ISSN 0859-600X
Volume XIII No. 4 October-December 2008

AQUACULTURE ASIA

Wastewater-fed aquaculture in India

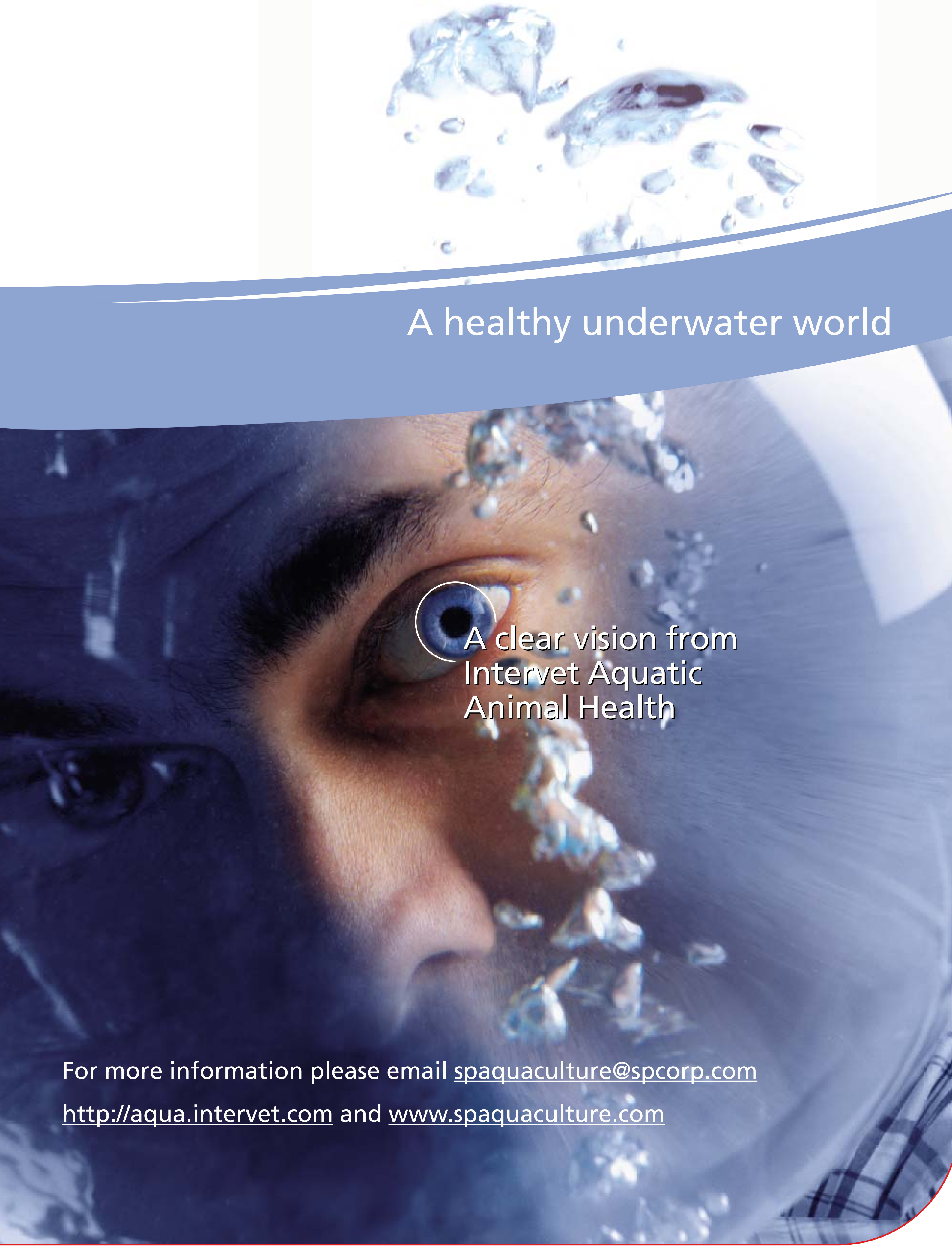
Culture-based fisheries, Laos

Catfish hatchery management, Vietnam

Mariculture in Sulawesi

Abandoned shrimp farm revival

Nodavirus: Emerging threat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AQUACULTURE ASIA

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

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Printed by

Scand-Media Co., Ltd.

Volume XIII No. 4
October-December 2008

ISSN 0859-600X

A matter of process

In the April issue I wrote a bit about the development and proliferation of competing standards for catfish aquaculture. There are a few problems with these and standards that have been developed for other aquaculture commodities to date. I remain convinced that most of the current crop will never see any significant adoption in the field, for the simple reasons that they are impractical and do not deliver much in the way of benefit to farmers. The root cause of this would appear to be something of a cultural clash between those developing the standards, and those who are supposed to implement them:

- The vast majority of Asian aquaculture is small scale and farmers are relatively poor. Aquaculture standards have to be developed and implemented *within this context*.

- Proposals for aquaculture standards tend to originate from developed nations where aquaculture is industrialised or large scale and there is a strong regulatory environment.

While the concepts behind standards are generally good, the actual process of their development is often poor, in that the consultative processes tend to be geared towards stakeholders in developed countries and fail to address important cultural differences and the socio-economic realities of small-scale farmers in the Asia region.

In developed countries it is quite common to conduct consultations by posting key documents on the web for comment and convening a few public meetings in major cities with key stakeholder groups and peak industry associations. It works because people have good access to information and communication facilities, farmers and other groups tend to be well organised with representative bodies to handle such matters, and culturally they are used to doing business this way.

But this is not an appropriate way to get the views of small-scale farmers in Asia. Most do not have access to documents on the web and they won't be emailing their comments to you anytime soon. They don't have powerful associations to lobby and represent their views. If you convene a public meeting, the odds are they won't even hear about it, let alone suspend their farming activities and travel in to engage in a vigorous debate (via translation!) about farming standards with groups representing largely foreign interests. Yet all too frequently, this is how the 'consultative process' is organised. The outcome of such processes tends to be a laundry list of presumed issues of interest to lobby groups, of which some are relevant and some are not; and arbitrary benchmarks that may be difficult or impossible for farmers to measure, let alone meet.

Consulting with small-scale farmers is not easy, yet it is incumbent on organisations that wish to develop credible standards for Asian farming systems to do so. Standards that are developed in ivory towers (from the farmers' point of view) and don't deliver a share of benefit back to them are unlikely to see significant adoption. The mark of a true standard is its adoption by the principal stakeholders, in this case, the farmers.

Simon Wilkinson

AQUACULTURE ASIA

In this issue

Page 3

Page 9

Page 12

Page 36

Page 45

Peter Edwards writes on

Rural Aquaculture

An increasingly secure future for wastewater-fed aquaculture in Kolkata, India?

A previous column 'Peri-urban aquaculture in Kolkata' (Aquaculture Asia, Volume VIII, Number 2, pages 4-6, 2003), was based on my involvement in the UK Department for International Development funded project 'Land-water Interface Production Systems in Peri-urban Kolkata'. The project addressed issues threatening the livelihoods of poor people who depended on wastewater-fed aquaculture for employment and/or as a source of relatively cheap fish.

It was pointed out that even though the fish ponds were recognised as a low-cost sewage treatment system for the city of Kolkata, the single largest threat to the system was filling in the ponds for urban and industrial development. The so-called East Kolkata Wetlands occupied by the wastewater-fed fish ponds were plagued with poor governance as an intersectoral planning and management body did not exist. Insecure tenure of the fish ponds had led to little desilting of the ponds for

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decades leading to shallow water that limited fish production. However, there was hope for improvements as the

A secondary sewage feeder canal in the foreground - nursing ponds in the middle ground and a large grow-out pond in the background.

A pond drainage outlet.

development of a new city to the north of the East Kolkata Wetlands had created a market demand for silt as landfill; and the East Kolkata Wetlands had been designated as a Ramsar 'Wetland of International Importance' in 2002 on the basis of wise use to produce a range of goods and services, especially a low-cost, efficient and eco-friendly system of sewage treatment and a habitat for diverse flora and fauna including waterfowl.

Five years later I was back earlier this year to assist Dr Stuart Bunting of the University of Essex, UK with an Asia Development Bank (ADB) funded project on 'Capacity building for the East Kolkata Wetlands'. We assisted the recently established East Kolkata Wetlands Management Authority (EKWMA) to prepare sections of an Environmental Management Plan for the East Kolkata Wetlands.

Overview

There are 254 wastewater-fed fisheries occupying an area of about 3,800 ha, the largest wastewater-fed system in the world, treating the city sewage and producing an average yield of 4 tonnes/ha of carps and tilapia. Details on the functioning of the system were provided by Dr Nandeesha in his article 'Sewage-fed aquaculture systems in Kolkata, a century-old innovation of farmers (Aquaculture Asia Volume V11, Number 2, pages 28-32, 2002).

Passing the 'The East Kolkata Wetlands (Conservation and Management) Act, 2006' represented a major constitutional commitment to preserving the wetlands for current and future generations. The Act presents a schedule of landholdings within the East Kolkata Wetlands, specifying their character and mode of use; and sets out the functions and powers of the EKWMA. A preliminary task of the EKWMA has been to develop the four sections of the environmental management plan in consultation with stakeholders, ie: Aquaculture Management Plan; Wastewater Management Plan; Waste Recycling Plan; and Best Practices Plan. We also prepared an Environmental Management Manual to support implementation of the East Kolkata Wetlands EMP with a summary of the main production systems in the East Kolkata Wetlands, highlighting constraints threatening specific production sectors and wise-use of the wetlands generally, and outlining Best Practices that should be promoted amongst wetland managers, user groups and other stakeholders to help safeguard and enhance the wetlands. Specific guidance in the manual includes Best Practices relating to upgrading and maintaining the canal system and fishponds; implementing the WHO guidelines for safe wastewater use; and prospects for enhanced aquaculture production.

Sustainable canal and fish pond rehabilitation, operation and maintenance

Two major constraints to more effective treatment and reuse of wastewater in the East Kolkata Wetlands fish ponds are insufficient wastewater entering the fish ponds; and reduced pond depth due to siltation. These are currently being addressed through various initiatives in various stages of implementation.

Wastewater from the inner city of Kolkata with about 4.5 million people, an average daily flow of wastewater of 1.1 million m^3, is not treated by a conventional sewage treatment plant but an estimated 30-50% of the sewage is treated by the maturation/ fish ponds of the East Kolkata Wetlands. Sewage mainly enters the fish ponds during 270-300 days of the year as the regulator gate at Bantala on the main sewage canals leading from the city is kept closed during the dry season to raise the level of wastewater in the canals so it flows into fish pond feeder canals and then into the ponds. However, the regulator gate is kept open during the monsoon season to lower the water level in the main canals to prevent flooding in the city. Thus, during the monsoon season the level of the fish pond feeder canals is usually too low to permit wastewater to enter the fish ponds by gravity. Farmers complain of inadequate wastewater to feed their ponds, especially in the rainy season. Increased wastewater flow would also allow up to 1,000 ha of former fish ponds currently being used to grow rice to be converted back to more economically attractive wastewater-fed fish culture. Several hundred hectares have already been reconverted to fish ponds from rice paddies over the last few years.

The overall aims of the current ADB-funded Kolkata Environmental Improvement Project (KEIP) of the Kolkata Municipal Corporation (KMC) are to provide better flood control of Kolkata and to improve environmental protection. A specific aim is to improve wastewater handling in the East Kolkata Wetlands to provide stronger wastewater to feed the fish ponds. KEIP is to separate currently mixed dry weather flow and storm weather flow at the main city pumping stations. It is proposed to construct a siphon just upstream of Bantala so that the entire dry weather flow throughout the year will be channeled into the fish ponds. The present fish pond intake at Bantala is to be abandoned so that the regulator gate can then be used solely for flood control, thereby resolving the conflict with fisheries. The main dry weather flow channels between the city and the fisheries are also being desilted. Two existing semi-derelict siphons on the main dry weather flow canal that feed fish ponds in the southern East Kolkata Wetlands area will also be upgraded to increase sewage flow.

The construction of sewerage and drainage networks by KEIP in areas outside the inner city will result in increased quantities of sewage. KEIP initially intended to construct two new sewerage treatment ponds to serve the new sewage and drainage networks but it is unlikely that these will be built as a recently completed study by Jadavapur University has concluded that the East Kolkata Wetlands can absorb the additional quantities of sewage from the outer city areas, only an estimated 13-14 %. KMC has decided to allocate KEIP funds from financial savings in the construction and operation

The regulator gates at Bantala which control the level of wastewater in the main canal.

The fish feeder channel at Bantala.

A satellite map of the East Kolkata Wetlands pond system.

of the sewerage treatment ponds to improve the supply and distribution of wastewater for the East Kolkata Wetlands fish ponds.

A project managed and coordinated by the Department of Housing, Government of West Bengal (WBHIDCO, 2004) has been implemented to deepen the fish ponds with the excavated silt used for land fill for an urban development to the north of the East Kolkata Wetlands, New Town or Rajahat.

We also recommended that KMC consider introducing a sewage tax derived from the central city to be used to maintain the main wastewater feeder canals to the fish ponds as the East Kolkata Wetlands provides an ecological service to the city by treating its wastewater. This saves an estimated total investment of US$ 125 million, excluding annual operation and maintenance cost, to treat the sewage from the inner city by conventional mechanical secondary sewage treatment.

Safe use of wastewater in aquaculture

The World Health Organization (WHO) has recently published revised guidelines for the safe use of wastewater in aquaculture. WHO recognizes that the use of wastes in aquaculture can help communities to grow more food, increasing household food security and improving nutrition for poor households in farming communities and urban areas and make use of precious water and nutrient resources, helping to achieve the United Nations Millennium Development Goals 1: Eliminate extreme poverty and hunger, and 7: Ensure environmental sustainability.

WHO recommends that practices and targets should be based on local social, cultural, environmental and economic conditions and be progressively implemented over time depending on current reality and existing resources, leading to continual improvement of public health. This is because introducing overly strict standards may not be sustainable and, paradoxically, may lead to reduced health protection because they may be viewed as unachievable and thus be ignored.

Health hazards

Various hazards are associated with waste-fed aquaculture: excreta-related pathogens (bacteria, helminths, protozoans and viruses), skin irritants, vector-borne pathogens and toxic chemicals. Fish passively accumulate microbial contaminants on their surfaces but they rarely penetrate into edible fish flesh or muscle except trematodes. The relative risk of disease from bacteria e.g. *Salmonella*, Protozoa e.g. *Giardia*, and viruses e.g. hepatitis, is low to medium although there are always high concentrations of microbes in the gut of fish. The major health hazard associated with wastewater-fed aquaculture is from food borne trematode worms (intestinal, liver and lung flukes) and schistosomes (blood flukes). Fortunately, their restricted geographical range excludes India. The risk from vector-borne pathogens e.g. malaria, is nil to medium, with no specific risk associated with aquaculture as mosquito larvae are readily consumed by fish.

Dredging the main sewage canal above above Bantala.

Manual desilting of a fish pond.

A large farm-level sewage pump.

Regarding the risks from chemicals, that from antibiotics is nil to low as they are not usually used in wastewater-fed aquaculture. The risk from heavy metals is low as most are likely to be removed by settling in the anaerobic wastewater canals supplying the fish ponds and by precipitation in the alkaline water of the fish ponds. Although they may accumulate in fish, concentrations of heavy metals from fish raised in wastewater-fed aquaculture do not usually exceed levels recommended by the Codex Alimentarius Commission. The

Pumped sewage distributed on a farm.

Small fish ponds converted from rice fields with a sewage feeder canal in the foreground.

Harvesting fingerlings from a nursery pond.

Final harvesting of fish by seining a large pond. Note the shallowness of the water.

A harvest of small carp.

A harvest of small Nile tilapia.

Government of West Bengal is making steps to prevent the discharge of industrial wastes into municipal wastewater and is relocating polluting tanneries from the city. The risk from halogenated hydrocarbons is low as they are generally in low concentrations in wastewater and fish raised in wastewater usually show only low concentrations.

Transporting fish to market on foot and by bicycle.

Arrival of fish at a wholesale market.

Purchased fish being kept alive by manual agitation of water in containers on a truck at a wholesale market.

Health protection measures

A variety of health protection measures can be used to reduce health risks to fish consumers, workers and their families, and local communities. It is recommended that reduction in the risk of exposure to pathogens be achieved by a combination of interventions or barriers i.e. constructing "multiple barriers" to prevent exposures to pathogens and toxic chemicals.

There is rapid die-off of pathogens in wastewater-fed "green water" ponds due to intense phytoplankton photosynthesis and high pH which is lethal to enteric pathogens so it is recommended that wastewater flow into fish ponds be suspended before harvesting fish to allow for die-off.

Aquacultural workers should limit their exposure to wastewater, in either the feeder canals or in ponds in which wastewater is being introduced. They should rinse their skin thoroughly with clean water after contact with wastewater or pond water contaminated with wastewater. Aquacultural workers as well as local communities should be provided with access to safe drinking water and adequate sanitation facilities. They should practice good personal hygiene, especially thoroughly hand-washing with soap and water prior to food preparation and eating, after defecation and after cleaning a baby's faeces.

Market hygiene should be improved by provision of clean water to transport fish and to handle fish at the market, as well as provision of adequate sanitation facilities at markets. Although pathogens rarely occur in fish muscle they may occur in fish intestines so prevention of cross-contamination with other food in the kitchen is essential when fish are being prepared for cooking. Cross-contamination of foods in the kitchen is the greatest risk which is reduced by hygienic processing and cooking.

The risk from infectious diseases from wastewater raised fish is also significantly reduced if the fish are thoroughly cooked before being eaten as with Bengali cuisine.

Towards enhanced fish production and profitability

Fish production and profitability of the East Kolkata Wetlands ponds are relatively low for semi-intensive fish culture compared to Andhra Pradesh (see my column in Aquaculture Asia, Volume 13, Number 3, Pages 3-7, 2008). Some East Kolkata Wetlands farms attain annual yields of 5-7 tonnes/ha but mostly farms produce 3-5 tonnes/ha, only one third to one half of sustainable production from well managed semi-intensive fish culture.

The major species currently farmed in the East Kolkata Wetlands (carps and Nile tilapia) are appropriate species for semi-intensive fish culture but improved strains would considerably increase production. Production of rohu could be increased by stocking an improved strain of rohu that has been developed by a Norwegian funded project through the Central Institute of Freshwater Aquaculture and tilapia production could be increased considerably by importing improved strains of Nile tilapia from Thailand. Production of large-sized tilapia is facilitated by use of mono-sex culture which should be explored alongside the introduction of improved strains.

As farming tilapia is still officially banned in India, permission would need to be sought to import new strains even though the species is a major component of production in the East Kolkata Wetlands.

Fish culture in much of the East Kolkata Wetlands is currently constrained by shallow ponds and inadequate distribution of wastewater although these are being rectified as discussed above. The widespread use of farm-level pumps to fill ponds with wastewater should eventually be unnecessary and this would increase profitability.

