ISSN 0859-600X

Volume XVII No. 4 October-December 2012

AQUACULTURE ASIA

Rohu biology and aquaculture

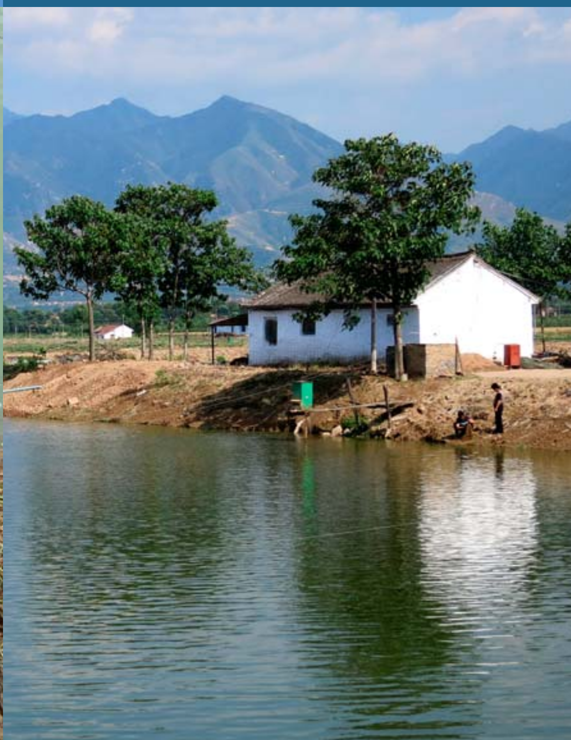
Sustainable intensification of aquaculture

Mariculture development in Sulawesi

Mahseer DNA barcoding

ASA field trials, China

Polythene lined ponds



MSD
Animal Health

Advancing Aquaculture Around the World

Global experience, local expertise and healthcare solutions for improved performance and sustainability in fish farming

For more information please contact aqua@merck.com
Or visit us at http://aqua.merck-animal-health.com

Aquaculture Asia

is an autonomous publication that gives people in developing countries a voice. The views and opinions expressed herein are those of the contributors and do not represent the policies or position of NACA.

Editor

Simon Wilkinson
simon@enaca.org

Editorial assistant
Nongluk Pituktammanat

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.

Contact

The Editor, Aquaculture Asia
PO Box 1040
Kasetsart Post Office
Bangkok 10903, Thailand
Tel +66-2 561 1728
Fax +66-2 561 1727
Website http://www.enaca.org

Submit articles to:
magazine@enaca.org

Printed by
Scand-Media Co., Ltd.

AQUACULTURE ASIA

Volume XVII No. 4 **ISSN 0859-600X**
October-December 2012

Upgrading the NACA website

Last year I spent quite a lot of time quietly building a new back end to the NACA website and moving some 10 years of data across to the new system. Finally it is ready to go and we are now offering some new services and have made a few changes to the site. The new features are:

- A Journals section, accessible from the main menu. This displays the current table of contents and abstracts of most major aquaculture journals, so you can browse through the lot of them at your convenience. Full papers can be obtained via direct links through to the publisher's websites.

- A site-wide subject tagging system has been developed, which allows you to find related content easily (although tagging of old material is still in process). This is currently available for the news, projects and partners sections and we are working to include publications and podcasts as well.

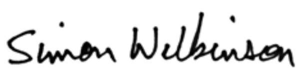
- The Podcast section of the website will now offer video in addition to audio podcasts. In addition to listening to presentations from technical meetings you will be able to watch the accompanying Powerpoint slides at the same time. Our first batch of videos are currently in production and should be online in a few weeks. The days of needing to physically attend a NACA workshop to find out what is going on are over!

- The publications section has actually had a very big overhaul but we need to go back and re-index all the 1,000 or so publications to take advantage of the new features, so that will be a while coming. However, a publications RSS feed is now available, so if you want to stay up to date with our free, full-text publications you can subscribe using your favourite RSS feed reader programme. A timeline page has been added, which allows you to browse publications by release date, going back to November 2003.

- A dedicated Partners section has been added to the site, which will feature profiles of participating network centres in addition to the regional lead centres. These will be added gradually as they are produced.

- A dedicated Projects section has been added, which provides a one-page dossier of each current project including background, news and publications. Completed projects are archived for future reference.

One major section of the website has been removed, the public forums. These were a long-running experiment that never really worked out, so for the moment they have been discontinued. We are investigating easier alternative mechanisms for community participation, such as integration with Facebook, so we may try again further down the road.



AQUACULTURE ASIA


p7.


p17.

CONTENTS


p30.

p20.

Peter Edwards writes on

Rural Aquaculture

Dr Edwards is a consultant and Emeritus Professor at the Asian Institute of Technology in Thailand where he founded the aquaculture programme. He has over 30 years experience in aquaculture education, research and development in the Asian region. Email: pedwards@inet.co.th.

American Soybean Association field trials in China

This column is based on the second of three legs of a journey I made in China in June last year. The first leg 'Aquaculture in Hubei Province, Central China' was reported on in the last issue of the magazine (Aquaculture Asia Volume XVII, No.3, pp.3-13) and my next column will report on the EU-funded Sustainable and Ethical Aquaculture Trade (SEAT) project in Guangdong Province. In this column I report on a visit to accompany Zhou En Hua, Technical Manager for Freshwater Aquaculture for the American Soybean Association (ASA) in North, Central and South China. Jim Zhang, Program Manager-Aquaculture for ASA in China joined us in Central and South China.

Overview of ASA

ASA or rather ASA-IM (ASA-International Marketing) has been conducting feeding trials and demonstrations with Chinese partners in aquaculture for about 20 years. Although the primary aim of course is to increase the export of American soybeans to China, this is being achieved through highly praiseworthy introduction and promotion of advanced and innovative production technologies in aquaculture as well as in livestock industries. Field-based research involves pond management as well as feed formulation. Chinese fish

Grass carp strain trial in Jiangsu Province. Note the diffuse aeration pipes.

farmers used to raise livestock primarily to provide manure to fertilise their ponds but there has been a major delinking of fish and livestock. There had been expansion as well as intensification of both livestock and aquaculture, with fish ponds too small to recycle the manure from large livestock production units. Furthermore, it is more profitable for farmers to feed fish with pellets than manure.

ASA-IM is currently works in the top 15 aquaculture production provinces in the country through the local government extension system, otherwise it would not be able to find farmers to work with or to supervise them regularly. Demonstration trials are carried out each year with 15-20 lead farmers in ponds and cages in both inland and coastal areas. As Zhou pointed out: ‘farmers need to see to believe’.

ASA-IM gives seminars and provides intensive short course training for farmers, extension officers and decision makers as well as conducting trials with farmers. Whenever staff from ASA-IM travel to monitor farmer trials, they are accompanied by the heads of provincial, municipal and county level extension officers as I witnessed. This amazingly efficient system of extension means that results of field trials are widely disseminated within each province in which a farm-based trial is carried out.

Grass carp feeding on floating pellets in Jiangsu Province.

Scale-up of successful farmer trials is achieved by inviting extension officers to visit demonstration farms. Farmer-trial results are published in Chinese as well as in English on the ASA-IM website. A wide variety of people - national level extension officers concerned with policy formulation, provincial extension officers, feed millers as well as trial farmers - are invited to an Annual Evaluation Workshop to provide a platform for exchange of ideas. ASA-IM publishes a special column to disseminate information in the government China Fisheries magazine. Nation-wide technical support is also provided through seminars, e-mail and phone calls.

The diffuse aerator in Jiangsu Province.

Grass carp stocking density trial in Shanxi Province.

ASA-IM is the main promoter of pelleted feed for fish in China. Although their feed formulae are made public it is difficult to measure the direct impact of the ASA-IM initiative as large farms as well as feed mills do not want to admit using someone else's formulae as they may have their own nutritionists and also want to protect 'trade secrets'. However, the sale of US soybeans in China continues to rise.

Farm-level production in the trials with common carp (*Cyprinus carpio*) and grass carp (*Ctenopharyngodon idella*) was 6-7 tonnes/ha although attaining 10-15 tonnes/ha was being researched with improved aeration. High production of common carp and grass carp could be readily achieved although less so with crucian carp (*Carassius carassius*). Trials in Beijing were also underway with sturgeon, a species with rapidly increasing importance as I reported in my last column.

Sampling grass carp in the stocking density trial in Shanxi Province.

Reduction in the omega-3 fatty acid content of fish fed a high soybean diet to reduce fish meal is a concern but ASA is developing a strain of soybean containing these fatty acids.

Jiangsu Province

The large 1,000 mu (67 ha) Pingwang Fish Farm in Suzhou, Jiangsu Province near Shanghai in Central China was established in 1950 as a hatchery for Chinese carps. It is one of the oldest fish farms in the Yangtze Valley. Previously it was a state farm but since 2004 it has been a private cooperative with 43 registered stakeholders. According to signs on the farm it is the 'Changyang Ecological Fishery Scientific and Technological Demonstration Zone' as well as hosting the 'ASA-IM Freshwater Feeding Demonstration Ponds'.

Weighing grass carp in the stocking density trial in Shanxi Province.

ASA-IM has been working with the farm for 5 years advising on experimental design, feed formulation and production management. Currently they are carrying out genetic research, evaluating the growth, food conversion ratio and disease resistance of pure strains of grass carp from three major river systems: the Pearl River in South China, the Yangtze River in Central China and the Heilongjiang River in North China.

The trials were all pellet feed based with no manure or grass added to the ponds. Although Sudan grass was growing on the pond dikes, the farm was discouraged from feeding grass to the grass carp as fibre was incorporated into the pelleted feed. The farm raised several species of fish but their feed was neither nutritionally balanced nor water stable. Nor would it be possible to satisfy several fish species with a single feed formulation.

The trial was using the 80:20 system promoted by ASA-IM, a simple system, always with a single major pellet-fed species and a filter feeder, usually silver carp, although the ratio may change somewhat e.g. it could be 70:30. Even if there were more than one target species, one would dominate with a ratio never less than 50:50. The 80:20 system promoted by ASA-IM iwas now being used all over China rather than the traditional polyculture of 7-8 different species and with different sizes of fish in the pond. Management of traditional polyculture was difficult and it was impossible to satisfy the nutritional requirements of many species with pelleted feed.

The stocking density in the trial was 500-600 grass carp and 100 silver carp per mu, equivalent to 0.75-0.9 and 0.15 per ha, respectively. Stocked fingerlings of grass carp were 50 g but those of silver carp were more than 200 g as small fingerlings would have limited impact on improving the water quality through filtering out phytoplankton from the residual fertilisation effect of fish faeces. The feed was extruded to produce a floating pellet with a crude protein content of 33% and 3% fat. Fish meal content was zero with 1% fish oil.

Following research carried out by Chinese scientists (Michael Cremer, personal communication), ASA-IM was promoting diffuse aeration of ponds with air distributed to the pond bottom and evenly throughout the water column through pipes from a compressor. Previously many types of aerators were in use - wheel, propeller and fountain types - but these were found to be more energy intensive and therefore more costly, and less efficient in terms of aeration. Dissolved oxygen is the first environmental limiting factor in pond aquaculture. Good aeration is important as it provides dissolved oxygen for the fish, improves water quality and reduces anaerobic decomposition of organic matter on the pond bottom which leads to production of toxic gases. Diffuse aeration also improves feed digestion and growth performance of the fish as well as reducing the incidence of disease through improvement of the pond bottom.

Production of fish larger than 1.2 kg was reported to be an extrapolated 9 tonnes/ha. However, production in carefully controlled scientific experiments has reached 2,500 kg/mu, equivalent an extrapolated 37.5 tonnes/ha.

Grass carp fetched a relatively high farm gate price of Y 16/kg (US$2.6) for live fish. However, the price varied seasonally, ranging from Y 10-12 to Y 18-20 (US$1.6-1.9 to $2.9-3.2). Oversupply drove the price down as most fish were stocked in February and harvested in November-December. ASA-IM was trying to promote processing of grass carp.

Shanxi Province

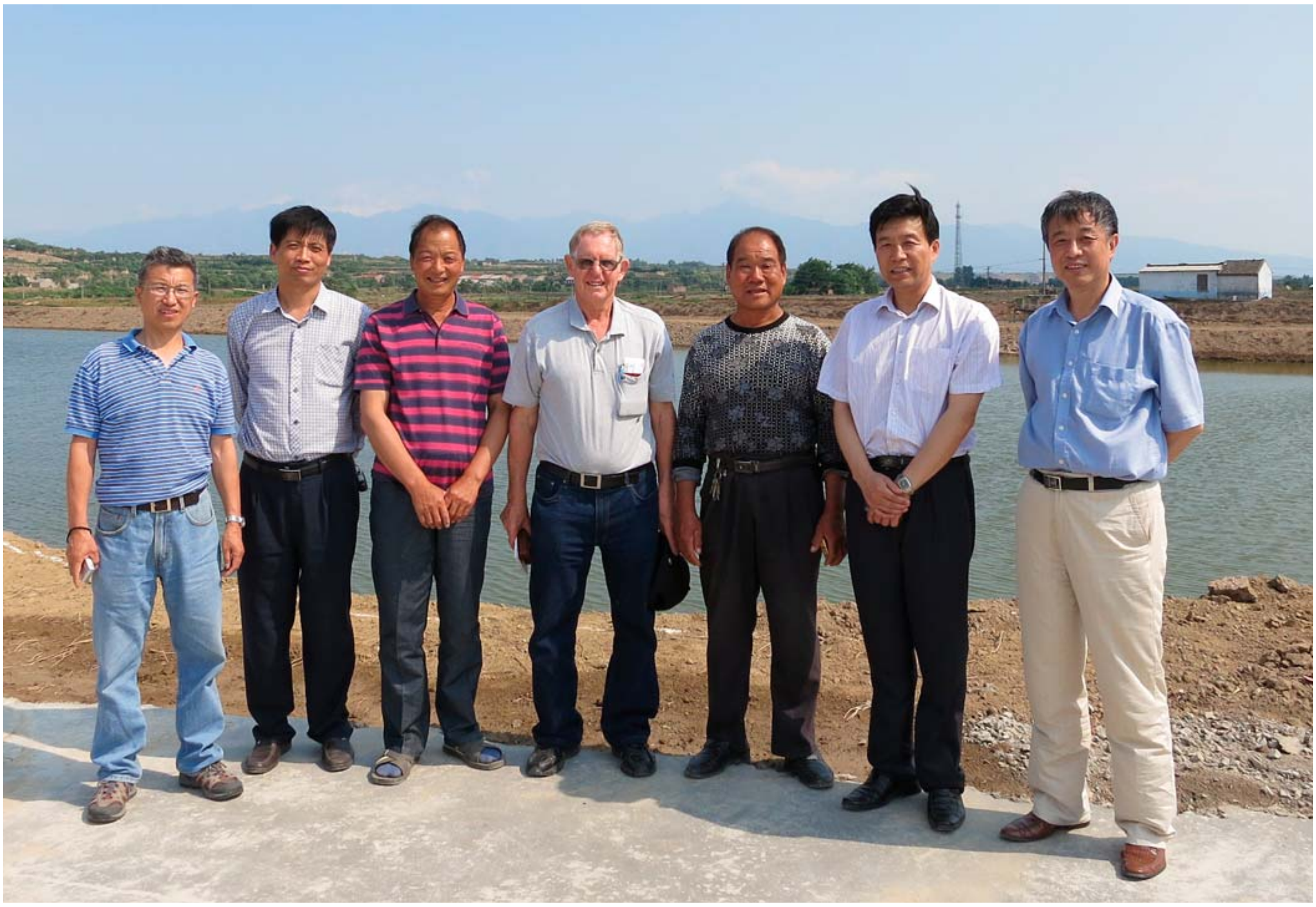
We flew to Yuncheng in Shanxi Province near Being in North China to visit a large cooperative farm with an ASA-IM trial, three clusters or cooperatives of small-scale farms and a small-scale seed farm. During lunch with extension officials I asked about aquaculture in the province.

Most of the farms in the province were reported to be small-scale farms, with each family having several ponds with a total area of 20-30 mu (1.3 - 2.0 ha); the many reservoirs

Zhou En Hua discussing the trial data with the farm manager.

Renovated pond and water supply at Yunyang small-scale farmers cooperative in Shanxi Province.

Pond with conventional and diffuse aerators at Hong Po small-scale farmers cooperative in Shanxi Province.



