ISSN 0859-600X

Volume X No. 3 July-September 2005

AQUACULTURE ASIA

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Cobia seed production in Vietnam

Contract hatchery systems for shrimp health

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Rainbow trout culture in Iran

Babylon snail growout

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

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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.

AQUACULTURE ASIA

Volume X No. 3 **ISSN 0859-600X**
July-September 2005

Probiotics: Snake oil or modern medicine?

I confess to being something of a sceptic when it comes to aquaculture 'probiotics'. I accept the argument that some 'beneficial' microbes may compete with 'harmful' microbes, or provide a range of other benefits that may contribute to stock health in some way. This seems quite likely and logical to me.

My objection stems from the way commercial aquaculture 'probiotics' are marketed and the lack of rigour with which they are tested, if they are tested at all. How do you know that any particular product works as advertised? Is it equally effective in all environments? What assurance do you have that it isn't actually *harmful?* Where is the science? For that matter, how do you know you are actually getting what you paid for?

In most cases, people have no real idea what is in the box. Most users of probiotics are simply pouring expensive powders and liquids into their tanks, ponds and feed and hoping that it works. Many view it as a kind of 'insurance'.

To my mind there are many parallels between probiotics in aquaculture and the 'natural medicine' industry - the only difference being that in aquaculture there are *more* snake oil salesmen - often trading on fear of disease - and the products are even *less* well studied. Where there is research on a product's efficacy, it is usually conducted or commissioned by the manufacturer - not exactly what you might call an independent authority.

In my opinion, products traded on the basis of their medicinal qualities (whether preventative or not) should be subject to the same regulation and scrutiny as conventional pharmaceuticals used in animal husbandry. Without science-based testing, probiotics remain the realm of snake oil salesmen and voodoo mythology. Science is not only necessary to evaluate the merits of probiotics, but also to standardise their use, and fully realise their potential and limitations as additional tools in (and not a substitute for) aquatic animal health management.

This is not to say I am a complete sceptic. I have spoken to some people using specific bacterial cultures to address specific bacterial disease problems in hatchery environments; but they are using a targeted, science-based approach, not a shotgun and prayers.

Lastly, we are thinking about overhauling the NACA website before the end of the year to make it more useful and relevant. So if the bits of pro-website propaganda scattered through this magazine haven't gotten to you yet, you might log on to www.enaca.org. Register as a member, go to the forums and tell us what you think. Post your comments in 'Website feature requests'. What would you like to see there? Continuously updated news headlines? Market price information? More publications from network centres? An online peer-reviewed journal? I don't know - you tell me! Go on. It's your network.

Simon Wilkinson

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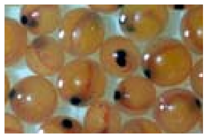

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Notes from the Publisher

Milestones: 25 years of NACA, 15 years as an intergovernmental organization

I would like to take this opportunity to thank Australia's Department of Agriculture, Forestry and Fisheries (DAFF) for seconding to NACA Dr John Ackerman of the Bureau of Rural Sciences, to assist in the assessment and development of approaches to tsunami rehabilitation. Dr. Ackerman worked in NACA HQ but also spent almost 3 weeks in Aceh. There he teamed up with Indonesian relief and development personnel to set up an information system that enables a better identification and monitoring of efforts and players in rehabilitation, and in developing a cash-for-work scheme that was kicked off by a modest but immediate contribution from NACA, augmented with a more substantial contribution from Aquaculture without Frontiers, and now topped up by a 600,000 US$ fund from the French Red Cross, which has requested NACA to act as the technical overseer for its part of the scheme (see NACA Newsletter April-June and July-September 2005). John, always in partnership and harmonious collaboration with local staff, also set up the groundwork for the FAO-GOI-NACA workshop on tsunami rehabilitation held in Aceh in July. After four months on secondment to NACA, John will be continuing to provide assistance to NACA and FAO, over the remainder of the year, mainly for ongoing rehabilitation work in Aceh.

John Ackerman (center) with some of the NACA crowd.

Establishment and institutionalization: From project to organization

This issue starts a 3-part historical series on the highlights and organizational development of the Network of Aquaculture Centres in Asia-Pacific. This first part highlights the creation of an independent organization and the strategies adopted to place the fledgling organization on a more stable footing.

Efforts to successfully transform NACA into an intergovernmental organization culminated during its First Governing Council Meeting, held in Dhaka in December 1989, when this status was formalized. The major activities toward this objective were:

- Development of the draft Agreement on NACA, finalized in 1987 by the Second Provisional Governing Council Meeting. It was adopted with some amendments on 8 January 1988 at the Conference of Plenipotentiaries convened by FAO at its Regional Office for Asia and the Pacific (RAPA) in Bangkok.
- Preparatory work for institutionalizing NACA included the formulation of the Schedule of Government Contributions; Rules and Procedures for the Organization; Financial Regulations; Employment Conditions; Staff Regulations; and development of the first Five-Year Work Program for Regional Aquaculture Development under the Intergovernmental NACA.
- Initiatives were taken to generate collaborative support from donor governments and agencies to implement priority field activities under the Work Program.
- In another effort to lay a strong foundation for the intergovernmental organization, a consultative meeting of agencies and organizations implementing aquaculture and related development programs was organized by the project. The meeting adopted a set of recommendations meant to foster closer collaboration among participating organizations and to assist and strengthen the governments in managing the intergovernmental body.
- A core group of five regional experts recruited under Special Services Agreements were trained to take over the operation of NACA. Specialists from the Network centres could also be called upon to assist countries of the region in various disciplines related to aquaculture research and development.
- The Headquarters Agreement between the Government of Thailand and NACA was developed, with Thailand continuing to host the project coordinating office of NACA and provide various immunities and privileges for the organization and staff.

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The result was the establishment of an autonomous intergovernmental organization. The strengthening of the Network centres attracted the collaboration of other organizations and agencies. An autonomous NACA, with its core program funded by member governments, created a conducive environment for bilateral and multilateral agencies to channel their assistance, thereby supporting the governments at managing NACA and further strengthening their collective efforts in expanding aquaculture development.

For a stable footing: The first 5-year Work Program

The NACA Project, having demonstrated the effectiveness of the network of regional collaborative efforts in developing aquaculture, was recommended to be elevated to the status of an intergovernmental organization and to be further strengthened, while continuing to establish collaborative arrangements with UNDP/FAO and other international and donor agencies. With further support, NACA continued to offer an opportunity for donor governments and agencies to work together on activities of mutual interest.

The obligatory contribution of member governments, based on a formula developed by agreement, was seen as sufficient only to maintain a core staff of nationals seconded by the governments or recruited directly. Therefore, donors had to be found for most of the field programs. In this connection, the Five-Year Work Program approved by the Third Provisional Governing Council Meeting held in Bangkok in January 1989 proposed a number of ways for obtaining external funding support. One of these was for NACA to undertake the responsibility of implementing projects of international agencies like UNDP and FAO, as well as the World Bank and Asian Development Bank, that fall within the field of interest and competence of the organization.

The diversity of problems in the region called for cooperative regional action for solutions. The network mechanism has shown the effectiveness of pooling of resources and sharing of responsibilities, as well as results of research and development in approaching common problems. Increasing aquaculture production was done by increasing the area or intensifying the production systems. In either case, either approach spawned associated and linked socio-economic and environmental constraints. The region's countries needed to adopt a collective approach in dealing with common problems through planning and adoption of realistic policies for orderly development.

NACA's work program for 1990–94 was planned with the above issues in consideration. Proposals for the support of research and training activities in this direction were formulated.

For the fish health program, support came from the ADB for a regional study on fish disease control and fish health management. This regional study consisted of expert visits to countries, consultations and a regional workshop, recommended a regional action program on fish health management including a networking mechanism for research and information exchange; a region-wide fish disease monitoring and reporting system; and a capacity building in prevention, diagnostics, treatment and regulation.

The interrelationships between the impact of environmental changes on the development of aquaculture and the impact of aquaculture itself on the environment became emphasized in the regional program; its objective was to ensure the development of the aquaculture sector in harmony with the rest of the economy.

Emphasis was made on the importance of research in the improvement of important aquaculture systems at the regional lead centres. Proposals were made to obtain funding support from donors to carry out farm performance surveys of selected systems and technologies in different countries to provide the basis for development planning, investment and successful farm management. A study of integrated fish farming systems was conducted in China and data were collected from other countries in the region. Further experimental studies were implemented to delineate pond dynamics and waste recycling. Appropriate bio-economic models of integrated fish farming systems and models of modified systems were constructed for the different sub-regions for field trials. The results obtained were disseminated in training and workshops, and used to formulate appropriate rural development programs.

Socio-economic aspects of aquaculture development were addressed with the aim of developing the capability of national administrators and planners to ensure sustainable aquaculture for growth and social development. NACA provided assistance to a number of governments in preparing national aquaculture development plans as well as in undertaking studies for aquaculture investments.

Updates

- We are pleased to announce that the Asian Development Bank has awarded NACA a 2-year contract to manage a project aimed at rehabilitating the aquaculture and fisheries sector of Aceh. The project will manage a US$30,000,000 grant to Indonesia under the Bank's Earthquake and Emergency Support Project (Fisheries Component). Our associates in this project are the Sloane Cook & King Pty Ltd, Australia and PT Trans Intra Asia, Indonesia.
- We have also expanded our tsunami rehabilitation and development activities in Southern Thailand to three communities - in Phangnga, Krabi and Trang - and are collaborating now with the Rotary International, the Thai Department of Fisheries, CHARM (Coastal Habitat and Resource Management, an EU supported project of the Department of Fisheries), and a Japanese civic group, the Chiba Conference on Environmental Protection and Education.
- India's Marine Products Export Development Authority has approved the extension of the MPEDA/NACA shrimp management and the environment project. The new phase will expand the project from Andhra Pradesh to other states and entails organizing and training more aquafarmer clusters. ACIAR has joined the project in India with a component that will standardize and calibrate PCR labs and train personnel, as well as conduct a rigorous study on the transmission of viruses that infect shrimp (more details in the NACA Newsletter). It is strong in scientific and technical capacity building.

Interdisciplinary research improves the efficiency of aquaculture production systems as in the case of animal husbandry, in which the interrelationships of various component disciplines (e.g., animal health, nutrition, reproduction and genetics) have been established and integrated into a multidisciplinary body of knowledge. Discipline-oriented studies on certain special areas are being done in NACA lead centres, but tertiary level education in the various disciplines, which can complement and strengthen aquaculture development programs, is lacking in the region. However, certain universities and institutions do have strengths in some special areas within these disciplines. Work Program 1990–94 spelled out a program to assist in the development or upgrading of tertiary level educational and advanced level research activities in selected institutions/universities within the region which would serve as centres of excellence in particular disciplines for meeting training needs.

The NACA and Seafarming projects (the latter also a UNDP/FAO regional project) shared management resources under a cost-effective arrangement. When the seafarming project terminated, its integration into the Intergovernmental NACA expanded the network with the addition of the eight seafarming nodal centres. This effectively brought coastal and marine aquaculture into the NACA program.

Aquaculture had been largely traditional until around the 1980s. The priority then was to increase production and therefore production technology was needed. At present, most of the technical skills and technologies are available for most culture systems. The NACA research and development program moved towards a multidisciplinary approach in order to address the broader, non-biotechnical constraints. The network umbrella concept was proposed. Under this would be a regionally coordinated multidisciplinary research and development program implemented by various centres of excellence, each with responsibility for a specific discipline. The same pooling of resources and sharing of responsibilities adopted by the NACA project was followed. This is taking some shape in the Asia-Marine Finfish Program.

One of the initiatives of the project, which contributed to laying a firm foundation for the Intergovernmental NACA, was the organization in June 1989 of a consultative meeting among agencies and organizations in the region implementing aquaculture development and related projects. The meeting adopted a set of recommendations to assure collaboration among them, foster cooperation in areas of mutual interests and avoid duplication of effort. The other initiative consisted of liaising with donor governments and agencies with the view of seeking collaborative support for the implementation of some of the field activities under the NACA Programme of Work. These were essential preparatory actions for the establishment of a fully functional independent NACA organization.

As originally planned, the project was phased out by 1989. However, consultations with officials concerned with the participating governments and institutions showed the need for international assistance in the early stages of the NACA network operating independently for the first time as an intergovernmental organization. The assistance would firm up the foundation for the intergovernmental body by providing advisory activities and funding support needed to consolidate and improve ongoing regional activities, initiate new programs, mobilize funding support and liaise with other institutions in and outside the region. It prepared the governments to fully assume the funding for the core program through their contributions. It also allowed NACA to continue to engage the services of the regional and national experts who had been seconded to the project by their governments and therefore were already trained in the various activities required to operate the network.

Next issue: The Second Five Year Programme of Work: Towards self-reliance and a broadening of emphasis.

Announcement

The Second International Symposium on Cage Aquaculture in Asia

3-8 July 2006, Zhejiang University Hangzhou, Zhejiang Province, China.

Cage aquaculture has a long history in Asia, but it is only in recent years that it has been widely practised and recognized for its potential, especially for off-shore cage culture in open sea. The first cage culture symposium was successfully held more than five years ago and the aquaculture community will be meeting again in Hangzhou city, China to discuss the recent advances, potentials, challenges and problems of cage aquaculture in Asia.

The second international symposium on cage aquaculture in Asia (CAA2) scheduled for 3-8 July 2006 will discuss the following topics:

- Recent advances and innovations in cage culture technologies
- Cage design, structure and materials
- Site and species selection
- Nutrition, feed, feeding technologies and management
- Disease prevention and health management
- Economics and marketing
- Sustainable management and development
- Policy and regulation
- Constraints to cage culture development
- Conflicts between cage culture and other stakeholders

For more information, contact:
Secretariat
2nd International Symposium on Cage Aquaculture in Asia
Tel. and Fax +86-571-86971960
Email: CAA2@zju.edu.cn
http://library.enaca.org/PDF/Flyer_CAA2_email_version.pdf

Peter Edwards writes on

Rural Aquaculture

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Asian Development Bank study on aquaculture and poverty

Young beneficiaries of fish pond harvests, Chandpur, Bangladesh.

The Operations Evaluation Department of the Asian Development Bank (ADB) has recently carried out a Special Evaluation Study (SES): "An Evaluation of Small-scale Freshwater Rural Aquaculture Development for Poverty Reduction". The multidisciplinary team was led by Njoman Bestari, Senior Evaluation Specialist, ADB and comprised several consultants: Nesar Ahmed (research associate, Bangladesh), Peter Edwards (aquaculture development specialist), Brenda Katon (research associate, Philippines), Alvin Morales (rural economist, Philippines) and Roger Pullin (aquatic resources management specialist). Cherdsak Virapat and Supawat Komolmarl collaborated with the team in Thailand.

The purpose of the study was to assess channels of effects of aquaculture to generate livelihoods and reduce poverty. The enabling conditions for aquaculture to benefit the poor were analyzed. The study distilled pertinent lessons for making aquaculture more relevant for poverty reduction for future ADB operations as well as for other individuals and organizations.