Supplementary feed is required to maximize the profitability of semi-intensive fish culture. This is best used later in the growth cycle to enable the fish to continue to maintain a rapid growth rate when they exceed about 100 g individual weight. Natural food alone is insufficient for larger sized fish to continue to grow and increase in weight. Although supplementary feed is used in the monsoon season to compensate for inadequate wastewater, its effective use is constrained by large pond size and harvest of relatively small-sized fish. The latter is a consequence of labour unions demanding excessive seining of ponds; although it leads to the production of relatively small and cheap fish affordable to the poor, it reduces the potential production and profitability of aquaculture in the East Kolkata Wetlands. The production of higher yields of large-sized fish in at least some ponds would improve the economic efficiency of fish production and at the same time lead to greater economic development and provision of jobs for poor workers. This should be explored through tripartite negotiation between fish producers, farm worker unions and government agencies. A three-stage system of nursing, rearing and grow-out ponds is utilized by some farms but, as discussed above, the most profitable way to farm fish is to stock large fingerlings of 100-200 g (the current size of final harvest) and harvest them only after their growth declines as larger fish fetch 2-3 times higher a price in local markets than small-sized fish.

First culture-based fisheries growth cycle in Lao PDR is overwhelmingly encouraging

Sena De Silva, NACA Director General

The first growth cycle trials for the project *Culture-based fisheries development in Lao PDR* were completed in May-June 2008. Although the rains occurred earlier than normal and restricted harvesting, the results obtained even with a partial harvest are extremely encouraging. All indications are that culture-based fisheries activities (CBF) are going to be adopted by many communities, including by some neighbouring villages acting on their own, and will contribute significantly to their nutritional, financial and social well being in the years ahead.

The objective of this ACIAR-funded project is to develop applied production models to optimize yields from culture-based fisheries in flood plain depressions and reservoir coves, thereby improving food fish availability and income generation. The project is being undertaken in eleven villages in two provinces of Lao PDR.

Community engagement in harvesting, Thong Van Village.

All fishery communities participating in the project - formed from farming communities with access to water bodies - gained significantly, not only in financial terms but also in the way of community development and well being. Individual communities have met at least once or twice a month and made collective decisions with regard to maintaining stocks, harvesting procedures and dates. They have also agreed on marketing strategies that include fixing a minimum saleable price for individual species of fish, and most important of all, the manner in which the profits are to be shared.

All communities without exception made substantial profits from the first year of activity, and deposited sufficient funds, ranging from 3.5 to 6.5 million kip (US$1 = 8,700 kip) to purchase fingerlings for the next stocking. The manner in which the rest of the profits were disbursed varies between communities. For example, all households engaged in the fishery activities were allocated a sum ranging from 3.5 to 6.0 million kip, depending on the returns, and in some communities those engaged in the activities were also paid a daily wage for their inputs, such as for guarding the stock. The entire village, including those households that were not actively engaged in fishery activities, was allocated 2 to 4 kg of fish per household for consumption, and fish were also contributed to social functions.

In some communities the proceeds from the harvests, after depositing funds for the purchase of new seed stock, were used entirely for community activities. For example, in the Thong Van Village (Paksan District, Borikhamxay Province) the funds were used to upgrade the village temple, and this community plans to use its future profits to upgrade the village school and so on. In other communities, in addition to sharing the profits amongst stakeholders, a certain proportion was used for community benefits such as the purchase of two hand tractors and repairing the village electricity transformer.

It was also evident that every community involved in the project has been contacted by neighbouring village communities with regard to the possibilities of their commencing CBF activities as well. In this regard two additional communities adjacent to Hoay Xi Village (Van Vieng District, Vientiane Province) have already commenced CBF in coves in the upper reaches of Nam Ngum Reservoir.

There are many factors behind the success of CBF in Lao PDR, which is likely to become a major extensive aquaculture activity in the country, providing significant subsidiary income to rural farmers, improving nutrition and contributing to the well being and harmony of communities. CBF activities in Lao have previously been undertaken in a somewhat under-developed form. The project has brought in some technical improvements, such as in the choice and ratio of species to be stocked, larval to fingerling rearing in hapas in the same water body as a means of reducing mortality of seed stock and engagement and organization of the community into fisher groups. The active participation of fishery personnel, headed by Mr Bounthong Saphakdy, Head of the Fisheries Division, Department of Livestock and Fisheries in the Ministry of Agriculture & Forestry, has facilitated better community organization for conducting the activity, for disseminating the principles of CBF and the benefits thereof, and for effecting inter-community exchange of ideas.

Envisaging the popularity of this activity, the project has begun to address potential bottlenecks in sustaining it. The foremost concern is to ensure that high quality seed stock is available to farmers. In this regard the project, in conjunction with the Department of Livestock and Fisheries, is proceeding to rationalize seed production in key hatcheries such as the Lao-Singapore Fisheries Station in Vientiane Province. In addition, the project is working closely with selected private hatcheries such as Mitsamphanh Hatchery. The seed stock utilized consists of indigenous species such as *Labeo chrysophekadion* (pa phia), which is much preferred by the consumer and commands a relatively high price (15,000 kip/kg) as opposed to exotic species such as silver carp (10,000 kip/kg). The project envisages in developing proper broodstock management plans for such key species in order to assure assist in maintaining seed quality.

Regular community dialogue is a key to success of CBF activities in rural Lao.

Temple improved using CBF earnings, Thong Van Village.

For more information visit the project web page at:

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

Revival of abandoned shrimp farms in Krishna District of Andhra Pradesh

National Centre for Sustainable Aquaculture (NaCSA)

Chinnapuram Village in Machilipatnam Mandal of Andhra Pradesh is one among the many villages with a large number of abandoned shrimp farms in Krishna district. Out of the1200 ha of pond area in the village around 800 ha is abandoned while farmers continue farming shrimp in the remaining area, where average productivity is very low due to poor farming and management practices. Farmers feel lucky if they harvest 50 kg shrimp/ha after four months of crop.

The National Centre for Sustainable Aquaculture (NaCSA) invited Chinnapuram farmers to a field day organized in Penduru (Bantumilli Mandal) during June 2008 (see NACA Newsletter, page 47). After witnessing the success of the Penduru society farmers during the field day, the farmers of Chinnapuram formed a society comprising 39 farmers (65 ponds, 38 ha) and for the first time purchased quality seeds through a joint contract hatchery system where they placed bulk orders to a hatchery, 45 days in advance of the planned stocking date, for production of required quantity and quality of seeds.

All the farmers in the new society agreed to use a uniform stocking density of 20,000 PL/ha and stocked their ponds at the same time thus avoiding any cross contamination. Farmers followed better management practices (BMPs) during grow out, avoided unwanted chemicals and kept their production cost to minimum through better feed management and by making use of amphipods grown in the ponds. Amphipods play an important role as source of nutritious food in the shrimp pond when the stocking density is low. Some of the Chinnapuram farmers have achieved a count of 20 tails/kg (50 g) in less than 100 days where amphipods are abundant in ponds. We have taken up amphipod culture demonstration in societies; more and more society farmers are interested to learn about this low cost and highly beneficial technology which can help small farmers immensely in reducing production costs. The society coordinator who was trained by NaCSA monitored all society ponds for water quality and ensured that best of the conditions were maintained.

Twenty farmers of Chinnapuram have harvested their crop so far. The average production per ha is 300 kg of 30 to 55 gm shrimp. The average FCR of harvested ponds is <1.0. The harvested farmers have made a profit of Rs. 45,000/ha/crop (in less than 100 days) which is five times the profit they use to make prior to intervention of NaCSA. We expect better profit for remaining ponds which are yet to be harvested. More than 80% of society farmers will make very good profit and all of them are very happy with the successful outcome. All the society farmers are willing to invest some part of the profit to deepen their ponds, strengthen the bunds and repair the common inlet and outlet canals which could further increase the productivity of their ponds in the coming summer crop. The detailed economic analysis of crop outcome will be prepared after complete harvest of all the ponds.

In order to create a wider awareness on the revival of shrimp farming, NaCSA organized a “Farmers Field Day” on 16th October, 2008 at Chinnapuram, Krishna District to allow others to witness the successful harvest of society farmers and also to discuss “the success of farmer societies through participatory approaches” on the occasion of the Kesavaswamy Aquafarmers Welfare Society’s successful crop outcome. More than 200 farmers participated in the event from Krishna and neighbouring Guntur District of Andhra Pradesh. The function started with welcoming of all the farmers by Sri. Rajkumar, Project Coordinator followed by brief introduction by Umesh N.R., CEO, NaCSA. Sri. Saifuddin Anis, Deputy Director of MPEDA urged participants to follow the example of the Chinnapuram farmers and achieve success in each and every society of Krishna District. Sri. Venkateswara Rao, president of Kesavaswamy Aquafarmers welfare society, sharing his society success with the invited farmers, explained in detail the better practices followed in the society starting with contract hatchery system. He mentioned that most of the Chinnapuram farmers had previously abandoned shrimp farming and remaining few had been on the verge of abandoning it completely due to failings in successive crops that had devastated their lives for almost 14 years since the outbreak of white spot disease in 1994. This successful crop is a turnaround in their lives which has provided a ray of hope for better future, and a motivation for other farmers in the village to organize themselves as aquaculture societies.

There was a very good direct farmer to farmer interaction during the meeting which made this field day a very successful event. Participant farmers were also keen to know more about the procedures for registration of their farms with CAA, procedures followed in contract hatchery system etc. which were explained in detail by Sri. A.B. Chandra Mohan, Regional coordinator of NaCSA.

The success of Chinnapuram farmers is being widely published through print and visual media for the benefit of rest of the farmers in the district. So far six societies have been formed in this village and many more farmers are coming forward to follow suit. More than 200 farmers (eight to ten societies) of Chinnapuram and about 1,000 farmers (40 societies) from other parts of Krishna district directly benefit through society concept in summer crop of 2009. This could be the beginning of revival of shrimp farming in abandoned areas of Krishna district. With some policy support most of the abandoned farms in Krishna District can be revived within next two years.

Positive impact and outcome of this demonstration:

- Chinnapuram Society farmers have achieved a successful crop for the first time in more than 14 years.
- Farmer unity and procurement of good quality seed through a contract hatchery system were the key reasons for the success.
- Reduced cost of production through efficient use of resources and no use of chemicals.
- Low cost amphipod culture techniques will be made popular among farmers in societies during coming summer crop.
- Farmers from neighbouring villages and other parts of Krishna District who have abandoned shrimp farming for some time are getting encouraged by the success of society farmers.
- Farmers from neighbouring district of Guntur who participated in the field day were also keen to follow the society concept in summer crop of 2009.

Growth of forward and backward industries linked with aquaculture in Kolleru Lake area, Andhra Pradesh, India

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India is the second largest producer of fish through aquaculture in the world, next to China, with more than seven million people directly engaged in the fisheries and aquaculture sector. While states such as West Bengal, Orissa and Assam have a long tradition of aquaculture, others with high potential such as Punjab and Haryana are also becoming more involved, in addition to the already established Andhra Pradesh, an east coast state in southern India that has the second largest freshwater fish production. Culture of the Indian major carps in earthen ponds represents the first phase of aquaculture in this state, which has been sustained for more than quarter of a century.

The major part of fish production of Andhra Pradesh is from the Kolleru area. Kolleru Lake is the largest natural freshwater lake in India, located between the deltas of the Krishna and Godavari rivers, with a surface area of around 901 km^2 at +10' MSL contour. Kolleru Lake serves as a natural flood balancing reservoir for the two rivers. The lake is fed directly by the seasonal Budameru and Tammileru rivers and is connected to the Krishna and Godavari systems by over 68 inflowing drains and channels. The lake is an important habitat for a variety of resident and migratory birds, including the Grey or Spot-billed Pelican. A notified wildlife sanctuary, the lake was designated a wetland of international importance in November 2002 under the International Ramsar Convention.

The Kolleru region is inhabited by a population of 200,000 people (1981 census) distributed in 60 bed habitations and 98 belt habitations spread over in 73 revenue villages including hamlets. The bed villages are island villages and the belt villages are border villages of lake. The major occupation of the residents in the bed habitation is fishing. The major occupation of the people of the belt habitation is agriculture which includes the cultivation of the lakeside areas in the upper reaches. Kolleru has been dominated by capture fisheries and aquaculture practices in this region were initiated in the 80's and have undergone rapid expansion and intensification taking the carp culture area in Andhra Pradesh state to about 80,000 ha. Almost 98% of the carp culture in Andhra Pradesh state is developed in and around Kolleru. Freshwater aquaculture incorporating carp species is a popular enterprise in Kolleru Lake region. The semi-intensive culture system practiced by the farmers has a production range of 7.5 – 12.5 metric tonnes/ha/year and contributes the major share to annual state production of 600,000 metric tonnes, achieved by growing basically two species rohu (80%) and catla (20%) with rare addition of mrigal or other species, in heavily fed and fertilized ponds of different sizes (Ramakrishna, 2007). In the course of time fish farming in this region has gathered a lot of momentum and grown into a substantial industry, stimulating the growth of a number of subsidiary industries. This has boosted the rural economy of the region with a huge potential for additional income and employment generation. The system is not only supporting thousands of people engaged directly in farming but also hundreds of thousands of people in allied industries and services. Taking into account this huge potential of aquaculture development in Kolleru Lake, a survey was conducted to study the growth of various backward and forward linkage industries related to aquaculture because input and supply agencies, services etc. form an important value chain in aquaculture systems.

Growth of fish needs centres.

Widely used plastic tanks and oxygen cylinders for live seed transportation.

Methodology

The authors made personal visits to the sites to take stock of the prevailing situation through close observations of the operations as they were being performed, and through interaction with the farmers, members of fishermen communities, farm managers, entrepreneurs, industrialists, suppliers and providers of various services engaged in different stages of value chain during 2007. Facts have also been gathered from various secondary published sources for an in-depth study.

Salient observations

Unlike traditional fishing activities geared mainly to self-consumption or for local marketing, fish farming has been mainly conducted as a business venture where production is undertaken primarily to meet the market demand. Increasing demand for fish in domestic markets and the complex network that affects the supply and price of fish is influencing aquaculture production both at national and regional levels. The study reveals that aquaculture practices in Kolleru Lake, although initiated in the eighties have added a new dimension to the economy of the region within a very short period, with the lake recognised by the FAO as one of the fastest growing aquaculture sites in the world.

As a growing economic activity, aquaculture has made it possible to introduce and try new and improved technologies, which have opened up new opportunities such as hatchery production of fish seed, feed production units, input suppliers, aqua-shops, net making units, ice plants, packaging industry and transport networks. In the process it has promoted the growth of a whole chain of activities, from hatcheries to marketing to retailing and export of fish and prawn, that have not only added value to the product, but also increased the demand and profitability of aquaculture at the farm level.

Kolleru aquaculture, as a business venture is undertaken primarily for the markets located at Kolkata, eastern, north and northeastern states of India and even Bangladesh. The latest survey indicates that progressive farmers are trying to establish post harvest facilities eyeing the markets of Thailand, Singapore, Vietnam and other Asian countries.

Growth of forward and backward linkage industries in aquaculture

Aquaculture in the Kolleru Lake area has had a significant positive effect on rural and urban fish supply and on income and employment generation. We have observed that there is a well-established linkage of aquaculture with various forward and backward industries. It is noteworthy that plastic tanks and oxygen cylinders are available on the road side in many places on the highway connecting Eluru and Bhimavaram. These are given out on rent for transportation of fish seed in the Kolleru lake area. This business has creating a significant scope for employment. We have also observed that the whole chain of activities beginning from the backward linkage

Growth of poultry farms.

Growth of boatmaking industry.

activities of production and marketing of fish seed, feed and other inputs like fertilizers and medicines, and forward linkage activities of icing and packing, transportation, storage, processing and retailing of the product have also made significant contribution to employment and income generation and revitalized aquaculture by opening up far-off markets.

Another important cottage industry that has arisen in the area is boat making. Boats are made of discarded telephone poles which are flattened in the industry before being used as a basic raw materials. The majority of ponds in Kolleru Lake area are large in size. Hence boats are frequently used for applying fertiliser, feed, lime and other inputs. The presence of poultry farms around Kolleru offers a supply of poultry manure, a basic organic input for pond fertilization, at a low price.

Many fish need centers and aqua-shops have come up in Eluru, Bhimavaram and neighbouring areas catering to range of farmers' requirements by providing inputs and information services to them.

The large pond size has made it feasible to go for a high degree of intensification. Producers have a high production potential and do have access to the capital or credit, which is required to take up aquaculture on a larger scale. They have also high risk bearing capacity, which the small farmers do not have. Kolleru aquaculturists being resourceful have better purchasing capacity of all the inputs required for production. They are better educated and experienced. Wherever suitable they can even think of integrating the aquaculture with other farming practices for higher profit and optimum utilization of resources.

The entire process of aquaculture seems to have been stimulated through interventions at three levels: (i) commercialization of production through adoption of scientific technologies and market-oriented approach (ii) development of forward linkages through improved post-harvest services like packaging, processing, storage, transport, efficient marketing systems and opening up of new markets as well, and (iii) backward linkages through the provision of inputs like seeds, fertilizers, manures, feed, medicines and aquaculture machinery. Wider availability of land resources in both size and suitability and assured supply of water has led to the commercialization of aquaculture production at Kolleru Lake area.

Rice mills are supplying huge quantities of husk to packers.

Production from the aquaculture ponds have efficient forward linkages with marketing chains. The marketing infrastructures are organized and efficient. The harvests are segregated and graded. There are several ice factories and rice mills supplying ice and husks for packaging of fishes.

Rice mills around Kolleru lake area have paved the way for successful aquaculture. They supply cheap rice bran, an important ingredient for fish feed. Husk produced at rice mills is used in packaging of fish as an insulator to maintain the cool conditions for a longer time, and can considerably slow the melting of ice. The labourers involved in packaging are efficient in quick packing of the produce whether at the pond site or at the ice factory premises. The organized transport agencies in the locality play a very important role in transporting the fishes to various places of the country quickly and efficiently. Producers sell the produce to the contractors, who in turn send the produce to different wholesalers located at various locations. Finally the consumers get their fish from the retailers/ venders who have got it from the wholesalers.

Growth of aquaculture has led to simultaneous growth of ancillary industries such as ice factories, feed mill plants, packaging centers and lorry supply agencies. Due to mass fish production many ice plants have been established in the local village areas namely Jalipudi, Sreparru, Pedapadu, Kalakarru, Singapuram, Akiveedu and other places. The ice is being used for packaging and keeping the fish fresh for several days. The ice plants are observed to employ many people for its operation who earn a good income. The credit for their well being goes to aquaculture development. Ice factories are the forward linkages of aquaculture. The husks from the rice mills are also used by the packers to prevent the ice melting for hours due to non-conductive nature of the material.

Along with huge export potential, the lorry supply agencies have come up in a good number employing many people. On an average 200 lorry loads of fish are flagged off daily from Kolleru lake area (Roy et al. 2008).

Several thermocol and plastic factories manufacturing plastic crates and thermocol boxes for carrying the fishes from the production centers to various places have come up in the locality. Themocol boxes being light and cheap have relative advantages over plastic crates. Being less costly they can be discarded after a single use and need not be brought back to the packing center for reuse. On the other hand the plastic containers are heavy and costly. The empty crates are brought back in lorries to the packing centers for repeated use, which involves substantial transport charges.

Creation of rural employment opportunities in sorting, packaging, transporting and marketing

It is estimated and reported that for a one-hectare pond two permanent labourers and 300 man days of casual labour are engaged for aquaculture. The traditional system allowed only casual labour for a period of 4-6 months in a year when the peak activities of fish culture go on. In addition to the direct labour employment in the culture practices, indirect employment in allied activities like ice factories, packing centers, lorry supply agencies and marketing is noteworthy. Marketing practice is observed to be absolutely labour intensive which leaves employment for labours in various stages like harvesting, sorting, packaging and weighing, icing at factory, loading and unloading at wholesale market and retailing in the consumer markets (Roy et al. 2008).

