and Japan. In 2007-08, Bangladesh exported 49,317 tons of prawn and shrimp valued at US$ 445.41 million, of which 30% was contributed by prawn[5].

The aquaculture and especially freshwater prawn practice in Chittagong is mainly pond based culture systems. The feasibility of freshwater prawn farming in the Chittagong region is well recognised. It is estimated that 55,000 ha area of ponds are suitable for prawn farming with fish in the region. The expansion of prawn farming would increase in income of

Macrobrachium rosenbergii broodstock.

A inside view of prawn hatchery of Chittagong.

Wild prawn fry collection from the Karnafuli.

Hatchery reared prawn larvae.

farmers, opportunities for investment, livelihood opportunities and economic development through exporting prawn. If prawn farming expand to 50% of 55,000 ha potent ion area, the country will earn an additional US $137.5 million yearly foreign exchange.

One of the more successful development programs Katalyst has been working with Winrock International in the prawn sector since 2006. Recently they have been emphasising the expansion of prawn farming in Chittagong region from 2009. To develop the nursery ponds they have provided a short term consultant who was responsible for providing field visits and all kinds of technical services to the farmers. The specific objectives are to provide technical services to the farmers, to train up some fishermen to practice prawn nursery and farming, to establish a balanced feeding regime, to build capacity of hatchery personnel and to build a chain among the actors related to prawn production.

Approach

To implement this project five potential upazilas (sub-district) namely Patiya, Anowara, Raozan, Hathajari and Banskhali of Chittagong district have been selected. A short term consultant has been appointment for monitor the overall prawn culture activity in the project area over a three month period in Chittagong districts. A work plan were prepared in discussion with hatchery owners that would be the source of fry to distribute the prawn farmers. Among the selected hatcheries Halda Hatchery, Urkirchor, Rowzan and Thai Bangla Hatchery, Patenga, Chittagong City Corporation installed seven and five demonstration ponds for nursery respectively. The consultant oversaw the following activities with service providers and demonstration farmers providing hands on training and method demonstration.

Under this program, Winrock International:

- Encouraged the development of the physical resources of demonstration farmers and quantifying different inputs required for prawn farming.
- Assisted hatcheries to select suitable lead farmers to establish demonstration farms and help hatcheries to make arrangement for quality grade inputs.
- Provided training for demonstration farmers and hatchery supervisors starting from pond preparation to grow-out farming, soil, water, feed and health management and provided guidance to hatchery technicians and demonstration farmers towards improved farming with hatchery PL/juveniles.
- Provided demonstrations on croppings pattern using nursed hatchery PL for round the year prawn farming, and training for stakeholders on how to document activities and input uses to do cost-profit analysis of prawn farming.

Outcomes

Prawn farming is a sector with a very high degree of diversity, involving a wide range of species, farming systems and production practices, and farming locations. There are

Prawn fry ready for packing.

Packing prawn larvae with oxygen.

Training program for the prawn farmers to share new information on prawn culture technology.

significant differences between and within countries regarding the levels of production intensity and yields, farm numbers and their sizes, and the various types of resources utilised.

Prior to starting prawn farming it is very important to ensure juvenile quality. So, to enhance the prawn farming in a certain area, sufficient nurseries should be developed to ensure good class juveniles are available. Development of prawn PL nurseries is a sensitive practice. To get a better result in nursery phases the project provided almost all farmers with training regarding nursery pond management.

To monitor the growth rate of hatchery PL used by the prawn farmers sampling was done every month. During stocking the average weight of the prawn fry was 0.05 g, pond depth 1.5 m and pond size were 0.2-0.4 hectares. After the third month or final sampling the average growth rate of prawns was 3.0 g. During the first month of sampling we was observed that the growth rate of *Macrobrachium rosenbergii* fry was as high as 3.5 g but then in subsequent months it fell to an average 2.0-2.5 g. This is happened because of insufficient feed supply due to low water levels. The farmers suffer from a shortage of balanced prawn feed from time to time.

Prawn fry sellers plying their trade in the market.

The selected nursery demo ponds were visited by the consultant regularly with the national consultant and individually. During the visit the consultant took samples of all abiotic and biotic factors of the pond ecosystem. He also observed growth performance, water quality, and other problems of the animals and solution of all problems, and suggested feed ration as per growth performance. During the sampling period 8-12 neighboring farmers observed the project activities and the consultant provided briefings on all culture practices to them. After the training, demonstration farmers are informed about quality, culture techniques, and management of hatchery PL/juveniles. They ensured that they avoided wild PL and their neighbours took oaths that they would as well. Demonstration farmers of surrounding areas were encouraged to adopt these prawn culture techniques. Farmers had a lack of knowledge on stocking density where they know the actual stocking density. They stocked PL without nursing which can lead to lower survival and production. The production cost of hatchery PL was lower than wild PL and farmer profitability was improved due to the better survival of the hatchery produced PL.

Adaptation of prawn larvae before the stocking in the pond.

Challenge for the prawn culture

A number of challenges were identified for the expansion of prawn farming in the Chittagong region, including lack of technical knowledge, high production costs, insufficient supply of prawn fry, water pollution, poor water quality, diseases, flood and inefficient marketing systems including quality issues and traceability. There is serious concern for the prawn farming sector due to the lack of technical knowledge of farmers. Inadequate technical knowledge on prawn farming may have an effect on productivity, profitability and sustainability of the industry.

The expansion of prawn farming depends on readily available postlarvae or juveniles. One of the major bottlenecks for prawn culture expansion is the lack of prawn fry. Although there are ten freshwater prawn hatcheries operational in the greater Chittagong region, the lack of technical knowledge, inadequate skilled manpower and insufficient supply of wild

Prawn specialist observe the condition of prawn fry after the adaptation period, prior to release into the pond.

broodstock are important reasons for the poor results of many hatcheries[6]. Inadequate supply of prawn fry can therefore be an important constraint for prawn culture expansion in the Chittagong area. Though farmers stocked hatchery PL, they have fixed belief that hatchery PL don't grow as well as wild PL. So they seemed to be reluctant to cultivate hatchery PL. However, after the demonstrations they have realised that the hatchery PL can grow at least as good as the wild PL if modern farming techniques rare be used. Usually high care and management is required for hatchery PL farming compared to that of wild PL. Due to lack of appropriate farming knowledge, soil, water, feed and health management, the growth performance of prawn in some farms is not satisfactory.