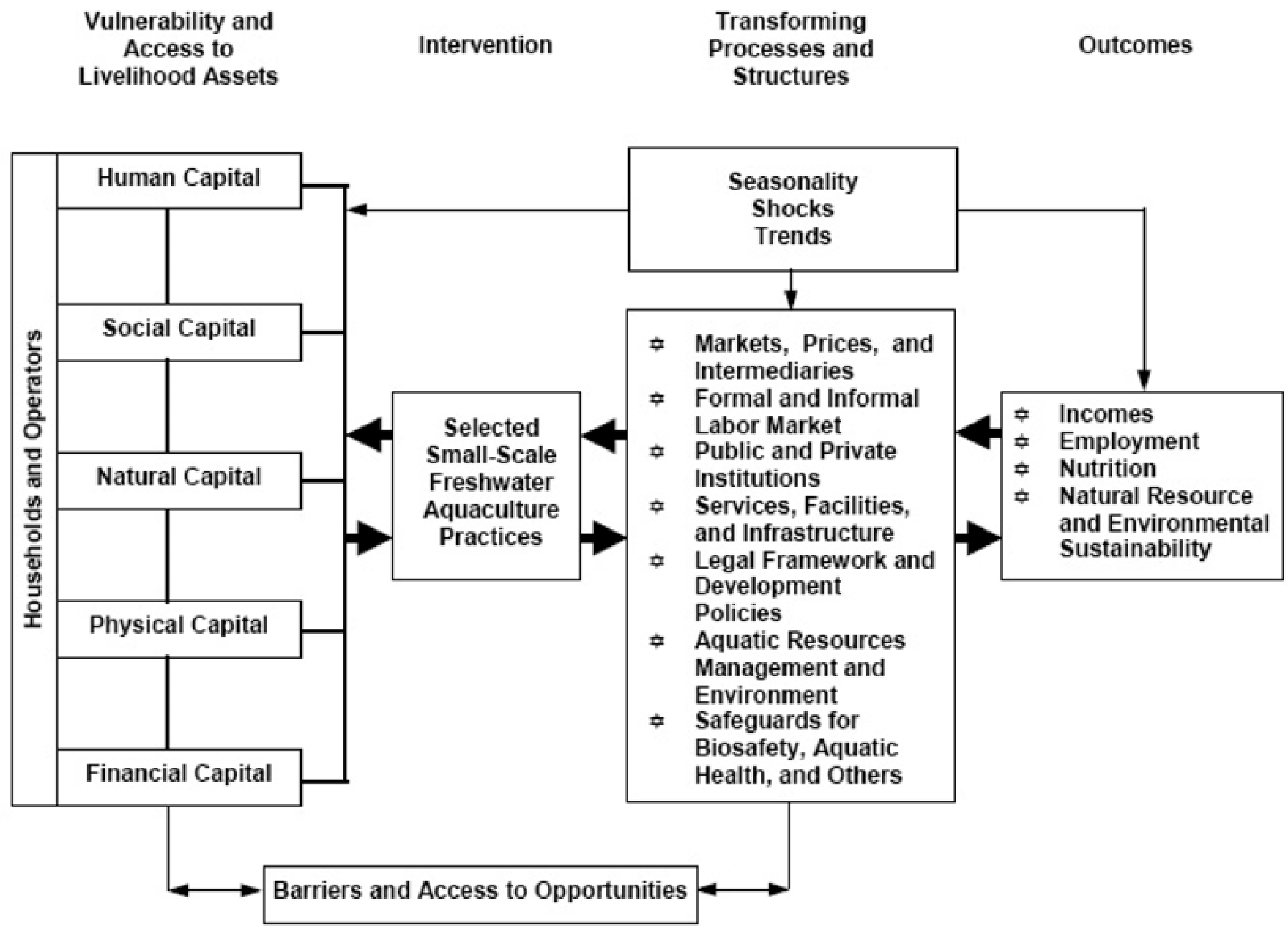
The study was guided by a conceptual framework for analyzing channels of effects, which combined key channels of effects from a previous ADB report on a modified poverty impact assessment matrix and the DFID sustainable livelihoods framework. The conceptual framework considered the five capital livelihood assets of small-scale farmers; their vulnerability to seasonality, shocks and trends; a series of transforming processes and structures; barriers and access to opportunities; and livelihood outcomes in terms of income and employment, food and nutrition, and natural resource and environmental sustainability.

Previous R&D initiatives of ADB were reviewed and eight case studies were developed in three countries (Bangladesh, Philippines and Thailand) to illustrate diverse contexts and to permit drawing general conclusions. The following four case studies were based on primary data collected by the team with the assistance of field assistants:

- Farming carps in household-level ponds in Kishoreganj, in the Greater Mymensingh Area (GMA), which is the major area for freshwater aquaculture in Bangladesh. The GMA has been targeted by donor-funded projects e.g., funded by ADB, DANIDA and DFID, since the 1980s.
- Farming carps in leased ponds by groups in Chandpur, Bangladesh. The groups comprised marginal and landless farmers, mainly women. The fish farming groups had been set up earlier as part of the small-scale fisheries development component of the ADB-financed Command Area Development Project to compensate for decline of wild fish through past construction of flood embankments.
- Farming tilapia in ponds in Central Luzon, the major area for pond farmed tilapia in the Philippines.
- Farming tilapia in cages in Lake Taal, Batangas, the largest cage production in the Philippines.

The contribution of freshwater aquaculture to human nutrition is significant in the three countries studied and especially so for the rural and urban poor with fish being the main sources of animal protein, essential vitamins and minerals and fatty acids. The poor typically have limited access to land and water although some do benefit directly from small-scale fish farming. The household-level ponds in Kishoreganj were mostly small-scale (0.5-1 ha)

Figure 1: Conceptual Framework for Analyzing Channels of Effects



and medium-scale (1-2 ha) landowners but 34 and 25% were below the poverty line, respectively; however, the rest were only precariously above the poverty line and an unexpected crisis could slide them into poverty. Just below half (43%) of the surveyed small-scale households farming tilapia in ponds in Central Luzon were below the poverty line. While most of the cage operators in Lake Taal were not poor, farming tilapia provided indirect benefits for the poor through direct employment as cage and associated nursery pond caretakers, through cage and net making, supplying feed, and harvesting and marketing fish.

The poor are unlikely to farm fish directly without access to land and water or natural capital. They also require access to other livelihood assets such as skills (human capital); information, training and advisory services (social capital), and household finance / savings and formal / informal credit (financial capital). However, the ability of poor people to farm fish for the first time for those involved was demonstrated by the groups of mainly women from marginal and landless households in Chandpur. An innovative organizational arrangement involved the Department of Fisheries, which mainly provided technology and training, and an NGO, which mainly provided microcredit and assistance in input supply and marketing, and training in financial management. The latter included a savings scheme to build up the financial capital of the poor households so that they would eventually be able to farm fish without project support.

However, freshwater aquaculture makes a significant contribution to rural economics in terms of employment and income. For example, it generated an output at farm gate of about $700 million in 2002 in Bangladesh. It is estimated that freshwater aquaculture contributed more than $1 billion to the country's rural economy in 2002, including post harvest handling and marketing. Current employment figures for freshwater aquaculture and its associated activities have been grossly underestimated. Survey respondents overwhelmingly believed that aquaculture had improved their welfare through fish consumption and increased incomes. The latter enabled poor farming households to improve their housing and sanitation, and to pay for clothes, health services and their children's education.

The main recommendation of the study is to obtain a contextual understanding of the major ways in which various types of small-scale freshwater rural aquaculture can benefit the poor and to determine the conditions for making aquaculture work for them. There is a need to:

- Analyze channels of effects for poverty reduction

A group of women fish farmers in Chandpur, Bangladesh.

Selling small tilapia in a market in Northeast Thailand.

Harvesting tilapia from a fish cage at lake Taal, Philippines.

- Recognize barriers, requirements and risks
- Assess specific demands on users' capacity to operate aquaculture systems
- Analyze available options for providing access to land and water
- Consider options for financing aquaculture investments and operations
- Analyze markets and marketing of aquaculture products and factors of production
- Analyze the labour market
- Understand the roles of services, facilities and support infrastructure
- Assess the roles of public and private institutions
- Assess the policy environment, legal framework, and their conditions
- Protect aquatic resources, environment and aquatic health
- Recognize multiple uses of water and minimize conflicts

It is suggested that use of the conceptual framework utilized in this study could help in future project preparation and design for aquaculture to fulfill its potential as a poverty alleviating mechanism.

Future columns will each deal with a specific case study but the study is available on the ADB web site and as a printed book with the title "An Evaluation of Small-scale Freshwater Rural Aquaculture Development for Poverty Reduction":

http://www.adb.org/Documents/Reports/Evaluation/sst-reg-2004-07/default.asp?p=opereval.

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New ACIAR projects to commence in Indonesia

David McKinnon[1] and Jes Sammut[2]

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Two new projects will commence this year in Indonesia, both funded by the Australian Centre for International Agricultural Research (ACIAR). These projects have a common theme of providing tools for the management of coastal aquaculture, and will be primarily based at the Research Institute for Coastal Aquaculture (RICA) in South Sulawesi. The projects, Land capability assessment and classification for sustainable pond-based, aquaculture systems (Dr. Jes Sammut, University of New South Wales) and Planning tools for environmentally sustainable tropical finfish cage culture in Indonesia and northern Australia (Dr. David McKinnon, Australian Institute of Marine Science) share the following common themes:

- Multivariate analysis of environmental & production factors;
- Identification of optimal environmental conditions for aquaculture systems;
- Development of coastal capability assessment techniques; and
- Development of a coastal classification scheme, mapping protocols and models.

Land capability assessment and classification for sustainable pond-based, aquaculture systems

Production failure and low yields in land-based, brackish water aquaculture are often associated with disease outbreaks, unsuitable pond management practices, and/or limiting environmental factors such as soil properties, water quality and hydrological conditions. The rapid expansion of land-based aquaculture systems in Indonesia has often resulted in the construction of earthen ponds in unsuitable environments due to a lack of effective site selection criteria and land capability assessment techniques. Intensive shrimp farming systems are often developed in areas that are more suited to less intensive or alternative aquaculture systems. Consequently, the development of land capability classification schemes is now a high priority in Indonesia to ensure that new aquaculture enterprises are sustainable.

Aquaculture stakeholders in Indonesia have identified a number of research needs to more properly manage brackish water aquaculture in Indonesia. These included: (i) identification of environmental constraints on pond production, particularly in reference to soil and water limitations; (ii) low cost techniques to characterise soil and water properties and to assess site suitability; (iii) protocols to classify and rank land capability for a range of aquaculture systems to maintain diversity and to reduce resource competition; and (iv) coastal resource and land suitability/capability mapping to guide environmental decision makers and coastal planners involved in the development of aquaculture industries.

The new ACIAR project will develop more effective and informative site selection criteria and land capability assessment techniques to produce land classification schemes and maps for a variety of land-based aquaculture systems in Indonesia. Land capability assessment protocols will be developed using geospatial data and satellite imagery for regional-scale environmental assessment. The project outputs will also include accompanying land capability maps for sustainable pond-based aquaculture and where required, combined land and water classification schemes. The classification scheme will use mapping units that identify environmental suitability for a range of land and sea-based aquaculture systems and prescribe important farm management practices to address common environmental limitations. Farm-level site selection criteria, utilizing low cost and simple technology, will be developed to

The environmental effects of cage culture have been comparatively well studied in North America and Europe, but this knowledge base may not be applicable to sea cage culture in the tropics.

enable farmers to make better choices for pond/sea cage location, design and management, and also to select the most appropriate form of aquaculture.

Project outputs will include:

- Land capability maps for sustainable pond-based aquaculture and where required, combined land and water classifications schemes. The classification scheme will use mapping units that identify land suitability for a range of land and sea-based aquaculture systems and prescribe important farm management practices to address common environmental limitations.
- Farm-level site selection criteria, utilizing low cost and simple technology, will be developed to enable Australian and Indonesian farmers to make better choices for pond/sea cage location, design and management, and also to select the most appropriate form of aquaculture.

Planning tools for environmentally sustainable tropical finfish cage culture in Indonesia and northern Australia

Sea cage culture in Indonesia is developing at an alarming rate. For instance, the value of grouper aquaculture in Lampung, East Sumatra, increased from $AUS 9,000 in 1999 to $AUS 680,000 in 2002 (Kawahara & Ismi 2003). If the industry continues to develop at this rate, and stocks cages beyond sustainable levels, continued and untreated environmental impacts could cause the collapse of the industry as well as impacts in surrounding waters.

Large schools of small wild fishes, such as these polka dot cardinal fish (Sphaeroma orbicularis) in the vicinity of fish cages in South Sulawesi, may alleviate or exacerbate environmental effects of aquaculture activities.

Environmental constraints on the development of fish cage culture in Asia include (i) a lack of equitable planning tools; (ii) no established means of estimating carrying capacity; (iii) a lack of tools for environmental impact assessment, and (iv) a very real risk of disease as a result of "clustering" of farms in bays and estuaries. In addition, reported economic losses associated with poor environmental management can reach or exceed 10 per cent of the value of production.

Disused pond at an Indonesian farm, resulting from inadequate site selection criteria.

Despite a substantial amount of information on the environmental effects of cage culture in Europe and North America, very little is known about the environmental effects of aquaculture in the tropics. European-style benthic capacity models are inadequate in the environments used for fish cage culture in Asia, where models based upon water quality may be appropriate. In Asia, fish cage arrays are more diverse and more extensive than in Europe. In any one area of coast, it is possible to find cage arrays producing a wide variety of species e.g. groupers, snappers, milkfish, siganids, lobster, oysters and seaweeds. These farms are often very close to each other, and so it is difficult to separate the effects of any one activity. Also, biological turnover rates are manyfold higher in the tropics than in temperate ecosystems. The most marked environmental effect of fish cage culture in temperate ecosystems is on the benthos underlying the cages, where waste products accumulate, sediments become anaerobic and large bacterial flocs (*Beggiatoa* spp.) accumulate. Organic material degradation in tropical sediments is faster than in temperate sediments.

Many waste materials are rapidly broken down either in the water column prior to settling.

Continued on page 17...

Assessing the consequences of converting to organic shrimp farming

Xie, Biao[1*], Li, Jiahua[2] and Wang, Xiaorong[2]

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Organic shrimp farming

Shrimp farming has undergone extraordinary expansion since 1976. Current annual production stands at around 1 million metric tones, which is equivalent to one third of total world shrimp supply. This development generates profit and income, but it also bears risks of negative environmental impacts, such as pollution, landscape modification, or biodiversity change[2,3,4,5].

The main input in most conventional shrimp culture systems is shrimp feed. Part of this is transformed into shrimp biomass but some is inevitably released into the water as suspended organic solids or dissolved matter such as nitrogen and phosphorus, originating from surplus food, faeces and excretion via the gills and kidneys. Other pollutants include residues of drugs used to prevent or treat disease. As a consequence, an increasing number of consumers, who are critical of conventional production methods, are willing to pay premium prices to enable the farmers to reduce economical and environmental pressure on production cost[6]. This has lead to the emergence of organic aquaculture, which has the goal of addressing the environmental, food safety and health problems faced by conventional aquaculture systems. As a relatively new concept, standards for 'organic aquaculture' have to be developed that will take into account consumer and conservation concerns about the sector, as well as the rapid development of industry. One of the main factors driving the development of organic farming is consumer concern over the use chemical substances in conventional production especially inorganic fertilizers and pesticides.