Conclusion

We feel that production activity, undertaken principally for self-consumption, cannot attain the scale needed for efficient resource allocation and technological advancement. On the other hand, aquaculture undertaken as an economic venture on commercial scale provides inputs and services needed for on-farm production, markets for farm products and livelihood opportunities like local seed and fingerling supply, production of feeds using local materials, and fabrication of various materials for farming activities. For all these activities several actors are involved in aquaculture chain e.g., fish farmers, hatchery and nursery operators, seed vendors, commercial fish feed manufacturers, domestic resume based feed producers, fishing equipment manufacturers, fish processors, fish traders and exporters etc. The additional employment and income generated in the value chain create demand for other products and support the growth of other economic activities. The key challenge in aquaculture development in medium and small-scale operation is to reduce poverty, vulnerability and marginalisation among people. It is quite satisfactory to note that growth of various forward and backward industries in aquaculture in Kolleru Lake area have helped in strength-

Fish packaging in an ice factory.

Manufacture of thermocool boxes for fish transportation.

ening resource management systems providing return, creating employment opportunities of the fishers living in the bed and belt villages leading to self sustainable aquaculture.

Acknowledgement

The authors are grateful to ICAR for funding the project through AP Cess fund of ICAR.

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Effective marketing strategies for economic viability of prawn farming in Kuttanad, India

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Kuttanad is a low-lying deltaic wetland ecosystem in South India formed from four river systems, with an area of some 1,160 km^2 and a population of more than one million people. Agriculture and fisheries provide the main source of income to the people of Kuttanad, and an intricate polder system (low-lying tract of land surrounded by dikes) has been constructed over the years for agricultural purposes.

Kuttanad is the home ground of the giant freshwater prawn, *Macrobrachium rosenbergii*, often sold under the trade name 'scampi'. Although paddy cultivation in rice fields is being practiced on a regular basis, the successful integration of scampi in the rice fields had in fact evoked much response among farmers of Kuttanad as a means for improving their economic status. During the past decade, there has been a phenomenal increase in the cost of rice production. Paddy farming has, therefore, become less attractive and due to the diminishing returns, there is a strong tendency among the farmers to abandon rice cultivation and look for alternative uses of their fields. The integration of paddy farming with prawn/fish culture has turned out to be the only viable alternative to effectively utilize the vast expanse of fertile derelict water bodies available in Kuttanad[1].

Freshwater prawn farming is carried out in three types of natural grow-out environments such as 'polders', which are utilized for rice culture mostly only once a year, the 'homestead ponds' and 'coconut garden channels'. The extent of the polders generally varies from 0.5 to 100 ha. Homestead ponds are comparatively smaller and their area ranges from 0.01 to 0.2 ha. The 'coconut garden channels', on the other hand, usually have water area in the range 0.2 to 7 ha. The

Giant freshwater prawn - Macrobrachium rosenbergii.

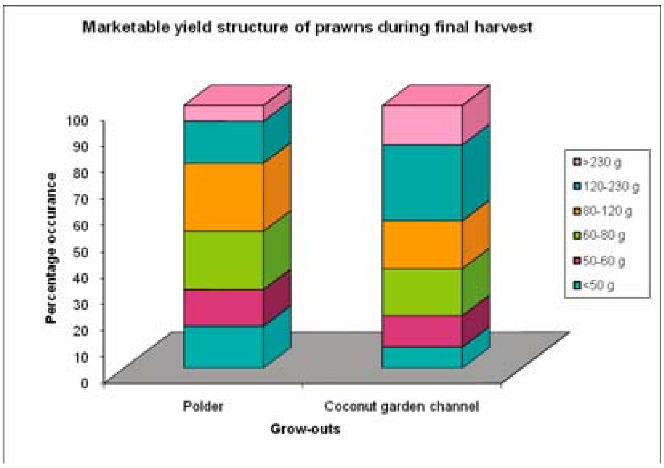
duration of culture varies from 5-6 months in polders to 8-10 months in coconut garden channels. In Kuttanad the majority of prawn farming activities occur in polders (65-75%) followed by coconut garden channels (15-25%) and homestead ponds[2] (10-15%). Unlike penaeid shrimp culture, the economic yield of *M. rosenbergii* in grow-outs is not a linear function of total biomass produced owing to the predominance of non-marketable undersized prawns in the harvested population. The differential growth pattern evinced in this species is one of the major bottlenecks confronting the profitability in the farming of this species[3]. The different size groups of prawns at the final harvest enable the exporters to grade them under different weight classes and prices. Hence larger prawns demand better prices, while the undersized prawns are usually low priced or not marketed.

Bottleneck in marketing

In Kuttanad, at present a bizarre and frail marketing structure persists that is often prone to variation with season and time. Prawns are marketed 'head-on' either under a six grade system (<50 g, 50-60 g, 60-80 g, 80-120 g, 120-230 g and >230 g weight classes) or under a two grade system (<50 g and >50 g weight classes). An attempt was made to analyze the different market grading structures prevalent in Kuttanad and their affect on the economic sustainability of the culture. Hence the final harvest details from two polders and two coconut garden channels that were uniformly stocked were economically analyzed under the two-market structure. The price structure prevalent for six-grade system were as follows: <50g = Rs.80/-, 50-60 g = Rs. 120/-, 60-80 g = Rs. 160/-, 80-120 g = Rs.200/-, 120-230 g = Rs. 260/- and >230 g = Rs. 320/-, while that for the two grade system was <50 g = Rs. 130/- and >50 g = Rs. 240/- (1 US$ = Rs. 42.20).

The final marketable yield structure of prawn from polder and coconut garden channels is given in the figure below. Results of economic analysis revealed that the margin of profit incurred in the polder increased from Rs. 26,258/ha under six-grade to Rs. 33,627/ha under 2-grade system. Contrary to this, in coconut garden channel six-grade system (Rs. 25,421/ha) was found to be nearly twice as profitable than two-grade system (Rs. 12,968/ha).

In the present study it was seen that a two grade marketing system was more profitable for polders, while for better economic returns a six-grade marketing strategy was beneficial for the coconut garden channels. This may primarily be because of the duration of culture in polders, which extends from five to eight months. During harvesting the resultant mean weight of the prawn fall just above the 50 g mark and since the percentage of larger prawns (>230 g) is considerably low it was found more appropriate to market the prawns under two grade system. On the other hand in channels the period of culture extends to 10 months or even year round, which along with low stocking density prevailing in the grow-out enables the prawns to grow to much larger weight groups (>230 g). Hence marketing under a six-grade system was found to generate more income in the channels. Consequently, large-size males, despite their relatively higher head to tail ratio, command a considerably higher price than females. Another management strategy to increase the revenue from polders was the practice of intermediate, partial harvest through cast netting, which is definitely a sound management strategy for two reasons. Firstly, the



Prawns are often grown in coconut garden channels.

females that dominated the population and matured relatively early at a small size (30-40 g) could be selectively removed in the early harvest. Selling of egg bearing berried prawns was also a major source of income to the farmer. Secondly the intermediate harvesting would remove the large males and allowed the smaller undersized males to grow until final harvest. Due to repeated harvesting the population density within the polder was kept at a minimal level, which in turn reduced the quantity of feed required. However, this method was not suitable for coconut garden channels since the only way to harvest prawns in these grow-outs is through complete draining.

A noteworthy observation in the present study was that most of the berried prawns during final harvest weighed from 50 to 55 g. It was also observed that the middlemen involved in the procurement of prawns avoided berried females or removed the egg mass before individually weighing the prawns. Without the egg mass, the weight of these female prawns fell below the 50 g and thereby demanded least price. To avoid this farmers are now compelled to extend their farming duration to even 8 months. Not only would this increase the cost of farming in the form of feed and management cost but also reduces the survival rate of prawns due to cannibalism inherent to this species.

Conclusion

A steady two-grade market structure is inevitable for making the culture of *M. rosenbergii* economically more viable and sustainable in Kuttanad, which also allows the farmers to curtail their farming operations from existing 8 months to 6 months. This in turn reduces the operational costs left aside for feed and management. Marketing based on two size grades was found to profitable and therefore advantageous for farmers of Kuttanad for polders with culture duration of six months. But for coconut garden channels where the culture duration extends above 10 months, the six-grade structure was profitable.

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Applications of nutritional biotechnology in aquaculture

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Nutritional biotechnology in aquaculture

Globally, consumption of food fishes is projected to reach 165 million tonnes by 2030. As wild catch fisheries are now approaching full exploitation worldwide, a large part of this increase will have to come from aquaculture. The identification of alternative fish species and suitable feed ingredients for their diet formulations has therefore become very important.

The main goal of fish nutrition as a scientific discipline is to produce feeds that support good growth rates while maintaining fish health and quality, resulting in a safe and healthy product for the consumer at least cost. In this regard many scientists are studying the safe utilization of nutrients and their interactions when alternative feed ingredients from plants are used to substitute for traditional (and expensive) fish meal and oil, as well as evaluating alternative marine ingredients. Research focuses on issues such as the characterization of nutrient effects on brooders fish, eggs, larvae, juveniles and at different stages of growth. Measurements include nutrients effect on growth, feed utilization, digestibility, alterations in metabolic pathways, fish health and welfare parameters, nutrient bioavailability and retention. Modern tools within genomics and proteomics are gradually being taken up and focused, giving the opportunity to discover novel pathways and effects of nutrients.

The aquaculture feed sector of India has made tremendous developments during the last two decades. At present about 20 million tones of manufactured aqua feed are being used in aquaculture sector, of which the majority is consumed in shrimp culture (Chandrapal, 2005). If the rapid growth of aquaculture persists, the feed requirement may increase many fold. Hence, more scientific understanding and interventions are required for sustainable aquaculture of the country.

Sustainable commercial carp feed production has became a challenge to the aquaculture nutritionists. It has been estimated that a feed with FCR 1.3 could make a commercial carp feed sustainable. Exploration of novel genes related to growth enhancement and use of different nutraceuticals have raised the hope of achieving that target. Isolating a potential growth hormone gene and subsequent transfer of that gene to enhance the fish production is approaching near to reality. Addition of new immuno-stimulants in aqua feed has increased the possibility of safer production through high-tech aquaculture. Strategies for increasing utilization of cheaper nutrients like carbohydrate by various technological interventions and addition of feed attractants paved the way for developing lower cost feeds sustainable carp culture (Gopakumar, 2003). Currently, quality enhancement of fish flesh by dietary and gene manipulation is a focused area of research in fish nutrition.

Besides feed development, feed management and feed quality are critical factors for profitability of fish farming, especially in intensive aquaculture. A biologically ideal feed may not be economically viable if feed management is poor. A balanced knowledge on fish nutrition and feed management is of paramount importance for sustainable fish production. The following are the priority areas of research in fish nutrition:

- Nutritional requirement of fishes with respect to growth.
- Selection of proper feed ingredients.
- Energy requirements in fish.
- Feed formulation and preparation.
- Feed processing and feeding techniques.
- Carbohydrate utilization as protein sparing effect in fish nutrition.
- Omega-3 fatty acids in nutrition and health.
- Nutraceuticals in fish nutrition.
- Fish nutrition, biochemical and physiological responses in extreme environmental stresses.
- Quality control and storage of feed ingredients.

- Anti-nutritional factors, their detoxification and pathology.
- Feed left -over & waste vis-a-vis water quality management.
- Molecular strategies to enhance fish flesh quality and quantity.

Biotechnology is also helping to answer some of the technical and environmental concerns of fish farming including aquaculture nutrition. Many of these centre around what the fish eat. Over the last decade, the world has witnessed spectacular growth in the aquaculture industry of many developing countries. It is further anticipated that world aquaculture production will continue to increase. Since nutrition and feeding play a pivotal role in sustainable aquaculture and since feed constitutes about 40-50% of total cost of aquaculture production. Use of nutritionally balanced and complete formulated feed will continue to play a dominant role in finfish and shellfish production. Hence, alternative and biotechnologically improved feed ingredients should be sought along with improvements in pond management and manipulation of pond productivity.

Right now, the most common protein source for many fish diets is fish meal, a byproduct of fish processing, used because of its high quality protein content. However, it has some disadvantages. In addition to its high cost, it contains levels of phosphorus far beyond the requirement for optimal growth in fish leading to potential environmental concerns. The excess phosphorus released into the water can cause problems such as eutrophication or excess algae growth.

Plant proteins as alternatives to fish meals

Plant protein has the potential to decrease the problem of phosphorus pollution, since plants do not contain such high phosphorus levels. Moreover, the use of plant protein as a feed ingredient can help to reduce the burden on fish meal supplies. As a result of these concerns, researchers are using biotechnology to produce alternative plant-based protein sources suitable for use in aquaculture.

However, the use of plant-derived materials such as legume seeds, different types of oilseed cake, leaf meals, leaf protein concentrates and root tuber meals as feed ingredients is often limited by the presence of a wide variety of anti-nutritional substances (Fournier et al., 2005). Plant proteins often require processing to remove these substances, which may be produced by plants as natural defence mechanisms. Important among these are protease inhibitors, phytates, glucosinolates, saponins, tannins, lectins, oligosaccharides and non-starch polysaccharides, phytoestrogens, alkaloids, antigenic compounds, gossypols, cyanogens, mimosine, cyclopropenoid fatty acids, canavanine, antivitamins, and phorbol esters. These compounds must be destroyed during processing to prevent harm to the fish. Problems associated with anti-nutritional factors can also be solved by producing feed enzymes to counteract them. Phytase is one example, which can help fish make the best use of the phosphorous available in a plant-protein based feed. One of the most exciting technological developments has come from the ability to manipulate the plant genome to produce products economically for use in aquaculture. The use of genetically modified crops to eliminate anti-nutritional factors and increase specific nutrients (limiting amino acids, n-3 fatty acids, etc.) is now possible. The packaging of genetically engineered proteins in corn seed to produce very inexpensive oral vaccines is also being pursued.

Feed additives

Adding specific nutrients to feed can improve animal digestion and thereby reduce feed costs. A lot of feed additives are being currently used and new concepts are continuously developed with the help of biotechnology.

Utilization of plant fibres in fish feed through enzymes

Although enzymes have been in use for a long time in other applications such as detergents, textiles, baking and brewing, their use in the animal and fish feed has been a recent phenomenon. This is because enzymes need to be designed to suit the appropriate application. Industrial enzymes are mainly produced from microorganisms by a process of fermentation and extraction. These enzymes can be produced in large quantities from genetically modified microbes with desired properties to make them economically viable. Feed enzymes need to be robust to stand variations in pH and temperatures. They need to have high temperature stability to withstand pelletization and also have a long shelf life. Over the years, feed enzymes have been going through an evolution from liquid to powder to granules in their product forms in order to make them more heat stable. Lately the granulation technology has been developed in a way that the enzyme molecules are coated with an inert material like cellulose and wax to give the enzyme full protection. This technology helps the enzyme to achieve longer shelf life and is most suitable for pelletized feed. In Europe and Australia, feed enzymes have been used for nearly a decade but their usage in Indian fish diets has been only in recent years because the technology for the production of these enzymes was not well developed in India.

Several alternate feed sources like sunflower, rapeseed and safflower can provide protein, and sorghum, millets or rice bran for energy could be used as feed ingredients if supplemented by substrate-specific enzymes. Cell wall composition of these high fiber feed ingredients show that they contain large amounts of arabino-xylans, pectic polysaccharides and some cellulose. Use of specific enzymes like xylanase, pectinase and cellulase could allow breakdown of the fibre releasing energy as well as increasing the protein digestibility due to better accessibility of the protein (Alford et al., 1996). In this way the feed cost could be reduced and the protein levels in the feed a increased. The scope for increasing the use of enzymes in the coming decade is certainly there when high quality enzymes become available with more predictable performances.

Phytase in aquafeed

One of the enzymes that has really caught on in India is phytase, an enzyme that breaks down the indigestible phytic acid (phytate) in cereals and oilseeds and releases digestible phosphorus. It has been known for several decades however the feed industry could not use it economically due to its high production costs. Microbial phytase became commercially available in 1990s as the result of biotechnological improvements.

Phytase reduces the use of expensive supplemental inorganic phosphorus such as dicalcium phosphate (Jongbloed et al., 2000). Phytase releases minerals (Ca, Mg, Zn and K), amino acids and proteins, which are complexed with the phytate molecule. Phytate itself is an anti-nutritive factor, which when hydrolysed gives better performance in animals. Today, a substantial numbers of farmers in India are using phytase to reduce the cost of their feed. One interesting observation made from the environmental point of view is in coastal region of Andhra Pradesh. Since phytase has been used in the poultry and aquaculture industries farmers have been benefiting from better control over algal blooms due to the reduction in ground water phosphorus levels. This shows that the phosphorus content in the poultry litter has come down due to usage of phytase which ultimately leads to the reduction of phosphorus in ground water.

Aqua feed manufacturers are also looking into the possibility of using phytase to release the non-available phosphorus from deoiled rice bran, Soya and wheat (Boling et al., 2000). There are various enzyme formulations available in the market with varied activities. Because the enzymes used by the feed industry are produced by different microorganisms, the enzyme characteristics as well as the composition of enzymes would be different. The manufacturer by experience and good quality control can guarantee consistent results. However, comparison of enzyme products is difficult except by in vivo testing. Each microorganism produces enzymes with different optimum pH values, different optimum temperature of operation and different affinity for the substrate in feed. It has not yet been possible to develop an in-vitro method that can predict in-vivo performance.

At present, most of the enzyme products in India are directly imported or the individual enzymes are imported and formulated. These enzymes attract import duty, making their usage expensive. There are very few companies producing enzymes in India due to lack of technology as well as appropriate seed organisms. Most of the multinational enzyme companies have spent years in R & D efforts for development of appropriate enzymes. India needs to look into these aspects and invest in enzyme production biotechnology units in the near future in order to make them economically viable.

Improving expression of the phytase gene in plants is underway as a means to commercially produce phytase, as in biofarming in which plants such as alfalfa are used as “bioreactors” and also by developing plant cultivars that would produce enough transgenic phytase so that their additional supplementation in grain or meals is not necessary.

Micro-nutrients and vitamins in fish feed

The absorption and availability of inorganic trace minerals such as zinc, cobalt, calcium etc., varies depending upon the nature of the minerals (sulphate, oxide or carbonate), their solubility and ionization. Trace minerals are now being attached to oligopeptides to make them more bioavailable. Commercial preparations of proteinated selenium and chromium are used in poultry production. In the case of vitamins, due to varying availability and stability of vitamins in ingredients, supplemental vitamins are widely incorporated in diets. These vitamins are much more stable than naturally occurring forms. Stability is achieved through the application of advanced technologies which involve preparation of biologically active derivatives, coating technologies, carriers and diluents (Bamji, and Lakshami, 1998).

Nutraceuticals

Nutraceutical implies that the extract of food is demonstrated to have a physiological benefit or provide protection against a disease and/or improve growth. Functional foods are defined as being consumed as part of a usual diet but are demonstrated to have physiological benefits and/or reduce the risk of disease beyond basic nutritional functions. Nutraceuticals are often used in nutrient premixes or nutrient systems in the food. In aquaculture, application of nutraceuticals includes addition of feed additives in feed such as antioxidants, vitamins, minerals, and carotenoids etc (Brower, 1998).