Group photo from left to right, Zhou En Hua (1), extension officers (2,6,7), farmers (3,5) and writer (4).

in the province were reported to have fish cages. Traditional manure-based aquaculture had ceased in the early 1990s. The main drivers to use feed rather than manure were the need to intensify as pond rentals and the cost of labour had risen. Manure-based aquaculture produced only 250 kg/mu (3.75 tonnes/ha) compared to 1 tonne/mu (15 tonnes/ha) for pellet-fed aquaculture.

There were 150,000 mu (10,000 ha) of fish ponds in Yuncheng Municipality, mostly converted from swamps or low-lying land unsuitable for agriculture, mainly from the early 1980s. Agricultural land could not be converted into fish ponds. Family farms leased the land from the local government for Y 350-500/mu (850-1,200/ha). The time limit on the lease from the government of a swamp to build a fish pond was not fixed but the farmer would need to pay for pond construction.

Shanxi Province has 115 counties but only those with significant aquaculture, 40 counties, had a fisheries extension service.

Yong Ji Farm

The 33 ha private farm was a cooperative with 15 shareholder farmers who leased the land from the local government and farmed fish together. It was a state farm until 2003. The farm produced mostly common carp but also grass carp and largemouth bass (*Micropterus salmoides*). Fish were bred in a large indoor hatchery.

As the province had a water shortage, ASA-IM trials starting 3 years ago successfully trialled common carp culture using recycled water with zero water discharge. Extruded feed was first trialled with grass carp in 2011 and it was found to be more efficient than sinking pellets, feeding with which was more or less guesswork. There was no wastage with floating pellets; as there was less contamination of pond waters it was easier to manage the ponds. It was also less labour intensive as automatic feeders with timers were used.

A grass carp stocking density trial was being monitored during my visit. Mr Zhou was trying to set up a grass carp model for maximum profitability for the farmer. Farmers think that the higher the stocking density of fish the better, but the most important parameter is the cost of feed, hence the rationale for the stocking density trial. In feed-based culture most nutrients for the fish are provided by the pelleted feed so pond dynamics are less important than least-cost formulation. Soybean is being used to replace fish meal but further experimentation on diet formulation is required. ASA-IM is currently achieving a FCR of 1.3-1.5 for grass carp.

The ponds were equipped with diffuse aerators. Stocking densities of 75 g fingerlings of grass carp were 600, 900 and 1,200/mu, equivalent to 0.9, 1.4 and 1.8/ m^2, respectively. Fish had doubled in size to 150 g in 32 days as the temperature was rising and was 22-23 degrees Celsius at the time of my visit with a FCR of 1.0 to date. The growing period in the cool temperate climate was only 7 months after which the fish were expected to reach 1 kg.

The local government in its concern for environmentally-friendly aquaculture was subsidising farmers to use extruded feed by paying for the cost of transportation of the feed by train half way across China from Chengdu in Sichuan Province.

Ladies from the Shanxi Aquatic Products Quality Assurance Monitoring Centre collecting fish samples at Hong Po farm.

Yunyang Small-scale Fish Farmers Cooperative

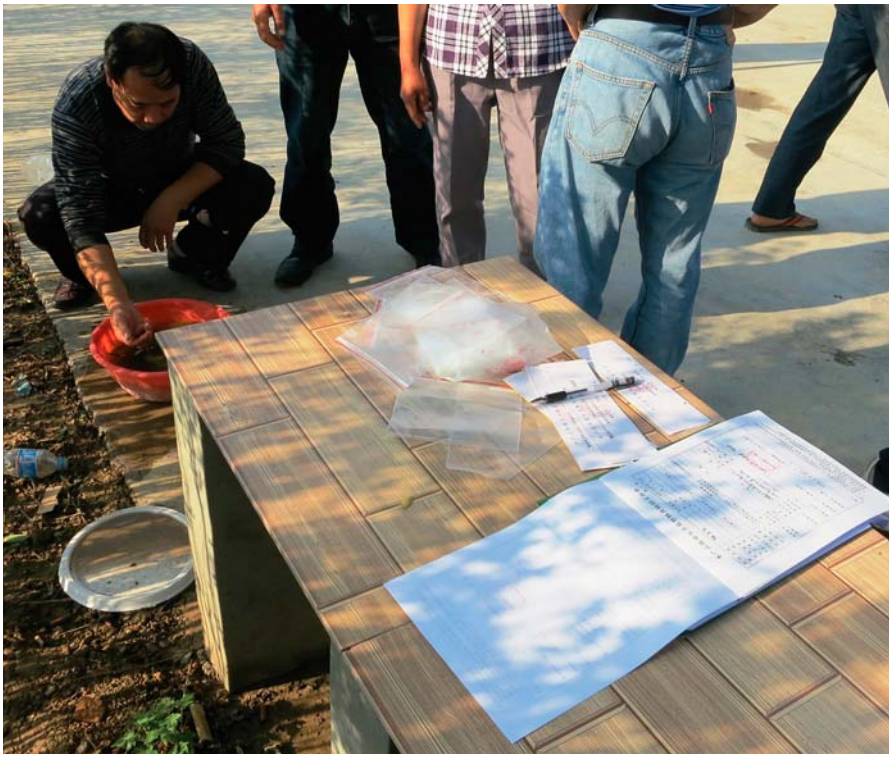
A total of 80 fish farmers farmed a total of 1,200 mu (80 ha) or an average farm size of 1 ha. In contrast to the large cooperative farm in which the stakeholder farmers raised fish together as a single farm, here the farmers managed their own ponds individually although they cooperated with input supply of seed and feed and marketing of harvested fish to have better bargaining power with middlemen. The smallest ponds were for nursing, 1 mu (667 m^2),

Small-scale nursery in Shanxi Province.

whilst grow-out ponds ranged in size from 5-20 mu (0.33 - 1.33 ha). Ponds averaged 2m in depth. The number of ponds per famer ranged from 3 -10 ponds.

The first fish farm was established in the early 1980s with the assistance of the local extension service. In the early days of fish farming the ponds were irregular in shape but recently the area had been renovated with redesign of ponds into rectangular shape and with provision of improved water supply and drainage. The water was pumped from the Yellow River located 3 km away into an irrigation canal that was mainly used to irrigate agricultural land. Funding came from their own savings as well as government subsidy. The farmers were in the process of constructing a meeting room during my visit.

The main species being farmed was grass carp followed by common carp and silver carp. The 80:20 system was being used as recommended by the local extension service. Grass carp comprised 80% of the total because of its higher price, currently a high of Y 15/kg but declining seasonally to Y 10.6/kg. The farmers were also using subsidised extruded pellets from Sichuan Province but most farmers in the area used sinking pellets from Charoen Pokphand Company.



Officers from the Shanxi Aquatic Products Quality Assurance Monitoring Centre collecting fish fingerling samples.

Hong Po Small-scale Fish Farmers Cooperative

The second farmers cooperative I visited comprised 33 farmers with a total of 1, 145 mu (76 ha) or an average of 2.3 ha/farmer. The system was similar to the previous cooperative. Rape was being grown on the dikes for extraction of rape seed oil.

During my visit two ladies from the Shanxi Aquatic Product Quality Assurance Monitoring Centre were collecting flesh samples of common carp which were sealed in plastic bags for laboratory analysis. The Centre samples farms in the province at random without prior notification.

A grass carp fingerling trial in Guangdong Province - the fingerlings are being innoculated against haemorhagic disease.

Xinmao Small-scale Fish Farmers Cooperative

This cooperative again operated a similar system to the two previous ones I had visited. Thirty farmers farmed a total area of 900 mu (60 ha), an average of 2 ha/farmer.

The technology had been introduced by the local extension service although the farmers were using locally available sinking pellets. I asked them what had they learned from the extension service? The answer: the stocking model, feeding practice and pond management. They could also telephone the extension service if their fish got disease. The provincial exten-

Close up of vaccination.

sion service provided training every year on technology transfer, including seminars on 'eco-friendly aquaculture technology'. Farmer visits were included in the program.

Small-scale Seed Farm

This 43 mu (2.9 ha) small-scale nursery with 12 ponds was being run by a husband and wife team. The husband had learned aquaculture from his father 30 years ago. They purchased early fry or hatchlings from South China in late march-early April and nursed them to 'summer fingerlings' of 3 cm size and produced larger fingerlings during the rest of the year. Most farmers in the area did not nurse but only stocked fingerlings for grow-out so nursing was a very profitable business.

They started with 4 ponds but would like to lease more than the 12 currently in use but no other farmers were willing to lease out their ponds. Ideally they would have liked to farm a total of 80 mu (5.3 ha) which the couple could manage with hire of seasonal workers to help to harvest and pack fingerlings.

During my last column I reported on research being carried out to artificially breed loach (*Misgurnus anguillicaudatus*) at Huazhong Agricultural University in Wuhan. To my surprise this farming family had been breeding this species for the past 3-4 years. At the time of my visit they had just injected Dom obtained from Ningbo, Zhejiang Province in Central China and reported that a single injection sufficed if the fish displayed good sexual maturity. This a good example of the need for increased communication about successful aquaculture practice both within as well as between countries to minimise 're-inventing the wheel'.

Guangdong Province

Here we visited two fish farms belonging to the HAID Company, again accompanied by provincial, municipal and local extension officers, and were hosted for dinner by Dr Wayne Chen, Director of Fishery Division, Guangdong Provincial Oceanic and Fisheries Administration.

The HAID Company, China is a high-tech corporation involved in R&D, production and sale of livestock and fish and shrimp feed. Currently it is China's largest producer of aquatic feed and

Yellow catfish in Guangdong Province.

Close up of yellow catfish.

extruded floating pelleted feed although Charoen Pokphand Company is the biggest producer of livestock feed in the country. The company was in its first year of working with ASA-IM and hoped to gain improved modern technology and management for their aquaculture business.

Dr Wayne informed us that almost all of the 1 million mu (67,000 ha) ponds in the province had adopted the 80:20 system, or a variation of it. Tilapia and grass carp were both major species in the province with production of 1 tonne/mu (15 tonnes/ha) and 2 tonnes/mu (30 tonnes/ha), respectively. The production of grass carp was double that of tilapia as the former species grows much faster. Some highly aerated and flushed ponds produced 4 tonnes/mu (60 tonnes/ha) of grass carp but this was not environmentally sustainable and contravened the regulation that ponds should not discharge effluents. Nor was such a highly intensive system the most profitable.

HAID Company Farms

The farms specialised in fingerling production and were relatively new, only developed 16 years ago, so they were never state farms but were privately owned from the start.

The first farm, 700 mu (47 ha), produced 1.2 billion fry and 50-60 million 50-100 g fingerlings annually. The main species was grass carp (80%) with 15% crucian carp and 5% yellow catfish (*Pelteobagrus fulvidraco*). I confess to never having even heard of yellow catfish before although the Chinese total production of the species in 2010 was more than 180,000 tonnes. It is a small sized and high-value species that is also exported.

ASA-IM were carrying out a feeding trial for grass carp fingerlings with three different experimental diets containing high levels of dietary protein from soybean protein concentrate. The 80:20 system was being used in the fingerling trial with grass carp stocked at 8,000/mu (12/m^2) and silver carp at 1,000/mu (1.5/m^2). The target size for harvested grass carp fingerlings was 150 g.

During the visit 5 g grass carp fingerlings were being inoculated against haemorrhagic disease by a specialised team from the area who visited other farms, charging a fee for their service. Team members could inoculate 10-20,000 fingerlings/day, depending on their skill.

The second smaller farm, 70 mu (4.7 ha) produced 200 million yellow catfish fry annually although the farm could produce 10 million/day with a good market for seed. As there is a size differentiation between the sexes, with the males growing to 100-200g but the females only to 50-100 g in a year, YY males were being crossed with ordinary females to produce all male fish.

Chinese Government policy

It is government policy to consolidate aquaculture farms so that they could be more efficient in terms of profitability as well as being environmentally friendly. Farmers are encouraged to combine to form cooperatives with at least 1,000 mu (1.5 ha)/farm and are given a lease for 30 years as all land belongs to the state. If farmers are not interesting in continuing farming, they could lease out their land or ponds to other farmers, either large or small. Furthermore, many small-scale farmers are getting old and do not wish to continue farming; nor do many of their children wish to become farmers. All the above factors are leading to farm consolidation.

Two types of cooperatives exist:

- A cooperative farm with stakeholders who farm collectively. Most of the large state farms before the era of privatisation have been leased out by groups of stakeholders.
- Clusters of small-scale farmers form a cooperative to bargain collectively for inputs (seed and feed) and to market fish but they farm individually. With small-scale farmers in clusters it is also easier for government to provide extension and for the private sector to service the farmers. Furthermore, farmers can bargain collectively and obtain better quality and market prices for inputs and market prices for produce from the private sector. Farmers thus can have the final say about prices rather than the middleman.

Dinner in Guangzhou - from left to right, Jim Zhang , ASA-IM (1), the writer (2), Dr Wayne Chen (3) and Zhou En Hua, ASA-IM (4).

AusAID funded project on Institutional Support for Development of Mariculture in South East Sulawesi commences

Brett Ingram

Fisheries Victoria. Email brett.ingram@dpi.vic.gov.au

The South East Sulawesi region is recognised as one of high aquaculture potential. At present it is renowned for its seaweed, grouper and lobster farming, which are all conducted on a small scale in the numerous bays of islands in the Banda Sea (see map below). Increasingly activities conducted in the region, particularly mining and forestry, are posing major challenges to maintaining the pristine marine environments required for aquaculture. Consequently, there is a need to adapt and improve farming practices to help meet these challenges.

A two-year project has been funded under the auspices of the AusAID Public Sector Linkages Program, to help address these challenges. The program involves a partnership between the Fisheries Department, Dinas Kelautan dan Perikanan, the University of Haluoleo in Indonesia and the Victorian Department of Primary Industries and Deakin University, Australia.

Lobster cages and seaweed growing area near Renda Island Village, Muna Island.

The new project aims to achieve sustainable development of the mariculture sector in South East Sulawesi, through enhancing the livelihoods of small-holder aquaculture farmers. To achieve this aim the project team will:

- Enhance technical capability of local institutions to facilitate adoption of a new industry development framework
- Develop and demonstrate pilot-scale case studies featuring an integrated resource management and value chain approach to agribusiness development, and a cluster-based approach to adoption of better management practices.
- Develop a provincial scale, strategic planning model designed to facilitate post-project dissemination of key findings and associated, longer-term industry development outcomes.

This new project builds on the positive outcomes of an earlier project 'Assessing mariculture market constraints and potential in South East Sulawesi: stakeholder engagement and situation analysis' previously funded by the Australian centre for International Agricultural Research.

In early September, the Australian project team of Dr Brett Ingram (DPI, Victoria) (Project Leader), Prof. Sena De Silva (Deakin University, Warrnambool) and Geoff Gooley (formerly DPI, Victoria) travelled to South East Sulawesi to start the work. The Australian team met with the principal Indonesian project collaborators:

- Prof. Dr. Ir. La. Ode Muh Aslan, Wa Iba Sahrir (Icha), and staff and students of the faculty of Fisheries and Marine Sciences, Haluoleo University, Kendari.
- Ir. H. Askabul M.Si and staff of Dinas Kelautan dan Perikanan, Kendari.

An important part of this first meeting was to visit the farms and the farmers whose livelihoods the project will improve and to bring all those together who will need to collaborate and share information in order to make this project a success.

The Project's Inception Workshop brought together farmers, seafood traders, researchers and government officers from Muna Island, Buton Island and Kendari. The workshop identified some of the more important problems the farmers were facing and discussed the strategies needed to mitigate these issues and to bring about improvements in the production and profitability of the farms. The participants were of the view that the development of better management practices featuring integrated multi trophic aquaculture for the major farmed commodities, and the adoption of a cluster approach and associated value chains, will be most appropriate for South East Sulawesi. The Indonesian Central Government has already initiated development of small scale farmer clusters to facilitate access to seed supplies and market channels. The group decided that it would be best to keep the focus on these existing clusters and work in conjunction with them to develop better management practices.

Through this project it is expected that small-scale famers will implement cluster-based better management practices, and develop sustainable seafood value chains. Public sector agencies will incorporate cluster-based better management practices and the integrated multi-trophic aquaculture concept in local and provincial development strategies for fisheries and mariculture development. With support from both government and educational institutions, such as Haluoleo University and the Dinas Kelautan dan Perikanan, this project will facilitate training, research and management actions which make cluster-based better management practices, integrated multi-trophic aquaculture and fisheries and mariculture value chains a feature for South East Sulawesi.