Standards for organic aquaculture were first developed by the Naturland association, an internationally operating certifier for organic agriculture[7]. Guidelines for organic aquaculture production have also been developed by others[8,9,10,11] in order to elaborate alternatives to conventional production systems. The International Federation of Organic Agriculture Movement (IFOAM), a large umbrella organization, has also drafted organic aquaculture standards[12], which have found application all over the world. The Food and Agriculture Organization/World Health Organization's international Codex Alimentarius Commission has finalized organic crop, livestock, processing, labeling, inspection and certification guidelines[1] but organic standards are not yet in place for aquatic animals and are still in draft form.

The organic sector in the world is booming with the largest ever wave of farm conversions underway[13] and aquaculture is also the fastest growing sector. There will likely be a niche for farmers interested in going the extra mile for organic aquaculture certification[14].

A fundamental principle in organic aquaculture production is to minimize its environmental impact as much as possible while developing a valuable and sustainable aquatic ecosystem. Aside from that, the term 'organic' is presently poorly defined, and is taken to mean different things by different people. One view, as it relates to the discussion in this article, is that certified "organic" products should be a complete or "holistic" concept, covering all aspects of production from origin of stock, feed and fertilizers to choice of production site, design of holding units, stocking densities, energy consumption and processing. The main principles for organic aquaculture production are[7]:

- Absence of genetically modified organisms (both brood and seed) in stocks and feeds.
- Strict limitation of stocking density (in regard to fish production).
- No artificial feed ingredients, ie. origin of feed and fertilizer from certified organic agriculture.
- Strict criteria for fishmeal sources (trimmings of fish processed for human consumption, by-catches from artisanal fishery; no dedicated fishmeal harvesting operations.); in general, decreased protein and fishmeal content of diets.
- No use of inorganic fertilizers.
- Restriction of energy consumption, e.g. regarding aeration.
- Preferences for natural medicines; no prophylactic use of antibiotics and chemotherapeutics.
- Intensive monitoring of environmental impact, protection of surrounding ecosystems and integration of natural plant communities in farm management.
- Processing according to organic principles.

Organic production is sometimes hailed as the true "sustainable agriculture"[15]. Its advocates claim that it has many social, environmental and economic advantages. While a number of studies have conducted comparisons between organic and conventional agriculture[6,15,16,17,18,19, 20,21,22,23,24] there are no published studies comparing the consequences of organic and conventional shrimp farming.

We conducted a one-year multidisciplinary field study of a shrimp farm undergoing transition from conventional to full organic status, by examining a range of ecological, culture and economic factors. This article describes our findings.

The farm

The study area is located in Xuwei salt field, Yellow Seaside, Lianyungang city of Jiangsu Province, China and was part of a 10-ha commercial shrimp farm. We studied four ponds, two undergoing conventional production and two undergoing organic production.

The ponds were about 0.33 ha (110 m length × 30 m width) and 2.8 m in depth. A 1500-W aerator was fixed in the center of each pond to prevent water stratification and to increase the concentration of dissolved oxygen to a small extent.

The farming system

The Naturland Standards for Organic Aquaculture[8] and IFOAM Draft Standard for Aquaculture Production[12] were adopted in the organic farming system. The ponds were stocked with native juvenile *Penaeus chinensis* (Chinese shrimp) bought from the shrimp farm of Sea Institute of Shandong Province. Shrimp were stocked in two systems on at a density of 16 individuals/m^2 with the body length of 0.84±0.16 cm. Before stocking, the juveniles were acclimatized to seawater with a salinity of 30 parts per thousand. In cooperation with the farmers, we chose appropriate management practices for the two systems (Table 1). The two systems had the same total water, nitrogen and phosphorus inputs. Disease and physical disorders were monitored throughout whole growing season by the farmers and by professional consultants who recommended organic and conventional treatments for their control.

One month before the beginning of the experiment, the two systems were fertilized with fully composted chicken manure to cultivate natural food. After stocking, composted chicken manure was applied in both the conventional and organic ponds, according to water color and secchi disc visibility, to keep the optimum water color and transparency of 30-40 cm during the experiment. Shrimp in conventional ponds were fed with a commercial pellet manufactured by the local Sulanlin Fishery Feed Co. Ltd., Jiangsu, China. Shrimp in organic ponds were fed with a formulation containing wild artemia from local salt pans, organic soybean from OFDC certified farms (an IFOAM accredited organic certifier in China) and natural clam, in accordance with organic requirements. Feeding was conducted twice per day in the beginning (April), gradually increasing in frequency to five times per day (August-September) as shrimp grew. Feeding behavior was monitored with check trays, and growth was monitored by sampling 20 individuals every 10 days. Aeration was applied twice per day from 0700–0800 and 1400–1500 h on sunny days before June, three times a day in July and August 0500–0600,1400–1500 and 2100–2200 h, and on cloudy or rainy days over the whole course of the study. The water in the systems was exchanged and added as required to make up for losses due to evaporation and seepage and to improve the water quality in the ponds. Water exchange normally happened at monthly intervals and varied according to the stage of the production cycle and different management systems.

Analysis

Standard water quality parameters were monitored (Table 2). Measurements of temperature, salinity, dissolved oxygen and pH of pond water were performed on site during the sampling process, at a depth of 30 cm in each pond. Ammonium, nitrite, nitrate and phosphate were quantified in the laboratory applying standard methods[41]. Discharged water quantity was recorded and water samples were monitored also. When harvesting, samples of fresh shrimp (20 individuals) were collected randomly from organic and conventional shrimp farming systems. Body length, body

Table 1. Management practice for organic and conventional shrimp ponds.

Management items	Organic shrimp pond	Conventional shrimp pond
Selection of site, interaction with surrounding ecosystems	Physical buffer zones around the organic pond; no mangrove existed.	No buffer zones; no mangrove existed.
Species and origin of stock	Native *Penaeus chinensis* adopted; no GMO involved;	Native *Penaeus chinensis* adopted; no GMO involved;
Breeding	Natural reproduction, no hormones used.	Natural reproduction, no hormones used.
Designing of holding systems, water quality, stocking density	Water quality conforming to the natural requirements of the species; 7.2 pieces/m^2	Water quality conforming to the natural requirements of the species; 7.2 pieces/m^2
Health and Hygiene	No medicine and treatment used; adopting optimized husbandry, rearing and feeding measures permitted in the Naturland Standards for Organic Aquaculture.	Bleaching powder, calcium oxide, keng iodine disinfectant and bioremediation products used during the culture period
Oxygen supply	A 1500-W aerator, temporarily used	A 1500-W aerator, temporarily used
Organic fertilizing	Certified Organic fertilizer (1000 kg/ha)	Composted chicken manure (1000kg/ha)
Feeding	Organic soybean; wild artemia and clam	Commercial pellet

weight and amino acid levels were analyzed.

We also calculated gross receipts using farm gate prices for shrimp sold at harvest or after storage. Prices for the specific size and grade and for conventional vs organic shrimps from our study were based on practical prices. Total costs included non-harvested variable costs (fertilizers, pesticides, feed, fuel, labour, electricity and housing), harvest variable costs (harvesting, grading, packing and storage) and fixed costs (machinery, interest and taxes).

Water quality

The quality of two pond systems was evaluated by analyzing the parameters mentioned above. The results were shown as follows:

pH, temperature, salinity and dissolved oxygen

The quality data are listed in Table 3. During the field experiment, salinity fluctuated between 13.5‰ and 19.6‰, temperature fluctuated from 19.5° to 29.8°C, pH from 8.4 to 8.9, and dissolved oxygen from 5.0 mg/l to 6.0 mg/l. There were no significant differences in above-mentioned parameters between conventional and organic treatments throughout the experiment.

The concentration of ammonium, nitrite, nitrate and phosphate are given in Figures 1-4, respectively. The pattern of all four nutrients shows considerable differences between the two production systems. Both systems displayed increases in the concentration of nutrients over time. However, levels of nitrite, nitrate and phosphate were significantly higher in the conventional system, while ammonium concentration higher in the organic system.

Disease

A potential incidence of viral disease was found in the conventional system in mid August, however, no disease was observed in the organically farmed shrimp throughout the whole growing season.

Table 2. Variables studied and corresponding methodology.

Variable	Monitoring	Method
pH	Twice daily	pH / mV meter / electrode
Dissolved oxygen	10 days	Oxygen meter
Salinity	10 days	Refaractometry
Temperature	Twice daily	Thermometer
Ammonium	Monthly	Nesselerization/ Spectrophotometry
Nitrite	Monthly	Diazotization/ Spectrophotometry
Nitrate	Monthly	Cadmium reduction/ diazotization
Phosphate	Monthly	Ammonium molybdate/ Spectrophotometry
Amino acid	When harvesting	Amino acid analyzer

Table 3. Temperature, pH, salinity and DO for organic system and conventional nutrients.

Parameter	Organic system	Conventional system
pH	8.4-8.8	8.6-8.9
Salinity (‰)	13.5-19.6	13.5-19.6
Temperature(°C)	19.5-29.8	19.5-29.8
DO (mg/l)	5.0-6.0	5.0-5.8

Harvest and shrimp quality

Due to early signs suggesting viral disease, shrimp in the conventional production system were harvested from 10-12 August. Shrimp from the organic system were harvested on September 15. The final culture duration was 127 days for conventionally farmed shrimp and 153 days for organic.

The harvested organic shrimp had a significantly higher average body length of 14.1 cm, and fresh body weight of 22.4g (dry body weight 6.1g), higher than conventionally farmed shrimp, which had an average body length of 10.6 cm and fresh body weight of 13.1g, (dry body weight 3.9g). The net organic shrimp yield was 3,060 kg/ha compared to 1,545kg/ha for conventionally farmed shrimp (Table 4). Survival in ponds was 85.4% for organically farmed shrimp and 73.7 % for conventional respectively. Feed conversion ratio was 1.18 for organic and 1.26 for conventional ponds. Analysis of amino acid content, an indication of shrimp quality, found that content in organic shrimp was higher for most, though not all, amino acids (Table 5). We conducted a 'taste panel' of 15 consumers to evaluate perceptions of shrimp quality. 80% found that organically farmed shrimp tasted better, and 100% indicated that it had a firmer texture.

Benefits of the two treatment systems

Net economic income in organic and conventional systems were 6182 and 103 RMB yuan/mu (here, RMB is the abbreviation of the currency used in P.R. China, and Yuan is its monetary unit whose exchange rate to US dollar is 1 : 8.3 or so; mu is Chinese unit of area whose exchange rate to ha is 1:15), with the ratio of total costs to gross receipts of 1 : 1.76 and 1 : 1.08 respectively. The organic shrimp system exhibited significantly better economic efficiency (Table 6).

We assessed the environmental benefits of the two production systems by comparing the total discharged nitrogen and phosphorus quantity. The total discharged water quantity during the culture period was lower for the organic system than for the conventional system (Table 7). The conventional system discharged 34.27 kg of nitrogen and 0.3747 kg phosphorus; some 14.89 kg and 0.3418 kg more than that for the organic system respectively. This indicates that the organic system performed better in terms of nutrient load on the environment.

Environmentally friendly production

Adverse environmental impacts related to shrimp aquaculture have been widely reported in the literature[3,25,26,27]. There is a large amount of nutrients in shrimp ponds derived directly from feeding and fertilization or indirectly from primary productivity, some of which is dissolved or suspended in water, some of which is deposited at the bottom of the pond. Much of these nutrients are wasted in the middle and later culture stages of the monoculture system because it cannot be fed upon directly by shrimp[28]. During the course of conventional aquaculture, untreated waste water laden with uneaten feed and fish faeces may contribute to nutrient pollution near surrounding water bodies[29]. Moreover, nitrogen wastes (for example, ammonia and nitrite) that exceed the assimilative capacity of receiving waters can lead to deterioration in water quality that is toxic to fish and shrimp. Leaching from both uneaten feed and shrimp faeces results in significant amounts of dissolved organic nitrogen being released in the water[30].

Our findings show that organic shrimp production can make more efficient use of input materials, effectively reducing the loading of organic matter both within the pond and in discharged waters. This difference is probably due in part to differences in the nutrient quality and composition of feed, which are likely to have a significant impact on nitrogen and phosphorus leachates. *Artemia*, fed to the organically farmed shrimp, is one of the best live foods for and can be digested fully by shrimp, with a protein conversion rate of around 80%, significantly more than fishmeal[31,32] upon which the artificial diet given to conventionally farmed shrimp was based. Soybean has a low phosphorus level[33], which results in lower phosphorus leaching if used as feed of aquatic animals.

However, we also found that the organic system has its own problems. The ammonium level is higher in the organic pond than in the conventional system. This may be attributed to the high NH_3 excretion rate from the gills of organically farmed shrimp. Previous studies have shown that the main source of ammonium is ammonia excreted from shrimp gills[30].

Table 4. Mean final sizes and yield of cultured shrimp in the organic and conventional systems. The parameters were presented as mean ± standards deviation except for net yield.

	Body length (cm)	Fresh body weight (g)	Dry body weight (g)	Net yield (kg/ha)
Organic	14.1±0.4	22.4±3.6	6.1±0.4	3060
Conventional	10.6±0.3	13.1±0.8	3.9±0.3	1545

Table 5. Amino acid content for harvested organic and conventional shrimp.

Amino acid	Organic (g/g DW)	Conventional (g/g DW)
Asp	0.091	0.064
Glu	0.116	0.055
Ser	0.031	0.032
His	0.013	0.009
Gly	0.074	0.060
Thr*	0.028	0.025
Arg	0.073	0.062
Ala	0.048	0.046
Tyr	0.024	0.021
Cys-cys	0.090	0.070
Val*	0.038	0.037
Met*	0.023	0.022
Phe*	0.028	0.026
Ile*	0.034	0.033
Leu*	0.058	0.055
Lys*	0.051	0.050
Pro	0.125	0.159
Trp*	0.012	0.009

* Essential amino acid for humans.

Disease

Disease is recognized as one of the biggest obstacles for the future of shrimp aquaculture and they indirectly have bearing on the environment[3]. Viral and bacterial diseases, together with poor soil and water quality, are the main causes of shrimp mortality[34,35], although deficient environmental management of shrimp farms is another determinant[36].

Management of the pond environment is probably the most important factor for disease prevention in shrimp mariculture[36]. Conventional shrimp farming systems are reliant on nutrient-

Table 6. Economic benefits for organic and conventional shrimp systems (unit: RMB yuan).

Treatments	Costs						Benefits		Total costs vs. gross receipt
	Seeds	Labour	Feed	Electricity	Housing	Other	Shrimp	Net income	
Organic	4000	8000	10920	5969	5000	2600	71400	30911	1:1.76
Conventional	4000	1000	1100	2468	0	200	9283	515	1:1.08

Table 7. Discharged water for the two production systems and correspondent nitrogen and phosphorus quantity (Nitrogen=NH_4^++$NO3^-$+NO_2^-; Phosphorus = Phosphate).