Nutraceuticals are also extracted from many fishes including omega-3 oil, chitosan and glucosamine, originally derived from waste products. Hundreds of tons of marine by-products are available annually which are driving force for both research and commercialization in the area of marine nutraceuticals.

Dietary amino acids through GMOs

Essential amino acids are added as supplements to the feed improve the balance of the amino acid profile. Since the amino acid profiles of feed ingredients do not normally match the profile of amino acid requirements of the target species, supplemental essential amino acids are added to improve protein utilisation. The new trend is to formulate diets on digestible amino acid levels thereby reducing the requirement for protein. So far lysine and methionine have been used as supplements. Lysine is produced by microbial fermentation and methionine is chemically synthesized. Genetically enhanced micro-organisms are being used to produce threonine and tryptophan on a commercial basis and soon other essential amino acids also would become available. Using all these amino acids it is possible to lower dietary crude protein level by 2 – 3 %, which is a substantial saving for the farmer. The concept of an ideal protein blend from GM feedstuffs and feed additives (such as amino acids and enzymes) will greatly help with decreasing the amount of nitrogen excreted in animal waste (Halver, 2002).

Toxin binders in fish feeds

Feed manufacturers have been incorporating various mold inhibitors in their diets to prevent mycotoxin formation. A variety of physical, chemical and biological approaches to counteract the mycotoxin problem have been reported, but large scale, practical and cost effective means for detoxification of mycotoxins containing feed stuffs are limited. Most of them are fungistats and not fungicides that only inhibit growth of molds and do not inactivate any toxins already present (Tuan et al. 2002). Present day methods generally use organic acids and their salts like propionic acid or adsorbents like bentonites, zeolites, hydroxyl aluminosilicates. In the future, biotechnology based products like microbes, herbal extracts or esterified glucomannan could be used. Extracts of garlic, onion, turmeric, neem have been shown to exert antifungal activity or inhibit aflatoxin production. Identification of the active ingredients would help in the development of genetically modified herbs with enhanced activities to make them cost effective.

Fish feed attractants

Colour, smell, odour, taste and flavour of several food and feed stuffs play an important role in attraction of animals towards a particular feed (Kozasa, 1986). New strategies including from the Central Institute for Fisheries Education, Mumbai, are being adopted to isolate, purify and utilize the various active principles and chemical ingredients from indigenous plants and traditional herbs as fish attractants in feed. This may help in reducing feed waste and scheduling of feeding frequency.

Probiotics in fish nutrition

Microorganisms are naturally present in the digestive system of the animals. Some microbes aid digestion, others can potentially cause pathogenesis. The microbial ecology of the gut merits greater attention due to its implications for nutrition, feed conversion and disease control. Use of antibiotics disturbs the microbiological balance of gut flora eliminating most of the beneficial flora. On stopping antibiotic treatment, pathogens begin to reestablish themselves in the intestine. Overgrowth of these organisms and subsequent invasion of the system by pathogenic organisms cause inflammatory, immunological, neurological and endocrinological problems. Using probiotics can help build up the beneficial bacteria in the intestine and competitively exclude the pathogenic bacteria (Gatesoupe 1999). Probiotic bacteria also release enzymes, which help in the digestion of feed. The concept of using probiotics in animal feed particularly poultry and aquaculture is slowly becoming popular. The common organisms in probiotic products are *Aspergillus oryzae*, *Lactobacillus acidophilus*, *L. bulgaricus*, *L.plantarium*, *Bifidobacterium bifidium*, *Streptococcus lactis* and *Saccharomyces cerevisiae*. These products can be administered through water or incorporated in the feed. Probiotics have been particularly useful in the early stages of chick growth since the gut of the newly hatched chick is sterile and administering probiotics through water at this stage helps to build up beneficial bacteria much faster than the normal course.

The most important quality parameter of probiotics is that the vegetative or the spore forms have to be viable to be able to multiply in the gut. Secondly they should be resistant to antibiotics, which are administered so that the gut ecology could be maintained. Genetic engineering would help develop probiotics with special properties like secreting enzymes and vitamins in large quantities. Such products would be the future generation feed additives.

Probiotics have also been used in a big way as pond cleaners in aquaculture. Probiotic bacteria directly uptake or decompose the organic matter or toxic material and improve the quality of water. The microbial cultures produce a variety of enzymes like amylase, protease, lipase, xylanase and cellulase in high concentrations than the native bacteria, which help in degrading waste. These bacteria have a wide range of tolerance for salinity, temperature, pH which usually exists in aquaculture operations. The use of antibiotics in aquaculture is banned due to rejection of export consignments of marine products. Hence usage of probiotics is propagated to counter the effect of viral and bacterial infections in commercial aquaculture. The pond probiotics also sometimes contain a special blend of denitrifying bacteria that remove the algae's primary source of food, nitrogen from the water. This drastic reduction in nitrogen concentration makes it difficult for the algae to bloom (Douillet and Langdon, 1994). The balance between phytoplankton, zooplankton and beneficial bacteria during culture period play a crucial role in the maintenance of pond health.

Prebiotics in fish nutrition

The concept of prebiotics in aquafeed is fairly recent. Prebiotics are basically feed for probiotics that are resistant to attack by endogenous enzymes and hence reach the site for proliferation of gut microflora. Some of the prebiotics that are currently used in animal feed are mannan-oligosaccharides (MOS), fructo-oligosaccharide and mixed oligo-dextran. Mannan-oligosaccharides are mainly obtained from cell walls of yeasts. Other sources of MOS are copra or palm kernel meal. MOS interferes with the colonization of the pathogens. Cell surface carbohydrates are primarily responsible for cell recognition. Bacteria have lectins (glycoprotein) on the cell surface that recognize specific sugars and allow the cell to attach to that sugar. Binding of *Salmonella*, *E.coli* and *Vibrio* sp. is shown to be mediated by a mannose specific lectin like substance present on the bacterial cell surface. Similarly fructo-oligosaccharides from chicory have been used as prebiotics to competitively exclude pathogenic bacteria (Xu et al. 2003). The pH of the lumen gets reduced thus preventing the entry of pathogenic bacteria. The concept of using prebiotics has not yet been accepted but the advantages of prebiotics are that it can stand high pelletizing temperatures in the feed and also have a long shelf life.

Quality management and detection of contaminants in fish feeds

Modern and biotechnological tools like PCR, biomonitoring and DNA/gene based diagnostics could be developed and used for detection of *Aspergillus* fungi, *Salmonella* species, mycotoxins and other contaminants in fish feeds and feeding environment. UV/visible spectrophotometric, HPLC and

Ag:Ab based detective technologies could also be utilized for detection of several other health hazardous contaminants, heavy metals, xenobiotics, antibiotics, pesticides and steroids etc., in fish feeds.

Growth Improvement and enhancement of quantitative traits in fishes

Enhancement of natural growth rates for fish in aquaculture has been extensively explored, with gains arising from improvements in husbandry, nutrition and genetic selection (Pennel and Barton, 1996). Growth enhancement can provide advantages for aquaculture by shortening production times, enhancing feed conversion efficiency, and controlling product availability. Endocrine approaches to controlling growth have also been extensively explored, principally applications of somatotropins such as growth hormone (GH), prolactin, and placental lactogen, insulin- like growth factor-1, thyroid hormones and sex steroids (Mclean and Devlin, 2000). In the recent past, there are instances both in India and abroad where growths of fish have been increased by incorporation of growth hormone gene with strong promoters.

Highly unsaturated fatty acids (HUFA) and qualitative enhancement of fishes

Highly unsaturated fatty acids (HUFA) are receiving considerable attention due to their involvement in human health. Fish is an important dietary source of long chain C20 and C22 highly unsaturated fatty acids (HUFA) (Ackman 1980), which are crucial to the health of higher vertebrates also. They play pivotal roles in number of biological functions including cardiovascular functions, neural development, eicosanoid signaling (Funk, 2001), regulation of gene expression and ion channel modulation (Kang et al., 2004).

Traditional emphasis has been on dietary lipids and oils because of their effects on lipid composition, in particular that of the lipoproteins. The classical way by which lipids were evaluated, however, gradually changed in the last decade as it became evident that fatty acids themselves regulate lipid homeostasis not only at the level of the lipids interacting with proteins, but also on the genetic level by affecting gene expression. Changes in the lipid content at high concentration are the major cause for several diseases, i.e., obesity, coronary heart disease and cancer (Kushi et al., 1997). Earlier studies clearly showed that risk of coronary heart disease was greatly reduced in populations where fish is major portion of food.

In the recent years research work has been initiated to conduct molecular analysis and characterization of delta-6 fatty acyl desaturase genes from several fin fishes which are involved in biosynthesis of omega-3 and omega-6 PUFA (Clarke et al., 1998).

Genetic manipulation in bacterial biofilms - a source for fish nutrition, live vaccines and anti-biofouling agents

Molecular approaches to characterizing biofilm structure and development offer considerable potential for finding novel biofouling and disease prevention strategies in enhancing aquatic productivity. It is now possible to determine the genes and pathways involved in regulation and synthesis of bacterial adhesive polymers and virulence antigens. Considerable progress has been made in understanding the nature and expression of surface polymers and bacterial vaccines produced by microorganisms such as the nitrogen-fixing *Rhizobium* species and the opportunistic pathogen *Pseudomonas aeruginosa* etc. Similar approaches can be applied to marine biofilm bacteria, to find the genetic determinants of adhesive production and the environmental factors that regulate synthesis (Harwood and Gibson, 1988).

Biomaterials also hold promise for counteracting biofouling, which long has been recognized as an extensive and costly problem. Bacterial biofilms form slime layers that increase drag on moving ships, interfere with transfer on heat exchangers, block pipelines, and contribute to corrosion on metal surfaces. Bacterial and microalgal colonization of surfaces is accompanied by settlement of invertebrate larvae and algal spores, eventually leading to “hard fouling” and the need for costly cleaning. The most effective anti-fouling coatings have utilized toxic chemicals, such as copper and organotins. There is an urgent need for non-toxic biofouling control strategies, due to heightened recognition of the impact that toxic coatings can have on the environment. Research is needed on the attachment mechanisms of marine organisms and the natural products they employ to prevent fouling of their own surfaces.

Developments of biosensors by genetic engineering for aquatic environment monitoring

Marine organisms can provide the basis for development of biosensors, bio-indicators, and diagnostic devices for medicine, aquaculture, and environmental monitoring. One type of biosensor employs the enzymes responsible for bioluminescence. The lux genes, which encode these enzymes, have been cloned from marine bacteria such as *Vibrio fischeri* and transferred successfully to a variety of plants and other bacteria. The lux genes typically are inserted into a gene sequence, or operon, that is functional only when stimulated by a defined environmental feature (Goldsmith et al., 2006). The enzymes responsible for toluene degradation, for example, are synthesized only in the presence of toluene. When lux genes are inserted into a toluene operon, the engineered bacterium glows yellow-green in the presence of toluene. This genetically engineered system “reports” that biodegradation of a specific chemical, in this case toluene, is proceeding. Another type of biomonitor that holds great promise is the gene probe, which can be used to identify organisms that pose health hazards or may be useful in research. Specific gene probes can be employed, for example, to detect human pathogens in seafood and recreational waters; fish pathogens in aquaculture systems; microorganisms capable of mediating desired chemical transformations (e.g., toxic chemical degradation, CO_2 assimilation, metal reduction); and specific fish stocks in fish migration and recruitment studies.

Bioremediation for improving aquaculture

Bioremediation shows great promise for addressing problems in aquatic environments wherein fishes are allowed to grow and fed with formulated and natural feeds in aquaculture. These problems include catastrophic spills of oil in harbors and shipping lanes and around oil platforms; movement of toxic chemicals from land, through estuaries, into the coastal oceans; disposal of sewage sludge in rivers/water bodies, bilge waste, and chemical process wastes; reclamation of minerals, such as manganese; and management of aquaculture and seafood processing waste (Queiroz and Boyd, 1998)

Nutrigenomics

Nutrigenomics is the study of molecular relationships between nutrition and the response of genes, with the aim of extrapolating how such subtle changes can affect animal health. Nutrigenomics focuses on the effect of nutrients on the genome, proteome, and metabolome. It is applying the sciences of genomics, transcriptomics, proteomics and metabolomics to animal nutrition in order to understand the relationship between nutrition and health. Nutrigenomics has also been defined as the application of high-throughput genomic tools in nutrition research (Müller and Kersten, 2003). This refers to genetic tools that enable literally millions of genetic screening tests to be conducted at a single time. When such high throughput screening is applied in nutrition research, it allows the examination of how nutrients affect the thousands of genes present in the animal genome. Nutrigenomics involves the characterization of gene products and the physiological function and interactions of these products. This includes how nutrients impact on the production and action of specific gene products and how these proteins in turn affect the response to nutrients. Nutrigenomics has been associated with the idea of personalized nutrition based on genotype. While there is hope that nutrigenomics will ultimately enable such personalised dietary advice, it is a science still in its infancy. Integration of genetic and metabolic studies using the zebrafish as a model affords an opportunity to dissect the fundamental pathways coordinating growth, nutrition and energy homeostasis. Goldsmith et al. (2006) revealed a critical transition in growth control during zebrafish caudal fin development.

Marine and aquatic biomass for energy production

Approximately 40 percent of all primary energy production, or photosynthesis, occurs in the seas. In this process, oceanic plants (phytoplankton, seaweeds, seagrasses) take up carbon dioxide and convert it into organic carbon (primarily sugars) and oxygen using light from the sun as an energy source. The oceans contain 50 times as much carbon dioxide as does the atmosphere, and it is estimated that primary production incorporates 35 gigatons of carbon into marine biomass annually. This abundant source of fuel for energy production has not been tapped commercially because it is not competitive with soybean meal and other easily harvested, traditional sources of biomass, and also because biomass is not presently competitive with other types of fuels, regardless of its source.

Among three strategic technologies being adopted in abroad, the first one , the enzyme that captures CO_2 for photosynthesis—ribulose bisphosphate carboxylase\oxygenase or "RUBISCO"—is relatively inefficient, so supercomputers are being used to verify structural information, and the enzyme is being redesigned to optimize its function. Second, the chemical composition of biomass can be altered to make it more suitable for particular applications. For example, marine microalgae are being genetically engineered to boost their lipid content, with the aim of providing a source of alternative fuels that is more economical than are conventional sources. Third, biotechnology is being used to convert biomass to ethanol and other alternative forms of energy and chemical feedstocks.

Acknowledgement

Authors are thankful to Dr Dilip Kumar, Director, Central Institute of Fisheries Education, Mumbai for providing necessary facilities to work on this area and prepare this manuscript.

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Some technical and management aspects of catfish hatcheries in Hong Ngu district, Dong Thap province, Vietnam

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Dong Thap Province in the Mekong River Delta (in Vietnamese it means Delta of Nine Dragons) has a tropical climate and an abundant supply of fresh water the whole year-round. It borders Cambodia to the North, Vinh Long Province to the South, Long An and Tien Giang Provinces to the East; and Can Tho and An Giang to the West.

Dong Thap is also known as one of the provinces where the tra catfish, *Pangasianodon hypophthalmus*, aquaculture industry is well established. In 2006, the province produced 300,000 tonnes of catfish, contributing 37.5 % to the total production of Vietnam catfish aquaculture production. Catfish aquaculture in the province also employs about 40,000 people, out of the 1.6 million people who are living there.

Since the breakthrough in artificial propagation of catfish species in 1996, many farmers in Hong Ngu district of Dong Thap have changed from traditional rice cultivation to catfish breeding and culture. This change has significantly improved the income of farmers over the years. Statistics for 2007 show that the province has 87 catfish hatcheries, producing more than 4.4 billion larvae per year. Together with its neighbouring province of An Giang, Dong Thap is considered an epicenter of catfish seed supply for the whole Delta. In this article, we report some technical and economical aspects of 30 hatcheries in Hong Ngu district of Dong Thap province, based on a survey undertaken between July to September 2006.

General characteristics of hatcheries

All surveyed hatcheries were built after 1999. It is usual that owners also act as the chief technicians, and their level of education varied, with 80% having high-school certificate or higher, and with an age range of 31 to 60 years old. The majority of chief technicians (73.3%) gained their expertise through training courses, while 13.3% gained their experience through university degree, and the rest (13.3%) learnt from other hatcheries. There are often three to six persons working in a hatchery, who tend to be mostly family members and one to two persons from outside, usually neighbours.

Hatchery areas ranged from 0.2 to 3.0 ha, about 40% of which is used as broodstock ponds. Hatcheries maintain on average about 1,700 brood fish (about 4 kg each) with capacity to produce about 200 million fry per year. However, not all broodstock are used every year. For example, only 26% of broodstock was used to spawn in 2005. Hatcheries kept about 4% of fry and rear to fingerling, and the rest was sold to secondary hatcheries or nurseries for fingerling rearing and subsequently sold to grow-out farmers. The price of fry and fingerlings have significantly declined over the years, from about 52 VND and 532 VND, respectively in 2001, to 1 VND and 106 VND in 2005 (1US$ = 15,800 VND in 2005). Relevant information on hatchery production is given in Table 1.

Broodstock management, breeding and seed quality

The origin of broodstock varies between hatcheries. About 43% of hatcheries obtained wild-caught broodstock, 30% have only broodstock from hatchery origin, and the rest have a combination of both hatchery-produced and wild-caught

Table 1. Average number of brooders, fry, and fingerlings produced in the 30 hatcheries surveyed from 2001 to 2005. Number in parentheses indicate the range.

	2001	2002	2003	2004	2005
Number of broodstock	202 (50 – 1,000)	248 (50 – 1,000)	374 (75 – 1,850)	382 (88 – 1,000)	456 (100 –1,125)
Number of fry/ year (million)	118.2 (6.0 - 300.0)	120.4 (6.0 - 300.0)	123.9 (5.0 - 300.0)	196.9 (5.0 - 500.0)	155.6 (6.0 - 800.0)
Number of fingerlings (million)	50.3 (0.1 - 500.0)	50.4 (0.1 - 500.0)	19.2 (0.2 - 200.0)	23.2 (0.2 - 300.0)	12.1 (0.2 - 150.0)

broodstock. Most broodstock (59.7%) are 5 to 7 years old, 38.3% are under 5 years old, and a very small proportion is older than 7 years.

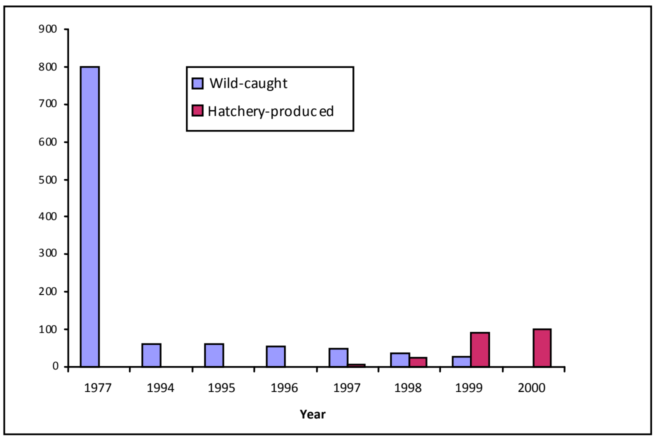
Broodstock can be from one generation or many. The number of hatcheries that had broodstock from one, two, three and four generations were 37%, 20%, 20% and 23%, respectively. It is interesting that 62% of hatcheries reported that broodstock procured from the second and third generations usually spawn at a younger age compared to those from the first generation.