For more information about the project, please contact:

Dr Brett Ingram
Fisheries Victoria, Department of Primary Industries
Private Bag 20, Alexandra. VIC. 3714. Australia
Email: brett.ingram ‘at’ dpi.vic.gov.au

Income enhancement of rural farmer through intensive fish culture in polythene lined farm ponds: A success story

Satyajit S. Belsare, Rajiv H. Rathod and Sandip S. Markad

College of Fishery Science, Maharashtra Animal and Fishery Sciences University, Nagpur, India

India produced more than 8.3 million tonnes of fish during 2009-10 by harnessing its vast inland and marine fisheries resources, and stands third in the world for total fish production. The fisheries sector provides employment to more than seven million people and has proved to be one of the major contributors to foreign exchange earnings of the country. The fisheries sector contributes nearly 1.5% of the national gross domestic product (GDP) and 5.3% to agricultural GDP.

The production from marine sector has almost reached its potential as most of the resources have already been overexploited and therefore there is little scope for increasing the production from that source. On the contrary, most of the inland fishery resources are underexploited and there is tremendous scope for triggering fish production from different inland fisheries resources.

Polythene lined pond of Mr. Chapale.

The majority of the Indian population is dependent on agriculture and allied sectors for their livelihood and income. Therefore, maximum emphasis is given to the development and improvement of these sectors. However, limited irrigation is one of the important and critical constraints in these sectors as only 35% of the net sown area in India is under complete irrigation.

To overcome irrigation problems as well as to boost the agriculture production the Agriculture Department of the Government of India has initiated a 'National Horticulture Mission'. Under this mission, construction of polythene lined farm ponds has been promoted wherein rain water can be harvested and stored for the irrigation of agriculture and horticulture crops. The area of such farm ponds varies from 0.2 to 0.6 ha with an average depth of about 4.0 m. Water is typically available for around 8-10 months in the farm ponds, which offers very good potential for fish culture, but at present most of these water bodies are merely utilised for storage of water and they are not used for aquaculture. Fish culture in such water bodies has potential to increase food production and economic return per unit area of land.

Considering this, a project was sanctioned to College of Fishery Science, Nagpur with financial support from the Department of Biotechnology to be implemented in Maharashtra State. Under this project, intensive fish culture activities in polythene lined farm ponds were demonstrated to the rural farmers in different regions of Maharashtra so as to increase the per unit farm production and enhance the income of farmers. This technology was inculcated and spread to farmers through on-field training and farm demonstrations.

This is a success story of a marginal farmer who, with the technical guidance from the project and his own determination, practiced intensive rearing of fishes in his polythene lined farm pond and augmented his farm production, in turn enhancing income generation from a meager area of 0.4 hectares.

Background

Mr. Shalikgram Chapale, a marginal farmer from village Rehaki, Taluka Selu, District Wardha of Maharashtra State owned around 4 hectares of agriculture land and utilised it for growing a variety of crops such as cotton, soybean, onions and oranges. But he faced severe irrigation problems mostly during summer months when the temperature could reach around 45-47°C. In 2007-2008, with financial support under the 'National Horticulture Mission' scheme of the Indian Government, he built a polythene-lined pond for water storage. This pond measured 60 m x 60m with depth of around 6 m and could accommodate approximately 20 million litres of water. The pond was built in an area which was prone to water logging and could not be used for agricultural production.

Stocking of stunted fingerlings in farm pond.

Mixing of supplementary feed ingredients at farm site.

Initially the pond was merely utilised to store the water for irrigation of agriculture and horticulture crops. Later, during 2008-09, Mr Chapale came to know about farming of freshwater fishes from an agriculture exhibition and immediately decided to take up this activity without much technical guidance. Spawn were procured from local fish seed suppliers and stocked in the pond without any management. The fish were fed arbitrarily with rice bran and ground nut oil cake regardless of biomass in the pond. This resulted in wastage of feed material, deterioration in water quality and eventually led to formation of algal mats at the surface. The fish were reared for approximately one year and not much water was changed except for the want of irrigation of agriculture crops. At the end of culture only 500 kg of fish could be harvested from the farm pond with an average weight of 600-650g. Further, the harvested fish comprised mostly of exotic carp varieties, common carp and grass carp rather than instead of Indian major carps (catla, rohu and mrigal), which fetched a very low price in market due to absence of consumer demand for these species.

Thereafter, Mr Chapale approched the College of Fishery Science, Nagpur, for technical support in the year 2010. A team of experts from the college visited his farm pond to get technical details. Mr Chapale explained various unconventional and organic farming techniques like vermicomposting, shed net technology etc. adopted by him to boost his agriculture production. He also expressed his willingness to take up the fish farming activity in a scientific manner.

Thereafter his farm pond was adopted for demonstration of intensive fish culture activity. He was explained the technical programme that would be adopted after the ensuing monsoon to boost his farm productivity, to which he agreed.

Vegetables grown on pond water in shed net through drip irrigation.

Technology

Prior to the fish seed stocking, the pond was dewatered to some extent and netted several times so as to remove unwanted fishes. The pond was then filled during the monsoon season. After initially filling the pond water was fertilised using different organic and inorganic manures (750 kg/ha raw cattle dung, 200 kg/ha ground-nut oil cake and 50 kg/ha single super phosphate) for plankton development. This mixture was applied in the entire farm pond particularly during broad daylight 15 days prior to stocking by broadcasting.

Stocking material: Amongst the Indian major carp varieties, catla (*Catla catla*) and rohu (*Labeo rohita*) are the most suitable species for cultivation in polythene lined farm pond owing to their faster growth and good market demand. The pond of Mr Chapale was stocked with stunted fingerlings procured from the fish seed production centre of the college. Due to the large size of the stunted fingerlings averaging 20g in weight, conditioning was done prior to transportation and later the 'open method' of seed transportation involving sintex tanks 1/4 filled with water and with proper oxygenation was adopted to transport them. The farm pond was stocked at an intensive density of around 12,000-15,000 fingerlings/ha. The fingerlings consisted of 30% surface dwellers, mainly catla, and 70% column dwellers, mainly rohu. A selectively bred strain of rohu, the 'Jayanti Rohu' developed by the Central Institute of Freshwater Aquaculture, Bhubaneshwar, Orissa, can also be a suitable fish species for culture in polythene lined farm ponds as it records 17% more growth than wild type.

Feeding and feed management: The farmer was made aware that feed management is an integral part for the success of this technology which involves intensive stocking densities and lack of a natural pond bottom. Supplementary feeding in the form of mixture de-oiled rice bran (DRB) and de-oiled groundnut oil cake (DGOC) was opted in the initial stage of culture. In the later stage commercial floating carp feed was used. Feed was initially applied at the rate of 10% of total body weight of fishes and gradually reduced to 2-3%. The feeding rate and percentage composition of feed provided during the entire culture duration is summarised in Table 1.

Farmer displaying his harvest.

Management of water and its quality: Water from these farm ponds was frequently used for irrigation of agricultural and horticultural crops. Therefore it was advised to retain a minimum water level of 1.5m by refilling them regularly with nearby perennial, seasonal or other water resources.

Furthermore, to improve the primary productivity of the pond and to enhance the production of desired plankton, phased manuring was suggested with a mixture of 750 kg/ha raw cattle dung, 200 kg/ha ground-nut oil cake and 50 kg/ha single super phosphate. Half of the above amount was made into thick paste by addition of sufficient water and was applied as basal dose 2-3 days prior to stocking and remaining was applied later in 2-3 split doses, depending upon the plankton population of the farm pond. As such fertilised water which was enriched with nitrogenous material through fish culture activity, it was used for irrigation of agriculture and horticulture crops such as cotton, capsicum and oranges etc. which in turn acted as organic fertiliser thereby augmenting the production of agriculture and horticulture produce and drastically reducing the cost of fertilisers.

Water quality was estimated during regular sampling with the help of field kits, wherein different water parameters viz. dissolved oxygen, pH, temperature, free CO_2, hardness, alkalinity, ammonia, hydrogen sulphide, nitrate, phosphate were estimated.

Growth and health monitoring: Regular sampling of the stocked fishes was carried out for monitoring health condition as well as growth of the fishes. General behaviour, movement, finnage, body colour and appearance were observed to check the general health status of the fish stock. The farmer was also advised to observe these parameters and report accordingly.

Length and weight measurements of the sampled fishes were taken during each sampling for estimation of growth. The fishes attained the marketable size of around 1 kg within 10-12 months of culture period.

Production: The stunted fingerlings stocked in the farm pond attained an average weight of 1 kg within the culture period of 10 to 12 months with average survival of around 85-90%. Harvesting of fishes from the farm ponds was carried out on partial basis as and

Table 1. Feeding rate in polythene lined farm pond.

Culture duration (post stocking)	Feeding rate (% body weight)	Feed composition (%)	
		DRB	DGOC
0-2 Months	10 %	80%	20%
2-4 Months	5%	90%	10%
After 4 months	2 - 3%	90%	10%

when fishes attained marketable size. Fish with a body weight of around 1 kg were harvested and sold in a nearby market on respective market days (usually Sunday, Tuesday, Wednesday, Friday). This aided in getting better price of around Rs70/kg for the fishes as compared to whole sale price of Rs. 45-55/kg.

Around 3.25 tonnes of fish was harvested during 2010-11 earning net profit of Rs. 134,000 while fish production of 5.5 tonnes was achieved during 2011-12 with net profit of Rs. 229,000. Thus, fish production of around 14 tonnes/ha can be achieved by adoption of this technology generating an income of around Rs. 400,000-500,000 per hectare. The economics of fish culture activity in an ideal 60 x 60 m farm pond is given in Table 2.

Table 2. Economics of an intensive fish culture in ideal 60m x 60m farm pond

Particulars	Quantity	Rate (Rs./unit)	Amount (Rs.)
Rohu & Catla fingerlings	7,500 no	3.00	22,500
Fertilisers			
a. Cow-dung	3,000 kg	0.50	1,500
b. Inorganic fertilisers	500 kg	5.00	2,500
Supplementary feed	7,700 kg	20.00	154,000
Miscellaneous	--	.	10,000
Total expenditure	--	--	190,500
Yield	5,500 kg	70.00	385,000
Net profit	**--**	**--**	**194,500**

The production of fishes in the farm pond provide a good source of protein rich and nutritious food for the rural folks. Moreover, irrigation of the agriculture and horticulture crops with nutrient rich water from the cultured farm ponds can augment the agriculture and horticultural production too. Such a fish culture activity can generate several direct and indirect employment opportunities for rural youths and folks.

Acknowledgement

The author humbly acknowledges the funding agency ‘Department of Biotechnology’, Government of India, New Delhi, India, for constant support. The author also acknowledges the help and constant guidance of The Director of Research, Maharashtra Animal and Fishery Sciences University, Nagpur in running this project efficiently and effectively. The Associate Dean, College of Fishery Science, Nagpur is also acknowledged by the author for his constant encouragement and guidance.

APFIC/FAORAP/NACA Consultation on Sustainable Intensification of Aquaculture in the Asia-Pacific: Towards A New Paradigm

An Asia-Pacific regional consultation on the sustainable intensification of aquaculture was held in Bangkok, Thailand, from 9-11 October 2012. The consultation was jointly organised and convened by the Asia-Pacific Fishery Commission (APFIC), the FAO Regional Office for Asia and the Pacific (FAORAP), and NACA.

According to the prospectus for the meeting, the world population is forecast to reach more than 9 billion by 2050. To feed these numbers, global agricultural output including crops, livestock and fisheries must increase by around 60% from present levels. Our starting position is that globally around one billion people are suffering from hunger and poverty right now. More than half of them, 578 million, live in the Asian region.

Fisheries products play an important role in food security and nutrition by providing low-cost animal protein, healthy fats and nutrients. Fish is often the only affordable source of animal protein available to poor and nutritionally challenged people, and can exceed 80% of dietary protein intake in some countries such as Cambodia. Due to stagnant capture fisheries production, aquaculture development is seen as the only way to meet the increasing world demand. Around 50% of global food fish supplies already come from farmed sources.

Asian aquaculture has grown rapidly over the past three decades, and now represents more than 90% of global aquaculture output by volume. The growth of the industry has largely been a result of two major factors; intensification through technological advances and increased use of feed and other resources. While the growth of Asian aquaculture has contributed to food security and rural livelihoods, it has also caused significant environmental disturbance.

Intensifying aquaculture production in a sustainable manner is a massive challenge. Just to maintain per caput fish consumption at current levels will require an increase in global supply of around 60%. The target will be even higher for the Asia-Pacific region when population trends and dietary preferences are taken into consideration. Meeting this demand using conventional farming practices will not be possible without causing irreversible environmental impact.

Mr Hiroyuki Konuma, FAO Regional Representative for Asia and the Pacific (right) and Dr Ambekar Eknath, Director General of NACA.

The utilisation of natural resources in agricultural production is increasingly being understood in terms of the related ecological costs. Maintaining environmental integrity while increasing food production by 60% will require that all agricultural sectors reduce their unit production environmental footprint. Many farming practices that are regarded as sustainable today will simply not be sustainable when conducted on a larger scale. Sustainable intensification of aquaculture therefore means doing more with less. Competition for essential resources such as water, suitable farming sites, energy, fishmeal, fish oil and other feed ingredients will inevitably constrain the growth of the industry. Aquaculture must use natural resources in a more efficient way, both in terms of farm productivity and environmental efficiency. Each kilogramme of food grown tomorrow must have less environmental impact than it does today.

We need to start building more efficient farming systems now and for tomorrow. As the leading aquaculture region with more than 90% of world production, this challenge presents both opportunities and responsibilities for the Asia-Pacific region.

Participation

The consultation brought together a diverse group of almost 50 stakeholders (representatives from 17 of the 22 country governments comprising NACA, regional and international bodies, selected leading regional and international actors from the public and private sectors) in a round table consultation.

A total of 14 presentations were made by participants. Working groups were an integral part of the consultation with plenary session feedback of discussions, and a final plenary session to draft the Consensus Statement.

Outputs

The consultation developed a regional strategic policy framework to guide national governments and regional organisations in promoting sustainable intensification of aquaculture in the Asia-Pacific region. The consultation also identified priority actions for the region and, where possible, practical measures for their implementation.

A technical publication is in preparation that will include review papers, documentation of existing successful practices and country position papers on the sustainable intensification of aquaculture in the region; and summaries of the meeting discussions, major findings, conclusions and recommendations. The Conclusions and Recommendations of the FAO/APFIC/NACA Regional Consultation on Sustainable intensification of aquaculture in the Asia-Pacific, entitled "Regional challenges and actions to support sustainable intensification" are being finalised.

Highlights

'1. 'Promising technologies for sustainable intensification of aquaculture'

I make no apology for leading off with my own presentation, as it addressed the important issue of definition. To meet the demand for food from a rapidly increasing and more affluent human population, there is the need to do so in environmentally and socially sustainable ways as well as to ensure that the world's poorest people do not go hungry The aims for the sustainable intensification of aquaculture are therefore not only to maximise productivity but to optimise across complex land- and water-scapes of production, food security, rural development, social justice as well as maintain environmental integrity.

This also means exploring the contribution that aquaculture could make to improving the livelihoods of millions of small-scale farmers in developing countries through more widespread dissemination of existing as well as new technologies, albeit in environmentally sustainable ways. Of course there is a need for intensification of aquaculture technology

Front row, right to left: Ramesh Perera, Australia; Simon Funge-Smith, FAO RAPA and Miao Weimin, FAO RAPA.

(production system intensification) but also for extensification (defined here as more widespread dissemination of existing technology to intensify livelihoods). I believe that the major potential to increase Asian aquaculture production is through wider dissemination of existing technology as there is huge potential for increased production, especially in less developed countries.

I concluded my presentation by also pointing out that from a technological point of view, there are no 'magic bullets' or panacea on the horizon although there are several promising technological developments. It is unlikely that various types of recirculation systems and off-shore cages will be implemented in Asia in near future as they are costly and high-tech. Furthermore, significant reduction of nutrients in intensive pond and cage aquaculture effluents remains elusive. Rather there are needs for further implementation of BMPs to improve existing systems and EAA to better integrate aquaculture into inland watersheds and coastal zones. Although global forecast is to double food production, national estimates are required to ensure that increased production responds to real demand rather than local gluts.