Parameter	Discharged water (m^3)		Nitrogen concentration of pond water (mg/l)		Phosphorus concentration of pond water (mg/l)		Nitrogen quantity in the discharged water (kg)		Phosphorus quantity in the discharged water	
	Organic	Non-org.	Organic	Non-org.	Organic	Non-org.	Organic	Non-org.	Organic	Non-org.
April	0	400	0.365	0.114	0	0	0	0.046	0	0
May	0	600	0.616	0.456	0	0	0	0.274	0	0
June	0	767	0.802	1.364	0	0.018	0	1.046	0	0.0138
July	800	834	0.906	2.456	0.001	0.029	0.725	2.048	0.0008	0.0242
August	1200	934	1.369	3.043	0.003	0.034	1.643	2.842	0.0036	0.0318
September	400	---	1.741	----	0.002	----	0.694	----	0.0008	----
Post-harvest	9240	9240	1.767	3.031	0.003	0.033	16.32	28.01	0.0277	0.3049
Total	11640	12644	---	---	---	---	19.38	34.27	0.0329	0.3747

rich feed inputs. If not properly managed, this can cause deterioration of the pond environment leading to disease[37].

Although based on a very limited trial, our study suggests that organic management practices may be able to reduce disease risks. This may be attributed to superior water quality in the organic shrimp pond. As for the other mechanisms, the authors are of the following opinions. In contrast to conventional production, the basic standards of organic aquaculture production include regulations concerning cultivating conditions, which serve as preventive measures. For example, we created physical buffer zones around organic pond to prevent the entry and spread of disease from off-farm. Adequate policies and regulations had been taken to control the entry and escape of species cultivated in the organic pond as well as movement of water and people.

Economic benefit

It appears that disease was the main proximate factor for the final economic benefit. We assessed the economic benefit of the two production system by calculating the net profit in this study. The organic system was significantly more profitable than the conventional system. Higher production costs for the organic system were largely due to differences in feed applications, labour, housing, electricity, operation etc. The cumulative gross receipt can vary depending on several factors, such as shrimp body length, prices, yields, shrimp taste and shrimp quality. Regarding shrimp body length, the breakeven point happened from July to August. During this period, first signs of disease appeared in the conventional system. In order to reduce disease risk, the grow-out period in shrimp farming is often shortened, resulting in harvesting of smaller shrimp. Sometimes, cultivation continues until first signs of disease appear when the crop is immediately harvested and can still be marketed, but at lower quality[38]. That was the case happened in our study too.

Product quality

The harvested organic shrimp was generally superior with regards to important variables such as taste, firmness and amino acid levels. In the consumer's mind, organic produce must be better and healthier than that produced under conventional farming system. This image is also the main motive for consumers who are willing to pay premium prices for purchasing organic food[39]. Therefore, quality differences have been the subject of many recent comparisons between conventional and organic food[17,40]. However, a clear comparison between organic and conventional produced products is difficult to establish due to the great variation within the production methods, concerning among other things, intensification, feeding rate or breeds used[6].

Conclusion

Our results show that the organic shrimp production system trialled in Lianyungang city of Jiangsu Province is not only better for the environment than its conventional counterpart, but has significantly comparable yields and higher profits while producing a better quality product. Although shrimp yield and quality are important products of a farming system, the benefit of the environment quality provided by the organic production system is equally valuable and usually overlooked in the marketplace. Such external benefits come at a financial cost to farmers.
It would be very interesting to compare organic and conventional shrimp approaches in a cost–benefit analysis including environmental costs and sustainability issues (environmental and economic) to see how we should optimize shrimp production. Due to high cost, organic farmers may be unable to maintain profitable enterprises without economic incentives, such as price premiums or subsidies for organic products. The challenge facing policymakers is to incorporate the value of ecosystem processes into the traditional marketplace, thereby supporting organic food producers in their attempts to employ both economically and environmentally superior organic management practices.

Acknowledgments

Financial support for this study was provided by the Technical Center for Nanjing University and Jiangsu Salt Industrial Group Company. The authors thank Ding Zhuhong, Wang Guichun and Qian Guangliang for their assistance in the field and in the laboratory. Sincere thanks are also due to shrimp farmers of Xuwei Salt Field who allowed us access to their farm for the duration of the study.

Fig. 1 Monthly patterns of NH_4^+ in the organic and conventional systems, April to September.

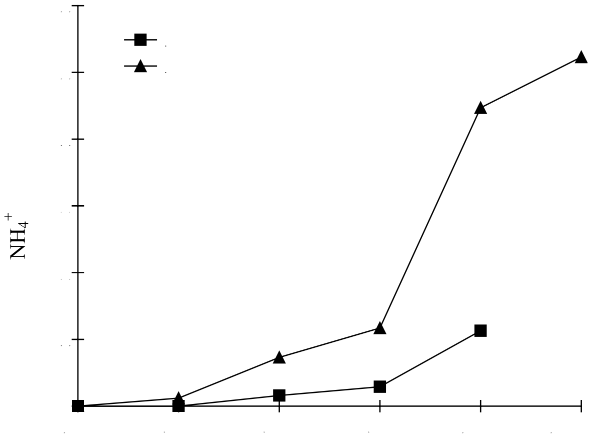


Fig. 2 Monthly patterns of nitrite in the organic and conventional systems, April to September.

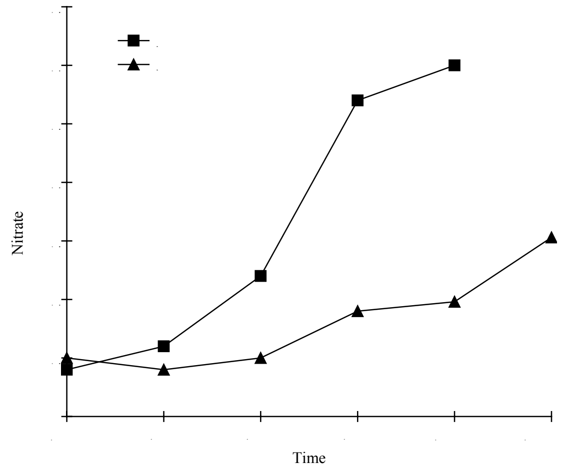


Fig. 3 Monthly patterns of nitrate in the organic and conventional systems, April to September.

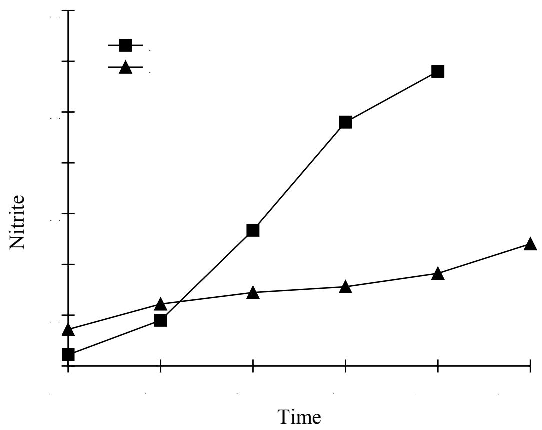
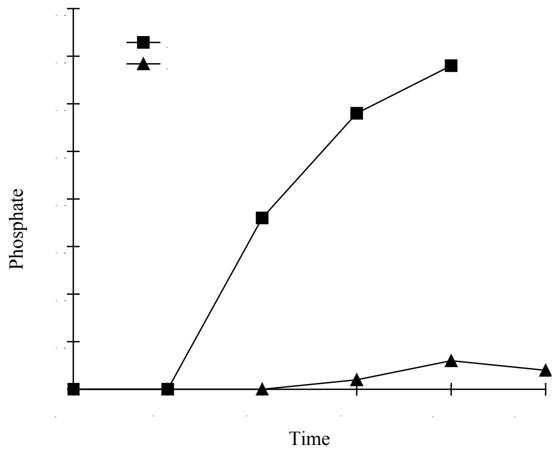


Fig. 4 Monthly patterns of phosphate in the organic and conventional systems, April to September.



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New ACIAR projects in Indonesia

...continued from page 10.

The sea-cage project will:

- Generate a model to estimate carrying capacity for fish cage culture in a broad range of habitat types across the tropics.
- Develop best practice guidelines for the aquaculture industry to minimise the environmental impact of waste products.
- Place emphasis on deliverables to management authorities that will be easily implemented.

Putting it all together: Minimising conflicts between land- and sea-based aquaculture

The land- and sea-based projects will jointly develop site selection criteria for coastal aquaculture to develop an overall coastal classification scheme. Many environmental problems can be conveniently avoided by appropriate farm siting (Phillips 1998).

The community benefits in both countries include more accurate site assessment, improved yields, more effective environmental decision-making, reduced social conflicts between land and sea-based aquaculture industries, minimised socio-economic inequalities, and improved resource management.

ACIAR will coordinate and run the land- and sea-based projects in parallel to result in a classification scheme and resulting management tools appropriate for the development of both industries. In the first instance, the tools developed will be applied to the coastal zone of South Sulawesi, but it is envisaged that these serve as a model for other locations in Indonesia and elsewhere in Southeast Asia. In Indonesia, a National Steering Committee under the chairmanship of the Director General of Aquaculture (DGA) will integrate project results and outputs into planning and decision making processes. Liaison and coordination with a Local Advisory Group in South Sulawesi will be mediated through the office of the DGA. A model and decision support system will extend the results to a broader range of environments, and will have application not only to the Indonesian and Australian situation, but to the tropical Asia-Pacific.

Who's involved?

These projects involve multi-disciplinary studies by a number of collaborating agencies. Most of the research will be based at the Research Institute for Coastal Aquaculture in Maros, South Sulawesi. Other agencies include the Gondol Research Institute for Mariculture in Bali, Gadjah Mada University in Yogyakarta, and Hasanuddin University in Makassar. For the land-based project, the project leaders are Dr. Akhmad Mustafa and Dr. Jes Sammut at the University of New South Wales, Sydney, Australia. The sea cage project is lead by Dr. Rachmansyah rsyah@indosat.net.id and Dr. David McKinnon d.mckinnon@aims.gov.au at the Australian Institute of Marine Science, Townsville, Australia.

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Recycling water and making money

By Hassanai Kongkeo and Simon Wilkinson, NACA

Harvesting the Artemia pond: The slowly turning paddlewheel and bamboo guides direct Artemia into the shallow-set net fixed in position behind, where it can be easily removed.

Serious about recycling

If you think that you can't keep reusing seawater, think again: Recently we visited a shrimp hatchery that has been recycling a single batch of seawater for *eleven years*. Only freshwater has been added to the system to control salinity, and no water has been discharged to the environment in the history of the farm. At the same time the water quality in production facilities is amongst the best we have ever seen, and the hatchery is generating a tidy profit from its water treatment ponds by making use of the hypersaline waters to farm *Artemia* biomass and reclaim nutrients at the same time.

The hatchery is owned and operated by Khun Banchong Nissagavanich, Vice-President of the Thai Shrimp Producer's Association, and located at Banpho District, Chachoengsao Province, nearly 60 km east of Bangkok. Khun Banchong specialises in *Penaeus monodon*, his hatchery has never produced *P. vannamei* and he has no intention to start now – particularly since the price of *P. vannamei* has crashed. While most of the Thai industry has moved away from *P. monodon* and the price of postlarvae has fallen, he points out that the price of *P. monodon* broodstock has also fallen to about 1,000 baht (US$25) per animal from former levels of 10,000 baht (US$250).

Although it is far from the sea (30km), he selected this site for his hatchery with an aim to use recycled water to keep water quality stable, reduce the risk of viral pathogens entering the hatchery system and to avoid ongoing costs such as transportation of brine, commonly practiced by many inland hatcheries in Thailand – Khun Banchong estimates that recycling water reduces his operational costs by 200,000 – 300,000 baht (US$5,000-7,500) per month. He believes that the stable water quality is a key factor in the sustainability of a shrimp hatchery and broodstock culture. Water drawn from the sea or from estuaries may fluctuate in parameters such as pH, alkalinity, salinity, temperature and plankton content, creating stress and variation in shrimp survival rates.

Before use in the hatchery, surface water from earthen treatment ponds is pumped into 30 ton concrete tanks where it settles for a few days before salinity adjustment. On average, water salinity in treatment ponds should be around 38 ppt. In the wet season, salinity may drop to 20 ppt, which requires addition of hypersaline water from the farm's *Artemia* ponds to adjust it up to normal seawater salinity (30-35 ppt). In the dry season when salinity in treatment ponds may rise to more than 40 ppt, it is necessary to dilute with freshwater. Then chlorine (30-50 UPN) is applied for elimination of phytoplankton and disinfection, followed by heavy aeration to eliminate residues. The treated water is pumped through an efficient filter system and ozonated before use in hatchery.

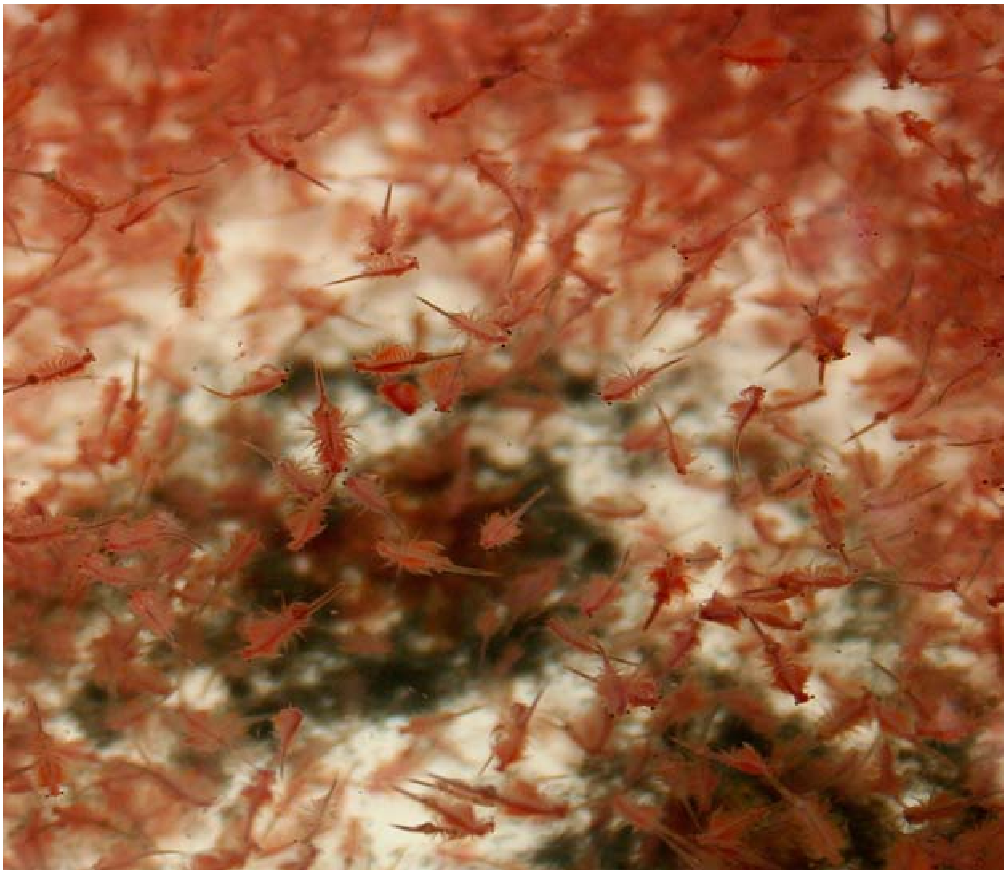
After hatchery use, water is drained to treatment ponds (0.2-0.4 ha) for sedimentation and breakdown of organic loads. Algae and seaweeds seeded in the ponds and mangroves planted around the edges assimilate some of the nutrients and dissolved organic compounds that are released. At night,

Water treatment canals and ponds are aerated and lined with mangroves to assist in improving water quality. The dykes are lined with 'pigface', a hardy and salt-tolerant plant, to reduce erosion.

aeration is also given to accelerate plant growth. Reducing nutrient loads helps prevent excessive phytoplankton blooms, which may destabilise water quality and cause shrimp mortality.