Broodstock ponds were repaired and cleaned every 1 – 1.5 years. During the pond maintenance period, water and sediments were drained out. Powdered lime was then applied at an average of 6 kg 100 m^{-2}. Brooders were stocked at an average density of four fish per $10m^{-2}$ with a sex ratio of one male to four females. Broodstock were fed with commercial pellet feed at an average of 6.20 kg of feed for 100 kg of fish per day.

Each brooder spawned twice to four times a year. In 80% of hatcheries, fish that had spawned were marked by writing on the head, and 13.3% hatcheries kept fish that had spawned in a separate pond. Average age at the first spawn was 3-4 years old, equivalent to 3-4 kg fish. The best spawners (in terms of fecundity, hatch rate and survival rate) were aged 4 – 5 years (4-5 kg fish). Fish that were older than 7 years (7-8 kg) were often removed from the broodstock.

The breeding season for catfish in Vietnam is from February to September, with a peak from March to July. Variation in spawning rate, hatching rate and other parameters are highlighted in Table 2.

Figure 2. Wild-caught and hatchery-produced seed production in Vietnam (Tung et al., 2001)



Broodstock were conditioned prior to the spawning season, normally from November to January, when they were fed with a special diet which contains more than 30% protein. Levels of maturity of females were checked by observing the oocytes using a catheter. As for males, milt was checked by stripping. The ratio of males to females for each spawning was usually one to four.

Females are injected with HCG (sometimes using LH as an alternative) five times including one preliminary dose of 1,000 IU/kg, two to three derivative doses of 500 IU/kg and one determination dose of 3,000-4,000 IU/kg. Sperm and eggs are mixed and then incubated in a system of conical jars (WEIS) at an average of 120,000 – 150,000 eggs in a 20 liter jar. Hatching time ranges from 3-5 days.

About 73% hatchery owners thought that seed produced from hatcheries are of equivalent quality to those collected from the wild, but suggested that seed from the F1 generation (i.e. their parents are collected from the wild) is probably of best quality. In contrast, other 27% believed that quality of seed collected from the wild are better than those produced from hatcheries. Inbreeding or genetic relationships amongst brooders are not taken into account in the management of broodstock in more than half (56.7%) of the hatcheries surveyed.

The price of larvae and fingerlings varied according to seasons. During the main spawning season, the price was often much lower (0.8-1.2 VND/larvae) compared to that during the early and late seasons (7-8 and 3-4 VND/larvae, respectively). Hatcheries claimed that they could not make profit during peak spawning season, and therefore they only spawned fish during early and late seasons, and only a small number of brooders were used in the main season.

Discussion

Catfish aquaculture in Vietnam has a history dating back to 1960s when fish were mainly grown in latrine ponds, and the produce were mainly for domestic consumption. Traditionally, the industry depended largely on wild-caught seed, mainly from Cambodian Mekong of Kampong Cham, Prey Veng and Kandal provinces and to some extent in Dong Thap and An Giang provinces of Vietnam. However, the Cambodian government banned the tra catfish seed collection in 1994 (Figure 2) and the break-through in catfish artificial propagation came about two years later. The industry since then has grown dramatically and has become of the fastest growing primary industries in the world.

Table 2. Performance of broodstock in different breeding seasons.

	February - March	March - July	July - September
Average success spawning rate (%)	59.3	91.4	57.7
Fecundity (1,000 eggs/fish)	49.7 ± 20.7	127.2 ± 43.7	59.7 ± 29.4
Fertilisation rate (%)	78.7 ± 15.1	93.6 ± 6.8	81.0± 14.4
Hatch rate (%)	75.6 ± 10.8	92.2 ± 7.6	72.0 ± 13.0

The success in hatchery production of tra catfish brought to the front problematic questions relating to impacts of breeding and management practices upon genetic diversity of cultured stocks, which is expected to be maintained for long-term sustainability of the sector. These problems are more pronounced with the fact that introduction of new genetic materials is almost impossible due to the ban of collecting wild seed imposed by Vietnam government in 2001. There have been documented cases in many fish species of genetic changes and loss of genetic variability in hatchery-reared stocks, and also resulting in alteration of genetic diversity of their wild counterparts due to interbreeding with escapees of hatchery-reared stocks (Crozier, 1993; Clifford et al., 1998) or those used for restocking (Bentsen, 1991; Hindar et al., 1991;). In this regard, the present preliminary survey has highlighted important implications in hatchery management of tra catfish farming in Vietnam.

This discussion will mainly focus on factors that could contribute to the reduction of effective breeding number (i.e. the number of broodstock that contribute their genetic materials to the next generation, one of the most important information on genetic status of the broodstock). It was observed that the number of broodstock maintained in each of the surveyed hatcheries is relatively high, ranging from 100 to 1,125. However, there was no information regarding the number of broodstock which were used for spawning and there is a possibility that not all fish are used to produce larvae. Furthermore, spawning rate in early and late season are relatively low (57.7-59.3%), which could further reduce the effective breeding number. This coupled with low fecundity, fertilisation rate and hatching rate (Table 2) exacerbate problems of inbreeding, and increased variance in family size (different number of survived offspring to be recruited as new broodstock).

Often hatcheries use milt from one male to fertilise eggs of several females, and in this instance the ratio is one to four. This highly skewed sex ratio would reduce the effective breeding number substantially, compared to the “ideal” sex ratio of one to one (Tave, 1999). Furthermore, the artificial fertilisation using pooled milt and/or eggs may result in increased variance of family size due to differences in ability to fertilise. This will eventually lead to reduction of effective breeding number (Wither,1988) of sperm/ eggs from different individual broodstock. In some hatcheries, individual broodstock were repeatedly used within a year (up to four times a year), and this will also further contribute to the reduction of the effective breeding number.

Economic factors, such as the fluctuation of price of larvae between seasons is also a factor to be considered. Often the price of larvae during the main breeding season is much lower than that during early or late season. This would encourage hatcheries to produce more larvae during off-peak seasons when broodstock performance is poor in terms of spawning rate, fertilisation and hatch rate.

In general, all issues discussed above highlight a common problem – reduced effective breeding number, and as a consequence, high levels of inbreeding (the mating between closely related individuals), as well as genetic drift (random changes in allele frequency). Inbreeding often causes a decrease in productivity (i.e. inbreeding depression), and genetic drift can alter gene frequency and eliminate alleles, which can decrease a population’s ability to survive or to adapt to an altered environment. The goal of management is to reduce inbreeding and genetic drift.

The issues highlighted in this paper are probably a result of lack of training for hatchery managers/ owners in genetic management of broodstock. It is crucial that a programme should be designed to target this technical level for better hatchery management. In addition, better management practices should be developed, based on more extensive surveys, and awareness on broodstock management should be introduced sooner rather than later in order to ensure good seed supply, contributing to sustainability of the sector.

The above suggestion does not imply training of hatchery managers in advanced genetic techniques but basic know-how on how to maintain and use available broodstock to the best advantage. This basic knowledge will be easily taken up by entrepreneurial Vietnamese hatchery operators, who are always willing to introduce improvements.

Acknowledgements

This study was undertaken under the auspices of the Ministry of Education and Training of Vietnam.

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Nodavirus: An emerging threat to freshwater prawn farming

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The giant freshwater prawn, *Macrobrachium rosenbergii* is a native inhabitant of sub-tropical and tropical waters. It is commercially important and one of the most cultured prawn species in Southeast Asia, as well as Israel, Japan, Taiwan Province of China, Latin America, the Caribbean and some countries in Africa due to its potential of fast growth, large size, disease tolerance and export market value[2]. Increasing demand for this species in both the domestic and export markets has led to a remarkable increase in the number of large scale culture systems with high stocking density and intensive feeding[2]. With the rapid development in hatchery production of post-larvae and the number of prawn grow-out farms, good husbandry and environmental management have often been neglected. Consequently, pathogens gain easy entry as the prawns are stressed and weakened under adverse environmental conditions[3].

Diseases of viral aetiology have caused havoc in the aquaculture industry, sometimes wiping out entire stocks within days of onset of infection[4]. *Macrobrachium rosenbergii* is often considered as a less susceptible species to disease problems when compared with farmed penaeid shrimp, perhaps because of the generally less intensified culture practices of freshwater prawn farming. However, recently disease problems have become of serious concern to giant freshwater prawn farming, probably because of the intensification of culture and the translocation of seed and broodstock[5]. The recent report of white muscle disease (WMD) in freshwater prawn hatcheries and farms has sent shock waves through the prawn aquaculture industry.

Whitish muscle disease (WMD)

Whitish muscle disease of *Macrobrachium rosenbergii*, also called "whitish disease" or "white tail disease", is a new serious epizootic disease caused by *Macrobrachium rosenbergii* nodavirus (MrNV). It was first observed and reported in a hatchery in Guadeloupe, French West Indies[6]. Then later on in China (both mainland and the Province of Taiwan) and India. It has caused immense economic losses in hatcheries and farms, with mortalities often reaching 100% in post-larval stages[10,13]. These viruses thrive in brackish and freshwater environment. The specific host is giant freshwater prawn and the affected life stages are larvae, post-larvae and early juveniles[7]. There is no evidence of adult life stages being affected but they might act as carriers. It has not been listed by OIE.

The geographical distribution of this virus is across northern South America (French West Indies, Dominican Republic and Caribbean region) and Asia (China, Taiwan Province of China and India). Clinical signs and mortality patterns appear similar in all locations and it may be assumed that movement of some common prawn population source might be the reason for the wide distribution of the WMD. However, further studies are required to understand the geographic distribution[7].

Normal and MrNV infected (right) prawns.

Pathogen and mode of infection

The causative agents of WMD are thought to be *M. rosenbergii* nodavirus (MrNV) and extra small virus (XSV). These two RNA viruses are invariably seen in association with infected prawns. MrNV is a small icosahedral non-enveloped virus, 26 to 27 nm in diameter that has been identified in the cytoplasm of connective tissue cells. The capsid contains a single polypeptide of 43 kDa (cp-43)[8]. The nodaviruses are known to contain a genome consisting of two single-stranded positive-sense RNA segments, RNA1, which encodes the viral part of the RNA-dependent RNA polymerase (RdRp) and RNA2, which encodes the capsid protein. In infected cells, RNA3, a subgenomic transcript of RNA1, is also present[9]. Viral replication takes place in the cytoplasm of connective tissue cells of most organs and tissues. XSV is also an icosahedral virus, 15 nm in diameter, its genome consisting of a linear single-stranded positive-sense RNA coding for a capsid protein, cp-17. Because of its extremely small size and absence of gene-encoding enzymes required for replication, it has been suggested that XSV may be a satellite virus, while MrNV plays the role of a helper virus[10]. However, the respective roles of the two viruses in the disease pathogenesis are not yet known[11]. This disease outbreak occurs in post-larvae 3–5 days to 3 weeks after desalting. Incidence of post-larval mortalities of 30-100% within two or three days of appearance of the clinical sign of opaqueness was reported[5]. Very few post-larvae presenting these signs survive and survivors seem to grow normally in grow-out ponds[7]. Bacteriological examination of affected PL showed the presence of *Staphy-*

Muscular opaqueness in infected prawn (above) and transparent normal prawn (below).

lococcus spp. as a predominant organism, while laboratory challenge of healthy PL with this bacterial isolate did not reproduce WMD[5].

Signs and symptoms

The clinical signs of this disease include lethargy, anorexia and opaqueness of abdominal muscle in post-larvae and adults. Whitish appearance of the tail is the prominent clinical sign, and therefore, the disease is also named as white tail disease. This milky opaqueness gradually expands on both sides (anterior and posterior) and leads to degeneration of telson and uropods in severe cases. Some infected animals without uropods have been observed. The discoloration appears to start at the tail extremity (telson region) and gradually progress towards the head. Eventually all muscles in the abdomen and cephalothorax are affected. The tissues most affected in moribund PLs/early juveniles are striated muscles of the abdomen and cephalothorax and intratubular connective tissue of the hepatopancreas[7]. The cephalothoracic region increases in size and it may become double the original size (referred to as branchiostegite blister disease (BBD) or swollen head syndrome). The cephalothoracic region when opened, may contain two sac-like structures with watery fluid above the hepatopancreas on either side. Histopathological examination of the infected animals reveals highly necrotic musculature. Multifocal areas of hyaline necrosis of muscle fibres are found in the striated muscle[7]. Degenerated muscle areas show aggregations of melanized nuclei, many of which look like inclusion bodies. The clinical signs and histopathology of WMD closely resemble to the idiopathic muscle necrosis (IMN) reported in *M. rosenbergii*[12].

Diagnostic methods

To curb the disease spread and to avoid economic loss, it is essential that a highly sensitive, specific and rapid diagnostic method be developed for early detection of both the pathogenic agents (MrNV and XSV) of the disease. The three basic methods in disease diagnosis are screening, presumptive and confirmatory methods[7]. The presumptive method includes gross observation of the presence of post-larvae with milky white colour abdomen followed by mortality, histopathological study of changes characterized by pale to darkly basophilic, reticulated cytoplasmic inclusions in the connective tissue cells of most organs and tissues (pryonin methyl green staining can be used to distinguish the characteristically green-stained MrNV viral inclusions from hemocyte nuclei) and virological studies. The screening and confirmatory tests can be done using viral genome-based detection methods using reverse-transcriptase polymerase chain reaction (RT-PCR) and loop-mediated isothermal amplification (LAMP). Other detection methods for MrNV include a double antibody sandwich enzyme-linked immunosorbent assay (DS-ELISA), triple antibody sandwich enzyme-linked immunosorbent assay (TAS-ELISA) and dot blot hybridization, in situ hybridization.

Reverse-transcriptase polymerase chain reaction

RT-PCR is the most sensitive of all diagnostic method to detect MrNV. This method is used to synthesis and amplifiy cDNA copies from RNA viruses. Identification of virus can be done using amplification of cDNA by specific primers. The primer sequence for MrNV is 5'-GCG-TTA-TAG-ATG-GCA-CAA-GG-3' (forward) and 5'-AGC-TGT-GAA-ACT-TCC-ACT-GG-3' (reverse) with amplified product size of 425 bp[7]. Although very sensitive and highly specific, it requires the use of a thermal cycler and hence can be carried out only in well-equipped laboratories. More recently a single-tube, duplex RT-PCR method has been developed for simultaneous detection of MrNV and XSV.

Loop-mediated isothermal amplification

A loop-mediated isothermal amplification (LAMP) procedure is described for rapid diagnosis of white muscle disease. It is a specific nucleic acid amplification method that can amplify target nucleic acid to 109 copies at 60–65°C in 1 hour[13]. The method relies on autocycling strand displacement DNA synthesis by the best DNA polymerase large fragment, a DNA polymerase with high strand displacement activity. As the reaction is carried out under isothermal conditions, it can be performed with a simple and inexpensive water bath. As there is no time loss in thermal changes, the amplification efficiency of the LAMP method is extremely high. The LAMP reaction requires four primers specifically recognizing six distinct regions of the template DNA. Hence, there is a high degree of specificity for detection. A positive reaction can be easily detected within one hour due to the production of a whitish precipitate of magnesium pyrophosphate thereby eliminating the need for agarose gel electrophoresis[14]. The time kinetics and sensitivity of the LAMP reaction can be further improved by the use of two additional loop primers. There are very few reports of the application of LAMP methodology for detection of RNA viruses. An RT-LAMP method has been developed as a rapid and convenient method for detection.

Transmission

Both vertical and horizontal transmission of MrNV has been observed[7]. Infected broodstock serve as carriers and results in diseased postlarvae. Even *Artemia* nauplii from infected *Artemia* stocks can spread the disease. Penaeid shrimps are not much susceptible to these viruses but experimental results indicate the possibility of shrimp acting as reservoir for MrNV and maintaining their virulence in their tissue system.

Conclusion

Prevention is better than cure, as there are no treatments to this viral pathogen, only through adoption of better management practices in hatcheries and farms can the spread and impact of white tail disease in prawn farming can be minimized. The early screening of broodstock and postlarvae should be strongly encouraged. Strict quarantine measures should is followed in translocation of prawn stock and seeds to avoid spread of pathogen. Broodstock or seed testing positive for MrNV must be discarded with proper zoosanitory methods. Further research is needed for through understanding of pathogen-host interaction, viral strain, immune response and drug development.

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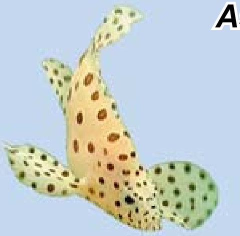

Asia-Pacific Marine Finfish Aquaculture Network

Magazine

SKRETTING

Asian seabass farming: Brainstorming workshop and training in India

Brainstorming workshop

A one-day brainstorming workshop to discuss the development of Asian seabass *Lates calcarifer* farming in India was organized at the Central Institute of Brackishwater Aquaculture (CIBA) at Chennai on 29 August 2008.

Dr. P. Krishnaiah, Chief Executive, National Fisheries Development Board (NFDB) inaugurated the Workshop. Shri Shambhu Kallolikar, I.A.S., Commissioner of Fisheries, Govt. of Tamil Nadu presided over the function as Chief Guest. Dr. A.G. Ponniah, Director of CIBA, welcomed the gathering. The workshop was facilitated by Dr. A.R.T. Arasu, Head, Fish Culture Division of CIBA and his team.

The workshop was attended by about 100 participants from aquaculture sector including the farmers from the states of Tamil Nadu, Andhra Pradesh, West Bengal, and Orissa, policy makers, administrators, officials from the State Departments of Fisheries of Tamil Nadu, Orissa and Gujarat, the Marine Products Development Authority (MPEDA), Government of India, Rajiv Gandhi Centre for Aquaculture (RGCA) and the scientists of CIBA, Central Marine Fisheries Research Institute (CMFRI) and other organizations. Key note addresses on the seed production of Asian seabass under controlled conditions, feed development and intensive culture of Asian seabass in pond based cages were delivered by the experts from CIBA, RGCA and MPEDA.

The discussion that followed the presentations was mainly focused on the availability of quality seed and cost effective feed. Farmers wanted to have a reasonable price for their produce that rewarded their investment and effort. It was also felt that although the intensive farming is technically viable, investment costs should be reduced and market linkages standardized.

Outcomes of the workshop

CIBA will take up demonstrations of seabass culture in farms of 1 or 2 ha minimum at three centres: two on the east coast i.e., Tamil Nadu and Andhra Pradesh, and one in the west coast which will be funded by NFDB.

Above and below: The workshop and hands-on training.

Entrepreneurs and farmers interested in seabass farming may also submit a proposal detailing their requirements. The NFDB will explore the possibilities of supporting such programmes within its norms.

Information on intensive cage farming in ponds may also be consolidated and the technologically and economically viable proposals may be also worked out.

The relative economic viability of different farming systems may also be examined and suitable protocols with the technical and economic details prepared as a package to assist farmers to adopt seabass culture.

Farmers who are interested to offer their facilities for demonstrations may do so in consultation with CIBA / RGCA.

Seed rearing centres can also be strengthened which can work as nursery centres to supply larger fingerlings for stocking, so that the culture duration can be reduced.