Prof. Sena De Silva, former DG of NACA (left) and Robins McIntosh, Senior Vice President of CP.

2. 'Standardised pond reconstruction in China: contributing to sustainable intensification of aquaculture'

According to Ms Wang Dan of the Bureau of Fishery, Ministry of Agriculture, China, the pond is the most important production system in Chinese aquaculture but most ponds in the country were built in the 1980s and have eroded dikes leading to shallow ponds and silted water supply channels. Low productivity leads to high food conversion ratios and increased incidence of disease. The Government introduced a pond reconstruction program in 2008 that supports pond clusters larger than 15 ha. In 2010, an area of 0.7 million ha of ponds were reconstructed with a target for 2015 of 1.3 million ha. Freshwater and marine pond reconstruction guidelines and effluent discharge standards are formulated by scientists and technicians who also provide guidance for reconstruction. Reconstructed ponds use less water, improve land use, are stocked at a higher density, have a more controllable environment including recirculation of water, are less polluting and provide better anti-disaster ability.

It is government policy to encourage land consolidation as small farms of only about 1 ha cannot provide a family with a decent living. National and provincial government support thus encourages land consolidation. Farmers transfer their land use rights to village-level cooperatives or companies and receive rent. The village-level aquaculture cooperatives are different from those of earlier days where farm households worked together as a single unit and shared everything. Today's cooperatives provide assistance in input supply and fish marketing to improve bargaining power but the households farm fish independently.

3. 'Sustainable intensification in aquaculture production: role of domestication and breeding'

Robins McIntosh of Charoen Pokphand Foods (CP), Bangkok, Thailand essentially presented a case study of CP's success in sustainable shrimp farming. He explained why Atlantic salmon, tilapia and Pacific white shrimp (Litopenaeus vannamei) are the most successful aquaculture species. In all three cases virtually unlimited resources and attention were initially given to broodstock development. As with GIFT tilapia, CP brought in founder populations of vannamei, leading to a new paradigm for shrimp culture in Thailand starting in 2002. The result has been a dramatic increase in the efficiency of Thai shrimp production with an average yield of 3,635 kg/ha on 85,000 ha of shrimp ponds changing to an average yield of 10,250 kg/ha on 55,000 ha of pond area in 2010. Thus intensification has led to greater land use efficiency and more control and predictability through better utilisation of genetic potential. It has also led to much greater profit. The cost of production and profit/kg of monodon in 2002 and vannamei in 2010 were US$5.27 and US$2.45, and US$0.43 and US$1.65, respectively.

While genetics has been the key to increasing sustainable production, this has been achieved through attention to the whole production system i.e. control of the pond environment and modifications to management. The pond environment must be optimised through biosecurity, provision of oxygen, predator/competitor exclusion and a clean pond bottom.

4. 'Marine capture fisheries as a source of food for aquaculture in the Asian region'

Simon Funge-Smith of the Asia-Pacific Fishery Commission posed the question 'how much of the marine fish catch is directed to aquaculture in Asia'? It is estimated that over 8 million tonnes of low value/trash fish are harvested in the South China Sea region, and typically comprise 40-60% of the catch of trawl fisheries. The demand for low value/trash fish for aquaculture is booming for crabs, lobsters and marine carnivorous fish, and perversely it keeps trawl fisheries profitable even though they have a major adverse impact on wild fish stocks.

An increasing amount of fish, as well as shrimp, are fed formulated feed with a high fishmeal content although a significant amount of fishmeal is derived from trimmings and processing waste from fish processing rather than from low value/trash fish with current demand for fishmeal for aquaculture about 2-3 million tonnes. Asian aquaculture is a major user of fishmeal compared to pigs and poultry, about 86 and 14%, respectively.

Some Asian fisheries are becoming 'low value/trash fish' fisheries with fishing directed to supply aquaculture with feeds. This is being facilitated by policy and perverse subsidies as aquaculture is being promoted through low taxes and limited environmental regulation while fuel costs for trawling are also being subsidised. Thus aquaculture is not paying the true cost for its feeds. While some new sources of fishmeal fisheries are being exploited and explored, coastal trawl fisheries have probably reached their limit in supplying low cost/trash fish. Furthermore, it is probably more efficient to trawl to provide fish to eat rather than to feed to fish. All trawling generates

The author, participating industriously even with a bolt through his leg. You just can't stop this guy - Ed.

some by-catch but this would be much less if trawling were undertaken responsibly. Aquaculture certification standards are now encouraging this through the incorporation of responsibly sourced fish products and fishmeal.

Simon ended his presentation by making the important point that most Asian aquaculture is not highly dependent on fishmeal. Fishmeal supplies are likely to become increasingly in short supply with rising cost. However, this is most likely to affect higher value fish and crustaceans, the production of which is most likely to be able to afford higher priced alternatives to fishmeal currently being developed.

Article contributed by Peter Edwards, Emeritus Professor, Asian Institute of Technology, Thailand and Adviser to NACA. Dr Edwards may be contacted at pedwards1943@gmail.com.

Taxonomic status of mahseer fishes in north-eastern India: a report on the recent DNA barcoding studies

Boni Amin Laskar

Department of Biotechnology, Assam (Central) University, Silchar, email: boniamin.laskar@gmail.com

The mahseer declaration, Kuala Lumpur 2006, recognises that "The mahseer is a cultural icon of diverse economic, recreational and conservation value in the rivers of eleven Asian nations with many new species transcending natural geographical boundaries". However, these important fishes are threatened in the north-eastern India as well as in other areas of their range due to growing harvest pressure. The two most threatened species of mahseer, viz. *Tor putitora* and *Neolissochilus hexagonolepis*, have been declared to be 'flagship species' in the north east. *T. putitora* is the "State Fish" of Arunachal Pradesh, and *N. hexagonolepis* is the "State Fish" of Nagaland. Yet the conservation of mahseer has been hampered as their taxonomy is somewhat confused due to the morphological variations they exhibit, which have confounded the understanding of actual species composition and distribution. The traditional taxonomy of mahseer in north eastern India has been facing several problems, mainly due to (1) lack of morphometric details in original descriptions, (2) the presence of very few original holotypes of mahseer species, and (3) disagreements in recognising specific morphological characters. Consequently, the taxonomy has been somewhat chaotic with a few mahseer species described multiple times.

In recent times DNA barcoding has emerged as a promising and an independent tool for accurate species level identification of animal taxa. This concept utilises the threshold level nucleotide differences called the "barcode gap" in the relatively conserved stretch of approximately 655 bp nucleotides at 5' end of the mitochondrial cytochrome oxidase c subunit (COI) gene. Based on the nucleotide sequences, accurate identification of organisms at species level is reasonably straightforward and this has been exemplified through numerous successful examples in other animal taxa. In addition to species identification the technique also bears application in monitoring of fish products for health and safety, and in regulating the commercial exploitation and trade of threatened species.

In a recent study of the fish diversity inventory in north eastern India through DNA barcoding, a team of researchers in Assam Central University Silchar led by Prof. S. K. Ghosh with the taxonomic expertise of Dr. B. A. Laskar of the Department of Biotechnology achieved success in publishing two articles in PLoS ONE, a peer reviewed and open access journal. In the first article, the team was able to inventorise 21 catfish species out of 27 reported species from north eastern India. The identification of four species, viz., *Amblyceps apangi*, *Gyptothorax telchitta*, *G. trilineatus* and *Erethestes pussilus* remained inconclusive due to shortage of congenric samples. The study confirmed the range expansion of *Ompok bimaculatus* in the north east and subjectively reaffirmed that *Mystus horai* is a junior synonym of *M. vittatus*. This article is accessible at:

http://dx.doi.org/10.1371/journal.pone.0049950

In another study, the same team sufficiently evident that *Tor progeneius* (jungha mahseer of Assam), which has been considered as an endemic and critically endangered species of mahseer in the north east, is actually a synonym of Tor putitora. In the study, the team used a combined approach of both molecular and morphological identification techniques. It was sufficiently proved that the samples of T. progeneius were different from *T. putitora* only with regard to the difference in lower lip structure. The original descriptor of *T. progeneius*, Mr. John McClelland, particularly mentioned the presence of long angular appendage to the lower jaw in a single specimen of mahseer caught from Sadiya that influenced him to designate such specimens as a distinct species. In that original description of that species, the other feature like number of lateral line scales as well as the body structure was described to be like those of *T. putitora*. This recent study however clearly showed that the specimens with longer median as well as the specimens with comparatively shorter median lobe though bear a few nucleotide differences but fall within the intraspecies range of nucleotide divergence on Kimura 2 parameter. Hence, the study retracted the species status of *T. progeneius* and considered it to be a synonym of *T. putitora*.

Secondly, the same study recovered a very old species of mahseer, *Neolissochilus hexastichus*, and restated it to be a valid species. The species has been concealed since its first description around 175 years ago due to lack of its morpho-taxonomic details and misidentification with *T. tor*. This study identified that *N. hexastichus* is the only congener of *Neolissochilus* whose labial groove is continuous versus interrupted in all other congeners. Traditionally, the two genera of mahseer have been differentiated based on the presence of the labial groove being interrupted in *Neolissochilus* and continuous in Tor. However, this generic key does not hold good in case of *N. hexastichus* and due to which the recurrent inventory of fish resources from the type locality of the species could not recognise the species to be different from *T. tor*. Consequently, the species *N. hexastichus* has been recognised as a synonym of *T. tor*. Nevertheless, this study suggests to adopt the character such as the difference in the number of gill rakers on the first arm of the gill arch (8-9 in *Neolissochilus* and 11-13 in Tor) as a key to genera between them. The said study is available at:

http://dx.doi.org/doi:10.1371/journal.pone.0053704

The study highlighted that *N. hexastichus* is only present in a particular drainage system in Dima-Hasao (formerly North Cachar Hill) district of Assam in the entire north east of India, which is poorly connected to other drainges. The limitation from geographical as well as water temperature regimes could have restricted the transcend of the species into neighboring drainages because almost all the streams and rivers of the region (Dima-Hasao) drain into Kopili River that finally discharges into the Brahmaputra River after travelling a very long stretch through the plains of Assam. As a known fact, all species of mahseer are classified as coldwater fishes that rarely tolerate the water temperature above 25°C. The water temperature as well as the other factors such as dissolved oxygen limit the normal movement of mahseer. Thus, the confined occurrence of *N. hexastichus* in the very small area raises a serious concern about the future sustainability of the species. Nevertheless, the study identified several anthropogenic threats such as dynamiting and fish poisoning in the mahseer habitats, particularly in the Dima-Hasao region. This situation demands urgent awareness raising and conservation initiatives for the culturally important and proud species of mahseer in north eastern India.

Figure 1 a & b (above, below). Two frequently observed morph samples of Tor putitora (the lower one was traditionally considered as a distinct species by the name T. progeneius because of differences in the structure of its lips).

Figure 2. Neolissochilus hexastichus (the color of the back, bases of caudal and dorsal as well as the upper part of the head in the sample was greenish gray, reddish yellow on rest of the body, and the tips of the fins red).

Biology and aquaculture of the rohu, *Labeo rohita*

Simon Wilkinson

Network of Aquaculture Centres in Asia-Pacific

Description and diagnostic characters

Labeo rohita, commonly known as 'rohu', is a riverine cyprinid reaching a maximum length in excess of 90cm (Beavan, 1877; Day, 1889; FAO, 2007). Rohu are characterised by a moderately elongate body with a deeply forked caudal fin. The snout is depressed bearing an inferior mouth with thick lips fringed with a distinct inner fold, no teeth and a small pair of maxillary barbels concealed in a lateral groove. Scales are cycloid but not present on the head. Colour is variable, ranging from dark blue-black to grey or silvery on the dorsal surface with silvery flanks and belly. Scales on the sides of the body often bear red markings. In some specimens the fins are black.

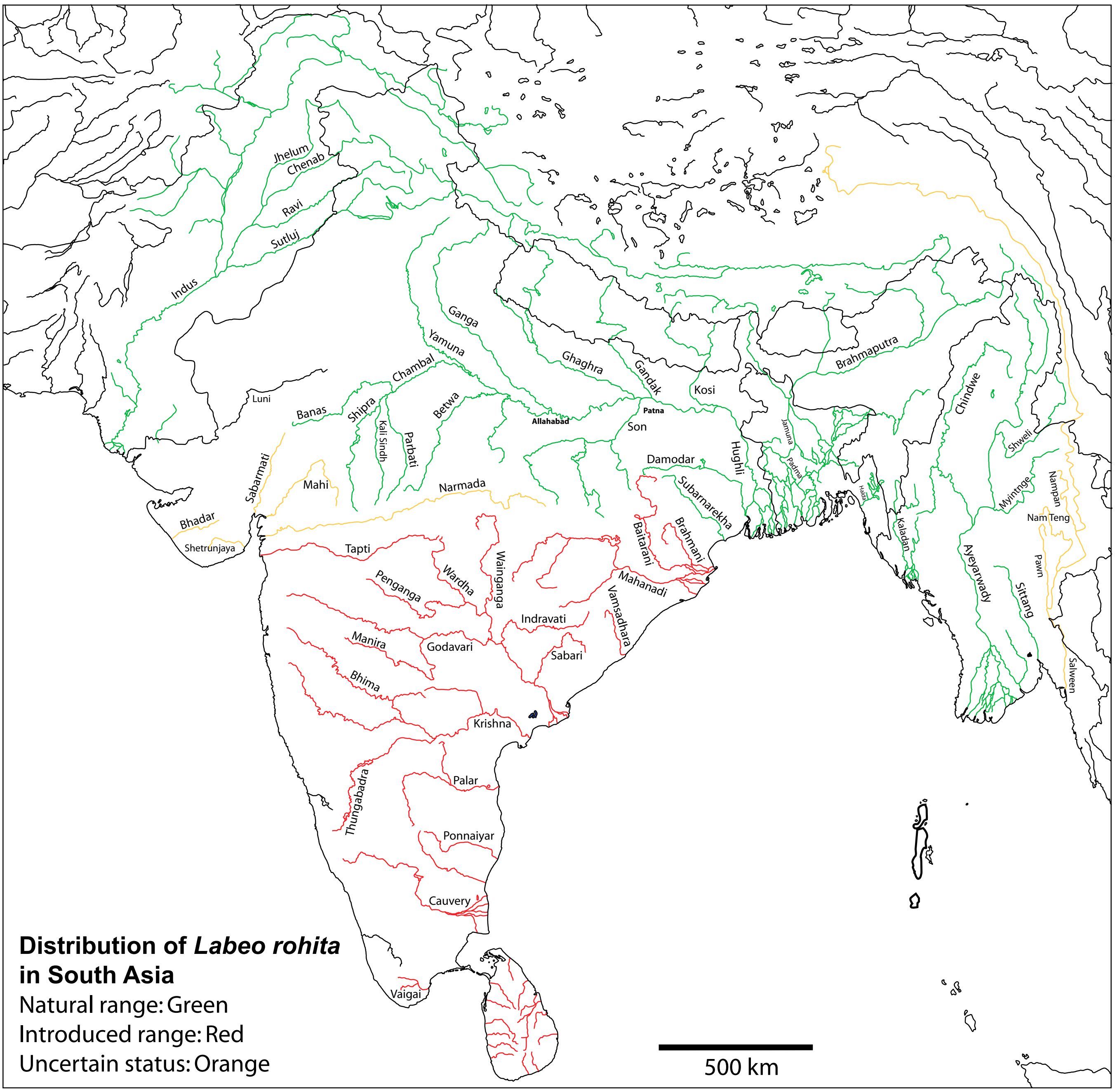
Distribution and habitat

Rohu is a primary freshwater fish sensu Myers (1938). The natural distribution of rohu extends from the Indus River Basin of Pakistan; eastward through the Ganges and Brahmaputra River Basins of northern India, Bangladesh and the lowland Terai region of Nepal (Day, 1889; Jhingran, 1991; Shrestha, 1995; Reddy, 1999; Hussain and Mazid, 2002; Reddy et al., 2002; Islam and Alam, 2004; Vass et al., 2011); to the Ayeyarwady and Sittang River Basins of Myanmar.