During the first two to three years of operation, water salinity in treatment ponds did not rise above 50 ppt, so not much freshwater was required for dilution to hatchery standard. However, when salinity reached 70-120 ppt in subsequent dry seasons a huge quantity of freshwater would have been required, so Khun Banchong began looking for an alternative way to use this hypersaline resource and converted two 0.5 ha treatment ponds for *Artemia* culture. *Artemia* are an ideal animal for this kind of environment, as they can grow and reproduce very rapidly in high salinity conditions where fish and other predators cannot survive.

Seaweed and macro algae are harvested daily from water treatment ponds and composted for a few days as a natural fertilizer. This is used to stimulate phytoplankton blooms within the *Artemia* ponds, upon which the animals feed. In this way the hatchery



Adult Artemia harvested from the water treatment ponds.

reclaims nutrients as *Artemia* biomass, which is sold as a secondary crop. Usually, one cycle of water treatment will take about 7-10 days.

Harvesting *Artemia*

The farm produces an incredible 200-600kg of *Artemia* biomass *per day!* This is sold at around 60 baht (US1.50) per kilo as feed for aquarium fish, Asian seabass nurseries and *P. monodon* broodstock culture. *Artemia* biomass is also exported, Around 80% is sold in frozen form, and 20% live.

Artemia is harvested with a very simple and effective set up: A surface-set net with bamboo guides is fixed in position behind a small, slowly rotating paddlewheel that maintains slow circulation within the pond. *Artemia* swimming in the surface layers are swept into the net, which is lifted and cleared periodically. The catch is transferred to small hapa-style holding cages at the pond side to await packing.

Looking into marine fish culture

With a practically unlimited supply of *Artemia* available on site Khun Banchong has recently begun experimenting with marine finfish culture; as every aquarist knows fish regard *Artemia* much in the same way that children regard lollies: They *love* it - *Artemia* biomass provides nutrient-rich feed (50-60% protein) and keeps water in rearing tanks relatively clean compared with non-living feed, thus contributing to higher survival. At present he is rearing mouse grouper (*Cromileptes altivelis*) in the hatchery for two months with near 100% survival before transfer to outdoor ponds. Stocking densities are around 500 3cm fingerlings per 10 ton tank with excellent water quality and scrupulous hygiene. It is early days yet, but his preliminary results are quite promising with some fish reaching 500g in 10 months of culture using live *Artemia* biomass as the primary feed for fingerlings held in the hatchery and *Artemia* mixed with trash fish in growout ponds. This is quite fast compared to a typical growout period of 18 months for *C. altivelis* on trash fish alone.

Inside the shrimp hatchery – preparing the ponds.

Mouse grouper fingerlings (Cromileptes altivelis).

Asia-Pacific Marine Finfish Aquaculture Network

Magazine

SKRETTING

July-September 2005

Advances in the seed production of Cobia *Rachycentron canadum* in Vietnam

By Le Xan

Research Institute for Aquaculture No 1.

Cobia culture is expanding throughout the world, notably in China and Vietnam. Cobia have an extensive natural distribution, grow quickly, and can feed on artificial diets. Under culture conditions, Cobia can reach 3–4 kg in body weight in one year and 8–10 kg in two years. Products from Vietnamese Cobia are exported to the US, Taiwan Province of China and local markets. The market price of one-year farmed Cobia are around US$ 4–6 kg in Vietnam. Research on seed production and grow out culture of cobia in Vietnam began in 1997-1998.

Adult cobia, Rachycentron canadum. These two were on the menu!

Broodstock and spawning

Broodstock can be acquired by purchasing wild fish or by collecting dominant individuals from grow-out operations (selecting broodstock from different parental lines to avoid inbreeding). Most fish more than two years in age have fully developed ovaries, but it is best to collect three-year old broodstock if possible. In Vietnam, cobia spawn twice per year during April to May and September to October. Conditioning of broodstock usually starts some 3-4 months before anticipated spawning, by feeding with trash fish, squid and swimming crab supplemented with mineral vitamins and 17α-methyltestosterone. The amount of trash fish fed is about 4 – 5%/body weight per day.

Mature fish are spawned in dedicated spawning tanks or sometimes in floating net cages. Spawning tanks are 60m^3 in volume with a depth of 2.5m. Female broodstock are administered with an injection of LRH-e or LRH-a at a dosage of 20 µg/kg female,

Australian Government
Australian Centre for International Agricultural Research

APEC

Hatchery-reared juvenile cobia.

with males receiving half of this dose. There isn't a need to inject all females but only one or two pairs. Spawning of cobia usually takes place at night, although it occasionally also happens during the day. After spawning, fertilized eggs are separated out and collected using seawater at 35–36‰. Sinking eggs should be discarded.

Eggs are stocked in the incubation tank at a density of 2000–3000 eggs/litre. The incubation tank is 500m^3 in volume maintained with light aeration. Water exchange is carried out at 200-300% per day, using an input and overflow pipe system.

Larval rearing

Cobia larvae are reared in cement ponds, composite tanks or earthen ponds. A suitable pond size is 400-500m^3 in volume with an average depth of 1–1.2 metres. Rearing ponds are fertilized to stimulate production of natural live feed before stocking with larvae. Live feed density needs to be checked frequently, and if low, must be supplemented with correctly sized live feeds (rotifer or copepod) to suit the larvae as they grow. After 22 – 25 days, larvae can be fed with mixed food or artificial diets. However, there may be a need to transfer larvae to a larval rearing tank where they can be trained to accept the new food and receive proper care.

A suitable size for larval rearing tanks is 3–10m^3 in volume. The optimal temperature for rearing the larvae is in the range 24–30^{O}C, with a salinity of 28–32‰,pH 7.5–8.5 and light intensity about 500 lux. Larvae of cobia that must be weaned can be reared in salinity of 20 – 22‰. The microalgae *N. ocullata*, *Chlorella* or *I. galabana* should be supplied and maintained at a density of around 40,000–60,000 cells/ml in the rearing tanks. We have found that dark coloured larval rearing tanks (green or black) tend to give better larval survival.

Density

The optimal density for larvae in rearing tanks varies with their age as follows:

- 1–10 days larvae density at 70–80 individuals/litre
- 11–20 days larvae density at 20–30 individuals/litre
- 21–30 days larvae density less than 10 individuals/litre.

In the earthen ponds, stocking density is 1,500-2,000 individuals/m^2.

Water exchange

Daily water exchange rates are:

- Between days 0–10, 0–10% of tank water is exchanged.
- Between days 11–20, 30–50% of tank water is exchanged using natural flow.
- After day 20, 100–200% of tank water is exchanged daily. We use a simple biofilter, but the electricity cost can be quite high.

Grading

Grading is very important to reduce cannibalism. By day 25, larvae harvested from rearing tanks should be graded into small and large size groups, and maintained separately with their own rearing regimes.

Feeding

First larval feeding is with rotifer *B. plicatilis* at a density of 15 individuals per ml until 12 days after hatching. *Artemia* nauplii can be given from 7–20 day old larvae. Artificial feeds can be introduced from day 17–18, but it typically takes around 3-4 days to train the larvae to accept them.

In feeding experiments using enriched rotifers and *Artemia* nauplii we found that the enriched live feeds give better results than unenriched feeds.

The composition of artificial diets we use are as follow:

- Fresh tunny meat minced: 47%
- Mixed fish meal (45% protein): 25%
- Soybean meal, rice bran meal: 15%
- Vitamins, mineral meal: 3%

All compositions are mixed; crushed and sieved to a size suitable for the mouth of larvae. Artificial diets should be made daily.

Metamorphosis in cobia requires around 25 days to complete at a temperature of 26–28^{O}C with adequate feed. After day 25, larvae can be weaned completely onto artificial diets.

In Vietnam, some hatcheries involved in rearing cobia larvae with the regime above achieve a survival rate of 15–20% (from day 0–day 25), and 40–50% from day 25 to 50, after which fry are around 7.5-8.5 cm in length.

Australian success with barramundi cod

Dr Shannon McBride

Technical Manager Good Fortune Bay Fisheries Ltd.

Good Fortune Bay Fisheries Ltd hatchery at Bowen, Queensland, Australia, has successfully produced 100,000 juvenile barramundi cod (*Cromileptes altivelis*) since January 2005.

The GFB Fisheries Ltd facility is a saltwater aquaculture site incorporating substantial broodstock, hatchery, nursery and grow-out facilities. The company produces saltwater barramundi (*Lates calcarifer*) and intends to further expand its production into reef fish species. High quality seawater is pumped directly from the ocean and is utilized in land-based raceways for grow-out operations. The site is adjacent to the Great Barrier Reef Marine Park and all operations are performed under strict environmental guidelines.

The broodstock are held in 50 m^3 temperature controlled tanks and husbandry conditions ensure a regular supply of high quality fertilized eggs. The hatchery has continued to build on the success of previous years and plans to double the production of barramundi cod this season.

The success in barramundi cod production has been assisted by information and technology made available through ACIAR and the Asia-Pacific Marine Finfish Aquaculture Network.

Research and development

GFB Fisheries Ltd is collaborating with the Northern Fisheries Centre in Cairns to assess the feasibility of industrial scale production of copepods as live feed for larval rearing in reef fish aquaculture. The use of copepods will be assessed by improved survival of barramundi cod in the hatchery and by expanding production to include coral trout (*Plectropomus* spp.).

As the number of juvenile barramundi cod produced at the site continues to increase, the company is looking towards the development of appropriate nursery and grow-out diets in conjunction with Ridley Aqua-Feed (Australia). These specific diets would minimize wastes, particularly nitrogen, and also optimize growth.

Future

GFB Fisheries Ltd. continues to develop its expertise in the production of barramundi cod, a reef fish highly valued by international markets. This is an exciting and challenging period for GFB Fisheries Ltd. as a leading Australian company in the development of reef fish aquaculture.

Grow-out raceways at the Good Fortune Bay facilities, Bowen, Australia.

Brief overview of recent grouper breeding developments in Thailand

Sih-Yang Sim[1], Hassanai Kongkeo[1], and Mike Rimmer[2]

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Juvenile coral trout (P. leopardus) produced at Trad Coastal Aquaculture Station.

Thailand's success in breeding grouper species dates back to 1984-85 when the Phuket Coastal Fisheries Research and Development Center (Phuket CFRDC) and Satul Coastal Fisheries Research and Development Center succeeded in breeding *Epinephelus tauvina* (possibly misidentified *E. coioides*)[1,2]. The Phuket CFRDC also achieved the first successful grouper larval rearing during September 1984 to February 1985, when some 130,000 fry aged 45 days were produced[3].

In October 1998, the National Institute of Coastal Aquaculture (NICA) based in Songkhla successfully produced giant grouper *Epinephelus lanceolatus* by artificial propagation, but the survival rate was very low. In September 1999, NICA had another success in giant grouper breeding using preserved milt to fertilise freshly stripped eggs[4]. Since that time, work at NICA has focused on shrimp aquaculture, while other coastal research stations in Thailand have continued to develop marine finfish aquaculture.

In 2002 the Krabi Coastal Fisheries Research and Development Centre (Krabi CFRDC), reported its first success in breeding and larviculture of tiger grouper (*Epinephelus fuscoguttatus*) with a survival rate of 2% to 70 day-old juveniles[5]. The Krabi centre has also succeeded in producing *E. coioides* fingerlings for some years and now provides 100,000 – 200,000 fingerlings per year to Thai farmers. With the recent worldwide interest in ornamental fish, thanks to the film 'Finding Nemo', it is notable that Krabi centre has been able to produce seven varieties of clownfish (anemone fish) native to Thailand[6].

After several trials in October 2003 the Trad Coastal Aquaculture Station (Trad CAS) in eastern Thailand successfully managed to produce its first batch of coral trout *Plectropomus leopardus* fingerlings[7], which it has been consistently producing in small numbers ever since. As of 16 June 2005 there were some 12,000 coral trout larvae at 31 days of age. Trad CAS also holds broodstock of *P. maculatus* (island or bar-cheek trout) but these have not yet spawned.

Mr. Thawat Sriveerachai, Chief of Trad CAS, said the key factor for success of coral trout breeding in Trad is water quality management. As Trad is subject to heavy rainfall throughout the year, it is important to protect the water quality in broodstock tanks from heavy variation, particularly in salinity. Trad station utilises recirculation systems and biological water treatment for coral trout broodstock, as well as other species. The recirculation system is a combination of traditional biological filtration plus bioremediation using shrimp, molluscs, sea urchins, swim-

Close up of a one inch coral trout (P. leopardus) fingerling in larval rearing tanks, Trad CAS.

ming crabs and fish. The water in the broodstock tanks is changed only once per year.