All stakeholders agreed that they should cooperate to have mutual, open dialogues at frequent intervals and be involved in evaluation of farming trials.

Training

A 10 days training programme on the Asian seabass breeding and culture was organized at CIBA, Chennai during 20-29 August 2008. It was attended by fifteen participants including farmers, scientists from CMFRI, Kochi, and Central Agricultural Research Institute (ICAR), Port Blair, Andamans, a lecturer from University of Kerala, Thiruvananthapuram, officers from MATSYAFED and Central Institute of Fisheries Nautical Engineering and Training, Kerala, consultants from Andhra Pradesh, officials from State Fisheries Department, Government of Orissa and technical staff from Annamalai University. The training provided hands on exposure to the participants on the seed production under controlled conditions and culture of seabass.

Comparative study for broodstock management of grey mullet (*Mugil cephalus* L.) in cages and earthen ponds with hormone treatment

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The grey mullet *Mugil cepalus* is a commercially important fish in the Bay of Bengal, locally known as khorul bata, commonly found in coastal and offshore waters of Bangladesh. It is caught in large quantities from shallow fishing grounds[1].

The grey mullet is available in the Bakkhali River estuary during their breeding season from October to December, where salinity may range from 0 to 35ppt. Broodstock of grey mullet are not well utilized in the coastal area of Bangladesh. Local fishers generally catch them with seine nets and sell them in the local market for human consumption without realizing the actual importance of grey mullet broodstock for hatchery operation.

Marine finfish hatchery techniques are not well developed in Bangladesh due to the lack of technical knowhow. Collection of the naturally produced fry of grey mullet is not popular and as a result there is limited seed available and farmers are not interested to develop mullet farming in coastal areas. The development of breeding technology for this species including through the proper management of broodstock would, however, open up new opportunities. The objective of this study was to develop breeding and hatchery technology for grey mullet using hormone treatment.

Harvesting grey mullet and other species from net and cages.

Materials and methods

Samridhi Multipurpose Aquaculture Farm and Fish Research Center (SMAFRC) and Bakkhali Associates' farm were selected for the study. Both research stations are private initiatives, located at Jilwanja, Cox's Bazar, about two km away, towards north-west of the Cox's Bazar bus terminal, on the left bank of the Bakkhali river estuary. The research work was conducted in two study area in the months of June to December, 2005.

Brood fish were collected from Bakkhali River by seine net at high tide. The live fish were returned to the stations in 2.5m PVC pipes to reduce physical injury. Broodstock at SMAFRC were stocked into ponds and at the Bakkhali Associates farm they were stocked into cages, both in equal proportions. Fish were acclimatized before stocking.

The pond of SMAFRC used for brood stock management was rectangular in shape and approximately 106 m^2 in area and 1 m in depth. Two types of cages (bamboo and net cage) were installed in the Bakkhali Associates farm for broodstock management. They were situated in proximity to the sluice gate area. Broodstock were reared for at least two months on the stations, maintaining water quality and supply of supplemental food to encourage gonad maturation.

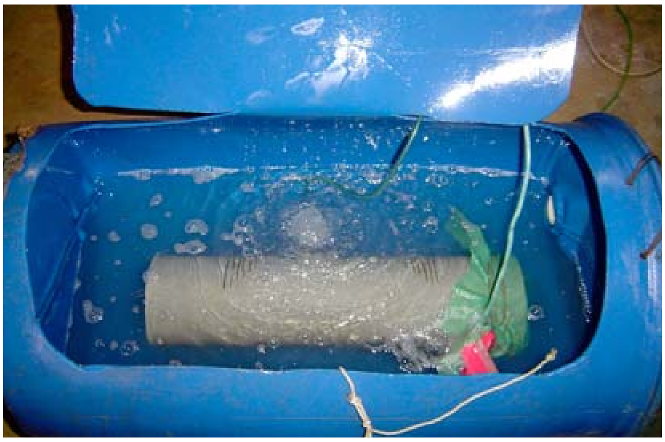
The Bakkhali River is the water source for both stations. In SMAFRC, water was taken in only during high tides at the full and new moon, when the water level reached the level of the inlet piple. However, water was more easily exchanged in Bakkhali Associate farm during every high tide. During this experiment, broodstock maturity was examined at stocking, middle salinity condition and at harvesting time (higher salinity condition) in ponds and cages. The gonadal-somatic index of the representative broodfish was determined during stocking and harvesting period in order to identify the gonadal maturation.

Hormone treatment of broodfish were performed in SMAFRC hatchery complex. The hatchery complex was facilitated with fresh and filtered sea water, aeration, siphoning system, temperature control, and sufficient number of tanks for broodstock, spawning, incubation and algal culture.

After two months of rearing in the ponds and cages, healthy and strong brood fish were collected and transferred to the hatchery for operation. Broodstock were treated with 1 ppm $KMnO_4$ as an antiseptic. Fishes were than weighted. Pond and cage reared brood fish (male and female) were kept in separate tanks until the hormone treatment was complete. Physio-chemical parameters of the tank were recorded. Broodfish were fed artificially prepared diets rich in protein. Spawners were selected by external morphological characters. In some cases, these characters are not reliable indicators of maturity. For this reason, ovarian maturity of the spawner was accurately measured[2].

Males were selected by the observation of flow of milt when gentle pressure was applied along the abdomen towards the cloaca. Three representative pond and cage reared female broodstock were selected for hormone treatment on the basis of their egg maturity. The egg size was determined in three observations[2,3]. Hormone treatment of gravid females was started when intra-ovarian oocytes were filled with yolk i.e. the tertiary yolk globule stage and having an egg diameter above 500µ, at least 600-650µ. Hormone was injected at the pectoral fin region or intra muscular region at 12 hour intervals. Stripping of brood fish was conducted 24 hours after the first injection and stripping percentage (weight of stripped eggs / body weight) was determined[4].

Bamboo and net cages for grey mullet broodstock.



Broodstock transportation container.

Brood fish in spawning tank.

Results and discussion

Broodstock maturity: Salinity plays an important role in broodstock maturation. Grey mullet reach full maturity at thirty parts per thousand (ppt) salinity[3]. The maturity of broodstock was observed by the determination of egg size, expressed as egg diameter (µ). First observations were done at 8 ppt or 10 ppt salinities during stocking, the second observation at 25ppt and final observation at 30 ppt in both experimental sites. In three observations, egg diameters were found between 200-585 µ in pond and 210 to 620 µ in cage reared brood. Mean egg diameters were calculated from 222.125 µ to 569.75 µ in pond reared and 222.88 µ to 608.75 µ in cage reared brood respectively. All of the male broodstock were sexually mature because they yielded milt when gentle pressure was applied along the abdomen.

From the experiment, it has been showed that maturation of eggs was directly proportional to the salinity. Salinity increased very slowly in the earthen ponds due to improper tidal water exchange. However, in the cage equipped station, salinity increased earlier than in the ponds due to more frequent tidal water exchange. Thus, egg maturation was delayed in broodstock kept within ponds because of inadequate water exchange.

Mature gonad indication: It was observed that gonad weight of two representative brood fish in pond and cages during stocking time was about 65 g and 105 g respectively and at harvesting time the gonad weight of the two representative pond and cage reared brood fish was 130 g and 200 g respectively. Gonad weight was higher (200 g) in cage reared broodstock than in those reared in ponds (130 g). The GSI value of the two representative weights of brood fish during stocking in pond and cage were about 6.5 and 7.0 respectively and after two month rearing in pond and cages, the GSI value of the same fish was about 11.81 and 12.34 respectively. GSI value was higher (12.34) in cage reared broodstock than in pond reared broodstock (11.81) indicating that the gonad of cage reared fish was more highly mature than pond reared fish.

Breeding performance by hormone treatment: In order to assess the spawning performance of grey mullet, broodstock were collected from pond and cage and transferred to the hatchery brood stock tank for hypophysation. For successful spawning, salinity was maintained at 30 ppt and water temperature at 22.7°C, dissolved oxygen at 6 mg/l and pH 7.8 in the broodstock and spawning tank. Pond and cage reared brood were kept in separate tanks for proper spawner selection. Among them, three pond and cage reared brood were selected on the basis of their body weight and egg maturity.

Egg maturity was found higher (600 to 612 µ) for selected cage reared brood-stock than pond reared broodstock (560 to 600 µ). Highly mature eggs require lower concentration of PG than dose

Hormone preparation.

Injecting hormone into grey mullet.

Collecting eggs from broodstock.

than slightly matured egg[5]. To determine the effective dose of pituitary gland for successful stripping, different concentration of pituitary glad were injected for representative pond (7mg/kg; 6mg/kg; 5mg/kg) and cage reared (5mg/kg; 3mg/kg; 3mg/kg) brood fish. They were applied on the basis of their body size and state of egg maturation.

From this experiment, it has been shown that pond reared broodstock with slightly mature eggs (560 to 600 μ) required higher pituitary gland dose (7mg/kg; 6mg/kg; 5mg/kg) and highly mature cage reared broodstock (600 to 612μ) required lower pituitary gland dose (4mg/kg, 3mg/kg, 3mg/kg) to attain the ripe stage, which enhanced successful ovulation. It has well been shown that stripping percentage was higher in cage reared broodstock (4.13%; 5.58; 5.18%) than pond reared broodstock (2%; 3.3%, 4.45%). Stripping was related with the hormone dose and egg maturation. Highly mature eggs (600 to 612 μ) required lower PG because they were in near about the ripe stage. This amount of pituitary gland was sufficient to attain the ripe stage and stripping percentage was recorded higher at this lower pituitary gland dose.

Conclusion

This type of experiment was the first time in Cox's Bazar where the utilization of coastal waters have been used both in cages and pond for the gonadal maturation of Mugil cephalus. With this scientific intervention, a remarkable maturity of grey mullet was found in cage reared broodstock compared to ponds. It has well been shown that cages located near the flow of tidal water can be better utilized for broodstock management, thus the gonadal maturation was facilitated in cages due to the availability of tidal water and increase in salinity which was not possible in the enclosed water in the inland pond systems of SMAFRC. This new concept in the arena of aquaculture will create a new hope for the fish farmers. If this technology is further developed and disseminated among the coastal people and fish farmers, they will be able to improve the hatchery technique of grey mullet. Thus, the economic development of the country will surely be improved.

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Eggs are put in a hatching jar for easy management.

The research team visiting the experimental pond.

Cultivation of gilthead sea bream (*Sparus auratus* L.) in low saline inland water of the southern part of Israel desert

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Fish development, growth and survival are influenced by various physiological factors among which water salinity is one important parameter. Many studies have indicated that the various developmental stages during fish embryogenesis depend on water salinity. Salinity also plays a key role in growth control, influencing growth rate, metabolic rate, feed intake and feed conversion. Keeping this in mind a short term trial was conducted to adapt and/or acclimatize the gilthead sea bream, *Sparus auratus* L., into low saline inland waters. Gilthead sea bream is a euryhaline teleost capable of living in environments of different salinities ranges from 2‰ to 60 ‰[1]. Adaptation of euryhaline fish to different environmental salinities induces changes/activation of ion transport mechanisms.

This adaptation is usually accompanied by changes in oxygen consumption, suggesting variations in the energy demands for osmoregulation[2]. *S. auratus* is available in the natural habitat ranges from the Mediterranean and Black Sea to the eastern Atlantic Ocean from Senegal to the United Kingdom[3]. It is commonly found in shallow lagoons along the coast, but migrated into deeper water to spawn after late autumn.

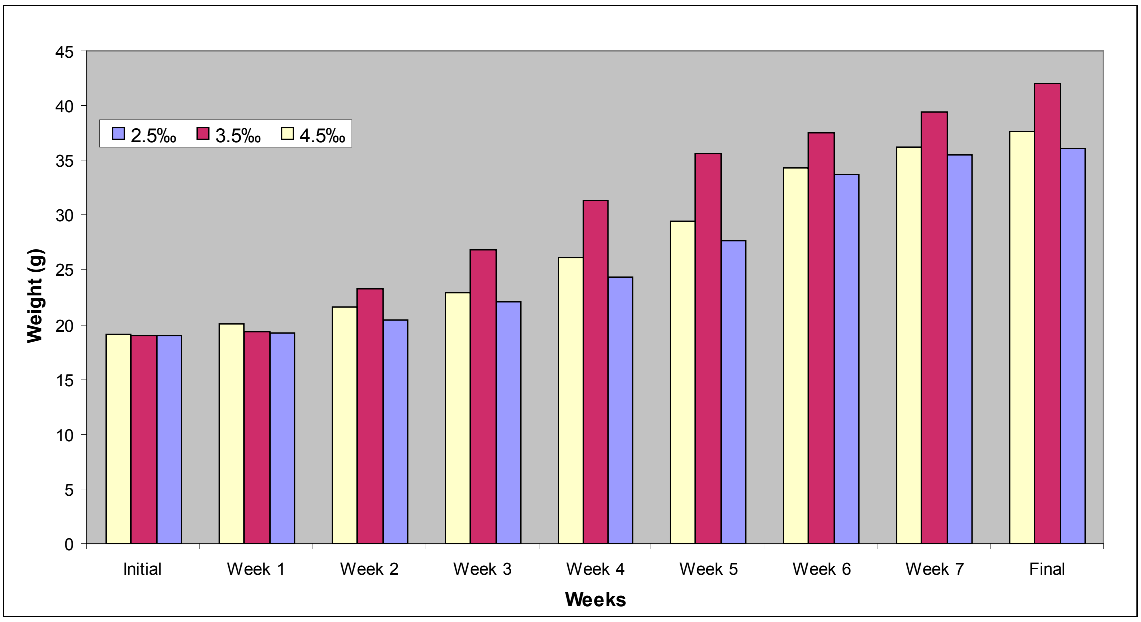
Main producers and production statistics

S. auratus is an economically important marine species. Extensive culture was popular in coastal lagoons and saltwater ponds, until intensive rearing systems were developed during the 1980s. The Italian 'vallicoltura' or the Egyptian 'hosha' are extensive fish rearing systems that act like natural fish traps, taking advantage of the natural migration of juveniles from the sea into coastal lagoons. Artificial breeding was successfully achieved in Italy in 1981-82 and large-scale production of gilthead sea bream juveniles was definitively achieved in 1988-1989 in Spain, Italy and Greece. The hatchery production and farming of this fish is one of the success stories of the aquaculture business. This species very quickly demonstrated a high adaptability to intensive rearing conditions, both in ponds and cages, and its annual production increased regularly until 2000, when it reached a peak of over 87,000 t (Plate 4). Most production occurs in the Mediterranean, with Greece (49 %) being by far the largest producer in 2002. Turkey (15%), Spain (14%) and Italy (6%) are major Mediterranean producers. There is also gilthead sea bream production in the Red Sea, the Persian Gulf, and the Arabian Sea. The main producer is Israel (3% of total production in 2002); Kuwait and Oman are minor producers.

Multiple use of low saline inland water

Two thirds of Israel is covered by desert, which is inhabited by only 2-3% of the population. Beneath this desert are large aquifers containing huge quantities of fossil, geothermal saline water. For the last 30 years this brackish water has been successfully used for irrigation of agricultural crops (e.g., tomatoes, melons, wheat, cotton, olives, etc.). In the past ten years, investigations have shown the significant potential of the geothermal, brackish water for the successful culture of aquatic organisms such as fish, crustaceans and algae. In order to improve the economic viability of both sectors - aquaculture and agriculture - it is obvious that a chain of users of the desert water is needed. Ramat Negev Highlands is a district in the Israeli desert with a community of 4,000 inhabitants and a current use of 4.5 million m^3 brackish water per annum. Seven drillings, to a depth of between 550-1000m, supply the brackish water at a salinity of between 2,680 – 4,360 TDS, at temperatures of between 39 - 41°C for aquaculture/agriculture. A practicable, efficient chain of users is illustrated below: Several wells, possibly linked, continuously supply brackish water to both first users - greenhouses (for heating) and thermal baths (medicinal or recreational). Water from the first two users runs to an environmentally controlled fish polyculture system. Water, rich with suspended organic material, leaves the fish culture system and enters a reservoir which stores the water to meet the demand of the next user - irrigation of agricultural crops, which supply, among other items, fodder for livestock including dairy cows, sheep and ostriches. Furthermore, a proportion of the original saline water can be cost-effectively desalinated and used as freshwater for human consumption. Efforts are being directed towards optimization of such models, for maximizing economic viability through 'denis' (sea bream locally known as) culture.

Fig 1: Weight gain (g) of sea bream reared at three different salinities (2.5‰, 3.5‰ and 4.5‰) for 8 weeks.



Adaptation of sea bream into low saline water

Sea bream rearing in low salinity water is becoming an important component of aquaculture growth and can be found in many regions[4]. Cultivation practices in the Mediterranean region vary considerably mainly due to the regional environmental conditions and available quality and quantity of water resources. In low salinity adapted fish, the passive outward flux of ions such as Na^+ and Cl^- from the fish to the external medium, via the gills, faeces, and renal system, must be overcome by active uptake of ions (e.g., Na^+, Cl^-, K^+, and Ca^{2+}) from the water and/or from the diet[5]. The gill is a major osmoregulatory organ in fish, undergoes large morphological changes, even at low salinities[1]. Adaptation to salinity regimes markedly lower than sea water is an important physiological ability in the many species of marine fish that constitute non-estuarine dependent nekton in estuarine ecosystems[7].

Research findings

Sea bream with an average body weight of 19 g were reared under three different salinity levels. Water of three different salinities was collected for the trials; one batch from the inland of the Negev District of Israel (low saline inland water I; 2.5‰), a second from the southern part of the desert (low saline inland water II; salinity 3.5‰) and the third from the Dead Sea area (low saline inland water III; salinity 4.5‰). Each tank was connected with water flow through system separately, along with a filtration unit. Continuous aeration was given to both systems. Every day morning, before first feeding (09.00 h) water salinity (‰), temperature (ºC) and water flow (L/min) were measured and recorded. Water flow was maintained between 2-3 L/min uniformly in all the three systems. Any fluctuation in the salinity due to evaporation was mitigated by the addition of de-chlorinated fresh water to maintain salinity consistent salinity levels throughout the trials. Each system was also provided with water heater (EHEIM Aquatics, Germany) to maintain the temperature at not less than 27°C. The experiment was conducted in nine (3 treatment x 3 triplicates) different plastic containers (each capacity 60 L) for 8 weeks.

A group of 135 individuals of *S. auratus* juveniles acclimatized at 6 ppt were collected from the hatchery of the Bengis Centre for Desert Aquaculture, Ben-Gurion University of the Negev, Israel. They were acclimatized in plasson systems (2.5 x 1 x 1 m) for one month. 15 randomly selected individuals were selected for each tank after recording initial weight. Fish weight was measured weekly to observe growth rate and fed ad libitum with the prepared commercial experimental feed (25% crude protein; crumbles; Zemach Feed Mills of Israel; Feed No. 4834) three times daily. Growth, survival, feeding behavior and feeding rate were calculated. Mean differences in growth rate and survival were assessed at $P<0.05$ using the students 't' test.

The growth and survival of water I, II and III reared individuals were presented in Table 2 and Fig 1. Overall, individuals reared in water II had superior growth to the other treatments ($P<0.05$), and also the best survival and FCR. Water I reared individuals also had relatively good survival. Water III reared individuals had the lowest survival and worst FCR, although the latter was not significantly different from water I. Water III reared individuals grew well up to one week (20.05 ± 6.91 g after 1 week, 21.56 ± 6.77 g after 2 weeks & 22.86 ± 7.64 g after 3 weeks), but after one week yellow water reared individuals (water II) grow faster than brackish water individuals (water III) (19.31 ± 5.32 g after 1 week, 23.28 ± 6.16 g after 2 weeks & 26.76 ± 7.05 g after 3 weeks).