Rohu does not naturally occur in the rivers of peninsular India, nor on its western coast (Day, 1889). However as a fish of considerable economic importance it has been widely translocated and has successfully established self-recruiting populations in most of the peninsular river systems India (Jhingran, 1991; Reddy, 1999; Gjerde et al., 2002), resulting in an almost ubiquitous distribution throughout the sub-continent. The status of rohu in the Salween River Basin of Myanmar, the eastern limit of its present distribution, is uncertain. It is considered native to the Salween River by the Myanmar Department of Fisheries (U Maung Soe, pers. comm.) but there are suggestions from Thai fisheries scientists that it may be introduced (Vidthayanon et al., 2005). Rohu has been translocated internationally to Bhutan, Laos, Madagascar, Mauritius, Philippines, Sri Lanka, Thailand, Vietnam and Zimbabwe (Fishbase 2008), China, the former USSR and Japan (FAO, 2007). Self-recruiting populations are reported to have established in Cambodia, Laos, Thailand and Vietnam (Fishbase 2008), the freshwaters of the Andaman islands (FAO, 2007), and within the Mekong Basin (Welcomme and Vidthayanon, 2003).

Most of the major river systems inhabited by rohu originate in the Himalayan range and Tibetan Plateau. However, rohu chiefly inhabit the lowland reaches where the rivers enter the plains at altitudes of less than 250 m (Shrestha, 1994). In Nepal they do not naturally occur beyond the foothills in the

A cultured rohu specimen from Myanmar.



The likely natural and post-translocation distribution of rohu in the South Asian region, as reconstructed from the literature and discussion with fisheries scientists from Thailand, India, Myanmar and Nepal. Note that altitudinal limits on distribution (>250m elevation) are not accounted for, and rohu are probably entirely absent from the mountainous northern reaches of these basins (ie. the Himalayan range), with the exception of some mid-elevation stocking. (Readers of the print edition are referred to the online version for a colour imprint of this figure, download from www.enaca.org).

lowland Terrai region although they are frequently stocked in impoundments at higher elevations (Gurung, Nepal DOF, pers. comm.).

The altitudinal distribution of rohu is likely constrained by temperature with a minimum of 22°C required for maturation and spawning (Jhingran, 1991). There are distinct temperature regimes between the upland and lowland reaches of the rivers, with a relatively well marked transitional point between them of around 21°C (Payne and Temple, 1996). Most of the main stem and snow-fed tributaries in the upland sectors of the Ganges-Brahmaputra system do not exceed this as higher air temperatures during the warmer months are mitigated by snow melt. The rivers rapidly warm up when they reach the plains, often reaching 33°C in the main stem of the Ganges and more than 30°C on the floodplains of Bangladesh in July, near the optimum temperature for growth of fry of 31-33°C (Das et al., 2005). Critical thermal minima/maxima for rohu fingerlings are in the vicinity of 12-14°C and 42-45°C respectively (Chatterjee et al., 2004; Das et al., 2005).

Systematics

Labeo was initially erected as a sub-genus of *Cyprinus* by Cuvier (1817) with key distinguishing sub-generic characteristics being i) fleshy crenulated lips, ii) the absence of a spinous ray in the dorsal fin, and iii) the absence of barbels (Reid, 1985). Rüppell (1835) later revised the diagnosis of *Labeo* to allow for barbels, which had been subsequently observed in some species, and also proposed its elevation to full genus rank, a view that was supported by Valenciennes and Cuvier (1842) and which subsequently gained widespread acceptance (Reid, 1985).

Rohu was first described as *Cyprinus rohita* by Hamilton (1822) on the basis of its gross morphology: "A proper *Cyprinus*, with two tendrils; with fifteen rays in the back fin, and seven in that behind the vent; with large scales; with the nose smooth and devoid of remarkable pores; with the lips indented on the edges; and with the under one reflected". However, it was subsequently reassigned to *Labeo* by Günther (1868), in line with Rupell's revised diagnosis of the genus. One junior synonym exists, *Rohita buchanani* (Valenciennes and Cuvier, 1842), which was not widely used. Some authors consider its scientific name as *Rohita rohita* (Kottelat, 2001; Vidthayanon et al., 2005).

The taxonomy of the genus as a whole has remained somewhat confused (Jayaram and Dhas, 2000). Approximately 105 extant species of *Labeo* are presently recognised, of which 69 occur in Africa and 36 in Asia (Fishbase 2008). Revisions of members from Africa (Reid, 1985) and the Indian region (Jayaram and Dhas, 2000) have been made on morphological grounds. However, to date the molecular genetic evidence for revision of the genus has not been evaluated and the genetic relationships between rohu and other species of *Labeo* remain unknown; hence the need to investigate the phylogeny of this important group of fishes.

Recently, a potential taxonomic issue has arisen within Myanmar, where some farmers recently claim to have identified a 'new species' of rohu characterised by a pink ('red') cast to the body (U Myint Swe, Myanmar DoF, pers. comm.). However, it is likely that this is simply a natural colour variant, possibly caused by differential water quality in the pond environment (U Myint Soe, Myanmar DoF, pers. comm.). Both red and black phenotypes are present in wild populations in Pakistan (Chatta, Pakistan Ministry of Food, Agriculture and Livestock, pers. comm.). A black phenotype has been reported from the Krishna River system of India, outside of the natural range (Jayaram and Dhas, 2000), which local fishermen considered to be a different species. The genetically improved 'Jayanthi' variety of rohu under development at the Central Institute for Freshwater Aquaculture (CIFA), India, is pink and becomes more so with every generation (Eknath, NACA, pers. comm.). A 'red rohu' has also been reported as the result of an artificially induced hybridisation of rohu with red male common carp (Rajts et al., 2002), resulting in a rohu body morphology phenotype with a red colour.

Trophic ecology

Adult rohu predominantly consume aquatic plants and phytoplankton captured via fine gill rakers, showing a strong preference for most green algae and diatoms such as *Ankistrodesmus*, *Zygnema*, *Spirogyra*, *Selenastrum*, *Pediastrum*, *Scenedesmus*, *Tetraspora*, *Stephanodiscus*, *Naviculla*, *Diatoma*, *Synedra* and *Nitzchia* (Khan and Siddiqui, 1972). Rohu also graze on periphyton on submerged objects (Reddy, 1999) and opportunistically consume insects (Weliange and Amarasinghe, 2003). In shallow ponds, lakes and impoundments rohu may shift to bottom feeding, consuming predominantly aquatic plants and detritus (Natarajan et al., 1975; Weliange and Amarasinghe, 2003).

Larval rohu feed mainly on zooplankton such as rotifers and cladocerans (FAO, 2007). Gut content analysis by Khan and Siddiqui (1972) and Weliange and Amarasinghe (2003) showed that juveniles feed on zooplankton but also begin to consume smaller algae such as *Cosmarium*, *Closterium*, *Euglena* and *Volvox*, whole avoiding green algae and diatoms. As the fish grow the morphology of the digestive system gradually changes from a form typical of a carnivorous diet to one typical of a herbiviorous diet (Sinha and Moitra, 1975).

Reproduction and growth

Rohu normally reach sexual maturity in their second year, although some pond reared specimens may reach maturity in the first year (Kumar, 1992). Peak reproductive performance in captivity is normally attained in the third year and declines thereafter (Tan Oo We, Myanmar DOF, pers. comm.). Fecundity of female rohu is in the range 250,000-300,000 eggs per kilogram (Kumar, 1992).

Indian major carps undertake a pre-spawning migration in the lead up to the monsoon (Payne and Temple, 1996), moving upstream with a clear peak in June/July observed on the Ganga River main channel (India) at both Patna and Daraganj, and usually beginning earlier in the Yamuna River. Catches at Allahabad and in the Yamuna River peak at this time and contain a high proportion of large fish (5-10kg). How far the fish travel during this migration is unknown.

Rohu spawn in the middle reaches of flooded rivers and adjoining areas during the monsoon season from April—September (Jhingran, 1991; Kumar, 1992), before moving laterally out onto the floodplains (Payne and Temple, 1996). Eggs are scattered over the bottom and are around 5mm in diameter, spherical, reddish in colour, negatively buoyant and non-adhesive (Jhingran, 1991). Eggs hatch from 14-18 hours post fertilisation, depending on temperature with larvae averaging around 3.78 mm in length on hatching. Under pond culture conditions rohu may reach up to 900 g within one year (Kumar, 1992; Reddy, 1999).

Spawning triggers for rohu are not well established. However, the Indian major carps require temperatures in excess of 22°C to spawn (Jhingran, 1991) and a rapid increase in water level appears to stimulate spawning activity. Flooding in the early phase of the monsoon is required and the fish do not spawn if the rains are delayed (Khan, 1947; Ganapati and Chacko, 1954 in Jhingran 1991). Rohu rarely spawn in ponds or impoundments unless induced by hypophysation (Kumar, 1992; Payne and Temple, 1996). However, natural breeding can be achieved in 'bhunds', a kind of pond that features a large catchment area so as to simulate flooding during rainfall (Kumar, 1992). Payne and Temple (1996) speculate that early peaks in conductivity and rapid rise in water temperature during the pre-monsoon period may be the early proximate stimuli that initiate gonadal maturation and upstream movement of Indian major carps in the Ganges system.

Population genetic structure

Given that rohu is a primary (obligate) freshwater fish, has a broad geographical distribution and inhabits the largest river systems in the Asian region, it is likely that some degree of population structure exists across its natural range. However, the available evidence is limited to two studies confined to Bangladesh and anecdotal reports from India. There is presently no available data on population structure over a larger spatial scale or between the major river basins.

An unpublished study conducted by the National Bureau of Fish Genetic Resources (NBFGR) purports to have identified six distinct genetic stocks of rohu in the Sutluj and Ghaggar rivers of the Indus basin; the Ganga, Rapti and Brahmaputra rivers of the combined Ganges-Brahmaputra basin; and the Mahanadi river (NBFGR website, the relevant page is no longer available online). No details were made available. Another anecdotal report (DARE/ICAR, 2003), possibly relating to the same study, indicates that genetic characterisation was conducted of six *Labeo* species including rohu across their natural range in India via RAPD profiling using 15 selected RAPD primers. The mean intraspecific genetic similarity value for rohu was 0.86±0.04, but the number of populations examined was not specified.

A comparison of genetic diversity between rohu populations in the Padma, Jamuna and Halda rivers of Bangladesh was conducted using RAPD markers (Islam and Alam, 2004). Pairwise FST values revealed a low level of genetic differentiation between population pairs, however a UPGMA dendrogram based on Nei's genetic distance segregated the geographically isolated Halda River populations into one group, and the Jamuna, Padma and hatchery populations into another group.

Khan et al. (2006) conducted a study of allozyme variation of five hatchery and three wild populations of rohu in Bangladesh. Alleles at three loci (Est-1, Gpi-1 and Gpi-2) proved variable for hatchery and river populations while Mdh-2 exhibited heterozygous genotypes for river populations only. A UPGMA dendrogram based on Nei's genetic distance segregated populations into three groups comprising i) the Padma, ii) the Halda and iii) the Jamuna plus five hatchery populations. In river populations, polymorphic loci per population (27.3 ± 5.3%), heterozygous loci per individual (15.5 ± 1.2%) and relative gene diversity (0.27 ± 0.08) were higher than those for hatchery populations (25.5 ± 1.8%, 10.7 ± 1.6% and 0.25 ± 0.01, respectively). Observed and expected heterozygosity were also higher in river populations (0.09 ± 0.03 and 0.14 ± 0.04 respectively) than in hatchery populations (0.08 ± 0.01 and 0.11 ± 0.01, respectively).The lower levels of genetic diversity observed in hatchery populations was believed to be due to inbreeding and/or genetic drift, and the lower levels of genetic diversity observed in the Jamuna population was suggested to represent recruitment from hatchery-produced seed. The high FST value observed between river populations (0.017-0.095) and the greater differentiation between the Halda and other river populations was consistent with the RAPD-based study of Islam and Alam (2004). However, in an analysis of 21 allozyme loci, Simonsen et al. (2005) found rohu sampled from the Halda and Jamuna-Padma rivers to have a close genetic relationship.

With regards to indirect indicators of genetic divergence, Reddy et al. (2002) conducted a trial of the growth and survival of wild rohu from five rivers (Ganga, Gomati, Yamuna, Brahmaputra and Sutlej) and one hatchery stock (CIFA broodstock, originally from the Mahanadi River, but bred in captivity since the early 1960s) in mono and polyculture. No effect of stock origin on survival was detected. A small but significant effect of stock origin on growth rate was detected. Overall the performance of different stocks was fairly consistent with the exception that wild stocks consistently performed equal to or better than the hatchery stock, which was believed to suffer from inbreeding depression, having been under culture for more than 30 years with infrequent introduction of external broodstock. The effect of heterosis on growth and survival of these stocks (excluding the Gomati) was later investigated in an experimental trial involving two complete diallele crosses (Gjerde et al., 2002). Little difference in performance was detected; total heterosis for each of the stock crosses in terms of survival and final harvest weight was low or negative and in most cases not significantly different from zero. The authors concluded that genetic improvement through cross breeding of Indian rohu stocks was of no practical benefit, as the genetic variance within stocks (full sib effect) was much greater than variance between stocks.

A similar trial was also initiated in Bangladesh in 1999 as part of a stock improvement programme for rohu (Hussain and Mazid, 2002). Rohu collected from the Jamuna and Brahmaputra rivers and a local hatchery stock were screened for morphological/meristic variation (number of fin rays, lateral line scales and vertebrae) and mated to produce three crossbred lines in a 3x3 diallele design. Minimal meristic variation was observed.

Conservation status, threats and management

Rohu is a widespread species and abundant throughout its natural range. It is not considered threatened at a species level. However, high fishing pressure at every stage of its life cycle and extensive habitat modification has seriously impacted the abundance of wild stocks (Payne and Temple 1996). From 1958-1966 Indian major carps represented 43.5% of total catch landed at Allahabad on the Ganges. From 1972-1976 major carps had fallen to 29% of the total catch, and only 13% by 1996.

As stock enhancement is widely practiced using both hatchery-reared and wild-caught translocated seed it is possible that homogenisation of genetically distinct rohu populations may be occurring. Insufficient information is available on population structure to make informed decisions regarding translocation. However, inbreeding as well as intentional and inadvertent hybridisation are known to be common problems in hatchery-produced rohu seed used for culture and restocking of open waters (Eknath and Doyle, 1990; Alam et al., 2002; Hussain and Mazid, 2002; Rajts et al., 2002; Simonsen et al., 2005; Khan et al., 2006).

Aquaculture

Traditional culture practices

Rohu has been traditionally cultured for several centuries at least. Day (1878) noted that rohu "...is esteemed excellent as food, and propagated with care in ponds in West Bengal". Similarly, Beavan (1877) wrote that "...rohu is perhaps the commonest of Indian fish, and the one most generally esteemed for eating purposes. It is to be found in all tanks and ponds, and, like other much domesticated fish, is often liable to variation".

Culture of Indian major carps was mainly confined to Bengal, Bihar and Orissa until around the end of the 19th century, after which it spread to other states (Jhingran, 1991). The industry was based on a traditional trade in carp seed centred in Bengal, described by Job (1951), and which still persists today. Wild spawn was harvested from the rivers during the breeding season July-September using small set nets called benchijal staked out in areas of moderate current. Spawn was temporarily stored in hapas while harvesting was underway before being packed in earthenware hundies for transportation by rail to Calcutta, where it would be on sold to the owners of ponds and nurseries. The nursing of spawn to produce fry and fingerlings extended the availability of seed to December. Seed was also produced to a lesser extent by naturally induced breeding in 'bundhs' (Kumar, 1992; Reddy, 1999).

The partition of India in 1947 divided Bengal into West Bengal (India) and East Bengal (present day Bangladesh) restricting the supply of seed to India from the main spawn collection grounds of Serajgunge, Rajshahi, Sarda and Kushthia in East Bengal. This together with the expansion of carp culture in India had led to a five-fold increase in the price of seed in Calcutta by 1950 (Job, 1951).

With the introduction of hypophysation technology in Indian major carps by Chaudhuri and Alikunhi (1957) the Indian carp culture industry quickly moved from near-full dependence on wild-caught carp seed to being dominated by hatchery reared seed. Similar trends have been reported in Bangladesh where more than 98% of all seed production now comes from hatchery sources (Banik and Humayun, 1998 in Hussain and Mazid 2002).

Above, below and following page: The fish seed market of Jessore, Bangladesh. Seed from local hatcheries and to a lesser extent wild sources is nursed in hapas in leased ponds at the market place. After reaching a larger size, seed is onsold to traders and local farmers. Seed is commonly packed in aluminium hundies or steel drums for transport by bicycle or truck.