Due to continuity of drought, the depth of water of the entire demonstration farm reached a minimum level. As a result, the growth of prawns of all the farms was not as expected. The water crisis seemed to be the main constraint to the satisfactory production of the demonstration farm. Inadequate rainfall was the main reason, which created this problem. Disease is also a common problem of prawn farming. A wide variety of diseases are found including shell diseases or black spot, white spot and gill disease. Environmental factors such as poor water quality and the presence of toxins are key causes for diseases[7].

Conclusions and recommendations

Freshwater prawn cultivation is a potential tool in the alleviation of poverty in Bangladesh. A good network and market structure are in place. Farmers' produce is also collected, serving as a major stimulus in the development and adoption of this new system. The expansion of freshwater prawn farming in the greater Chittagong region will play an important role in the economy of Bangladesh. The establishment of prawn farming can increase income, opportunities for investment, and employment opportunities. It is assumed that prawn farming with fish can help Bangladesh keep pace with current demand for food through fish production and economic development through export oriented prawn production. It is estimated that around 55,000 ha area of ponds are suitable for prawn farming with fish in the greater Chittagong area. If prawn farming expand to 10% of 55,000 ha potential area, the country will earn an additional US$16.5 million yearly foreign exchange. It is also projected that the country will earn an additional US$137.5 million yearly, if prawn farming expands to 50% of potential area.


Harvesting prawns from pond.


Prawn on sale in the fish market.

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Floating hapa technology for the mass production of *Oreochromis niloticus* in Bangladesh

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Tilapia have been the subject of intensive investigation since their introduction for aquaculture, beginning in the 1950's. The widespread utilisation of the hormone methyl-testosterone (MT) to achieve the production of all male fry has been a significant factor in permitting development of Tilapia as an aquaculture commodity on global markets[1].

FAO predicts that by 2010 aquaculture's contribution will supplant capture fisheries as the worlds leading source of aquatic products. Intrinsic to this rapid growth has been the emergence of important tropical freshwater species including Nile tilapia (*Oreochromis niloticus*) as significant new sources of white fish on the global market. This species becomes popular worldwide because of its easy reproduction, adaptability to intensive culture, acceptability of low input and sustainable feeds, resistance to impaired water quality, and widespread consumer acceptance. By production volume, tilapia culture is one of the largest freshwater aquaculture species worldwide and is mostly produced using semi-intensive systems in developing countries[2].

The basic element of a profitable fish production operation is the ready supply of quality breeding material including brood fish, eggs, larvae, nursed fry and fingerling. Broodstock management is an essential component of fish farming. Effective broodstock management depends on hatchery managers, technicians and fish farmers who work at maintaining, selecting and reproducing the broodfish for local distribution. Obtaining quality broodstock requires sound knowledge on managing and selecting breeders that are unrelated (not close relatives). It is imperative to keep records of the breeders to manage the stocks. These records need to be collected for each generation, and include, for example, numbers, sex, holding facility, growth rate, survival, fecundity and deformities. The key to good broodstock management is obtaining and maintaining good quality broodstock.

In Bangladesh present national goal is to increase fisheries production from all sorts of water resources. Bangladesh has large number of ponds and seasonal water bodies such as roadside canals and ditches where tilapia could be a suitable culture species. Nile tilapia is an important species farmed in small-scale aquaculture by resource-poor farmers. It is preferred by farmers because of its desirable features such as faster growth rate compared to other short cycle fish species including other commonly used tilapia strains. Tilapia farming is socially more acceptable and technically and economically more viable and sustainable than many other species. Tilapia culture is a profitable enterprise and even small farmers of Bangladesh can afford to culture tilapia to augment their income. Tilapia is consumed by poor people as it is relatively low priced commodity[3].

Oreochromis niloticus broodstock.

Primary stages of the collected eggs in hatchery.

To control breeding during the culture period researchers have used 17-α methyl testosterone (synthetic testosterone) to produce all male populations. This however is not completely degradable and residues can be accumulated in the food chain. Recently preliminary studies in the Department of Animal Nutrition and Aquaculture in the

Hapa set up for management of tilapia broodstock.

University of Hohenheim, Germany have shown that a plant extract, saponin, influences the growth and reproduction in tilapia[4].

Our study

The present study was carried out at Rainbow Fisheries and Hatchery Limited of Chittagong which is located at the northern part of Chittagong. The study was done in a rectangular shaped earthen pond of the hatchery. There were 20 hapas in the pond to manage broodstock for about six months. One three chambered hapa was selected for the experiment among all.

Water and soil samples were collected from the study area and analysed by standard formula. Nylon net of mesh size 50mm was collected for hapa preparation and bamboo (3 metres long) was collected for hapa frame construction. The seams were sewn typically to make a rectangular shape with a nylon thread and double stitched to prevent splitting. Bamboo poles were installed to tie the hapa. Then the rectangular shape of a bamboo frame was constructed to make a basin like structure with a vertical bamboo pole in each corner to keep it in place. Hapas were installed in broodstock ponds in such a way that the open part of the hapas was two feet above the water surface. Hapas were designed to allow the fish to be crowded to one end for collection so that brooders could be examined for eggs and any diseased fish could be removed easily. The total area of the broodstock hapa was 45m2 (9m × 5m), which was divided into three chambers of (3m × 5m) each.

Adult GIFT tilapia weighting 130-150 gm were collected from brood stock pond of the hatchery at March 17, 2009. The broodstock were treated with 50 ppm formalin for 10 minutes. The selected male and female broods were kept separately in two separate hapas which were set up in the broodstock pond. The stocking density of broodstock in the hapa was 4 indviduals/m2 with a male : female ration of 2:1. A total of 180 broodstock (120 male and 60 female) were stocked in hapas at 60 individuals per chamber. Collection, sorting and stocking of broodstock was completed before 9am to avoid temperature stress. After rearing of 20 days the broodstock were ready for mating. To maintain sufficient natural feeds in the pond fertilisers were applied at a reduced rate (urea 25 kg/ha and TSP 10kg/ha) at 15 days interval. Sometimes organic mature was applied at the rate of 2 tonnes/ha. A supplementary food also served, which was locally made, consisting of meat bone 10%, wheat flour 60 % and oil cake 30%. The feeding rate was 3% of total body weight per day. Feeds were administered by broadcast.

The eggs were taken in clean petri dish (small weight-box) with the help of a forceps and washed several times. The number of eggs in the small portion which was taken from the total egg was counted. Finally using the total number of eggs was estimated for each individual according to the following formula:

Total number of eggs = Total weight of eggs x No of egg obtain in counted portion / sample

Findings

Fecundity is the important factor to know the breeding performance of any brood fish. After three months from stocking, the final average fecundity was found 2.65 eggs/g body weight, ranging from 2.27-3 eggs/g, with average fecundity ranging from 366-655 eggs per fish.