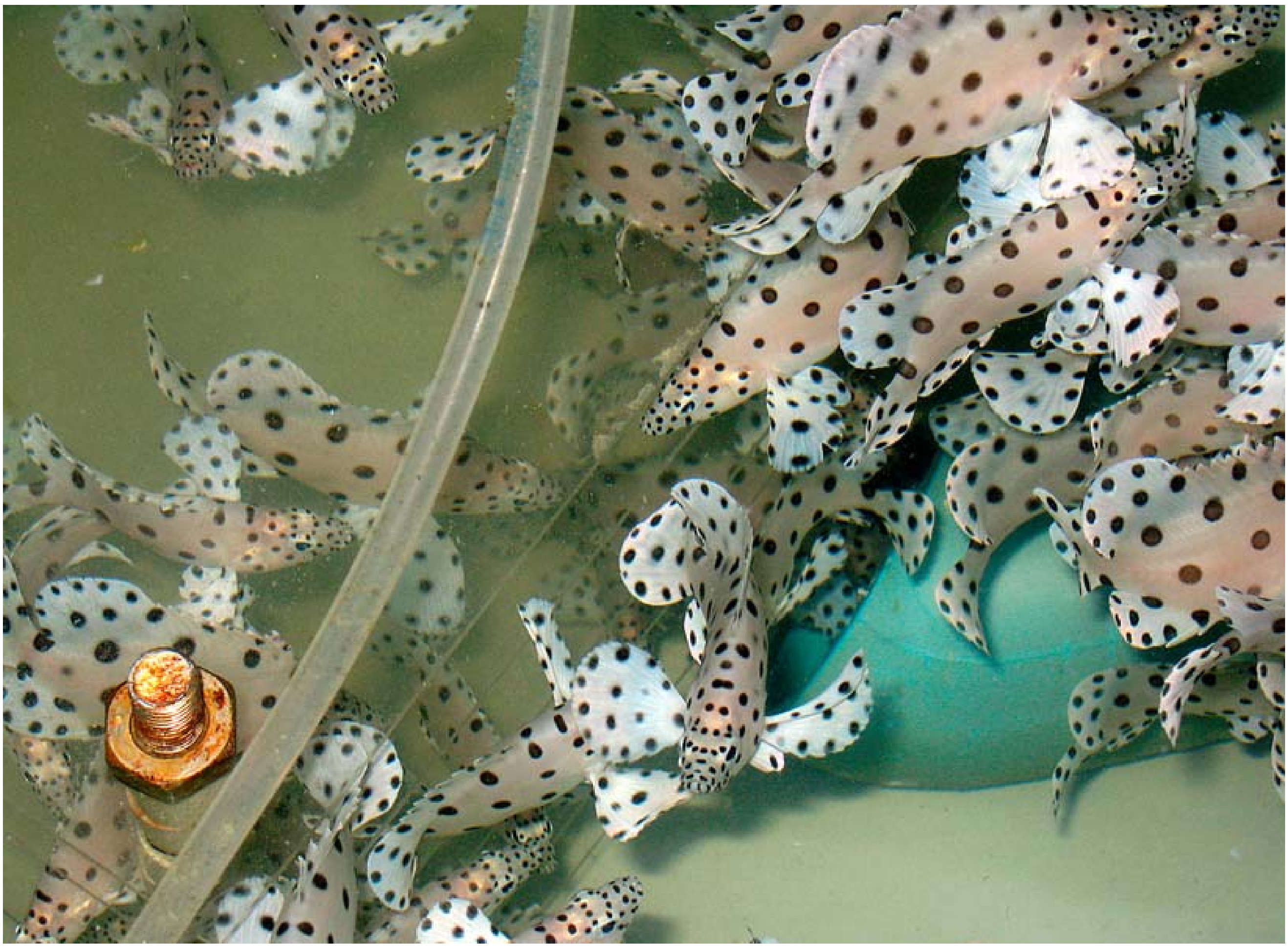
The recirculation systems used at the Trad centre are low cost and relatively robust. In contrast, many of the more sophisticated recirculation systems available in the market today may not suitable for marine finfish species, are expensive, costly to maintain and problematic.

Trad CAS researchers have noticed that larval quality and survival is improved by enhancing the fatty acid composition of the live feeds used in larval rearing. Larvae fed nutritionally enhanced live feeds are usually of better quality and do not show the same 'shock' behaviour seen in larvae fed traditional live feeds.

In 2005, the Rayong Coastal Fisheries Research and Development Center (Rayong CFRDC) made a breakthrough in mouse grouper (*Cromileptes altivelis*) larval rearing. The center uses the a simple recirculation system similar to Trad CAS for their broodstock holding facilities. The broodstock tanks are rather small at 3×5×1.2 m. Although mouse grouper broodstock successfully spawn in these tanks, egg production is low, which limits fingerling production.

Rayong CFRDC also operates a large broodstock holding cage facility at nearby Koh Samet. This facility holds broodstock of several grouper species including *P. maculatus*, *E. fuscoguttatus*, *E. lanceolatus*, *E. coioides*, mangrove snapper *Lutjanus argentimaculatus* and cobia *Rachycentron canadum*. Like Trad, Rayong have not been able to spawn their *P. maculatus* broodstock, despite attempts at hormonal induction of spawning.

There is considerable interest amongst the private sector in Thailand in developing marine finfish hatcheries. There is already considerable production of seabass (*Lates calcarifer*) in Thai hatcheries, and many are keen to diversify their production to higher-value species such as groupers. A major constraint to diversification amongst private hatcheries is access to eggs and larvae. Many are now working with the government centers and stations so that when fertilized eggs are available in government facilities, they can obtain them for grouper larviculture trials. The government also provides training and technical support on grouper hatchery technology to the private sector.



Mouse grouper fingerlings produced at Rayong Coastal Fisheries Research & Development Center.

Acknowledgments

We thank the following experts for their hospitality and provision of information for this article.

- Dr. Renu Yashiro, Director of Rayong Coastal Fisheries Research and Development Center, Department of Fisheries Thailand.
- Mr. Paiboon Bunliptanon, Director of Krabi Coastal Fisheries Research and Development Centre, Department of Fisheries Thailand.
- Mr. Thawat Sriveerachai, Chief of Trad Coastal Aquaculture Station, Department of Fisheries Thailand.
- Mr. Ekapol Wanagosoom, Partner and Manager of Aqua-Larval Farm, Thailand

E. coioides broodstock in the floating cage facilities, Krabi CFRDC.

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Marine finfish broodstock facilities of Rayong CFRDC near Koh Samet

Application of probiotics in rotifer production systems for marine fish hatcheries

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There is an urgent need to develop microbial control strategies in marine fish hatcheries. Disease outbreaks are a major constraint to hatchery output, and use of antibiotics is generally considered undesirable within intensive grow-out systems. Recent advances in science have made it possible to use probiotics, so-called 'friendly' microbes, as an additional tool in health management. 'Probiotics' is a catch all term commonly used to describe microbes (or products containing microbes) that perform beneficial functions, and which are normally seeded within the production system in some manner. The seeding of biofilters with bacteria capable of breaking down nitrogenous wastes is a classic example of the use of 'beneficial' microbes within aquaculture. More recently, attention has focused on use of probiotics that can assist in disease control, for example by competing and interfering with other harmful microbes.

Microalgal production facility.

The 'probiotic approach' has some advantages over conventional use of antibiotics and other chemicals. The use of probiotics tends to focus on disease prevention rather than cure, and as a more 'natural' alternative, they are not currently subject to the same restrictions in international trade.

Probiotics are widely used in aquaculture applications, especially in commercial shrimp hatchery and farming systems. In recent times, use of probiotics has been also extended to marine finfish hatcheries, the shellfish industry and in live food production systems. Live food used in marine fish hatcheries, such as the rotifer *Brachionus plicatilis*, is an important carrier of bacterial pathogens that can result in larval fish mortalities. At the Aquaculture Fisheries and Oceanography Department (AFOD) of the Kuwait Institute for Scientific Research (KISR), the seawater used for live food production is treated through use of protein skimmers, pressurized sand filters, cartridge filters and UV sterilizers before the water is stored in a reservoir for use. However, pathogenic bacteria still occur in the live food production system, especially in the intensive rotifer cultures using chemostats, and several incidences of larval fish mortality have been attributed to pathogenic bacteria from this source. To overcome this problem, the conventional rotifer batch culture method was adopted at AFOD instead of using intensive continuous chemostat cultures, since the continuous cultures build up undesirable bacterial loads over several months. Aiming to deliver desirable probiotics to marine fish larvae, recent studies at AFOD have focused on using commercially available probiotics in rotifer production systems. This article describes the efficiency of using commercially available probiotics for rotifer production and some of the possible advantages of using probiotics in the intensive rotifer production systems for commercial applications.

Source of probiotics and application method

We used a commercially available probiotic Alken Clear-Flo® 1006 (ACF-1006), procured from Alken Murray Corp., USA. ACF-1006 is a dry synergistic blend of bacteria specially designed to discourage disease proliferation in aquatic environments by enhancing the immune response of cultured species while eliminating specific pollutants that foster pathogenic *Vibrio* spp., and other disease causing species. This product uses a consortium of six gram-positive bacilli and ten gram-negative vegetative strains. It is a free flowing brown powder with a bacterial count of $3.5x10^{12}$ CFU/g. Before application, the dry product was mixed in the proportion of 10g of product to 150ml of seawater. The mixture was allowed to hydrate for two hours, stirring vigorously every 30 minutes. After final settling, the supernatant liquid layer was poured off for use. The first set of experiments evaluated the efficiency of ACF-1006 for feeding the rotifers using:

- ACF-1006 alone at a feeding rate of 1g/million rotifers/day;
- ACF-1006 at 1g/million rotifers/day plus *Chlorella* at a cell density of 25 million cells/ml;
- ACF-1006 at 0.5 g/million rotifers/day plus *Chlorella* and bakers' yeast at 0.5 g/million rotifers/day;
- *Chlorella* in combination with bakers' yeast at 1 g/million rotifers/day (control); and
- *Chlorella* alone at 25 million cells/ml.

The experiment was carried out in 5 litre beakers at a controlled temperature of 24.5-25ºC using three replicates for each treatment.

Based on the results obtained during the first experiment, the second experiment was carried out in 1m^3 capacity conical fiberglass tanks to understand the production dynamics of rotifers with and without probiotics. The water temperature was controlled at 25±1 ºC. In the first treatment with probiotics, seven replicated cultures were carried out using a feed combination of *Chlorella*, bakers' yeast and ACF-1006. Bakers' yeast and ACF-1006 were used at a feeding rate of 0.5g/million rotifers/day each. In the second treatment without probiotics, six replicated cultures were carried out using a feed combination of *Chlorella* and bakers' yeast at 1g/million rotifers/day. Rotifer harvests were made every alternative day as per requirement and the tank culture volume was adjusted by the addition of seawater and *Chlorella*.

Production dynamics of rotifers with and without probiotics

Among the different treatments used during the first set of experiments, a significantly higher (P<0.01) rotifer density and culture duration was observed when rotifers were fed with a combination of *Chlorella*, bakers' yeast and ACF-1006 compared to that of other treatments in the culture system. Maximum densities of 309.7±9.1 and 304.3±27.1 rotifers/ml were observed in this feed combination on days 8 and 9. The culture duration was also extended when using the probiotic combination in the feed compared to that of without probiotic. However, the rotifer growth was poor while using ACF-1006 alone and the culture declined on day 9 of the observation period showing that use of probiotic alone as a feed was not conducive for rotifer cultures.

In the second set of experiments significant increase (P<0.001) in the rotifer productivity was observed when using ACF-1006 along with *Chlorella* and bakers' yeast in the 1m^3 capacity rotifer production tanks compared to that of using *Chlorella* and bakers' yeast alone without probiotic. The rotifer productivity averaged 12.13±1.89 rotifers/ml/day when using ACF-1006 along with *Chlorella* and bakers' yeast. Without ACF-1006 the rotifer productivity averaged 6.64±3.60 rotifers/ml/day.

Extended rotifer cultures of more than 27 days were observed in the ACF-1006 feed combination compared to that of without ACF-1006, which declined on day 13 of the experiment. The rotifer growth rate and doubling time

Seawater treatment system for live food.

Rotifer chemostat production facility.

was also significantly higher (P<0.001) while using the probiotic in the culture system compared to that without it. The rotifer instantaneous growth rate (*K* value) averaged 1.96±0.45 when using ACF-1006 and averaged 0.78±0.17 without the probiotic. The rotifer doubling time averaged 0.37±0.09 days with probiotic and 0.92±0.20 days without, showing the efficiency of using the probiotic in the culture system. A significant increase (P<0.001) of the ciliate *Euplotes vannus* was also observed in cultures containing probiotic compared to those without.

Future prospects

The results of these investigations show that using of the ACF-1006 probiotic in the rotifer culture system can enhance rotifer growth rate and productivity, as well as extend the culture duration. In general, rotifer productivity under semi-continuous or batch culture systems at AFOD yields about 52 to 60 rotifers/ml/day. The intensive chemostat rotifer production system developed at AFOD using 1m^3 capacity tanks yields an average of about 255 to 261 rotifers/ml/day with a feed combination of *Nannochloropsis* and bakers' yeast. Such systems are desirable in commercial ventures due to their ability to produce a large rotifer biomass per unit space and time, compared to that of batch cultures. However, although the rotifer productivity is considerably higher in the chemostat culture system than conventional culture methods, we no longer use the chemostats due to the undesirable bacterial build up under long-term culture conditions. The results of our investigation suggests that application of commercial probiotics in the rotifer cultures can help to eliminate this problem and ensure the health of the marine fish larvae due to the encapsulation of probiotics in rotifers. However, further investigations are required to evaluate the beneficial effect of using probiotic fed rotifers to marine fish larvae. Further research is also required to assess the efficacy and use of other commercial probiotics and local isolates of beneficial bacteria towards bio-encapsulating rotifers as feed for marine fish larvae, as well as to enhance the rotifer productivity and culture tank conditions.

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Collaborating organisations

Contract hatchery systems: A practical approach to procure quality seeds for aquaclubs of small-scale shrimp farmers in India

By Arun Padiyar, NACA

Stocking high quality and healthy seed is fundamental to producing a successful crop in shrimp farming. Small-scale farmers with limited holdings find it a daunting task to procure good quality seed. At present, to obtain a small quantity of clean seed for their individual requirement, they must visit several hatcheries, spend considerable cash on testing seed batches and at the end they are still are uncertain of the seed quality that they will finally obtain. This process of seed selection is time consuming, expensive and has the risk of farmers not being able to get quality seeds at the right time. To address this problem, the Shrimp Health Management project in Andhra Pradesh state supported by MPEDA, NACA, ACIAR and ICAR introduced a "contract hatchery seed production system" to help farmers participating in Aquaclubs (farmer self help groups, described in an article in the last issue of Aquaculture Asia) easily obtain quality seeds.

Building trust: Mr. Ravi, a farmer representative, inspecting the quality of shrimp larvae through the microscope.

What is a contract hatchery system?

Under this system, Aquaclub farmers collectively place a bulk order to a hatchery, 45-60 days in advance of the planned stocking date, for production of required quantity and quality of seeds. Through a consultative process, initially facilitated by the project team, mutual agreement is formed between selected hatcheries and aquaclubs. These agreements include agreements on better management practices to be used in hatcheries and other terms and conditions for production and procurement of quality seed.

How it was done in Aquaclubs?

About 45-60 days before the stocking date, Aquaclub leaders visit 4-5 hatcheries. They observe the hatchery facilities and discuss the quality requirements and production procedures with the hatchery owners and technicians. Once the farmers have reviewed hatchery facilities, production processes, qualification and experience of technicians they entered into an agreement with the hatchery owner on the terms and conditions and farmers place the order for supply of seed in bulk quantities (which may be up to 5-10 million PLs). In addition, they may also offer an additional 5-10 paise premium (20-30% more than normal market price) for shrimp seed produced according to their requirements. By offering a premium price for bulk purchase of quality shrimp seed both the hatchery and farmer benefit.

Production and quality criteria agreed by hatcheries and Aquaclubs

Since 2004, several contract hatchery systems have developed in Andhra Pradesh. The following are some of the important production and quality criteria mutually agreed by hatchery owners/operators and Aquaclubs:

- Single brooder spawning and no mixing of nauplii batches in PL tanks.
- PCR testing (for white spot virus) on nauplii batches.
- Selection of highly active nauplii by light attraction.
- Maximum feeding with high quality *Artemia* and reduction of artificial feeds.
- No use of banned antibiotics.
- Reduction of stocking density in PL tanks (60-80 animals/litre).