This study shows that gilthead sea bream can adapt to a wide range of salinities with adjustment in body fluids, which are more evident at the extreme range of salinities (2‰ - 60‰). The results indicate that the most favorable conditions for maximum growth of sea bream fry are the low salinities rather than brackish water or the open sea. This is in accordance with the general knowledge on this species biology, which indicates that fry remain in the coastal lagoon areas for the first year of their life[8]. However, it should be noted that salinity effects are very difficult to distinguish from those of other factors, because food quality and quantity may affect salinity tolerance[9].

In terms of survival the best performance may be achieved at water salinity of 3.5‰. This indicates that the intermediate environment of 3.5‰ salinity is best, not only form the point

Table 1: Water quality measurements during the experimental period (mean values ± standard deviation).

Water quality parameters	Low saline inland water I (2.5 ‰)	Low saline inland water II (3.5 ‰)	Low saline inland water III (4.5 ‰)
Salinity (‰)	2.5 ± 0.3	3.5 ± 0.2	4.5 ± 0.4
Temperature (ºC)	29.6 ± 2.0	28.2 ± 2.4	27.2 ± 1.9
Water flow (L/min)	2.1 ± 0.24	2.1 ± 0.24	2.1 ± 0.24

Table 2: Weight, weight gain (g) average weight gain (%), specific growth rate (SGR; %d-1), food conversion ratio (FCR) and survival (%) of sea bream (*S. auratus*) reared at 2.5‰, 3.5‰ and 4.3‰ water salinities.

Parameters	I Low saline inland water (2.5 ppt)	II Yellow water (3.5 ppt)	III Brackish water (4.5 ppt)
Initial weight	19.05 ± 3.95	19.01 ± 4.34	19.07 ± 5.21
Final weight	36.11 ± 9.65	42.01 ± 12.47	37.59 ± 10.6
Weight gain	17.06	23.0	18.58
Average weight gain	89.55	120.98	97.73
SGR	0.4960	0.615	0.5287
FCR	2.34	2.1	2.45
Survival (%)	70.5	73.3	60.0

of view of good growth, but also fish adaptation and survival. These parameters are very important for commercial scale aquaculture. This is in accordance with other studies on euryhaline species and supports the observation that lower salinities than those naturally occurring in open waters are the most favorable for rearing of this species[4]. The ability to adapt to lower salinities is based on the rapid reversion of the osmoregulatory mechanism on the cell membrane level[11]. Differences in survival ability are attributed to the ability of fish to conclude this reversion as quickly as possible and successfully. The iso-osmotic point for marine species between body fluids and the sea water was found to be around 10 ± 2‰[12], below which the reversion of the osmoregulatory mechanism occurs.

Conclusion

Sea bream is able to withstand a wide range of environmental salinities with minor changes in plasma osmoregulatory variables and the effective regulation of the gill Na^+, K^+ and ATPase. Further research is necessary to investigate the effect of adding salts that are deficient in low saline water sources into the diets of sea bream to make this culture practice as more feasible.

Acknowledgement

The Bengis Centre for Desert Aquaculture, the Albert Katz Department of Dryland Biotechnologies, the Jacob Blaustein Institute for Desert Research, Ben-Gurion University of the Negev, Israel is gratefully acknowledged for providing the postdoctoral fellowship grant to the second author. Mr. David Benzion and Mr. Alan Wass are thanked for their technical help.

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Mariculture development opportunities in SE Sulawesi, Indonesia

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The island of Sulawesi, Indonesia, is recognized by the government of Indonesia as a major area for development of mariculture. Within Sulawesi, one of the least developed areas is SE Sulawesi Province, which consists of twelve districts, comprising ten regencies and two towns, including Kendari which is the major population and commercial centre.

SE Sulawesi is a relatively impoverished region of Indonesia. The fishery related activities are of importance to this region and currently estimated to account for about 12 percent of the annual GDP, to which mariculture contributes approximately 3-4 percent. In 2007 aquaculture production in the Province reached 153,160 t, valued at approximately 1000 billion Indonesian Rupia, with seaweed production showing the highest growth. A total of 115,483 households and 160,140 persons were involved in aquaculture in the Province.

SE Sulawesi and the associated islands have many accessible and well sheltered bays and inlets with abundant natural resources for mariculture, including good water quality. Resident coastal communities are eager to increase their quality of life through adoption and development of commercial production systems for various local products including grouper, seaweed, lobster, abalone, pearl oyster and sea cucumber.

Mariculture and fisheries development is often seen as an important strategy to contribute to poverty alleviation of rural coastal communities. The Government of Indonesia, having recognized this fact, is in the process of initiating development activities in partnership with the Australian Government

Typical cage farms in Kendari Bay, SE Sulawesi.

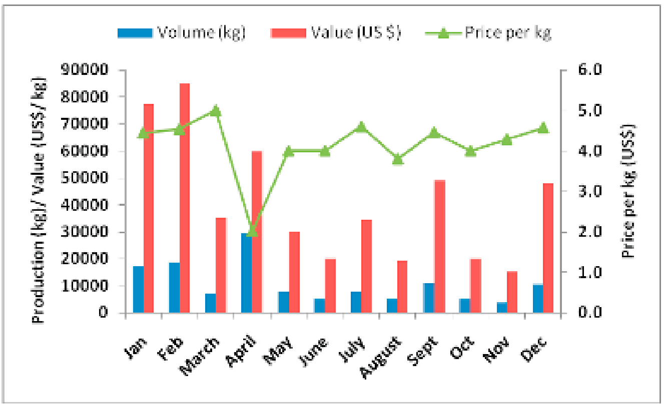
through the 'Smallholder Agribusiness Development Initiative' (SADI). The purpose of this initiative is to reduce poverty and improve livelihoods for smallholders in eastern Indonesia. The Australian Centre for International Agricultural Research (ACIAR) coordinates the 'Support for Market Driven Adaptive Research' (SMAR) sub-program of SADI.

SMAR is a sub-program of the larger 'Smallholder Agribusiness Development Initiative' of the Australian and Indonesian governments designed to address long-standing issues and constraints relating to agricultural production and rural poverty in Eastern Indonesia. The purpose of SMAR is to develop strengthened, province-based agricultural R&D capacity that is market and client-driven and effectively transferring knowledge between stakeholders.

This article provides a brief introduction to mariculture activities for selected species in Kendari Bay, one of the main production regions in SE Sulawesi. It also outlines a new ACIAR-SADI funded project entitled 'Mariculture Market Chain Development in SE Sulwesi' being undertaken on a collaborative basis by Haluoleo University and the provincial fisheries service in SE Sulawesi, the Indonesian Centre for Marine and Fisheries Socio-Economic Research, the Network of Aquaculture Centres in Asia-Pacific and the Victorian Department of Primary Industries, Australia.

Grouper farming

Grouper farming is one of the most popular mariculture activities in the Kendari region. The main species farmed are the mouse grouper, *Cromileptes altivelis*, tiger grouper *Epinephelus fusgoguttatus* and possibly greasy grouper *E. tauvina*. The farming activity essentially consists of the fattening of 5-7cm fingerlings, most of which are procured



Monthly changes in live grouper production in SE Sulawesi, the total revenue and price per kg in 2007. Based on data from Dinas Kelautan Dan Perikanan (Provincial Fishery Service).

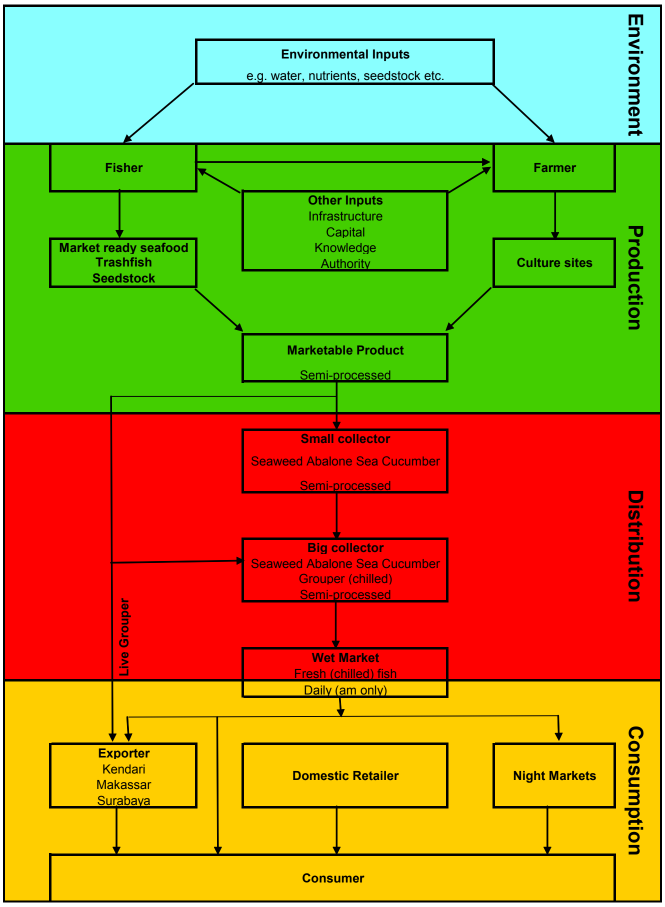
from hatcheries in Situbondo, Java and from Bali Island. The price of fingerlings is based on the length; a 1 cm fish costing around 3,000 Rp on delivery at the site.

The grouper are fattened in net cages (5 x 5 x 3m), of wooden or bamboo frames; each farmer owning and managing up to four-six cages. They are fed small, low-valued fish species, more often than not caught by the farmers themselves by gill netting, or from fixed weirs erected by the farmers (locally known as sero). The latter is a traditional mode of fishing, with the weir ownership passing hands from generation to generation. During the peak season, 50-80kg of fish are caught each day. Some of the larger operators obtain the low-valued fish through contracted artisanal fishers, purchased at around 12,000-20,000 Rp/kg, depending on the season.

Almost all farmed grouper are exported live to Hong Kong. Fish are harvested at a size ranging from 0.5 to 0.75 kg. Live haul boats arrive in the region on a regular basis and all transactions are cash-based.

Farming of grouper occurs through the year, with a peak period from December to March. In general, the farm-gate price of live grouper is relatively static through the year, with a marginal increase during February- March, the time of the Chinese New Year, and a rapid drop in the following month e.g. the price in the live fish restaurant trade in Hong Kong and Singapore ranges from about US $ 14 to 20, depending on the season and the species, as compared to

SE Sulawesi Mariculture Market Chain



Schematic summary of existing mariculture supply chain in Kendari Bay, SE Sulawesi with focus on grouper, sea cucumber, abalone, spiny lobster and seaweed.

A lobster farmer with a young animal.

the average farm-gate price of US$ 5 / kg. Mouse grouper often commands a 20-30% higher price than the tiger grouper. Interestingly, the almost complete dependence of SE Sulawesi grouper farming on hatchery-reared seed stock is heartening, especially from sustainability and biodiversity view points, and should be encouraged.

Spiny lobster farming

The most commonly farmed spiny lobster species is *Panilurus versicolor*. The type of cage used (5 x 5x 3 m), and the farming activity, including the procurement of low-valued fish for feed is very similar to that for grouper farming. However, in this instance the seed stocked, as in other parts of SE Asia, is wild caught. The wild seed stock supply is based on a tribe-based artisanal fishery in the waters surrounding the Tiworo Islands. The available seed stock are typically young lobster of about 100 g in weight (9-12 individuals/kg), costing 300,000Rp/kg (approximately US$10-12). They are fattened for 12-14 months and sold live to local wholesalers for export.

Lobsters are stocked at a density of 50 individuals/cage and harvested at a size of about 750-1000 g. The feeding of lobsters is well controlled, with each lobster typically being fed 1-2 small, low-valued fish per day. Most lobster farmers have their own sero (weir) for harvesting fish to feed lobsters. Lobster farmers also believe that putting papaya (*Carica papaya*) leaves and stems into the cages increases the moulting frequency and hence growth. Although indigenous knowledge may not necessarily be backed up by science, there may be a need to more closely investigate such an issue as a means of determining whether further improvements could be brought about in the spiny lobster production system.

The provincial fishery service (Dinas Perikanan) provided free seed stock to farmers in 2007 and 2008 through an Indonesian Government sponsored program to encourage lobster farming. The mortality rates in lobster farming are very low, and thus far disease problems have not surfaced. These factors have contributed to a significant shift to lobster farming from grouper. This shift has been further encouraged by the increasing cost of hatchery-based grouper seed, primarily brought about from increases in cost of transportation of seed over long distances.

Seaweed farming

Seaweed farming is a predominant activity in SE Sulawesi, largely because of the accessibility of protected inshore waters and the ideal ambient environmental conditions, the very low investment costs involved and strong market demand for the product. Although typically a lower valued product compared to other mariculture species, the farm-gate price of dried seaweed has more than doubled over the last several months, and currently ranges from 16,500 to 17,000 Rp/ kg. The commonly cultured seaweed is *Kappaphycus cottoni* (formerly *Eucheuma*). Unlike grouper and lobster farming, seaweed farming is typically a family activity, with all adults of the household being involved in one way or the other.

In the province, seaweed farming is conducted in community-based clusters, with each consisting of 10-15 (and up to 60) families managing/owning an area of about 1-2 ha/ family. The harvesting season is June-December, with about four-five harvests/year, averaging 1-1.5 t (dry weight)/harvest. Although seaweed farming is currently profitable, it is also a farming system that is very environmentally friendly as it is carbon sequestering. In the recent past it has encountered some disease problems, in particular “ice-ice”, caused by reduced salinity from increased freshwater run-off into Kendari Bay. According to the farmers, two strains are farmed in the area, with one being faster growing and more resistant to disease. Farmers also believe that the quality of the available seed stock has deteriorated over the years.

Market chain and industry development

The new ACIAR project in SE Sulawesi is a scoping study with the objectives to:

- Facilitate local leadership and support for mariculture industry development

Cultured Kappaphycus cottoni ready for harvest in Kendari Bay.

- Identify opportunities for adopting market driven, agibusiness approach to development for smallholders, and

- Prepare an industry development strategy with local stakeholder network.

Key initial activities for the project are to undertake a baseline survey to characterise and map existing mariculture supply chain dynamics in the province, with the emphasis being on a combination of high (abalone, grouper, spiny lobster, sea cucumber) and low-valued (seaweed) species and products in Kendari Bay (see opposite) and Buton and Muna Islands.

The existing supply chain is heavily dependent on environmental inputs of water, nutrients, seed and feed, etc, and is traditionally structured in terms of the key 'production, distribution and consumer' sectors. It has limited information flow between the sectors, disproportionate sharing of the value of the products between supply chains participants and is constrained by limited inputs (e.g. seedstock), capital, infrastructure, skills and lack of a coordinated marketing strategy. On the positive side, natural resources are still plentiful/underexploited, diverse and relatively unmodified.

Local stakeholders are enthusiastic about the opportunities and have a desire to improve their livelihoods through consideration of strategic intervention and practice change.

The scoping study is due for completion in mid 2009, at which time the feasibility will be determined of progressing to a 'stage 2 – market chain/industry development phase'.

A look into the future

The mariculture practices in the SE Sulawesi region are mostly simple, environmentally friendly, and can be considered as an ecosystem-based approach to mariculture, provided that the there is no over expansion and intensification in the foreseeable future. Perhaps one of the main drivers in this regard is that the practices tend to remain as a community-based activity, coordinated through village committees in such a manner that they are within the financial capabilities of the mostly smallholder farmers. A further strengthening of the village committees through enhanced networking, as well as forming clusters amongst villages, could lead not only to improvements in the practices per se but also enable market opportunities and improved trade of the farmed commodities.

The mariculture farming systems in SE Sulawesi also provide a good opportunity to introduce "Better Management Practices" (BMPs) as had been done with commodities (Umesh et al., 2007) elsewhere, with encouraging results. The adoption of BMPs has lead to an improvement in overall production,

A seaweed farming cluster, Kendari bay.

reduced disease occurrence and better market access and farm gate prices, the latter being often an Achilles heel for small-scale farmers in relatively remote localities.

Finally, studies along the value chain, as the current project is evaluating, will be useful to bring about a more coherent trade of the farmed products in the region. Such steps will eventually lead to better farm gate prices, and also adoption of better, ecologically acceptable farming practices. Specifically, the ACIAR scoping study is investigating a new conceptual framework for developing the existing mariculture industry in SE Sulawesi. This will feature strategies for transforming the existing supply chain into a more functional market chain, underpinned by enhanced stakeholder networks and associated information systems, marketing strategies, risk management and capacity building. A community-based approach to trophically balanced mariculture, integrating the environmental benefits of seaweed farming with production of higher value products, has the opportunity to adopt an effective and distinctive market brand for the province. This will require substantial changes to existing supply chain characteristics and functions, led by private sector 'chain champions' working across production, distribution and consumer sectors, and in partnership with government, IGO/NGOs and tertiary sectors. In the longer term, the livelihoods of those coastal communities in SE Sulawesi involved in the mariculture industry will benefit greatly if sustainable industry development can be achieved, noting of course the inevitable emerging challenges from climate change, biosecurity threats and market globalisation.

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Improved hatchery and grow-out technology for marine finfish

Makassar, Indonesia, was host to the annual meeting of the project *Improved hatchery and grow-out technology for marine finfish aquaculture in the Asia-Pacific region*, 22-25 July 2008, organised by the Australian Centre for International Agricultural Research (ACIAR) and the Research Institute for Coastal Aquaculture (RICA) Maros. The meeting was officially opened by the new Director of the Agency for Marine and Fisheries Research, Mr Gelwyn Yusuf and introduced by the new Director for Seed Production in the Directorate-General of Aquaculture, Prof. Ketut Sugama. The objectives of the project are to:

- Improve hatchery production technology for high-value marine finfish addressing larval nutrition and digestion, verification of intensive and semi-intensive hatchery techniques, live prey selection, production of SS-strain rotifers, use of ultra-small copepod nauplii as first feed prey, reducing cannibalism and feed development for late larvae and juveniles.

- Develop cost-effective grow-out diets, including through improved ingredient digestibility, lower cost-feeds, investigation of nutrient requirements, development of low-polluting feeds, commercial testing of feeds and investigation of feed on product quality.

- Facilitate technology adoption, through by identifying constraints and solutions to technology uptake, extension, training, communication and networking.

The project is one of a broader, inter-connected series funded by ACIAR that aims to develop better management practices for marine finfish aquaculture.

Other related projects include:

- Land capability assessment and classification for sustainable pond-based aquaculture systems (FIS/2002/076).

- Planning tools for environmentally sustainable tropical finfish cage culture in Indonesia and northern Australia (FIS/2003/027).

- Improved hatchery and grow-out technology for marine finfish aquaculture in the Asia-Pacific region (FIS/2002/077).