Hapas were installed in pond, so this work was done under naturally existing parameters. No major changes of parameters were found during the study period, only lime was used to control the pH concentration of water at a rate of 100 – 150 kg/ha every fortnight. Tilapia are more tolerant than most commonly cultured fish to salinity, high water temperature, low dissolved oxygen, and high ammonia concentrations. Water temperature of the pond where the experimental hapas were set up varied from 27˚C to 31˚ C, pH value varied from 6.6 to 7.0, the level of dissolved oxygen was 4.9 to 5.7, transparency ranged from 27 cm to 40 cm (table 1). Total suspended solids ranged from 219.62-243.53 mg/L.

At stocking time the average length was (10.7 ± 0.23) cm and final length was estimated (17.4 ± 0.19) cm. The average weight of the brood was (150 ± 0.12) gm during stocking and at the final stage it was found (255 ± 0.19). The specific growth rate (SGR) was recorded 0.3% /day. Mean daily growth rate in terms of weight was recorded 1.346 g/day. And

Hapa set up for tilapia production.

mean daily growth rate in terms of length was recorded 0.047 cm/day. Average feed conversion ratio (FCR) observed after the experiment was 1.9.

Benefits of the hapa culture technology

Hapa culture technology has no requirement for land – clearly a key strength for the landless; however, it is possible that access to water may be limiting. Capital investment and working capital requirements for each crop is low for most systems, related to the small scale of enterprise and the short production cycle. However, systems generating the highest returns typically require the highest start-up investment. Financial return varies from medium to very high depending on the species and culture system. The return to labor when operating only one hapa is rather low, but increases rapidly as cage numbers increased. Co-operative use of labor could also result in high returns to labor irrespective of the number of hapas. Moreover, the risk to hapas from flooding and cyclones was generally rated low by villagers, since small cages are relatively easy to move and re-moor. Theft and vandalism varied greatly between communities, but was sometimes significant. The risk from disease has not been an issue to date, but experience elsewhere in Asia suggests that disease may be anticipated if hapa culture takes off. Almost every kind of enterprise has economies of scale, especially in terms of labor productivity, and cage culture is no exception. This makes small scale production vulnerable to competition from larger and more efficient enterprises. However, co-operative use of labour may allow small scale producers to realise these economies of scale and remain competitive. It also builds on existing strengths and resources: plenty of natural food is available from the wild, and it is possible to use flexible labour from within the family.

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Feeding broodstock with formulated feeds.

Preparing hapas for deployment in the pond.

Cultured tilapia for sale in the local market.

Management in seed production of golden mahseer, *Tor putitora* in hatchery conditions

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Angling - a good catch.

Golden mahseer, *Tor putitora* are large cyprinids, inhabiting the clear, pristine and fast flowing waters of Asia, from the cool waters of Himalayan streams to the tropical rivers of South East Asian jungles. Mahseer in the Indian sub-continent are described as the 'King of Indian Aquatic Systems'. Encounters occur in the Tor zone (600-1,200 m) of the glacier-fed Himalayan rivers with much more extended distribution to the lower reaches in the peninsular Indian rivers.

Mahseer as a sport fish provides unparalleled recreation to anglers from all over the world, better than salmon. For the fishermen, mahseer is of considerable importance because of its large size. As a food fish, it is highly esteemed and fetches the highest market price in North and North East of India. Despite their abundance at one time, the mahseer population has been declining in number and size in natural waters and is in serious danger of extinction. Its population is declining in the natural water bodies because of degradation of the aquatic environment and biological changes in the ecosystem due to urbanisation as well as over fishing especially with pressure from illegal catching methods such as electro fishing, poisoning, and dynamiting. As a result, the population has become unsustainable with fish catch from fisher communities being low in most parts of the country, and the fish likely be declared endangered in the near future. Developments of captive breeding and culture techniques are the means for conservation and promotion of a sustainable fish population[1].

Almost 20 different species of Tor have been reported from many rivers, streams and lakes of all along the mid-Himalayan belt from Assam and Sikkim, and more broadly Afghanistan, Bangladesh, China, Myanmar, Thailand, Cambodia, Laos, Nepal, Pakistan, Vietnam, Indonesia and Malaysia. In natural systems the fish has been known to reach 2.75m in length and 54 kg in weight, although specimens of this size are rarely seen nowadays.

Food and feeding

Golden mahseer is known to be an omnivorous fish in its adult stage. In earlier days considering the mouth opening and massive size, the fish was thought to be a carnivore. Mahseer have been found to also feed on green filamentous algae, insect larvae, small molluscs and algal coatings on rocks[2]. In natural habitats the food of mahseer fingerlings has been reported to consist of insect matter (81.4 percent), plant matter (15.9 percent) and other items including fish (1.6 percent). Scientists have noted that mahseer is an intermittent feeder[3].

Green filamentous algae and other water plants, biofilms and insect larvae have been recorded from the stomach contents of the Putitora mahseer. Diatoms formed the most preferred food component supported by green algae, blue green algae and both micro and macro-benthic animals. Various species present in the gut included *Navicula*, *Amphora*, *Cymbella*, *Synedra*, *Fragillaria*, *Oscillatoria*, *Zygnema*, *Spirogyra*, *Tribonema*, *Areella*, *Keratella* and *Chironomus*[4].

Site selection of mahseer farm

In successful aquaculture programs the selection of site for a farm is most important. The available quantity of water must be taken into consideration for the capacity and type of farm to be developed.

The water source to hatchery should be of good quality and adequate in quantity. Water from a spring sources is the most ideal for mahseer cultivation, as temperature regime does not fluctuate much. The oxygen content of water is of paramount significance and should be in the range of 7.0-9.0 mg/l at all times in all seasons. The water temperature between 20.0-25.0°C during breeding and marginally higher during rearing phase is desirable[5].

For water supply to a mahseer farm direct access to the spring or stream through a feeding channel should be preferred. It is always better that the water is passed though a de-silting device or a deep storage chamber before it is fed to the farm. The source of a stream, a brook or a spring should have enough water to compensate for losses through seepage, infiltration and evaporation. The distribution of water in the farm should be so regulated that each unit of the farm should have separate inlets to receive the required quantity of fresh oxygenated water in various components such as the hatchery, nursery and raceways or growing ponds with proper outlets also. Overhead tanks with pumping facilities can be a suitable alternative[4,5].