- PCR testing (for white spot virus) and MBV testing at PL 10-15 stage.
- Uniformity in size and color of PL batches.
- Selection of highly active PL.
- Maintenance of hatchery management (tank-wise) and trace-ability record books.
- Complete access on an Aquaclub farmer representative for entire seed production period of 25-30 days thus bringing transparency in hatchery production activities.
- Option to farmers to reject the seed at the time of packing if the batch fails quality tests.

Aquaclub farmers and hatchery operators are highly appreciative of this transparent and mutually beneficial system. Some of the important benefits as expressed by farmers and hatchery operators include:

- Farmers procure good quality seeds at the right time and there is no delay in stocking dates.
- Farmers are well prepared, financially and mentally to purchase the seeds.
- Farmers know the exact date of seed supply and hence prepare the ponds, well in advance.
- Quality of seeds is assured until packing and farmer confidence in seed has increased due to adoption of agreed better management practices in the hatchery.
- All the Aquaclub farmers in a cluster stock seeds from a single hatchery during the same period thus avoiding any cross contamination problem.
- Hatchery owners receive a premium price for the seeds.
- Marketing burden on hatchery operators is reduced significantly because a good relationship and understanding develops between farmers and hatchery operators during the contract period of 30 days. Farmers better understand the effort and difficulties in producing good quality seeds due to transparency in the production line, and farmer develop a positive attitude towards supporting the hatchery by not rejecting the seeds without good reason.
- No use of banned chemicals in hatcheries reduces the risk of chemical residues in shrimp and hence provides a basis for better marketing of shrimp at the farm gate and international market.
- Traceability can be easily offered to the end customer due to maintenance of records in hatcheries. Combined with record keeping at the farm level, the system offers a basis for implementing traceability of shrimp product.

Farmers visually inspecting the quality of PL.

Farmers inspecting the hatchery facilities.

This system being developed in Andhra Pradesh offers plenty of benefit to both farmers and hatcheries. In addition, there is reduced tension among farmers in procuring the required quantity of good quality seeds at the right time and no tension to hatchery operators in marketing the seeds leading to a win-win situation for both farmers and hatchery operators. This system has great potential and offers the right kind of platform to improve interaction between farmers and hatchery operators, to their mutual benefit.

Recirculation systems: Sustainable alternatives for backyard shrimp hatcheries in Asia?

Thach Thanh[1], Truong Trong Nghia[2], Mathieu Wille[3] and Patrick Sorgeloos[4]

With an expected production this year of 200,000 ton, Vietnam is well on its way to become one of the biggest shrimp producers in the world. Production is largely concentrated in the Mekong Delta in South Vietnam. Owing to the optimal climate conditions and availability of land suitable for pond construction, this region accounts for as much as 75 % of the total 400,000 ha of cultivated shrimp ponds in the country. The significant increase of shrimp farming (for comparison, in 1998, production was only 50,000 tons) has lead to an increasing demand for shrimp seed. Although there has been a proliferation of hatcheries in the delta, local production is far from sufficient to fulfill the need for shrimp seed in the area (Hai *et al*. 2000). About 80% of the post-larvae supplied to shrimp farms are still imported from the provinces in the center of the country, where high-quality seawater is plentiful. As post-larvae are in short supply, farmers often settle for lower quality. Lack of technical knowledge and poor hygienic conditions in the hatcheries, aggravated by the long transport by road, further result in weak and infected post-larvae being stocked into the ponds, which in its turn leads to serious disease outbreaks during grow out.

To overcome this weakness, the College of Aquaculture and Fisheries (CAF) of Can Tho University (Vietnam), inspired by technologies for rotifer culture (Suantika *et al.* 2000 and 2001) established by the Artemia Reference Center of the Ghent University (Belgium), developed a simple, but reliable shrimp larval rearing protocol, using a recirculation system, to produce high-quality post-larvae without the need for prophylactic antibiotic treatment and with very low seawater requirements.

System design and general rearing techniques

One rearing unit consists of four tanks of 4 m³ each, connected with a central filter system via a protein skimmer operated with ozone. The main filter unit consists of one concrete tank subdivided into three compartments. Water flows into the first compartment through a submerged bin filled with activated carbon (neutralization of residual ozone in the water coming from the protein skimmer); the first, second and third compartments are filled with sand, coral and gravel respectively. Several air-water lifts operate these three compartments as submerged biofilters; water flows from one compartment to the other via bottom overflows; water finally returns to the central reservoir through a mounted 500-l plastic bin, filled with gravel, acting as a dry trickle filter. The total volume of the filter system is 4 m³.

Seawater is made up with 120-g/l brine hauled in from the coastal salt works of Vin Chau about 60 km away from Can Tho. Brine is diluted with freshwater to 30 g/l. The water is then treated overnight in 20-m³ concrete tanks with hypochlorite, neutralized with thiosulphate and aerated for another 48 hours to eliminate possible chorine residues. Before use, the water is allowed to sediment for an extra 24 hours.

Initially, a batch culture system is applied. Water is pumped via a protein skimmer, operated with ozone, to half-fill the culture tanks (approximately 2 m³). In the tanks, the water is thoroughly aerated for another 24 hours before stocking with nauplii. Around 800,000 to 1,000,000 nauplii from one spawn are stocked in each culture tank, corresponding to 400-500 nauplii/l at half tank volume or 200-250/l at final volume.

Larvae are fed *Chaetoceros* algae three times per day, at concentrations that are gradually increased from an initial 50,000 cells/ml, to 115,000 cells/ml at the zoea 2 stage and approximately 200,000cell/ml at zoea 3. During the batch culture period, every other day, 1g/m³ of a commercial probiont mixture (BZT Aquaculture, USA) is added. According to the manufacturer, the probiont mixture is composed of *Streptococcus faecium*, *Bacillus subtilis*, *B. licheniformis*, baker's yeast, *Aspergillus spp*., amylase, protease and lipase.

At the time of molting from zoea to mysis stage the compound feeds Frippak and Lansy (INVE NV/SA, Belgium) are added as daily rations varying from 1 to 4 g/m³ per day, spread over three feedings depending on the larval stage and survival. From mysis 2 onwards umbrella-stage *Artemia* are introduced.

Through daily addition of fresh seawater, water volume in the tanks reaches 4 m³ by the time larvae reach the post-larvae stage, approximately eight days from the start of the batch culture. At that time the tanks are connected to the filter system and recirculation culture starts. The bio-filtration unit has been pre-conditioned during the batch culture phase: the filter is filled with disinfected/ozone-treated water and inoculated with a commercial nitrifying bacteria culture (NMX bio-filter starter, INVE NV/SA, Belgium). For consecutive runs, substrate from other operational biofilter systems might also be used as inoculum. During start-up, every other day, NH_4Cl (5 mg/l) is added as substrate for the nitrifying bacteria; after seven days, when all ammonia is converted (checked daily using test kits), the NH_4Cl dose is doubled and ammonia and nitrite levels checked again after three days, followed by a new addition of NH_4Cl; 24hrs later ammonia levels are normally close to zero and the culture tanks can be connected to the bio-filter.

From PL1 to PL5 newly-hatched *Artemia* nauplii are fed. From PL5 onwards 12-hour enriched (DHA

Top view of a round 4-m³ larval rearing tank with aeration lines and the cylindrical overflow screen to retain larvae and live food.

Selco; INVE NV/SA, Belgium) Instar II *Artemia* are used. Cylindrical filter screens are employed to retain the *Artemia* nauplii within the culture tank. Recirculation rate starts at 300 % of the tank volume per day, but is eventually increased up to 400 % per day when nitrite and ammonium test kit results reveal a decrease in water quality in the culture tank.

At PL10, half of the water is drained, and freshwater is added gradually over a period of 2 days, until harvest at PL12, in order to adjust the salinity to the salinity in the ponds (normally 10 g/l). The water that was drained is treated again (see above) and re-used for the next culture cycle. All tanks, as well as the biofilter are disinfected with hypochlorite before starting a new batch.

Survival at harvest of PL12 ranges from 20 to 80 %, with half of the batches ≥ 60%. *Artemia* consumption amounts to 3 kg of cysts per million PL12 produced. The private hatchery of Mr. Thach Thanh operates four independent recirculation units consisting of fifteen 4-m³ tanks, each one producing on average 250,000 PL12 per cycle. With a total culture period of approximately 25 days, 4 cycles were completed over the last 6 months, giving a total production of 15 million PL. Staff requirements amount to two persons for the hatchery and one person to operate the maturation unit. The maturation system is set up in a separate unit and uses the same source of seawater and a similar recirculation system with submerged and trickling filters and protein skimmers with ozone injection. Wild spawners are used as brood stock. Usually only the first 2 spawns are used as nauplii quality is known to go down from the third spawn onwards. Total investments to upgrade the former hatchery facility from batch to a recirculation system amounted to approximately 3,000 US dollars.

These "CTU PLs" as they are referred to by farmers, are sold at US$4 per 1000. "Regular" post-larvae from the more common open-system hatcheries normally only fetch US$2 per thousand, as farmers experience the quality of the post-larvae produced in these recirculation systems as superior. Reasons for the better price setting are (i) better score (>80) for the Watchana Sunthorn test; (ii) better survival during grow out of 70-80% successful harvest compared to 30-40 % for batch system PL; and (iii) lower incidence of WSSV infection and losses during grow out; in many cases, only ponds stocked with CTU PL survive during heavy WSSV epidemics.

From the approximately 1500 hatcheries in the Mekong delta, 200 have already successfully adopted this recirculation technology. Expertise during start-up/conversion is provided by staff of Can Tho University.

Although the developed rearing techniques evolved from the specific conditions in the Mekong Delta, the reliability of this closed system to produce healthy shrimp post larvae without the need for prophylactic antibiotic treatment, makes its extension and application in other shrimp producing regions worthwhile to investigate. In addition, a strategy for the improvement of sanitary measures for the overall production should be developed. Such a strategy will result not only in better PL quality but higher production and consistency between tank production. A similar strategy was developed by FAO under the project TCP/RLA/0071(A), which resulted in the publication of the technical paper: Health Management and Biosecurity Maintenance in White Shrimp (*Penaeus vannamei*) hatcheries in Latin America (FAO, 2003). This document could be used as a reference and adaptations to better suit *Penaeus monodon* postlarvae production systems could be introduced.

Notes

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Mr. Thach Thanh explaining his recirculating broodstack maturation system with on the left the individual broodstock containers and in the middle the filter unit with "homemade" protein skimmers and the submerged and trickling filter.

Rainbow trout culture in Iran: Development and concerns

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Rainbow trout, *Oncorhychus mykiss* is one of the most important salmonid fishes cultured in fresh and brackish water in Europe, the Americas and many other parts of the world. Global production of rainbow trout in 2001 was 510,000 tons, with Chile producing 109,000 tons and Norway 71,000 tons. Although rainbow trout culture in Iran has long history there are no records until 1961. In 1962, a fish farm called the Mahisara of Karaj near Tehran began commercial culture on a small scale, expanding its operations from 1965 to 1967 by importing some 15 million eyed eggs from abroad. In 1966, a private company called Jajeroud Rainbow Trout Aquaculture entered commercial production. After some years, fish farms like Jajeroud and Karaj could produce rainbow trout from these imported eggs. In 1977, another fish farm called Yegandasht in Fars Province started work on rainbow trout after the Islamic Revolution of Iran. While the first two farms succeeded in breeding rainbow trout, Yegandasht could not, due to problems with high temperature in their area.

Between 1979 and 1989, several aquaculture centers were built that were capable of breeding rainbow trout. With the establishment of these facilities, Iran began to produce its own eyed eggs, larvae, broodstock and trout feeds. Suitable climatic conditions, increasing demand for safe food and fish as a source of protein, together with self-sufficiency in related industries helped to provide economic justification for continuing investment in the development of new rainbow trout farms and hatcheries. According to surveys, the western provinces and northwest of Iran with cool springs and rivers have better potential for rainbow trout culture in Iran.

Kelardasht broodstock pond.

State of rainbow trout culture in Iran

In 1989 the production was 440 tons in nine provinces. From 1995 onwards, rainbow trout culture also began to be practiced in cages, pens, earthen ponds and agricultural reservoirs. By 2003, production had reached 23,137 tons. This consisted of 527 tons from individual farms, 3,227 tons from small farms, 1,050 tons from fish culture complexes, 524 tons from recirculation systems, 438 tons from earthen ponds, 367 tons from closed water bodies and 75 tons from paddy fields. Total production of rainbow trout in 2002 is shown in Table 1.

Trout farms are distributed primarily in the center, western and northwestern parts of Iran, mainly in mountainous areas with cool summers and freezing winters. Farming systems in these areas tend to be simple concrete raceway canals. As the number of farms has increased and culture techniques and facilities have improved, the annual production of trout has grown from 280 tons in 1978 to more than 23,137 tons in 2003. Seven provinces account for around 70% of production, namely: Charmahal Bakhtiari 19% Lorestan 13.2%, Fars 12.3%, Mazandaran 10.6%, Kohkilouyeh 5.9%, West Azerbaijan 5%, and Tehran 4.5% respectively.

Current status of hatchery technology

In order to support the needs of the growing fish farming industry governmental rainbow trout hatcheries were established in 1988 in Yasuj (Kohhgilooyeh Province) and Kelardasht (Mazandaran province). In recent years there has been a trend to privatize hatcheries, and now most fingerlings are produced by the private sector.

Import of eyed eggs of rainbow trout

Since 1990, eyed eggs have been imported from Denmark, Italy, UK and Australia in eleven stages that are described in Table 3.

Production of fry fish in public hatcheries

Total production of rainbow trout fry in Yassouj and Kelardasht in 1985 was 1,804,560 pieces. In 2003 this amount rose to 3,293,470 pieces and around 23.9 million eyed eggs were produced. Table 4 compares these amounts among affiliated centers of Shilat-Aquaculture Dept.

Production of fry fish in private sector hatcheries

At present there are 60 private sector hatcheries including both licensed and unlicensed facilities, working in 13 provinces. In order of relative importance, they are in Mazandaran, Tehran, Lorestan, Charmahal and Bakhtiari, Eastern and Western Azarbaijan, Kurdestan, Fars, Kouhkilouieh and Boyer-ahmad, Hamedan, Qazwin, khorasan and Guilan Provinces. Table 5 shows fry fish production in private sector hatcheries in 2002.

One can see from Table 6 that:

- The contribution of public hatcheries to fry production has fallen from 22.6 percent in 1993 to 1.7 percent in 2002 and while the contribution of private sector hatcheries increased to 98.3 percent.
- Regarding eyed eggs of rainbow trout, public sector production from 1995 to 2002 was primarily to compensate for the lack of fry and to adjust the price.

Status of rainbow trout feed

Rainbow trout feed in Iran is usually made in dedicated fish feed factories from imported ingredients including Kilka fish powder (anchovy) and soybeans mixed with some other local ingredients. In 1995, a small amount of early diet for rainbow trout was imported from Italy (40 tons) and in 2003 some 300 tons of early and broodstock diets were also imported. In recent years some factories have been producing feed with formulations proposed by Fisheries of Iran (Shilat).

Table 1: Provincial rainbow trout production in Iran, 2002.