However, wild carp seed harvesting and nursing operations continue to be locally important in some areas of Bangladesh, India and Myanmar.

Contemporary culture and trade

Since the 1970s rohu has commonly been farmed in polyculture with the Indian major carps catla, *Catla catla* and mrigal, *Cirrhinus mrigala* (some consider *Cirrhinus cirrhosus*) (Reddy et al., 2002; FAO, 2007), often with the

addition of common carp, *Cyprinus carpio* and Chinese carps (silver carp, *Hypophthalmys molitrix* and grass carp *Ctenopharyngodon idella*). Due to its wider feeding niche, rohu is usually stocked at higher levels than the other two major carps. Recently, rohu has also been cultured more intensively in monoculture system, particularly in Myanmar.

Rohu is typically reared extensively utilising fertilisation and natural pond productivity, or fed on a supplementary basis with very low cost agricultural by-products, reaching a typical harvestable size of 1-1.5kg within 12 to 18 months (FAO, 2007). In Myanmar large fingerlings of 400-500g are often stocked on contract farming arrangements with feed manufacturing companies targeting export markets (U Zaw Linn, Htoo Thit Pellet Factory, pers. comm.). These may reach 2.5kg within 10 months. Low cost pelleted feeds are used by about 20% of farmers in Myanmar.

Total world aquaculture production of rohu in 2009 was 1.27 million metric tonnes (FAO, 2011), making it the 10th largest finfish under culture in terms of volume. Major producing countries are India, Bangladesh and Myanmar. While India is by far the largest producing country, rohu culture in Myanmar had entered a phase of rapid expansion due to the comparatively recent establishment of very large estate-style farms on the order of 400ha facilitated by state concessions, investment incentives and the emergence of an export trade in rohu beginning around 1995 (Aye et al., 2007). However, extensive destruction of major farming and seed collection areas in the Ayeyarwady Delta by Cyclone Nargis in May 2008 is likely to impact production for some time.

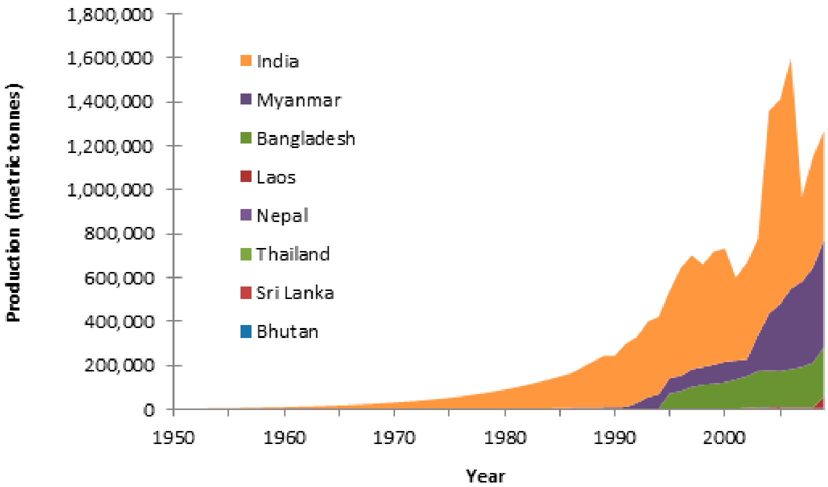
Rohu is emerging as an internationally traded commodity. Exports from Myanmar were forecast to reach US$120 million in 2007 (Aye et al., 2007), targeting largely Bangladesh and South Asian expatriate communities in the Middle East, UK and other European countries. About 40% of Myanmar's production is exported with fish 2kg and up trading for about US$1.35/kg with a premium price of $1.75/kg for fish 5kg and up (2007 prices). Fish are gutted and individually blast frozen, with fish averaging 1.5-2kg predominantly sent to the Middle East while UK markets prefer larger fish 3kg and up. A substantial proportion of the fish sent to Bangladesh is re-exported. In Thailand, farmed rohu is predominantly used in processed foods such as fish cakes, rather than sold fresh (Kamonrat, Thailand DOF, pers. comm.).

Above, below: The fish seed market of Jessore. Purchased fingerlings being transported out by rickshaw and truck.

Stock enhancement and culture-based fisheries

Significant stock enhancement of floodplains occurs in Bangladesh and Myanmar (De Silva and Funge-Smith, 2005). In Bangladesh, stocking of floodplains and beels (depressions in the floodplain that may retain water

World aquaculture production of rohu by volume 1950-2009 (FAO 2009).



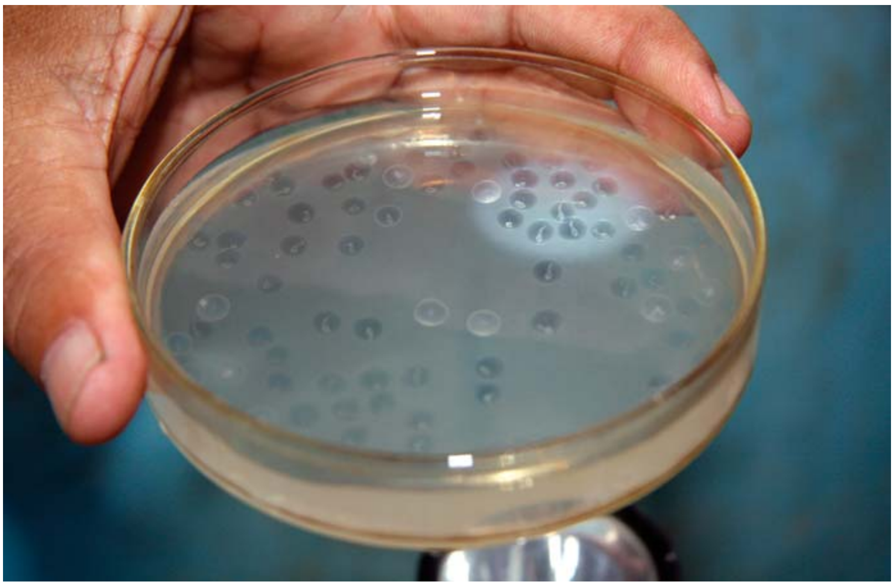
year round) commenced in 1989 with 149,500 ha of floodplains stocked over a six year period predominantly with carp fingerlings, of which rohu comprised 16-30%. This work was initiated through donor-supported development (De Silva and Funge-Smith, 2005) including the 3rd Fisheries Project (1991-1996) (Ahmad et al., 1997; Payne and Cowan, 1997).

The DOF has continued to support large-scale stock enhancement of floodplains through its carp seed restocking programme (Hussain and Mazid, 2002).

In Myanmar, rohu is released for stock enhancement on an annual basis by the Department of Fisheries (U Maung Soe, DOF, pers. comm.). Rohu fingerlings are collected from the wild by licensed seed collectors, predominantly fished from two locations in the Ayeyarwady Delta. The collectors sell to farmers and to holders of traditional lease fisheries in floodplain areas, and also give a proportion of their catch to the DOF as payment for their license. DOF distributes these fingerlings to a network of 27 government hatcheries throughout the country where they are on grown to broodstock and subsequently used to produce F1 hatchery seed, which are both released into rivers for stock enhancement and sold to farmers, or on grown to broodstock and used to produce F2 hatchery seed, before being discarded.

In India, rohu along with the other Indian major carps is one of the predominant species released into open waters and impoundments for stock enhancement and culture-based fisheries (Sugunan, 2001). By 1950 the Central Inland Fisheries Research Station had commenced large scale transfers of seed to deficit states by rail and air from Barrackpore to Hyderabad, Nagpur, Bombay, Madras, Tripura and Bhopal (Job, 1951). However comments made by Beavan (1877) suggest that stocking of rohu in impoundments may be a substantially older practice. Induced spawning of rohu through use of bhunds began as early as 1882 (Mondal et al., 2005)

Rohu is often stocked in impoundments in the mid hills and valleys of Nepal (Gurung, Nepal DOF, pers. comm.), although it does not reproduce there. It is also stocked in impoundments and wetlands as part of culture-based fisheries programmes in Sri Lanka (Pushpalatha and Chandrasoma, 2010), Laos (Arthur et al., 2010) and Vietnam (Phan et al., 2010).



Fertilised rohu eggs.

Known culture issues

Inbreeding depression and genetic drift

One of the major problems in seed production of rohu and many other cultured species in Asia is a lack of basic knowledge in broodstock management (Hussain and Mazid, 2002; Rajts et al., 2002; Khan et al., 2006). Since the introduction of induced spawning of Indian major carps in the late 1950s hatcheries have commonly recruited successive generations of broodstock from their own seed production. Hatcheries frequently maintain a bare minimum of broodstock and rarely introduce new genetic material in order to minimise production costs. This has lead to a widespread perception that seed quality has declined due to inbreeding, expressed as slow growth rates, deformities, susceptibility to disease and poor survival.

The effects of inbreeding are difficult to isolate from other variables in the farm environment, however the available evidence supports the hypothesis that genetic degradation of hatchery stocks is occurring. In a demographic study Eknath and Doyle (1990) demonstrated that inbreeding of rohu was occurring rapidly in hatcheries surveyed in India, particularly in the smaller hatcheries, with effective population size (Ne) ranging from 3.6 to 22.07 across the 18 farms surveyed. Similar trends were observed in other major carp species, suggesting that this is a widespread phenomenon.

Khan et al. (2006) conducted a study of allozyme variation in four loci of five hatchery and three wild populations of rohu in Bangladesh. Genetic diversity of river populations (average polymorphic loci per population 27.3 ± 5.3%, heterozygous loci per individual 15.5 ± 1.2% and relative gene diversity 0.27 ± 0.08) was higher than that of hatchery populations (25.5 ± 1.8%, 10.7 ± 1.6% and 0.25 ± 0.01 respectively). consistent with a previous RAPD based study by Islam and Alam (2004). Similarly, Hansen et al. (2006) found significantly lower levels of genetic variation in hatchery vs wild samples of Catla catla in Bangladesh, both in terms of expected heterozygosity and allelic diversity. Estimates of effective population size were found to be low and pairwise comparisons of genetic differentiation were low between wild samples but high between hatchery samples, suggesting strong genetic drift and inbreeding to be issues of concern in hatchery populations.

The tangible impacts of inbreeding depression have rarely been quantified in the region. However, in a comparison of growth and survival of six putative rohu stocks Reddy et al. (2002) found that wild rohu sampled from five different locations all outperformed a captive hatchery population that had been maintained at the Central Institute for Freshwater Aquaculture (India) since the 1960s for seed production purposes, largely in isolation.

Hybridisation and introgression

Indian major carps produce fertile hybrids that can be backcrossed to the parental species (Padhi and Mandal, 1997). Naturally occurring hybridisation of Indian major carps has occasionally been reported, mainly from reservoirs but also in dry bundhs (Reddy, 1999). However, natural hybrids are likely to be quite uncommon as rohu and other Indian major carps do not naturally breed in impounded waters and the major carp species maintain separate genetic identities in the wild.

Introgressed hybrids are common in hatchery reared stocks of rohu in Bangladesh (Hussain and Mazid, 2002) and probably also in India and Myanmar due to the nature of breeding practices. Mixed species of major carp (catla,

Rohu hatchery, Myanmar.

rohu and mrigal) are often spawned in a common breeding pool or tank following administration of hormone (Padhi and Mandal, 1994; Reddy, 1999, Tan Oo We, Myanmar DOF, pers. comm.). Using nuclear DNA RFLP markers Padhi and Mandal (1997) found the prevalence of major carp hybrids produced under such conditions to be around 10% in a farm surveyed in West Bengal. Mishra et al. (1998 in Reddy 1999) made similar findings (7.24-9.2 and 7.24-9.24%) in a survey of a hatchery in Uttar Pradesh, India. In an analysis of seed from a hatchery in Mymensingh, Bangladesh using allozyme electrophoresis, Simonsen et al. (2004) found around 30% of presumptive *L. rohita* to be *L. rohita* x *C. catla* or *L. rohita* x *C. cirrhosus* hybrids and 40% of presumptive *Catla catla* to be *C. catla* x *C. cirrhosis* hybrids. Similarly, an allozyme and mitochondrial DNA study of hybrid prevalence in Bangla desh by Simonsen et al. (2005) found that around 24% of all hatchery reared major carp seed were hybrids, with a few instances of backcrossing noted.

Experimental hybridisation and growth trials have been conducted on every possible combination of the Indian major carps (reviewed by Reddy, 1999). Overall results have not been particularly impressive and there appears to be little commercial demand for hybrids. However, commercial hatcheries in Bangladesh often use sperm from closely related species to fertilise eggs, particularly if there is a shortage of conspecific sperm (Khan et al., 2006).

Translocation and homogenisation of wild rohu stocks

With inbreeding, hybridisation and translocation widespread, concerns have been raised over the potential impact of hatchery-produced rohu seed on the genetic integrity of wild stocks (Hussain and Mazid, 2002; Rajts et al., 2002; Simonsen et al., 2005; Khan et al., 2006). Unfortunately very little information is available on the structure and degree of differentiation of wild rohu populations and so the significance of this issue, if any, is largely unknown. However, there are instances where human mediated hybridisation has been recognised as a threat to wild populations and species potentially leading to extinction either through demographic extinction or by genetic assimilation (Allendorf et al., 2001; Wolf et al., 2001). A regional loss of genetic integrity due to translocation has been reported in silver barb populations in Thailand (Kamonrat, 1996) Low levels of introgression have also been recorded in natural populations of the Thai walking catfish *Clarias macrocephalus* as a result of interbreeding with escaped hybrid catfish (*C. macrocephalus* x African catfish *C. gariepinus*) from aquaculture (Na-Nakorn et al., 2004; Senanan et al., 2004).

The large-scale restocking of public waters with rohu principally occurs in Bangladesh and Myanmar (De Silva and Funge-Smith, 2005). It is primarily undertaken as a development activity to support the livelihoods of poor fishers, a clear priority to governments when compared to somewhat intangible environmental issues, and so unlikely to stop. Issues of genetic integrity must therefore be addressed through improvement of practices at the hatchery level and in the seed distribution (translocation) chain (Rajts et al., 2002).

References

Ahmad, I., Bland, S.J.R., Price, C.R. and Kershaw, R. (1997). "Open water stocking in Bangladesh: Experiences from the Third Fisheries Project." FAO/DFID Expert Consultation on Inland Fishery Enhancements, Dhaka, Bangladesh, Food and Agriculture Organization of the United Nations.

Alam, M.A., Akanda, M.S.H., Khan, M.M.R. and Alam, M.S. (2002). "Comparison of genetic variability between a hatchery and river population of rohu (*Labeo rohita*) by allozyme electrophoresis." Pakistan Journal of Biological Sciences 5(9): 959-961.

Allendorf, F.W., Leary, R.F., Spruell, P. and Wenburg, J.K. (2001). "The problems with hybrids: Setting conservation guidelines." Trends in Ecology and Evolution 16: 613-622.

Arthur, R.I., Lorenzen, K., Homekingkeo, P., Sidavong, K., Sengvilaikham, B. and Garaway, C.J. (2010). "Assessing impacts of introduced aquaculture species on native fish communities: Nile tilapia and major carps in SE Asian freshwaters." Aquaculture 299: 81-88.

Aye, K.M., Lay, K.K., Win, H. and De Silva, S. (2007). "A new freshwater aquaculture practice that has successfully targeted a niche export market with major positive societal impacts: Myanmar." Aquaculture Asia Magazine XIII(4): 22-26.

Banik, R.C.K. and Humayun, N. (1998). "Fishery resources statistics." In: Fish Week '98 Compendium. Dhaka, Department of Fisheries and Ministry of Fisheries and Livestock: 100-102.

Beavan, R. (1877). "Handbook of the Freshwater Fishes of India." London, L. Reeve & Co.

Chatterjee, N., Pal, A.K., Manush, S.M., Das, T.K. and Mukherjee, S.C. (2004). "Thermal tolerance and oxygen consumption of *Labeo rohita* and *Cyprinus carpio* early fingerlings acclimated to three different temperatures." Journal of Thermal Biology 29: 265-270.

Chaudhuri, H. and Alikunhi, K.H. (1957). "Observations on the spawning in Indian carps by hormone injection." Current Science 26: 381-382.