Hatchery unit of golden mahseer

Hatcheries need appropriate facilities for incubating the eggs as well as for their development up to the stage suitable for shifting into nursery tanks. Low cost hatchery structures

Fertilisation.

can be built from tin or plastic sheets supported on frames. For long term prospects, the structure can be a room made of concrete bricks, etc. or erections on the wood logs if it is considerably cheaper at the site. The floor should be cemented with a gradient to facilitate cleaning and removal of water. The hatchery should be protected from direct sunlight and should have adequate neat and clean working space.

Troughs

Hatchery troughs and trays are basic requirements of a hatchery for incubating the fertilised eggs and raising fry up to first feeding stage. The hatching troughs may be of various shapes and sizes, but should have the capacity to hold sufficient water for rearing the eggs, larvae and early fry. We used rectangular troughs (220 x 50 x 40 cm. or 220 x 60 x 50 cm) to rear mahseer eggs. The depth of these troughs may be increased by 10-25 cm. to facilitate the rearing of spawn and fry of mahseer. These troughs can be made from cement concrete, aluminium, flat galvanised iron sheets but preferably of fiberglass. The arrangement of hatching troughs may be in a series so that, water from source flows into the first or head trough to subsequent troughs. Additional water supply to augment the dissolved oxygen content can be provided for each trough. Each trough should have separate inlet and outlet mechanism for water. A trough with at least five hatching trays can hold 20,000-25,000 fertilised eggs.

Trays

The shape and size of the hatchery trays are in accordance with troughs, so as to fit about 4-5 trays in each trough. The trays are made of fiberglass / wooden frame and may be rectangular or square in shape. The bottom of each hatching tray is fitted with the synthetic netting cloth (mesh size 2 mm) to ensure regular water movement and the height of each tray ranges from 7.5-10 cm. The outside dimensions of each tray are such that they can be accommodated in series along the length of a trough. Water enters at one end of the trough and leaves from the other after passing in each of the serially arranged hatchery trays. Each tray (50 x 30 x 10 cm) has a capacity to hold 4,000-5,000 fertilised eggs.

Nursery ponds

The nursery ponds are the other important component of a hatchery, which are used for rearing the early fry of mahseer during their initial feeding stage. These tanks may vary in shape and size but should not be very deep. Efficient nursing of tiny mahseer fry can be possible in shallow tanks. The suggested size of the rectangular nursery tanks can be 2.0 x 0.5 x 0.6 m or 2.0 x 0.75 x 0.60 m and circular tanks (diameter 2.2 m x 0.75 m or 0.60 m) preferably of cement / fibreglass with suitable water inlet and outlet facilities can also be used. A water flow rate 3-4 litres/minute for raising 0-3 months old fry should be maintained in the nursery ponds.

Rearing ponds

To provide sufficient space for rearing mahseer fingerlings, two types of earthen ponds with proper water supply system can be prepared in the farm. First, the smaller ponds (5.0 x 1.5 x 0.75 m) for immediate stocking of advanced fry from the nursery tanks and secondly, the larger size of rearing tanks (10.0 x 4.0 x 1.0 m) to grow one year old fish. These fry ponds/tanks can also be constructed using stone pitching, cement or made of fiberglass with continuous water renewal facilities (flow rate 4-6 liter/min.). In these ponds fry can be stocked at a density of 1,000 m^2.


Preparing mahseer seed for transport.

Water reservoir (outlet channel)

The outlet channel of a mahseer farm should be wide enough and preferably extending from above to the end of the farm to hold the outgoing water from nurseries, rearing and stocking ponds. A direct inlet can also be provided from main feeding channel, so that the flow rate could be raised as and when desired for stocking the brood fish. The outlet channel can also function as spawning channel during the spawning season when brood fish need running water environment.

Water supply

The available quantity of water is also to be taken into consideration for the capacity and type of farm to be developed. The ideal requirement of water in term of quantity at various stages of mahseer rearing is as below:

Water flow	Rearing capacity
1 litre/minute	Incubation and rearing 2,000 eggs at 20-28°C.
3-4 litres/minute	Rearing 2,000 fry (0-3 months) at 20-27°C.
4-6 litres/minute	Rearing 1,500 fingerlings (4-9 months old).
Flow through hatchery	
Overhead tank	1,000 litres capacity installed at a height of 5 m above
Hatchery tanks	Galvanised iron sheets or fiber glass of 200 x 60 x 30cm size.
Hatching trays	50 x 30 x 10 cm. with synthetic netting cloth 1 mm mesh size. 5,000-6,000 eggs can be stocked.

Spawning

Golden mahseer are an intermittent breeder and fish lay eggs at intervals through out the year, but peak spawning occurs in the monsoon. The mahseer prefers clean water for breeding and has migratory habits. During the floods, the mahseer ascends to upper reaches of the river, traversing long distances to find fresh breeding grounds for spawning. They lay their eggs in sheltered rock pools, a batch of eggs at a time, repeating the process several times in a season. Mahseer most certainly breed at the commencement of the rains. The breeding season as well as spawning in many hill-stream fishes, including golden mahseer, are initiated by a specific combination of temperature, pH, velocity, turbidity and rains, which collectively induce the fish to spawn. We observed was identified five distinct stages in breeding females, which we categorised as stage I (immature), stage II (maturing), stage III (ripening), stage IV (ripe) and stage V (Fully ripe)[6].

Artificial propagation

Supportive breeding programmes are one possible option for increasing the population of mahseer in natural water bodies. This involves culturing them and propagating their seed on a large scale, with due consideration of genetic issues of both broodstock and wild populations, and transporting them to streams, lakes and reservoirs for release. Seed of mahseer was earlier collected from natural sources but recently it is produced through artificial propagation.

Breeding and rearing

Induced spawning can be carried out in an ordinary manner. Selected broodstock are stripped of their eggs and milt by exerting pressure on the caudal portion of the fish. The stripped eggs are collected in the plastic trays and the milt is spread over the eggs and then mixed with a feather and allowed to stand for five minutes. After that, the eggs are washed thoroughly with clean oxygenated water three to four times to remove the excess milt. Then the trays containing eggs are filled with fresh water and allowed to stand for 15-20 minutes in shade to allow the eggs to swell and harden before releasing them in hatching trays. The fertilised eggs are demersal, lemon yellow or brownish golden in colour. We observed a fertilisation rate of 90-100%. Hatching period of *Tor putitora* is 80-96 hours in water temperature 22-24.0°C[7]. Once the yolk-sac is completely absorbed and swim up fry start moving freely, the stock is shifted to nursery tanks and stocked @ 8,000-10,000/tank with water flow of 2-3 litres per minute. The young ones are fed with artificial feed. With a view to develop table size fish or brood stock, the natural seed or hatchery reared seed can be stocked in the earthen ponds, cement ponds, running water ponds or cages[1,7].