The backyard grouper hatchery technology development facilitated through these ACIAR projects has been widely adopted in Indonesia. In 1999, only five hatcheries in Indonesia produced grouper fingerlings and by 2004 the number had increased to 147. Hatcheries are no longer confined to Bali but have spread across to Lampung, East Java, and new investments in hatchery production are also in development in Riau. The technology was first successful in producing *Cromileptes altivelis* in 1998, followed by *Epinephelus fuscoguttatus* in 2001. Since then this technology has been applied to other marine finfish including grouper species such as estuary grouper *E. coioides*, *E. polyphekadion*, *E. corallicola*, coral trout *Plectropomus leopardus*, and the golden trevally, *Gnathanodon speciosus*.

The expansion of hatchery production in northern Bali has generated a range of associated employment opportunities for input suppliers. One example is the provision of small 'mysid' shrimp which are harvested from ponds (tambak) in East Java, and transported live in oxygen-filled plastic bags to northern Bali by motor cycle. Project staff report that every morning, a number (<10) of motor cycles transport live mysid shrimp to the Bali hatcheries to provide feed for juvenile groupers.

The simplicity, flexibility and economic viability of the hatchery technology are key factors that have facilitated its uptake and spread within Indonesia. Increasingly, the technology has also been applied in other countries, in part through the Asia-Pacific Marine Finfish Aquaculture Network grouper hatchery production training course conducted annually in Indonesia since 2002. A total of 101 participants from 22 countries have been trained since the course began. The technology is simple and not mechanically complicated so a technician or owner who runs a hatchery does not necessarily need to be highly educated or technically skilled. The flexibility of the technology also enables the hatchery systems to switch between fish species or between fish and shrimp. The low investment and operating costs required enable fishermen or other small players with limited finances to participate in the hatchery business either in the form of employment or by running their own.

The project workshop was followed by a one-day symposium in Bahasa Indonesia to extend the project's research findings to farmers and the private sector, universities and local government officers, and to promote interaction between them. The symposium was attended by a total of 61 people.

Ketut Sugama (left) and Gelwyn Yusuf (right).

NACA Newsletter

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

ISSN 0115-8503

Volume XXIII, No. 4
October-December 2008

Regional technical cooperation in reducing dependence on trash fish

A project on *Reducing the dependence on the utilization of trash fish/low-value fish as feed for aquaculture of marine finfish in the Asian Region* was approved in July 2008 under FAO's Technical Cooperation Program. The project involves China, Indonesia, Thailand and Viet Nam and aims to assist development of sustainable grouper/Asian seabass farming systems in these countries. An inception planning workshop for the project was held in Krabi, Thailand from 8-10 September 2008, hosted by the Thai Government.


Participants in the inception workshop, 8-10 September 2008, Krabi, Thailand.

The inception planning workshop was convened to:

- Discuss the project concept, rationale, outputs and activities.
- Finalize questionnaires for livelihood analysis of trash fish/low-value fish (hereafter referred to as 'low value fish' which is more accurate) suppliers and environmental impact assessment components.
- Discuss and finalize the methodology to study the farmers' perception on the use of low-value fish vs formulated feeds.
- Determine the in-country logistics of conducting different project components and to finalize the survey plans for each country.
- Reach agreement on and to finalize the overall work plan including time frame of implementation and responsibilities of all project holders.
- Identify important issues/problems to be addressed before launching the field activities.

The workshop included presentations on mariculture in the four participating countries, i.e. China, Indonesia, Thailand and Viet Nam highlighting the status of the sector and importance of the present TCP for its sustainable development. Presentations were also made on environmental impact assessment, surveys and livelihood analysis of low-value fish suppliers and rapid rural appraisal (RRA) of the farmers' perception on the use of low value fish as opposed to compounded pellet feeds.

During the plenary session, extensive discussions were held on the design, scope and strategies for implementation of different project activities with country specific considerations. Some related logistic and procedural issues were also discussed. The workshop agreed on: i) the extent on the information to be collected for livelihood analysis of low value fish supplier, ii) type, size and location of samples for livelihood analysis survey in respective countries, iii) methodology of RRA for the farmers' perception study, iv) methodology of environmental impact assessment including type of water quality monitoring, sample size and frequency of data collection, and v) a broad framework for farmer's participatory trials including the selection of site in each country, type of species, number of farms, cage size, duration of growth cycle and monitoring requirements.

The workshop was attended by sixteen participants (eleven from four project participating countries, China, Indonesia, Thailand and Viet Nam, three from NACA and two from FAO) and one observer from a feed industry.

NACA would like to thank the Government of Thailand and staff of the Department of Fisheries for hosting the workshop and for their excellent hospitality. Further details of the workshop report and the proceedings are available from Mohammad R. Hasan at FAO/HQ (E-mail: Mohammad.Hasan@fao.org) and Sena S. De Silva at NACA/Bangkok (Email sena.desilva@enaca.org). For more information, please also see the project website at:

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

Culture, capture conflicts in Indonesian reservoirs: Phase 2

Phase two of the ACIAR-funded project *Culture, capture conflicts: Sustaining fish production and livelihoods in Indonesian Reservoirs* got underway on 20 August with formal inception taking place at the Directorate General of Aquaculture in Jakarta, presided by Dr Marde Nurdjana in the presence of Prof. Sena S De Silva (Principal Investigator and Director General of NACA) and Mr. Julien de Meyer, ACIAR Country Manager, Indonesia.

The second phase will develop and fine tune co-management measures that have resulted from the project's earlier research, primarily based on carrying capacity estimations for the three reservoirs under consideration. The project will now focus on the Jatilnuhur (8,300 ha) and Cirata (6,200 ha) reservoirs, which account for about 10,000 and 60,000 tonnes/ year of cage-farmed tilapia and common carp, and 12+ and 10 tonnes/year of capture fishery production consisting mainly of tilapia, catfish and *Colostoma*, respectively. Fisheries activities in these two reservoirs provide 5,000 to 6,000 livelihoods directly, and many more indirectly.

The project is headed under the guidance of the Director General of the Directorate of Aquaculture (DGA) Dr Made L. Nurdjana, and coordinated by Dr Reza Shah Pahlevi, Head of Program Division, with the field team headed by Dr. Fatuchri Sukadi, ably supported by Maskur, Station Head of the Main Centre for Freshwater Aquaculture Development, Sukabumi; Dr Sonny Koeshendrajana, Centre for Marine and Fisheries Socio-Economic Research Agency for Marine and Fisheries Research and Development; Dr Endi Setiadi Kartamihardja, Central for Capture Fisheries Research, Agency for Marine and Fisheries Research and Development; Ms Rina M. Si, Center for Fisheries Extension, Agency for Marine Affairs and Fisheries Human Resource Development, all of the Ministry of Marine Affairs and Fisheries; together with Dr Sutrisno Sukimin, Faculty of Marine Science and Fisheries, Bogor Agricultural University, amongst others.

Although inception was delayed by a few months due to the introduction of new regulations, the team has continued to advance the project. The key areas of progress are:

- A draft plan co-management plan, drawn up based on consultations with stakeholders during the work of the first phase and the plan has been released to stakeholders for common on 3 July 2008.
- The recommendations on stocking of the reservoirs to support the capture fisheries and to facilitate the reduction of nutrient loading has begun to be implemented, with 2.1 million milkfish fingerlings (5 to 7 cm; hatchery reared and salinity adapted) released to Jatilnuhur reservoir. The stocking program was inaugurated by the Hon. Minister for Marine Affairs & Fisheries, Dr Freddie Numberi on 30 July 2008.
- 30,000 fingerlings have been stocked in Cirata reservoir, where the fishers are in a process of beginning to get organised. This program will proceed based on the progress of in the involvement of the fishers in the co-management process, which is advancing fast and efficiently.

Cages on Cirata Reservoir.

Above, below: Preparing seed for stocking and discussions, Jatilnuhur Reservoir.

- The fishers of Jatilnuhutr have already agreed to the principle that the Society will levy Rp 1000/kg of milkfish landed and the proceeds be utilized for procuring seed for the next round of stocking (seed costs Rp 2000/ tail). The results of the stocking program will be closely monitored.

- The DGA has allocated the equivalent of AUD$ 47,000 to facilitate the implementation of the co-management plans in the two reservoirs, and expects to use the lessons learnt to other reservoirs in Indonesia.

- In addition, the Directorate of Human Resources Development has appointed two Research Assistants to monitor the effectiveness of the stocking program as well as for interacting and facilitating the farmer and fisher interactions in adopting co-management strategies for sustaining the capture fishery and the cage culture operations of the two reservoirs, which are of immense significance to the communities involved.

- It is interesting to note the increasing involvement of provincial and district organisations in extending their support and cooperation in implementation of the co-management strategies. For example, the Bupati Purwarkarta District Organization, responsible for local fisheries regulations, issued a decree on the minimum mesh size and types of fishing gear that could be used in Jatilnuhur reservoir for the first time ever on 14 July 2008. The fishers are all willing to comply with these regulations now that they have witnessed the benefits of the stocking program – a clear example of the project's impact on policy development.

- A further stakeholder meeting of fishers, cage culture operators and Provincial and District DINAS officials on 20 August 2008 to apprise them of the concurrent developments that have taken place and the plans for fine tuning the co-management plans with the concurrence of all stakeholders, and implementing the same over the ensuing one to two years. Hopefully this will reduce the incidence of fish kills, increase the well being of capture fishers and make the fishery activities in the two reservoirs sustainable.

What is the next step?

At the stakeholder meeting held on 20 August it was decided that one cage culture zone out of the five in Jatilnuhur will be adopted as 'demonstration zone' for the implementation of the co-management plan within the next two months. This unit will be closely monitored and will be available for cage farmers from other zones as well from Cirata and Saguling reservoirs to visit and observe the activities. As time progresses, gradually the implementation of the co-management strategies, together with Better Management Practices to other cage farming zones, with suitable modifications.

For more information about this project, please refer to the project summary page at:

http://www.enaca.org/modules/inlandprojects/index.php?content_id=3

Progress on the IFC/NACA ACEH Shrimp Project

The objective of the project, jointly implemented by the International Finance Corporation (IFC) and NACA, is to support the recovery of brackishwater shrimp and fish pond farming in Bireuen district of the Province of Nanggroe Aceh Darussalam in Indonesia. The project started in 2007, assisting 47 farmers in 12 villages of Gandapura sub-district for the first crop, and 83 farmers for the second crop, in the same location. The emphasis was on assisting farmers to implement a simple set of "Better Management Practices" (BMPs) adapted for local conditions.

In 2008, the project was extended to a further 3 sub districts and 34 villages, assisting 260 farmers, 360 ponds for a total of 200 hectares (water surface area) responding to increased demand from farmers to join the project.

The project team was made up of 15 field facilitators providing technical guidance and BMPs to farmers. The team resided in the villages of duty, where they provided technical guidance to the farmers on a daily basis. No financial support was provided, except quality shrimp seed was subsidized to the farmers, who paid about 30% of the seed price. The seed (PL25) was screened for WSSV through PCR three times before distribution to farmers. The history of each pond was determined by field staff throughout the culture period, and comparisons were made with non-assisted farmers.

Extension video show and discussion.

During 2008, new extension channels for BMPs were introduced: 13 BMP video shows were organized in villages, and 45 BMP radio talk shows organized with call-in facility to allow farmers to ask questions. BMP "spots" containing a total of 10 key BMP's were aired five times per day by three different local radio stations. At the same time, distribution of BMP material (manuals, leaflets, posters) has been carried out widely in project and other areas. The result has been a strong interest in participating in the project.

Above left, right: Preparation and stocking of PL.

A healthy crop ready for harvest.

The impact on farmers receiving technical assistance was monitored, with excellent outcomes. Ponds throughout the project have been found to be have a 25-30% increase in net profit over non-assisted ponds. The success rate in the third crop (2008) was 62% at an average productivity of about 200 Kg/ha. As per baseline surveys, non-assisted farmers widely used pesticides (54%, 47%, 49% for crops 1,2, 3) in the form of cocktails of agricultural products, while assisted farmers did not use pesticides at all. The project initiated local farmers groups, and meetings are held on a monthly basis, to discuss technical issues with the project staff.

The project introduced in 2008 some BMPs for shrimp harvesting, in collaboration with FAO and a nearby processing plant: demonstration harvests have been carried out by project staff under the supervision of an international specialist, to be shipped to a local processing plant which has sent the product to Japan for evaluation by a lead exporter and consumers. At the field level, a strong collaboration with FAO, ADB, ACIAR and UMCOR has been conducted. Furthermore, two benchmark reports have been commissioned by the project, on mangrove plantation feasibility and gender balance in the district. A “coastal aquaculture livelihoods baseline study” by FAO was actively facilitated by the project, through provision of data and organization of focus groups.

The project also mediated a canal rehabilitation by USAid for the sub district of Gandapura.

The outcomes show the benefit of simple technical assistance in reducing risks and improving crop outcomes through simple management improvements for farmers of Aceh in the recovering post-tsunami environment.

Indian shrimp farmer societies succeed through better management practices

The Krishna district covers about one third of the total brackish water area developed into shrimp ponds in Andhra Pradesh, India. Although untill the mid 1990s shrimp farmers earned good returns and investment in technologies for good management practices were generally ignored. As a result, shrimp farming in Krishna district failed to withstand the impact of viral disease outbreaks in the mid 1990s. As the situation failed to improve, a large number of farmers abandoned shrimp farming. Presently, farmers from socially and economically challenged communities dominate the shrimp farming population in the district who lack skills, information and organization.

In Andhra Pradesh NaCSA has organized more than 100 farmers societies, 30 of them are in Krishna District. The first three societies in Krishna were organized in Penduru village, which is located in Bantumilli mandal of Krishna District. There are 164 farmers involved in shrimp farming owning 384 ponds in 600 acres farming area. Out of this, 63 farmers formed into three societies in the village earlier in the year.

All the 63 farmers (84 ponds, 67 ha area) agreed to follow the better management practices (BMPs) starting with getting disease free seed through contract hatchery system where farmers collectively placed bulk orders to a hatchery, 45 days in advance of the planned stocking date, for production of required quantity and quality of seeds. Through a consultative process, facilitated by the NaCSA team, a mutual agreement has been formed between the selected hatchery and three societies. The agreement included included screening broodstock for disease, using only disease free broodstock for seed production, single spawner systems, no use of banned antibiotics, good feeding practices and other terms and conditions for production and procurement of quality seed.

After 110 days of successful culture farmers started harvesting, none of the ponds were affected by disease. To share the successful experiences of Penduru society farmers NaCSA organized farmer field day on Wednesday, 11 June, 2008 in Pendurru village to spread the awareness about “participatory approaches” among farmers across Krishna District. More than 200 farmers from different parts of Krishna participated in the programme along with the presidents of 30 societies. It was a learning experience for all the Andhra Pradesh society coordinators participating in the function. The function began with a brief introduction by the CEO of NaCSA followed by Sri. Vijay Aqua Farmers Welfare Society President Sri. Srinvasa Rao, who shared his society’s success with the invited farmers. Sri. Chinna,

Andhra Pradesh shrimp farmer society coordinators.

a farmer from Sri. Sivsai Welfare Society explained in detail the better practices followed in the society starting with the contract hatchery system. Sri. Saifuddin Anis, Deputy Director of MPEDA urged all the farmers to follow the example of Penduru farmers and achieve success in each and every society. Prof. Sharma from Nagarjuna University stressed the importance of participatory approaches and the technical information available from NaCSA through society coordinators to society farmers. Later Chandra Mohan of NaCSA made a presentation in Telugu about better management practices and presented the current market situation. All the participant farmers keenly listened to the Penduru farmers experience and later discussed the requirements of their own societies. One common demand from all the societies is to get assistance in supplying electricity to their farms.

Positive outcome of this demonstration

- No disease incidence: None of the three Penduru societies ponds were affected by disease. More than 50% of non-society ponds affected with white spot disease in this area in this summer season. Photo: Andhra Pradesh shrimp farmer society Coordinators.

- Increased confidence in contract hatchery system: Prior to the demonstration, farmers from this area never went to hatcheries to purchase seed, they were all dependent on poor quality seed from commercial nurseries. With 100% success now they are confident about getting good quality seed through the contract hatchery system.

- Reduced cost production: Through efficient use of feed (FCR of 1:1) and other resources, including reduced use of chemicals, all the farmers will achieve a very good profit for the first time in many years.
- Production of safe shrimp: No use of antibiotics. Seed, shrimp and other inputs have been screened for antibiotic residues and they were negative.
- Motivated farmers in abandoned areas: Seeing the success of the Penduru farmers more and more neighboring farmers and farmers from abandoned areas are coming forward to organize themselves as societies. We could see the positive impact of this success in coming crops as new societies implement BMPs and more societies will be organized in Krishna District. This could pave the way for full scale revival of most of the abandoned ponds in Krishna and other places.

This article reproduced courtesty of the National Centre for Sustainable Aquaculture, (MPEDA, Ministry of Commerce & Industry, Govt. of India), Plot No.8, SBI Officers' Colony, Rajendra Nagar, Kakinada – 533 003, Andhra Pradesh, India.

In brief

Multidisciplinary situation appraisal of mangrove ecosystems in Thailand

The MANGROVE Project has published a new report, *A multidisciplinary situation appraisal of mangrove ecosystems in Thailand*, which is now available for download.

The Nakhon Si Thammarat Province from the southern part of Thailand has been selected for the appraisal due to their highest priority and score provided by expert evidence. The three communities have been selected to represent different characteristics of the mangrove ecosystem; (1) Ban Kong Khong, Pak Phanang Fang Tawan Ok Subdistrict, Pak Phanang District to represent a community with healthy and old mangrove forest, (2) Ban Pak Nam Pak Phaya, Ta Sak Subdistrict, Mueang District to represent a community with new mangrove plantation areas from abandoned shrimp ponds and (3) Ban Talad Has, Pak Phun Subdistrict, Mueang District to represent a community with new mangrove area from a new sedimentation area, respectively.

The report is available for free download from:

http://www.enaca.org/modules/wfdownloads/singlefile.php?cid=196&lid=953.


European Union
Sixth Framework Programme
Mangrove Project

Final Report of Work Package 1:
Multidisciplinary Situation Appraisal of
Mangrove Ecosystems in Thailand

Project full title: "Mangrove ecosystems, communities and conflict: developing knowledge-based approaches to reconcile multiple demands"

Contract Number: FP6-003697

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Version: September 2, 2007

University of Essex

New CIFA Director appointed

Dr. Ambekar E. Eknath (photo below) has assumed the post of Director, Central Institute of Freshwater Aquaculture (CIFA), taking over from Dr. N. Sarangi who retired on 30 June. Dr. Eknath is an internationally acclaimed geneticist who has worked with the WorldFish Centre, Philippines and GenoMar, Norway in managerial capacities. He has been associated with many international organizations over the years including NACA, ADB, FAO, INGA, UNDP and the World Bank. He played instrumental role in developing genetically improved farmed tilapia (GIFT), a variety that contributes significantly to the food fish production in many areas of the world.

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NACA is a network composed of 17 member governments in the Asia-Pacific Region.

FAO Glossary of Aquaculture

The FAO Glossary of Aquaculture, previously published on the web in April 2006, has now also been made available in hard copy print, CD-ROM and PDF form to reach a wider audience and to assist those without fast internet connections.

The Glossary contains approximately 2,500 terms and includes definitions, information sources, synonyms, related terms and images when available.

Terms and definitions are available in five FAO official languages (English, French, Spanish, Arabic and Chinese).

The PDF version is available for download from the FAO website at:

http://www.fao.org/fi/glossary/aquaculture/