Cuvier, B. (1817). "Le règne animal distribué d'après son organisation, pour servir de base à l'histoire naturelle des animaux et d'introduction à l'anatomie comparée." Paris, Chez Deterville.

DARE/ICAR (2003). "DARE/ICAR Annual Report 2002-2003." DARE/ICAR.

Das, T., Pal, A.K., Chakraborty, S.K., Manush, S.M., Sahu, N.P. and Mukherjee, S.C. (2005). "Thermal tolerance, growth and oxygen consumption of *Labeo rohita* fry (Hamilton 1822) acclimated to four temperatures." Journal of Thermal Biology 30: 378-383.

Day, F. (1878). "The fishes of India; being a natural history of the fishes known to inhabit the seas and fresh waters of India, Burma, and Ceylon." London, William Dawson & Sons Ltd.

Day, F. (1889). "The Fauna of British India Including Ceylon and Burma." London, Taylor and Francis.

De Silva, S.S. and Funge-Smith, S.J. (2005). "A review of stock enhancement practices in the inland water fisheries of Asia.", Asia-Pacific Fishery Commission.

Eknath, A.E. and Doyle, R.W. (1990). "Effective population size and rate of inbreeding in aquaculture of Indian major carps." Aquaculture 85: 293-305.

FAO. (2007). "*Labeo rohita* (Hamilton, 1822)." Cultured Aquatic Species Fact Sheets, 2007, from http://www.fao.org/fishery/culturedspecies/Labeo_rohita/en.

FAO (2011). "Fishstat Plus: Aquaculture Production 1950-2009." Rome, Food and Agriculture Organization of the United Nations.

Froese, F. and Pauly, D. (2008). "Fishbase." Froese, R. and Pauly, D.

Ganapati, S.V. and Chacko, P.I. (1954). "Some observations on the spawning of the Indian carps in the "bundhs" of Bengal." Indian Geographer 27(3-4): 1-17.

When hatcheries in Bangladesh have an excess supply of eggs they often use sperm from other carp species to fertilise them, or hybrids may inadvertently be produced through use of common spawning pools. This is a presumptive catla (Catla catla) x common carp (Cyprinus carpio) hybrid. The body plan is distinctively catla but the enlarged scales are typical of the mirror variety of common carp. The hatchery owner claimed there were no hybrids on his farm.

Gjerde, B., Reddy, P.V.G.K., Mahapatra, K.D., Saha, J.N., Jana, R.K., Meher, P.K., Sahoo, M., Lenka, S., Govindassamy, P. and Rye, M. (2002). "Growth and survival in two complete diallele crosses with five stocks of Rohu carp (*Labeo rohita*)." Aquaculture 209: 103-115.

Günther, A. (1868). "Catalogue of the fishes in the British Museum." London, Wheldon and Wesley Ltd. and Verlag J. Cramer.

Hamilton, F. (1822). "An account of the fishes of river Ganges and its branches." London, Edinburgh and London.

Hansen, M.M., Simonsen, V., Mensberg, K.L.D., Sarder, M.R.I. and Alam, M.S. (2006). "Loss of genetic variation in hatchery-reared Indian major carp, *Catla catla*." Journal of Fish Biology 69 (Supplement B): 229-241.

Hussain, M.G. and Mazid, M.A. (2002). "Genetic status and improvement strategies for endemic and exotic carps of Bangladesh." Genetic Management and Improved Strategies for Exotic Carps in Asia, Dhaka, Bangladesh.

Islam, M.S. and Alam, M.S. (2004). "Randomly amplified polymorphic DNA anlysis of four different populations of the Indian major carp, *Labeo rohita* (Hamilton)." Journal of Applied Ichthyology 20: 407-412.

Jayaram, K.C. and Dhas, J.J. (2000). "Revision of the Genus Labeo Cuvier from the Indian region with a discussion on its phylogeny and zoogeography. Pisces: Cypriniformes, Cyprinidae, Cyprininae." Calcutta, Zoological Survey of India.

Jhingran, V.G. (1991). "Fish and Fisheries of India." Delhi, Hindustan Publishing Corporation (India).

Job, T.J. (1951). "Fish seed industry in India." Indo-Pacific Fisheries Commission.

Kamonrat, W. (1996). "Spatial genetic structure of Thai silver barb Puntius gonionotus (Bleeker) populations in Thailand." Biology. Halifax, Dalhousie University. PhD: 193.

Khan, H. (1947). "Observations on the spawning of carp in a tank in the Punjab." Poceedings of the Indian Science Congress 34(3): 184.

Khan, R.A., Alam, M.S. and Bhuiyan, M.M.H. (2006). "Allozyme variation of hatchery and river populations of rohu (*Labeo rohita*, Hamilton) in Bangladesh." Aquaculture Research 37: 233-240.

Khan, R.A. and Siddiqui, Q. (1972). "Food selection by *Labeo rohita* (Ham.) and its feeding relationship with other major carps." Hydrobiologia 43(3-4): 429-442.

Kottelat, M. (2001). "Fish of Laos." Columbo, WHT Publications (Pte) Ltd.

Kumar, D. (1992). "Fish culture in undrainable ponds. A manual for extension." Rome, Food and Agriculture Organization of the United Nations.

Mishra, A., Jain, A.K. and Singh, S.P. (1998). "Rate of spontaneous hybridization in "mixed spawning" of Indian major carps." Fish Genetics and Biodiversity Conservation 5: 417-428.

Mondal, B., Mukhopadhyay, P.K.M. and Rath, S.C. (2005). "Bundh breeding of carps: A simple innovative technique from District Bankura, West Bengal (India)." Aquaculture Asia Magazine 10(2): 9-10.

Myers, G.S. (1938). "Fresh-water fishes and west Indian zoogeography." Annual Report of the Board of Regents of the Smithsonian Institution 92: 339-364.

Na-Nakorn, U., Kamonrat, W. and Ngamsiri, T. (2004). "Genetic diversity of walking catfish, *Clarias macrocephalus*, in Thailand and evidence of genetic introgression from introduced farmed C. gariepinus." Aquaculture 240: 145-163.

Natarajan, A.V., Ramakrishnaiah, M. and Khan, M.A. (1975). "The food spectrum of trash fishes in relation to major carps in Konar and Tilaiya reservoirs (Bihar)." Journal of the Inland Fisheries Society of India 7: 65-75.

Padhi, B.K. and Mandal, R.K. (1994). "Improper fish breeding practices and their impact on aquaculture and fish biodiversity." Current Science 66(9): 624-626.

Padhi, B.K. and Mandal, R.K. (1997). "Inadvertent hybridization in a carp hatchery as detected by nucluear DNA RFLP." Journal of Fish Biology 50: 906-909.

Payne, A.I. and Cowan, V. (1997). "Review of stock enhancement in the floodplains of Bangladesh." Dhaka, Bangladesh, Food and Agriculture Organization of the United Nations.

Payne, A.I. and Temple, S.A. (1996). "River and floodplain fisheries in the Ganges basin." Fisheries Management Science Programme, Department for International Development.

Phan, V.T., Ersbøll, A.K., Bui, T.Q., Nguyen, H.T., Murell, D. and Dalsgaard, A. (2010). "Fish-borne zoonotic trematodes in cultured and wild-caught freshwater fish from the Red River Delta, Vietnam." 10 9: 861-866.

Pushpalatha, K.B.C. and Chandrasoma, J. (2010). "Culture-based fisheries in minor perennial reservoirs in Sria Lanka: Variability in production, stocked species and yield implications." Journal of Applied Ichthyology 26: 99-104.

Rajts, F., Huntington, T. and Hussain, M.G. (2002). "Carp brood stock management and genetic improvement programme under the Fourth Fisheries Project." Workshop on Genetic Management and Improvement Strategies for Exotic Carps in Asia, Mymensingh, Bangladesh.

Reddy, P.V.G.K. (1999). "Genetic resources of Indian major carps." Rome, Food and Agriculture Organization of the United Nations.

Reddy, P.V.G.K., Gjerde, B., Tripathi, S.D., Jana, R.K., Mahapatra, K.D., Gupta, S.D., Saha, J.N., Sahoo, M., Lenka, S., Govindassamy, P., Rye, M. and Gjedrem, T. (2002). "Growth and survival of six stocks of rohu (*Labeo rohita*, Hamilton) in mono and polyculture production systems." Aquaculture 203: 239-250.

Reid, G.M. (1985). "A revision of the African species of *Labeo* (Pisces: Cyprinidae) and a re-definition of the genus." Thesis Zoological 6: 223-226.

Rüppell, W.P.E.S. (1835). "Neuer Nachtrag von Beschreibungen und Abbildungen neuer Fische, im Nil entdeckt." Abhandlungen aus dem Gebiete der beschreibenden Naturgeschichte 2(1): 1-28.

Senanan, W., Kapuscinski, A.R., Na-Nakorn, U. and Miller, L.M. (2004). "Genetic impacts of hybrid catfish farming (*Clarias macrocephalus* x *C. gariepinus*) on native catfish populations in central Thailand." Aquaculture 235: 167-184.

Shrestha, J. (1994). "Fishes, Fishing Implements & Methods of Nepal." Lashkar, India, Gupta, M.D.

Shrestha, T.K. (1995). "Fish Catching in the Himalayan Waters of Nepal." Kathmandu, Ms. Bimala Shrestha.

Simonsen, V., Hansen, M.M., Mensberg, K.L.D., Sarder, R.I. and Alam, S. (2005). "Widespread hybridization among species of Indian major carps in hatcheries, but not in the wild." Journal of Fish Biology 67: 794-808.

Simonsen, V., Hansen, M.M., Sarder, M.R.I. and Alam, M.S. (2004). "High level of hybridisation in three species of Indian major carps." NAGA 27(1-2): 65-69.

Sinha, G.M. and Moitra, S.K. (1975). "Functional morpho-histology of the alimentary canal of an Indian freshwater major carp, *Labeo rohita* (Hamilton) during its different life-history stages." Annals of Anatomy 138: 222-239.

Sugunan, V.V. (2001). "Status of culture-based fisheries in small reservoirs in India." Reservoir and culture-based fisheries: Biology and management, Bangkok, Australian Centre for International Agricultural Research.

Valenciennes, A. and Cuvier, G. (1842). "Histoire naturelle des poissons. Tome seizième. Livre dix-huitième. Les Cyprinoïdes.".

Vass, K.K., Mondal, S.K., Samanta, S., Suresh, V.R. and Katiha, P.K. (2011). "The environment and fishery status of the River Ganges." Aquatic Ecosystem Health and Management 13(4): 385-394.

Vidthayanon, C., Termvidchakorn, A. and Pe, M. (2005). "Inland Fishes of Myanmar." Bangkok, Southeast Asian Fisheries Development Center.

Welcomme, R.L. and Vidthayanon, C. (2003). "The impacts of introductions and stocking of exotic species in the Mekong Basin and policies for their control." Mekong River Commission.

Weliange, W.S. and Amarasinghe, U.S. (2003). "Accounting for diel feeding periodicity in quantifying food resource partitioning in fish assemblages in three reservoirs of Sri Lanka." Asian Fisheries Science 16(3-4): 203-213.

Wolf, D.E., Takebayashi, N. and Rieseberg, L.H. (2001). "Predicting the risk of extinction through hybridization." Conservation Biology 15: 1039-1053.

NACA Newsletter

Published by the Network of Aquaculture Centres in Asia-Pacific, Bangkok, Thailand

ISSN 0115-8503

Volume XXVII, No. 4
October-December 2012

Outcomes of emergency consultation on shrimp early mortality syndrome / AHPNS

An emergency regional consultation on "Early Mortality Syndrome" of shrimp, or Acute Hepatopancreatic Necrosis Syndrome, concluded on Friday 10 August 2012 in Bangkok, Thailand. The consultation brought together over 87 participants including international shrimp health experts, regional governments and industry to share information on this emerging disease, its occurrence, pathology and diagnosis, and to develop a coordinated regional response to the issue. The consultation was jointly organised by NACA and the Australian Department of Agriculture, Fisheries and Forestry.

Early mortality syndrome or AHPNS?

Heavy mortalities during the early stages of a shrimp crop are not unusual and there are a variety of management and pathogen related factors that can cause such losses, which are often described by the catch-all term "early mortality syndrome". However, in 2010 a new and distinctive pattern of mortalities began to be noticed, affecting both *Penaeus vannamei* and *P. monodon*.

The syndrome involves mass mortalities of up to 100% during the first 20-30 days after stocking. Affected shrimp consistently show an abnormal hepato-pancreas, which may be shrunken, swollen or discoloured; loose shells, corkscrew swimming, pale colouration and slow growth. Given that these symptoms appear to be distinctive, the name "acute hepatopancreatic necrosis syndrome" has been proposed as a more appropriate term, to distinguish this condition from other causes of early mortalities.

The syndrome was first reported from China and Vietnam in 2010, Malaysia in 2011, and in 2012 it has also been reported in Thailand. The syndrome has caused severe economic losses throughout the region. The cause is not yet known.

A case definition for AHPNS

Reporting of AHPNS has been confounded by the lack of a clear case definition, which has led to many different disease problems being incorrectly reported as "EMS". Prof. Don Lightner proposed the following animal level case definition for AHPNS, which was generally agreed on by the consultation:

Idiotpathic: No specific disease causing agent (infectious or toxic) has been identified.

Pathology: Acute progressive degen-eration of hepatopancreas from medial to distal with dysfunction of B, F, R and E cells, prominent karyomegaly and necrosis and sloughing of these tubule epithelial cells. The terminal stage shows marked inter- and intra-tubular hemocytic inflammation and develop-ment of secondary bacterial infections

Participants in the Asia-Pacific Emergency Regional Consultation on Shrimp Early Mortality Syndrome / Acute Hepatopancreatic Necrosis Syndrome.

that occur in association with necrotic and sloughed hepatopancreas tubule cells.

At the pond level, the following clinical signs could be used for presumptive diagnosis which can be further confirmed by histopathology at the animal level:

- Often pale to white within hepatopancreas connective tissue capsule.
- Significant atrophy of hepatopancreas.
- Soft shells are often observed along with partially full to empty guts.
- Black spots or streaks within the hepatopancreas are sometimes visible.
- The hepatopancreas does not squash easily between thumb and finger.
- The onset of clinical signs and mortality starting as early as ten days post stocking
- Moribund shrimp sink to the bottom.

For a more thorough discussion of the case definition and research progress on the causes of AHPNS, please listen to Prof. Lightner's presentation Characterisation, distribution, impacts and case definition (see links below).

Looking for the cause

While the apparent spread of AHPNS throughout the region suggests that an infectious or at least biological agent may be involved, thus far, laboratory challenge tests have failed to demonstrate that the disease is transmissible and no infectious agent or toxin has been identified. Testing of feeds from affected farms and two crustaceacides including cypromethrin have similarly failed to reproduce the disease. At this stage the cause is unknown, and the possibility of an infectious agent or toxin cannot be discounted.

For a detailed discussion, please listen to Prof. Tim Flegel's presentation Research progress on bacterial and viral causes of AHPNS, and Prof. Chalor Limsuwan's presentation Management of EMS – what works and what does not? (links below).

Preparing for future

As the emergence or discovery of new diseases is a regular occurrence in aquaculture, the consultation also discussed arrangements to improve response to future disease emergencies. At present, obtaining extra-budgetary funding to deal with a disease emergency often requires lengthy approvals processes and funds may not be granted until the situation is sufficiently 'hot' to persuade administrators of the need.

As successful containment of a disease is only possible during the early stages of an outbreak, participants indicated the need to develop a 'fast response' mechanism that would allow rapid deployment of investigatory or response teams. One possibility proposed was the establishment of a regional emergency aquatic animal disease fund with pre-agreed procedures for activating an investigation or response, to be coordinated by a regional mechanism such as NACA

While governments were seen as the main parties responsible for contributing to such a fund, industry representatives indicated they had also made substantial private investments in investigating AHPNS and other serious disease issues, and were open to the possibility of contributing to such a fund when a need arose.