Air transport of eggs

Fish with empty gut contents consume less oxygen. Moreover, faces, urea and ammonia produced during digestion deteriorate water used for transport. So, fish should be prepared for stress before transport. For fish transport different sizes of plastic bags or containers of different size and shape manufactured from PVC, fiberglass, iron or aluminium are used. Fish are frequently injured during conditioning and transportation. Use of 0.05–0.3% kitchen salt during transportation decreases activity and stress-sensibility of fish. Overloading of transport facilities must be avoided. After transportation, gradual equalisation of temperature and water quality is essential during release of the fish[8].

Seed ranching

The lack of a well established hatchery technology for mahseer and for rearing of its seed was one of the major obstacles in introducing the mahseer ranching. The Directorate of Coldwater Fisheries Research, Bhimtal, ICAR has taken a very bold step for seed production of golden mahseer in the hatchery complex of the Directorate and releasing the seed in the different streams/rivers/lakes in all over India to increase the population of this fish in the natural habitat and also to conserve the germplasm from extinction. The hatchery-produced seed has been transported to Department of Fisheries, West Bengal; Department of Fisheries, Sikkim as well as other Institutions. The Directorate also stocked golden mahseer in Shyamlatal lake of Kumaun region, India during 2001 wherein it has survived very well, grown to mature sizes and now turning out to be an attraction for tourists. It can be expected that stock so introduced, may continue for generations and may be served as natural sanctuaries. These kinds of efforts can be suggested in all the regions wherever mahseer exists.

Conclusion

To conclude, mahseer, which enjoyed the status of a fighting opponent to the fishers for a quite long time, is presently struggling for its mere existence. Sincere input from the scientific community as well as the planners in the right direction is the need of the hour to save these creatures from extermination. The potential of the species as a cultivable and sport fish has to be exploited with further research and planning, keeping an eye on their conservation. The efforts taken by the early workers especially the anglers and fishery biologists to study this group in a comprehensive manner have to be gratefully acknowledged. It was their studies, which have laid the strong foundation of mahseer research in India.

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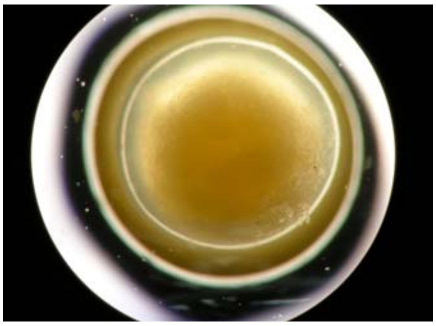
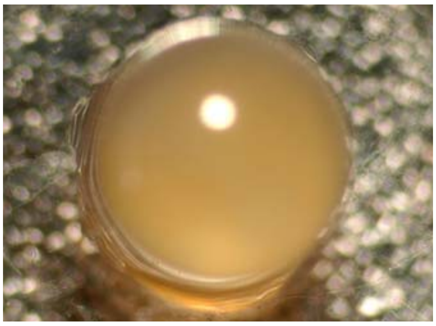
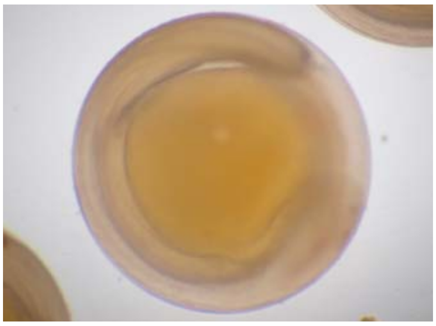


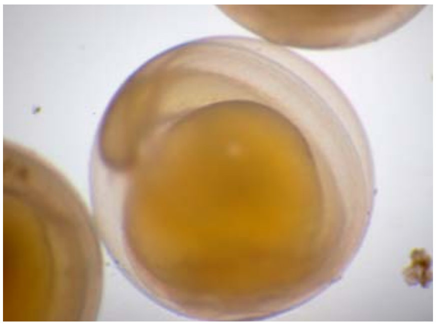
Fertilised egg.



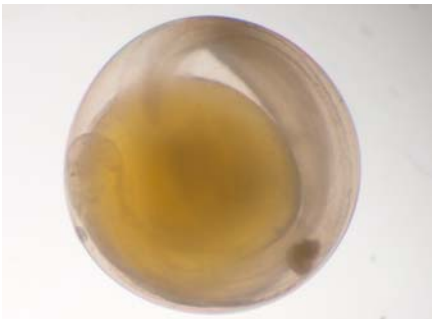
Early morula stage.



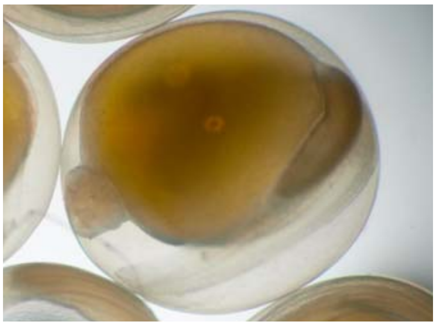
Blastopore.



Formation of somites.

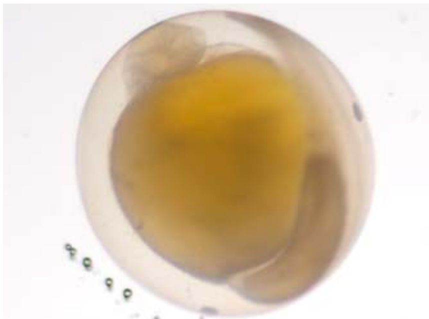


Appearance of eye.

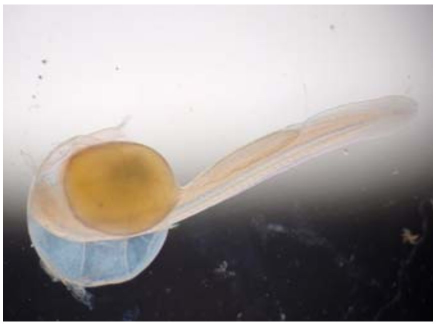


Pigmented and circulated eye.

Three quarters of egg surface covered.



Appearance of pectoral fin.



Hatching.

Hatchling.

Early stage hatchling.

One day old hatchling.

Swim up fry.

30 day old fry.

90 day old fry.

NACA Newsletter

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Global Conference on Aquaculture 2010

The conference was a runaway success and the clear highlight of NACA's activities for 2010. More than 500 people joined an all-star cast of presenters in Phuket, 22-25 September, to discuss the current status of the sector, emerging issues and strategies for its sustainable development in the decade ahead.

The conference was opened by Dr Somying Piumsombun, Director General of the Department of Fisheries, Thailand, with welcoming remarks by Mr Hiroyuki Konuma, Assistant Director General, Fisheries and Aquactulture Department, FAO; Mr Thammarat Wanglee, Advisor to the Minister of Agriculture and Cooperatives, Thailand; and Professor Sena De Silva, Director General of NACA.

Keynote addresses were given by Professor M.S. Swaminathan, speaking on "Aquaculture and sustainable nutrition security in a warming planet", and by Mr Jiansan Jia, FAO, speaking on "Global Aquaculture development since 2000: progress made in implementing the Bangkok Declaration and Strategy for Aquaculture Development beyond 2000".

The conference began with the presentation of a series of regional reviews, summarising the current state of aquaculture development in different areas of the world, followed by thematic reviews and plenary lectures over the four-day programme. Each review was followed by an expert panel discussion,

where the participants were given the opportunity to react to the presentation and discuss it with panel members, and to make recommendations.

Phuket Consensus

A key output of the conference was the Phuket Consensus, a declaration on aquaculture development for the coming decade. A draft declaration was circulated amongst the conference materials for consideration and comment was collected over the four days.

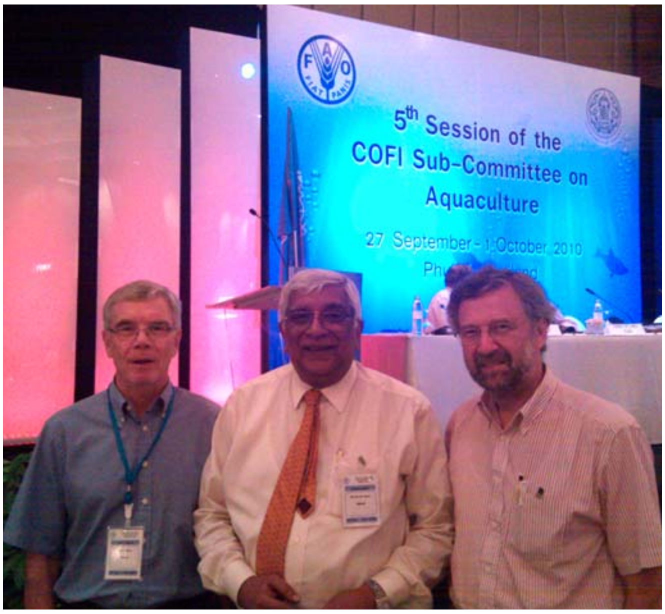
Recommendations made during thematic sessions were also collected and appended to the document. In the final plenary session, the conference reviewed the full declaration on screen and discussed it further. The Secretariat published the draft document on the web for a two-week period of additional comments before finalising it for publication.

The Phuket Consensus builds on and extends the Bangkok Declaration and Strategy, which was adopted by the previous Global Conference on Aquaculture in 2000. While reaffirming commitment to the principles laid out in the Bangkok Declaration, the Phuket Consensus recommends additional actions to address contemporary priorities and emerging issues.

Of the recommendations, several that are perhaps worth highlighting were to intensify assistance to small-scale farmers, to give special emphasis on Sub-Saharan Africa and the least aquaculturally developed countries, to help accelerate their social and economic development, and to intensify international and regional mechanisms for technical cooperation. The Phuket Consensus is available from the link below (see next section).

Audio recordings are available

All presentations at the conference were recorded, and we are pleased to announce that these are available for free download as MP3 files from the NACA website at the link



Three veterans of aquaculture and also of the first Global Aquaculture Conference, held in Kyoto in 1976. From left to right, Brian Davy, Sena De Silva and Patrick Sorgeloos.

Professor M.S. Swaminathan, keynote speaker at the conference, being presented with a gift from NACA's Director General.

below - there is an entire week of listening available! The unedited slides from each presentation are also available for download, along with the conference programme, 'who's who' guide and all other conference publications. We hope that this will increase accessibility of the materials to those who could not attend, and also provide some useful teaching materials:

http://www.enaca.org/modules/aqua2010/

Publications

The edited manuscripts for each of the reviews presented at the conference will be published in both hard copy and electronic form. The publications arising from the conference will include:

- A volume containing the regional and global aquaculture reviews.
- A volume containing the keynote addresses, plenary speakers, presentations and invited lectures
- The Phuket Consensus and the recommendations of the conference.

Participants will receive a free copy of the printed proceedings when available and the electronic versions will be publicly available for free.

NACA would like to thank our partners, the Thai Department of Fisheries and FAO for their excellent collaboration in hosting and organising the event, as well as the panel members, presenters and all participants who together contributed towards a very enjoyable and educational programme.

NACA would also like to thank our sponsors for their support: The Thailand Convention and Exhibition Bureau, GTZ, Intervet Schering-Plough Animal Health, Wiley-Blackwell and Gaware Wall Ropes.

Reducing the dependence on trash fish as feed for marine finfish

On-farm trials to determine the efficiency of trash fish vs pellet feeds in marine finfish culture have been completed under the project Reducing dependence on the utilisation of trash fish as feed for aquaculture of marine finfish in the Asian region. The trials were conducted in cage-based farms in China (Zhanjiang), Indonesia (Lampung), Thailand (Krabi, Phang Nga and Phuket) and Vietnam (Nha Trang).

The data from each country was analysed in respect of growth, production and economic benefit for the two feed types. The details of these analyses will be made available on this site and in respect of some of the countries published in peer reviewed journals.

The species used in the trials were:

- China: Crimson snapper/Red snapper (*Lutjanus erythopterus*) and Green/orange-spotted grouper (*Epinephelus coioides*)
- Indonesia: tiger grouper (*Epinephelus fuscoguttatus*).
- Thailand: Asian seabass (*Lates calcarifer*) and tiger grouper.
- Vietnam: Pompano (*Trachinotus blochii*) and red snapper.

The result of the trials indicate that the differences in the efficacies of the two feed types were not markedly different, for all the species tested, even after accounting for differences in the locations for any one species.