Disease card, audio recordings and report of the meeting

The following resources are now available for download from the NACA website:

A disease card to assist with field level diagnosis.
http://www.enaca.org/modules/wfdownloads/singlefile.php?cid=10&lid=1060

Audio recordings of the technical presentations, as MP3 files.
http://www.enaca.org/modules/podcast/programme.php?programme_id=9

The final report of the meeting.
http://www.enaca.org/modules/wfdownloads/singlefile.php?cid=11&lid=1059

Our thanks

NACA wishes to sincerely thank the Australian Department of Agriculture, Fisheries and Forestry for funding the emergency consultation, and for their rapid and timely response to this issue, which has been of great assistance to the region. OIE support for the participation of OIE Crustacean disease experts is gratefully acknowledged. Finally NACA wishes to thank all the resource experts, national participants representing the competent authorities and lead research institutions, regional and international organisations and private sector for their contribution to the consultation.

Workshop on Aquaculture Planning and Management Tools

A three-day workshop on the Evaluation and Adoption of Aquaculture Assessment Tools in the Asia-Pacific Region was held from 3-5 July in Pattaya, Thailand. The purpose of the workshop was to conduct a regional evaluation study on adoption of existing aquaculture assessment tools in Asia and the Pacific, and to develop a regional strategy to promote wider application of such tools in the region.

The workshop, jointly convened by FAO, NACA and the Asia-Pacific Fisheries Commission (APFIC), was held in response to recommendations of the APFIC regional consultative workshop on "Strengthening Assessments of Fisheries and Aquaculture in the Asia-Pacific Region for Policy Development and Management" (4-6 October 2011, Yangon, Myanmar). Participants included experts from 9 countries (Australia, China, India, Indonesia, Malaysia, Philippines, Republic of Korea, Thailand and Vietnam), SEAFDEC AQD, OIE Tokyo, the SEAT project and several people from the private sector.

Participants in the Workshop on Evaluation and Adoption of Aquaculture Assessment Tools in the Asia-Pacific Region.

The workshop considered ten country case studies and develop a regional strategy and action plan for promoting wider adoption of aquaculture assessment tools in the Asia Pacific. A regional synthesis document is also in preparation, based on the case studies, and will be published in due course.

Workshop observations and recommendations

The workshop noted that the current status of aquaculture as a major supplier of fish for food is expecting to become increasingly important into the future. This is particularly the case in Asia, where a growing population, economic development and stagnant capture fisheries will increasingly require aquaculture production to fill the demand for fish. Aquaculture must achieve this against a background of increasing competition for land, water, energy and other resources such as fishmeal and fish oil required for feeds. The general trend is towards increasing intensification of aquaculture within existing areas. The workshop identified a number of key risks and concerns that face the sustainability and stability of the aquaculture sector as it consolidates and intensifies into the future:

Loss of market access due to:

- Food safety concerns, residues, contaminants.
- Inability to meet requirements for health certification (e.g. evaluation of competent authority by importing country).
- Technical barriers to trade.
- Negative consumer perception.
- Loss of production or economic impact of:
- Loss of right to use water/land/ environmental service (e.g. restriction of water, zoning).
- Farm closures due to environmental concerns (e.g. inability to meet effluent/impact standards).
- Stock/production losses as a result of environmental impacts.
- Trans-boundary diseases.
- Declining genetic quality of stock.
- Genetic or biodiversity impacts from introduction, movement or escapees.
- Poor economic viability of farms, economic impacts, social impacts.
- Small farmers inability to meet export standards.
- Burden of compliance with certification requirements.
- Rising cost of feeds/energy/labour/ inputs.
- Access to feed ingredients, notably fishmeal and fish oil.

The workshop was informed of the wide range of tools that were being applied in the region and noted that the manner of application is highly context specific. The workshop identified some key considerations relating to the use of tools for planning and management and these can be clustered into four key areas:

- Biosecurity.
- Food safety.
- Environmental and social impact/ protection.
- Animal welfare.

The workshop considered the application of the tools and particularly what action was required at national and regional level to promote wider adoption. The workshop noted that constraints on the effective use of these of the tools were due to:

- Limited incentives and awareness; long term benefits are not immediately apparent to industry/producers.

- Lack of supporting legislation, institutional mainstreaming.
- Financial constraints, cost recovery.
- Lack of capacity and technical skill to apply them.
- Lack of basic methodology or regional minimum requirements (e.g. carrying capacity, genetic risk analysis).
- Constrained access to technical information (e.g. language barrier).
- Ineffective integration between different agencies with responsibilities linked to planning and management.
- Lack of buy-in by producers wary of regulatory controls and potential increased costs.

Regional recommendations

The workshop concluded that in order the improve the application and coverage of the tools for aquaculture planning and management there were some key support which could be made available at regional level:

- Collate an aquaculture planning and management toolbox for the region. This would be based on existing source materials as well as case material from country specific applications to form a toolbox resource available as an online resource. There are opportunities to learn lessons from development of animal health systems in the region as well as EIA or other tools from other sectors. A regional consensus process would be required to harmonise the minimum requirements of the tools.
- Once tools are identified and available, initiate capacity building and adoption. A comprehensive series of course modules on tools for aquaculture planning, assessment and management will need to be developed, including a regional training course which could be used by training institutions. These training materials would contain generic guidelines.
- Promote/encourage networking for information sharing. Documentation of success stories and best practices in the application of tools relevant to the context of the region should be undertaken. A review of how tools for planning and management are used may benefit or marginalize small-scale producers.
- Develop a regional support programme. This could be done within the framework of NACA, noting that these capacity development and information sharing needs cross cut three of NACA's core thematic programmes, ie. health, food safety and sustainable aquaculture. Seeking regional support to the programme (including a request to FAO for regional TCP support) should be undertaken as a priority, and the general capacity building issue should be brought to the attention of the NACA Governing Council and APFIC 32nd Session. Member countries should consider raising this as a regional need at the FAO Sub-Committee on Aquaculture and the FAO Committee on Fisheries.

National recommendations

At the national level the workshop noted that in-country action to improve the use of the tools and their effectiveness would include:

- Scoping of the national aquaculture sector using an EAA approach to prioritise key areas where tools are required or priority issues which need to be addressed through the use of specific planning and management tools.
- Undertake a review of how the competent national agencies could coordinate more effectively in the key areas of food safety, environmental management and biosecurity. Strengthening integration and coordination such that this supports sectoral management and minimising negative impacts should be investigated. Agencies should review the legislation and regulatory implications of this and consider upgrading relevant national legislation/policy accordingly.
- The competent agency for fisheries/aquaculture should undertake awareness raising and develop a communication strategy to sensitise policy-makers, regulatory agencies, farmers over the application of the tools and their benefits to the sector.
- Develop the opportunities presented by effective public private partnerships in providing services to the planning and management of the sector (e.g. private testing systems, quarantine, EIA, certification quality testing etc.).
- Look into how national competent agencies could benefit from the effective use of services and the oversight mechanisms that ensure they effectively support the aquaculture sector.
- Provide relevant training in the use of specific tools at national level.

The workshop findings and recommendations, country papers and the regional synthesis will be published as a FAO/NACA technical publication in due course.

Workshop on Proficiency Testing Programme for Aquatic Animal Disease Diagnostic Laboratories in Asia-Pacific

The two-day regional workshop was held at Centara Grand Hotel in Bangkok, Thailand. It was organized by NACA with funding from the Australian Government Department of Agriculture, Fisheries and Forestry (DAFF) and in collaboration with Australian National Quality Assurance Programme (ANQAP) and the Animal Health Laboratory of Commonwealth Scientific and Industrial Research Organisation (CSIRO). The workshop was undertaken as a preliminary activity of the whole Regional Proficiency Testing (RPT) Programme, with the following specific objectives:

- To strengthen Asia's regional capability to diagnose important aquatic animal diseases that impact on trade, industry sustainability and/or productivity.
- To train participating laboratory personnel in diagnostic standards, and proficiency testing procedures, and to provide technical assistance to improve laboratory performance.
- To establish a laboratory proficiency testing programme that meets regional needs and which can be accessed following completion of the project.

Forty-five participants attended the workshop, representing forty-three aquatic animal disease diagnostic laboratories from thirteen Asia-Pacific countries (Bangladesh, Cambodia, China, Hong Kong, India, Indonesia, Iran, Malaysia, Myanmar, Philippines, Sri Lanka, Thailand and Vietnam). Dr. EM Leano (Coordinator, Aquatic Animal Health Programme, NACA) welcomed all the experts and participants on behalf of NACA Director General, Dr. AE Eknath, while Dr. I Ernst (DAFF) gave an overview of the project and purpose of the current workshop. The importance of aquatic animal disease diagnostics in facilitating trade and detection of transboundary diseases was presented by Dr. CV Mohan (Manager, Research and Development, NACA). Highlighted in the presentation were the serious diseases affecting cultured fish and shrimps in the region, and new/emerging transboundary diseases (i.e. IMNV and EMS/AHPNS) which are causing severe economic losses in countries where outbreaks have been reported.

Dr. HT Myint (OIE Tokyo) elaborated the different OIE standards focusing on diagnostics of important aquatic animal diseases that are present in the region. The detailed procedures on the conduct of the actual RPT were presented by Drs. N. Gudkovs (CSIRO) and S. Warner (ANQAP) where participants were briefed on how the samples will be prepared, distributed and analysed, the results form filled-up, the results sent back to ANQAP, and the summary report sent to all the participating laboratories. Confidentiality of the results submitted and reported was emphasized.

Representatives from each participating country had presented the current capacities of the different laboratories in terms of PCR diagnostics, as well as the list of priority diseases that will be included in the RPT programme. After a series of discussion facilitated by Dr. M Crane (CSIRO) and nominations from the participants, the following aquatic animal diseases were decided for inclusion in the panel of pathogens that will be used for the four rounds of Regional LPT in the next two years (2013-2014):

It was noted that not all the diseases included in the list will be sent to all of the participating laboratories during the rounds of testing. Samples to be sent will depend on the list requested by each laboratory based on their current capacity to perform PCR diagnostics for detection of the pathogen(s) involved.

Rank	Disease agent	OIE listed
1	White spot virus	Yes
2	Yellowhead virus	Yes
3	Taura syndrome virus	Yes
4	Infectious myonecrosis virus	Yes
5	Infectious hypodermal and haematopoietic necrosis virus	Yes
6	Megalocytiviruses (RSIV, ISKNV, GIV etc.)	Yes
7	Nervous necrosis viruses	No
8	Koi herpesvirus (CyHV-3)	Yes
9	*Macrobrachium rosenbergii* nodavirus (MrNV and XSV)	Yes
10	Spring viraemia of carp virus (SVCV)	Yes

Participants in the Workshop on Proficiency Testing Programme for Aquatic Animal Disease Diagnostic Laboratories.

AFSPAN Project gets underway

The first meeting of the AFSPAN Project has concluded in Penang, Malaysia, hosted by the WorldFish Center from 10 to 13 September. The inception workshop was convened to allow technical and country partners to discuss the work programme, identify in-country data gathering requirements and to develop implementation strategies for the project.

Understanding aquaculture's role in food security, poverty alleviation and nutrition

Information on the direct and indirect socio-economic impacts of aquaculture is limited in most developing countries. While aquaculture is often advocated as a tool for rural development, there are large gaps in the existing research base and many issues such as the contribution of aquaculture to human health, nutrition and micronutrients critical child development are often simply overlooked. As a result, aquaculture is often overlooked as a possible development assistance intervention, or conversely, may be introduced in inappropriate circumstances.

AFSPAN's goal is to develop methodologies that can be applied to understand the 'big picture' role of aquaculture in a development context. The project seeks to build an inter-disciplinary framework for a wholistic assessment of aquaculture across a broad range of indicators, incorporating food security, poverty alleviation and human nutrition issues and the linkages between them. It is anticipated that a better understanding of the role of aquaculture will permit more effective targeting of aquaculture-related development interventions.

Developing the framework

The crux of the workshop was a joint review of the work programme by all partners, including discussion on prospective case studies and data collection arrangements. The project is being implemented through a set of nine work packages investigating different aspects including the role of aquaculture systems, social and cultural issues, nutrition, trade and markets and international cooperation. These will contribute to the development of an integrated analytical framework for quantifying the contribution of aquaculture in a broad development context. The work programme will operate across twelve developing and low-income food deficit countries, with the involvement of 20 partner organisations.

In the coming weeks and months, AFSPAN partners will share their work and experience through the project website. If you would like to keep up to date with developments, you may like to subscribe to the email newsletter to the AFSPAN RSS feed, both of which are available at www.afspan.eu.

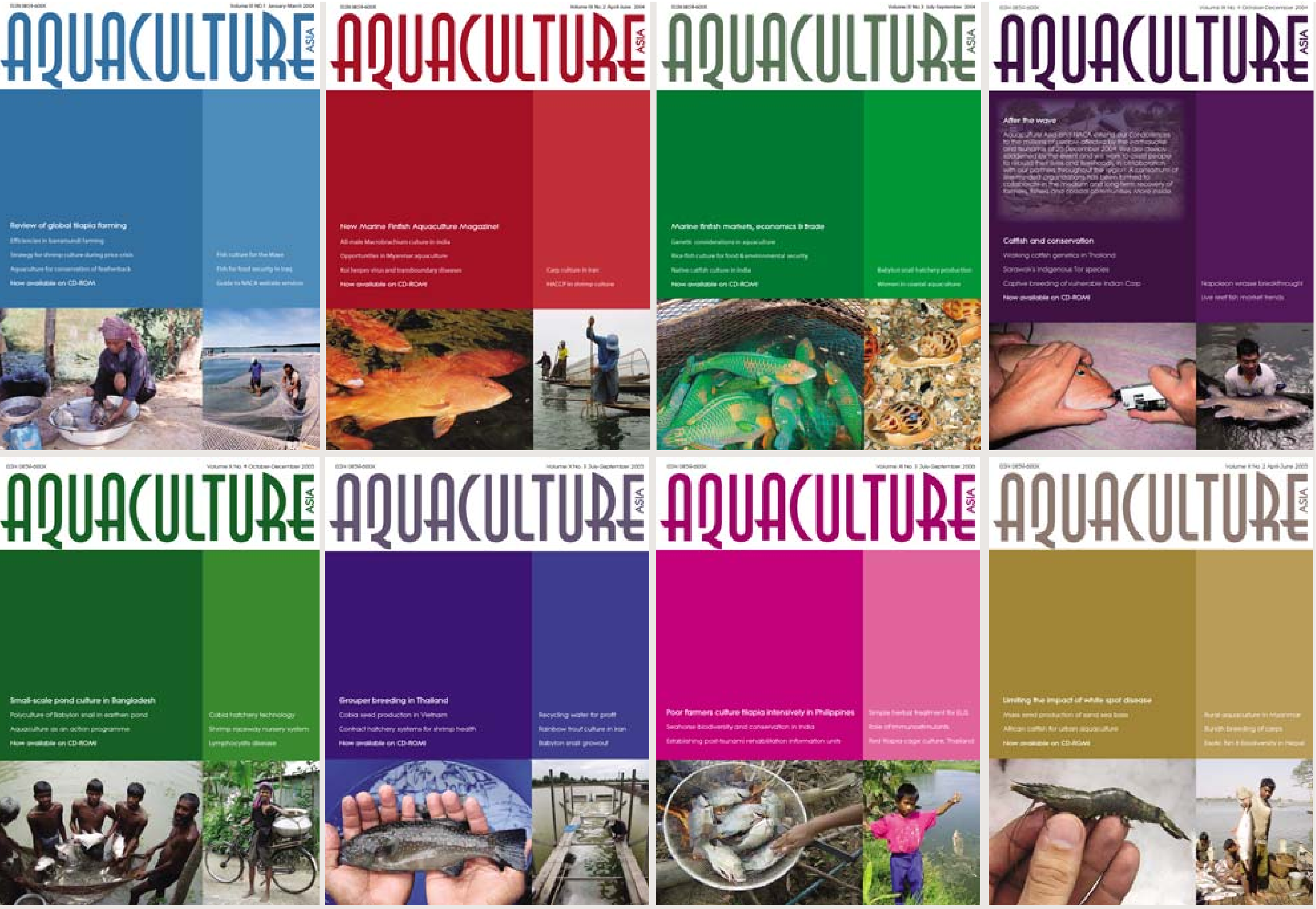
Network of Aquaculture Centres in Asia-Pacific

Mailing address:
P.O. Box 1040,
Kasetsart University
Post Office,
Ladyao, Jatujak,
Bangkok 10903,
Thailand

Phone +66 (2) 561 1728
Fax +66 (2) 561 1727
Email: info@enaca.org
Website: www.enaca.org

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

Participants in the AFSPAN Inception Workshop.


AQUACULTURE ASIA


AQUACULTURE ASIA