The trials also showed that all species can be weaned from one feed type to the other without any significant impacts on feed intake and or overall performance. In all the participating countries there was consensus that use of pellet feed offer many advantages and that the farmers were willing to make a shift from trash fish/ low value fish to pellet feed. Equally, one of the constraints in this regard was the lack of feeds specific for grouper species, difficulty in accessing pellet feeds and the cost.

Most stakeholders were of the view that small scale farmers in a locality should form associations and make purchases collectively, thereby increasing bargaining power and even perhaps access to credit from the suppliers. The stakeholder consultation held in Krabi, Thailand requested the development of dissemination material indicating the advantages of using pellet feed in marine cage culture, which was followed by other participating countries.

The trial results were presented at stakeholder meetings in each of the countries, in June-July 2010, when feedback will be used to develop appropriate strategies, including dissemination mechanisms of the major findings. For more information please visit the project web page at:

http://www.enaca.org/modules/marinefishprojects/index.php?content_id=2

21st NACA Governing Council & 10th Technical Advisory Committee

Two of NACA's key events were held in conjunction with the Global Conference on Aquaculture 2010. The 10th Technical Advisory Committee (TAC) met on 21 September to propose new directions and priorities for the work plan, which were reviewed by the 21st Governing Council meeting.

TAC 10 was chaired by Dr Ambekar Eknath, Director of the Central Institute for Freshwater Aquaculture, India. The meeting was requested to focus on ways to improve the involvement of governments in project development and implementation, in-country ownership of projects and activities, and ways to sustain project outcomes. As most NACA projects are donor funded, the distribution of projects amongst members tends to be somewhat weighted towards prevailing areas of donor activity and interests, and sustaining the outcomes beyond the life of the project is always a challenge.

Participants in the 21st NACA Governing Council Meeting.

Key TAC recommendations to address these issues include:

- Establishing working groups for each of NACA's six thematic work programmes, drawing on experts from member governments and Regional Lead Centres. The working groups would be tasked with developing project concepts in partnership with the Secretariat, but would also take a lead role in project implementation.
- Convening a ministerial level meeting of member governments, chaired by NACA and FAO, to elevate the profile of aquaculture in the region and the benefits of the networking mechanism that NACA provides to its members.
- Establishment of a special fund within NACA to support activities and countries for which donor funding is difficult to attract.
- Commissioning a review of NACA's impact over the past 20 years including government involvement, success stories, strengths and weaknesses, and a vision and recommendations to position the organisation for the next 20 years.

The 21st NACA Governing Council was chaired by Dr Nanthiya Unprasert, Deputy Director General of the Department of Fisheries, Thailand. The opening ceremony was marked by the presentation of a Silver Medal Award to Mr Miao Weimin by the Government of China, for his outstanding contribution to foreign aid in developing countries. The award was made at a recent conference on the 60th anniversary of Chinese foreign aid, where a number of outstanding personnel were recognised including Mr Weimin. The award was presented by Mr Tang Shengyao and Mr Xu Pao on behalf of the Chinese Government Ministry of Agriculture and RLC China respectively. The Director General congratulated Mr Weimin and thanked him for his more than 20 years of support of NACA.

Member governments endorsed the recommendations of the 10th Technical Advisory Commiittee including the establishment of working groups, the special fund and the concept of a ministerial-level meeting, the logistics of which is currently being explored. Members identified ornamental fish culture as an emerging area of interest in the region, and more broadly inland aquaculture, culture based fisheries, health and biosecurity were areas of strong common interest. The 22nd Governing Council will be hosted by the Government of India in Kerala.

Training course on application of business management principles in small-scale aquaculture

NACA in conjunction with Nha Trang University and the Fisheries Training Program of the United Nations University successfully conducts the first training course on “Application of Business Management Principles in Small Scale Aquaculture”.

Thirteen people attended the course, coming from Cambodia (1), India (1), Indonesia (2), Myanmar (1), Thailand (1) and Vietnam (7). The participants were a mix of farmer leaders, government officers, researchers and university teachers. They either had direct experience in small scale aquaculture or closely worked with small scale farmers, and their experience reflected the current aquaculture practices and systems prevailing in the region as well. Such a dynamic group also enabled the training course to examine aquaculture development issues from different perspectives and provided an excellent environment where participants were able to interact with others with diverse opinions and views.

Trainers were professionals from Hólar University, NACA and Nha Trang University. They were familiar with development context and issues of small scale aquaculture in the region and experienced in teaching and training. The training team collectively possessed strong academic backgrounds and expertise in economics, business management, rural development and aquaculture technology.

Course contents and delivery

The course consisted of ten stand-alone but complementary modules prepared considering aquaculture practices in Asia and current global development trends. A pre-training need assessment was carried out to determine knowledge

gaps. The course examined important physical, biological and socio-economic factors which affect farm economic performance. The concept of better management practices, food safety, global trade, scale of production and role of farmers’ organisations were emphasised. Economic principles were presented and discussed in close association with Asian small scale aquaculture practice. Participants were requested before the course started to collect farming operation data of either their own farms or systems they were most familiar with. This data represented a range of farming systems and formed the base information and cases for participants to apply analytical skills to real world situations. Participants were encouraged to examine the data critically and suggest improvements and plan for future operation.

The training took a learner-centred, four-phase experiential learning approach, which requires participants' active participation in various training activities including:

- Experiencing through lecture, reading, recalling and sharing participants' specific experiences, case studies and field trips.
- Processing though group discussion, sharing experiences, analysing cases/ data, and reporting.
- Generalising through summarisation, group discussions on some conclusive statements, and reflecting what participants have learned to their working experiences.
- Applying through individual planning on how the knowledge and skill gained here will be used in participants' work situation and serve the need of small scale farmers in their areas.

Results and evaluation

In the final evaluation of the course, participants ranked all the sessions to be very relevant, useful, and important. Their opinions showed that such a training course was important in capacity building of small scale farmers in applying business management skills in their aquaculture practice. This would help them to adapt to dynamic global economic environment and remain competitive.

All participants successfully completed the training programme with upgraded knowledge and skills in economics, farm planning and management. All of them demonstrated their confidence in improving farming efficiency through applying economic principles and analytical and management tools in their case studies. They expressed their determinations to extend what they have learned in the training course to other farmers. It is expected that extension of the knowledge from this and future training courses to farmers will have a assist in sustainable development of small scale aquaculture in Asia.

In delivering the sessions, trainers tried to simplify the complex economic concepts and presented them in a direct and applicable way. Participant experiences were incorporated in almost every session so that they could understand the concepts and apply skills through examining their own farming practices. This methods proved to be very effective in stimulate their learning interests and self motivation, and hence ensured a high level of efficiency of knowledge and skills transfer.

Look to the future

Uplifting business management skills for small scale aquaculture farmers in Asian requires a long term effort and is in great need. Along with technological advances, application of business management principles in small scale aquaculture is becoming critically important to retain its sustainability. Considerable attention and inputs are expected from academic institutions, governmental organisations, NGOs and other development agencies to ensure that capacity building of small scale farmers in this aspect is not neglected and the endeavour sustained and successful.

The training team of the course is currently still working on the training materials and course contents, looking for further improvement based on participants' evaluation and trainers' feedback.

NACA will make all endeavours to conduct this course in 2011, and perhaps as regular yearly event thereafter, with suitable modifications to the course material to 'pitch' the course more and more to the aquaface- the rural small scale farmer, in a manner comprehensible, applicable and adaptable to him/her.

Sri Lanka Journal of Aquatic Sciences goes open access

The Sri Lanka Journal of Aquatic Sciences is now offering free access to its full-text articles via download. The journal may be accessed online from the SLJOL website at the link below. Readers can register on the site to receive email notifications each time a new issue is published:

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NACA is a network composed of 18 member governments in the Asia-Pacific region.

Now we're on Facebook too

NACA has recently established a Facebook page, our major news and publications are now published there in addition to the website:

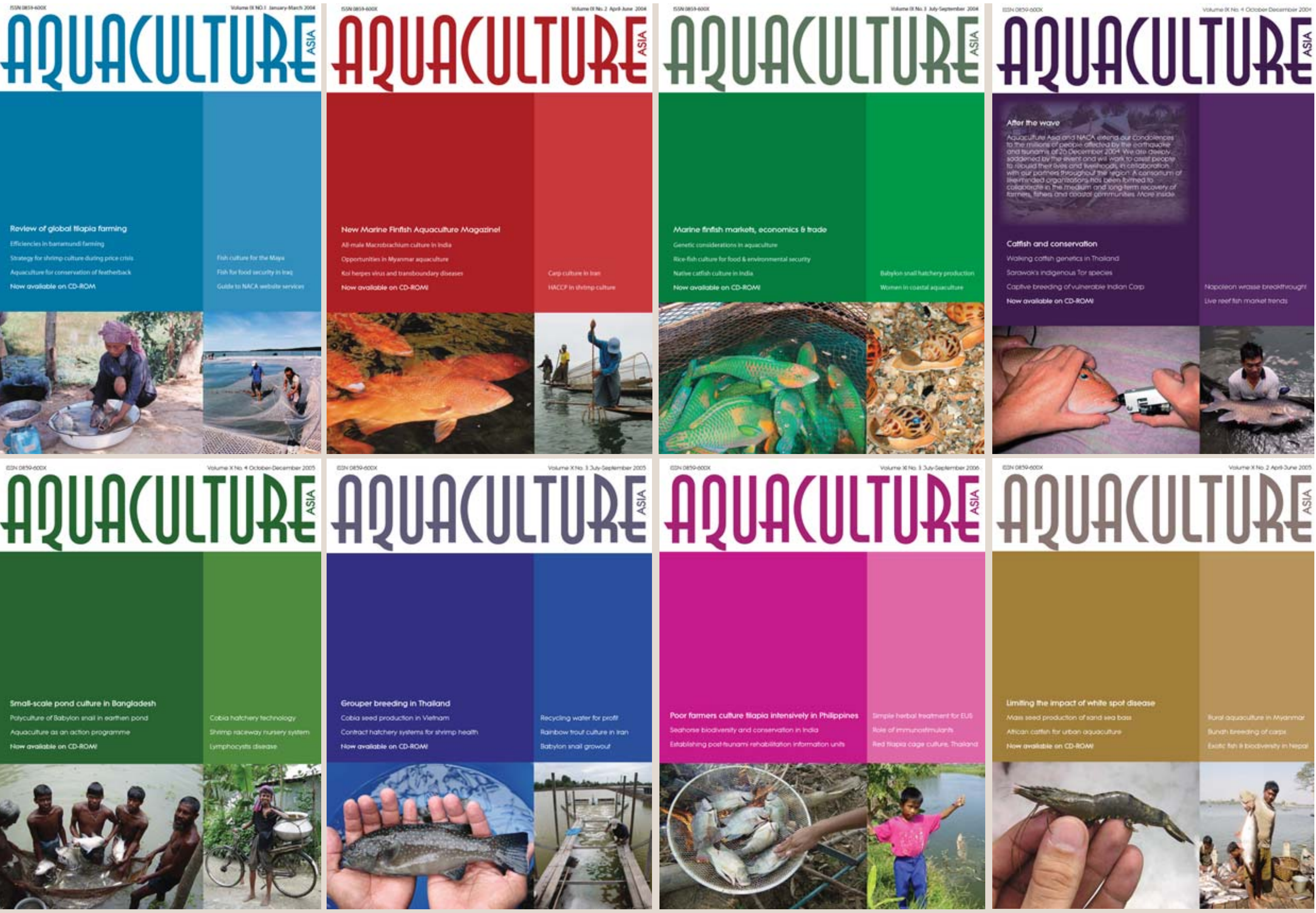
http://www.facebook.com/pages/Bangkok-Thailand/Network-of-Aquaculture-Centres-in-Asia-Pacific/135401153147891

Don't forget you can find NACA on Twitter as well, under the name AquacultureAsia:

http://www.twitter.com/AquacultureAsia

And we have an email newsletter you can use to stay in touch, sign up at:

http://www.enaca.org/modules/newsletter/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Have your say on the future of aquaculture development

With aquaculture now providing nearly 50% of global food fish supplies, FAO in partnership with NACA and the Thai Department of Fisheries, organised the *Global Conference on Aquaculture 2010*, to evaluate where the sector stands today and prepare for the challenges ahead. The objectives of the conference were to:

- Review the present status and trends in aquaculture development.
- Evaluate progress against the 2000 Bangkok Declaration & Strategy.
- Address emerging issues in aquaculture development.
- Assess opportunities and challenges for future aquaculture development.
- Build consensus on advancing aquaculture as a global, sustainable and competitive food production sector.

The presentations and complete audio soundtracks from the conference are now available for download from the conference website at the link below.

Enquiries and further information

Please visit website for more information, or feel free to contact the conference secretariat:

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