Province	No. farms	Total area(m^2)	Production (t)
Ardabil	21	26949.6	301.6
Azarbaijan East	13	34129	482.6
Azarbaijan West	17	32882	776
Chaharmahal	55	126665	3064.8
Esfahan	16	42339	505.2
Fars	40	111722.5	1970
Gilan	22	42752	334.2
Golestan	11	9610	92.3
Hamadan	6	41870	1256.5
Ilam	17	134355	233.4
Kerman	6	23520	95.9
Kermanshah	8	13738.5	251.3
Khozestan	0	0	0
Khorasan	41	82912	475.9
Kohgilooyeh	36	63909	935.3
Kordestan	7	11261	194.9
Lorestan	47	133796	2120.2
Markazi	0	125485.2	295.9
Mazandaran	53	125690	1712.9
Qazvin	16	17944	212.9
Qom	0	43090	63
Semnan	8	7025	139.9
Sistan	0	38280	59.3
Tehran	19	94940.83	699.9
Yazd	1	49650	95.3
Zanjan	1	13458.2	159.3
Total	**440**	**1421024**	**16016.7**

Consumption status and marketing of rainbow trout

There is a good market for rainbow trout in the larger cities and producers are still making a good margin despite an increase in production costs. Most rainbow trout farms in Iran deliver product as fresh fish and this has constrained market development and delivery time to some extent. Regarding processed products, in recent years fish have also been delivered frozen and gutted, which has played a major role in increasing fish consumption by the public.

With respect to special norms of fish consumption in Iran, until recently, farmed fish was only used in some special areas at certain limited times of year, and then only in some particular kinds of cooking styles. Although in recent years consumption of rainbow trout has been successfully promoted, the annual per capita fish consumption in Iran is still 5 kg, well below the average of global average of 13 kg.

Due to the flesh color of rainbow trout, its quality is not well accepted and although the market demand for trout weighing more than 500 grams is good, the average market weight of fish is around 250 grams, and fish need at least 15 months to reach this size.

Table 2: Number of farms, pond area and annual production of rainbow tout in Iran, 1993-2003.

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
No. of farms	31	39	69	80	116	165	258	306	380	461	562
Pond area (ha)	8.96	11.94	12.6	16.5	23.5	32.8	46.1	51.92	68.4	73.9	89.8
Production (MT)	835	1200	1500	1900	2510	4994	7000	9000	12170	16026	23137

Source: Yearbook of Iran Fisheries Statistics 2001.

Developmental goals of rainbow trout production in Iran

In line with finding and developing potentially suitable sites for rainbow trout culture in Iran, by 2002 more than 21 fish culture complexes in 11 provinces were established with a total production capacity of 7,512 tons.

In addition to identified complexes, after feasibility studies construction has commenced on some 25 other fish culture complexes with total production capacity of 8,644 tons in 11 provinces.

Five complexes of these projects with a 7.5 Hectare of land use and production capacity of 1,570 MT are located in Lorestan, Kordestan, Hamedan and Western Azarbaijan Provinces. These complexes are in use and produce rainbow trout at the time being.

In 2002, some 488 government licenses were issued for rainbow trout culture. The combined capacity of these projects is 6,131 tons and they are located in 26 different provinces of the country. If this trend continues, it is likely that production will reach 25,000 tons this year and continue to sky-rocket. Most of the development will be in provinces such as Mazandaran, Lorestan, Kordestan, Charmahal and Bakhtiari, Fars, Western Azarbaijan and Hamedan.

Some restrictions and problems

Other rainbow trout breeding and culture complexes in the country (with or without official licenses) need more fry to continue expanding their production. Due to lack of broodstock management programs, genetic problems are emerging among hatchery-produced fry, which is likely to result in a decline in production rate and productivity. To date, different lines of broodstock that were imported as eyed eggs have been cross-bred, resulting in a loss of genetic diversity, reduced production rate and increased food conversion ratio.

Eyed eggs.

Larvae.

Table 3: Import of eyed eggs according to country of origin and different species of rainbow trout.

Country of origin	Delivered to	Imported
Denmark	Tehran, Korasan, Fars	1990
Australia	Tehran	1991
UK	Kohkiloieh	1994
Italy	Kohkiloieh	1994
Denmark	Kohkiloieh	1994
Fish Farm Services (UK)	Tehran	1995
Cofradex (Denmark)	Fars	1996
Leonardi (Italy)	Fars, Charmahal, Khorasan, Mazandaran, Lorestan, Tehran, Azarbeyeja v.	1997
Fish Farm Services (UK)	Tehran	2003
Aqualand (France)	Charmaha, Tehran, Kohdilioieh	2003
Fish Farm Services (UK)	Mazandaran, Kohkiloieh, Tehran	2004
Aqua Forsk (Norway)	Kohdilioieh, Mazandaran	2004

Feed problems

Another problem faced by the industry is the low quality of locally produced feed, which has a high food conversion ratio and impacts productivity in farms.

Market related problems

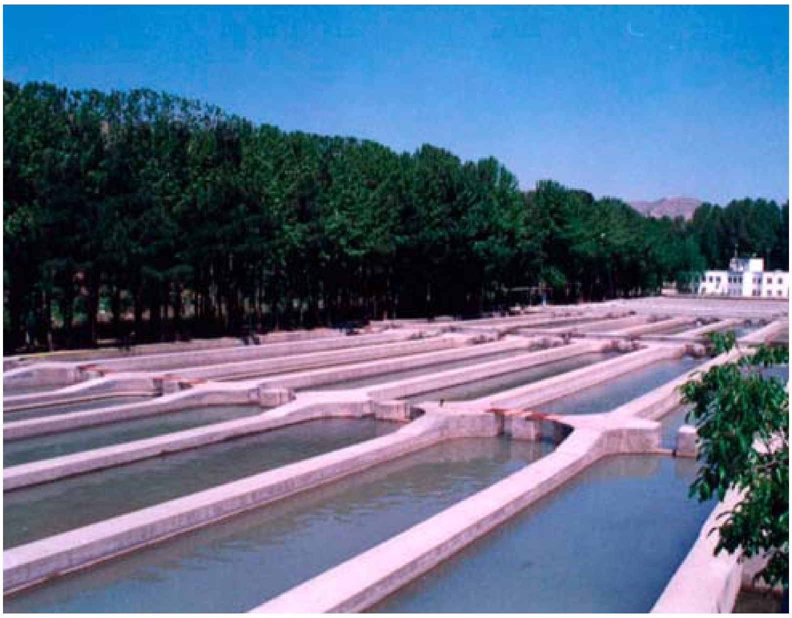
There is a risk that the rapidly increasing production of rainbow trout in Iran will saturate local market demand, due to lack of diversification and low capacity of these markets, leading to a price fall.

In 1992, the value of aquaculture in Iran was US$58 million. The most important species were, by value: Silver carp 52%, common carp 24%, grass carp 15%, bighead carp 4.3%, rainbow trout 4% and shrimp 0.4%. The value of aquaculture increased to US$263 million in 1994, US$382 in 2000 and US$537 million in 2001, by which stage the contribution of the main species was: Silver carp 44%, rainbow trout 22.5 %, common carp 14%, shrimp 8.5%, grass carp 7% and big head carp 4% in 2001.

Needs for expansion of the industry

Regarding the genetic problems of rainbow trout, the only solution is to design a national plan for selecting better species and genetic management of broodstock. Some activities in this area commenced three years ago after an FAO Expert level mission to Iran. The required surveys have been carried out and with a joint technical cooperation project will be started in near future.

To solve the problem of low feed quality there is a need to develop rainbow trout feed formulations according to latest world standards. In this regard, some specialized factories for fish feed production must be set up to produce



Jajerood, one of the oldest trout farms in Iran.

Transfering eggs to incubators at the Kelardast center.

Table 4: Hatchery production among breeding and aquaculture centers affiliated to Aquaculture Dept. of Shilat, 1998-2002.

Center	Subject	1998	1999	2000	2001	2002	2003
Yasooj	Eyed eggs	23,064,266	26,055,303	30,341,407	20,694,149	32,300,000	23,212,517
	Fingerlings	2,555,870	1,602,987	494,471	338,000	-	-
Kelardasht	Eyed eggs	-	-	-	834,170	2,363,580	700,000
	Fingerlings	3,968,000	2,530,000	2,435,936	2,141,947	2,083,971	3,293,470
Total	Eyed eggs	23,064,266	2,6055,303	30,341,407	21,528,319	34,663,580	23,912,517
	Fingerlings	6,523,870	4,132,987	2,930,407	2,479,947	2,083,971	3,293,470

feed with quality raw materials, at a reasonable cost.

To address the marketing problem for rainbow trout products, it may be desirable to:

- Open new rainbow trout processing factories to supply a more diversified range of products to markets.
- Increase the quality of products so as to open trade with international markets.
- Further publicize fish consumption within Iran.

For more information visit the website of the Iranian Fisheries Organization (Shilat) at http://www.iranfisheries.net/english.

Table 5: Fry production in private sector hatcheries, 2003.

Province	No. centers	Fingerlings
Azarbayjan E.	6	4,000,000
Azarbayjan W.	3	11,000,000
Ardabil	4	2,700,000
Esfahan	3	12,000,000
Tehran	7	10,500,000
Charmahal	3	22,000,000
Khorasan	5	8,000,000
Zanjan	1	1,000,000
Fars	4	14,000,000
Qazvin	8	3,800,000
Kordestan	4	5,000,000
Gillan	1	3,000,000
Kohkeiloei	7	12,000,000
Lorestan	6	35,000,000
Markazi	1	5,000,000
Mazandaran	15	20,000,000
Semnan	1	1,200,000
Hamadan	1	2,000,000
Total	80	172,200,000

Table 6: A decade of fingerling production in private and government hatcheries.

Year	Public production		Private production	Public sector	Private sector
	Eyed eggs	Fingerlings	Fingerlings	%	%
1994	-	1,943,000	6,480,000	23	77
1995	11,000,000	2,197,000	7,580,000	32	68
1996	14,000,000	6,000,000	22,940,000	21	79
1997	14,000,000	6381,000	31,700,000	17	83
1998	23,064,000	6524,000	38,300,000	16	84
1999	26,055,000	4,133,000	69,090,000	7	93
2000	30,341,000	2,930,000	74,300,000	4	96
2001	21,528,320	2,480,000	91,000,000	3	97
2002	34,664,000	2,084,000	119,724,000	2	98
2003	23,913,000	3293,000	172,200,000	2	98

Table 7: Concentrated fish feed for rainbow trout.

Name of factory	Province	Nominal capacity
Chineh Co.	Tehran	14,000 tons
Abzi Ghaza Co.	Tehran	6,000 tons
Gosht fars Co.	Fars	6,000 tons
Khorak Dam Mazandaran Co.	Mazandaran	6,000 tons
Daneh Roz Co.	Lorestan	6,000 tons
Keshte Sanate Mahabad Co.	Azarbayjan W.	5,000 tons
Niro Sahad Co.	Azarbayjan E.	4,000 tons
Por Samar Co.	Azarbayjan E.	5,000 tons
Dam Tiour Ravansar Co.	Kermansha	5,000 tons
Khorad Dam Pars	Tehran	5,000 tons
Behparvar Co.	Tehran	5,000 tons
Tovovi 199 Gorgan Co.	Charmahle	5,000 tons

Table 8: Fish Production in Iran 1990-2001.

1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
2,679	2,026.5	2,325	2,505	17,820.5	21,000	26,600	30,864	57,431	77,000	99,000	121,700

Large-scale growout of spotted Babylon, *Babylonia areolata* in earthen ponds: Pilot monoculture operation

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Recently, there has been considerable interest in the commercial culture of spotted Babylon, *B. areolata*, in Thailand. Unfortunately, while local demand has been rising there has been a catastrophic decline in wild populations in the Gulf of Thailand.

From an aquaculture point of view, the spotted Babylon has many positive biological attributes, production, and market characteristics and is considered a promising new candidate species for land-based aquaculture in Thailand. To date, large-scale grow out of spotted Babylon has been trialed using flow-through seawater systems in concrete / canvas ponds. However, this culture technique requires a high investment in pond construction, buildings and facilities. Operational costs are also high, and overall such systems are not profitable enough to support commercial operations. A cheaper production system is needed, and so we conducted a study to determine the feasibility of growing spotted Babylon to market size under monoculture in earthen ponds. The study included a financial investment analysis including biological, production, cost, and market price variables to help make decisions about culture methods and the commercial feasibility of this enterprise.

Due to a decline in global shrimp prices, there is now considerable disused shrimp pond infrastructure available in Thailand. Our study may provide an opportunity to develop an alternative crop to make use of these facilities.

Spotted Babylon of 150 – 200 snails per kg after harvest from earthen ponds.

Pond design and operation

This study was conducted at the Research and Technology Transfer Unit of Thai Babylon Breeding and Culture, Chulalongkorn University, Petchaburi province, Thailand. Eight 20 x 20m earthen ponds of 1.5m in depth were used for the trials. Pond dykes were 1.5m in height, 3m in width at the base and 2.5m in width at the top. Pond bottoms were covered with a 10-15cm layer of coarse sand. Each grow-out pond was fenced with a plastic net of 15mm mesh size and 1.2m in width, supported with a bamboo frame for strength. The plastic net must be buried under sand about 6 cm in depth to limit movement of snails along pond bottom and pond wall, and to facilitate harvesting.

Prior to the start of grow out, all ponds were dried for two weeks, and filled to a depth of 70cm with unfiltered seawater from a nearby canal. Water level was maintained at this level by adding seawater to replace that lost through seepage and evaporation. The intake system is powered by one 5.5-hp engine equipped with water pump and intake/outlet pipes 12.5cm in diameter.

Seawater is delivered to each pond through an unlined canal 80cm wide and 30cm deep. Two air blowers (2 Hp) were used to supply high volume air for all grow-out ponds. Air was delivered to each pond through four polyethylene pipes 18m long and 1.6cm in diameter, suspended about 10cm off the bottom using bamboo sticks. The air pipe was pierced with holes of 1.5mm in diameter at 2m intervals. Aeration was provided for 16-20 hours daily, but not applied during feeding.

Grow-out operation

Juvenile spotted Babylon with an average shell length and body weight of 1.1cm and 0.5g respectively were purchased from a private hatchery. Individuals from the same cohort were sorted by size to minimize differences in shell length and to prevent possible growth retardation of small Babylon by larger animals. The initial stocking density was 200 snails/m^2 (80,000 snails per pond). The snails were fed with fresh trash fish at about 15-20% of body weight once daily in the morning (09:00). Feeding was monitored daily by means of baited traps. The amount of food was adjusted every 30 days after measuring average body weight. Fifty percent of seawater was exchanged at 15-day intervals. Before exchange, seawater was sampled 25 cm above pond bottom and assayed for temperature, salinity, pH, alkalinity, nitrite – nitrogen and ammonia – nitrogen following standard methods by APHA. Dissolved oxygen was measured daily and no antibiotic agents were used throughout the entire culture period. Grading was not carried out. For growth estimation, fifty baited traps were used to sample spotted Babylon in each pond at 30 days intervals. The snails were cultured until they reached the marketable size of 120-150 snails/kg.

A 20.0 x 20.0 x 1.5 m grow-out earthen pond for monoculture of spotted Babylon in a total farm area of 0.8 ha in Thailand.

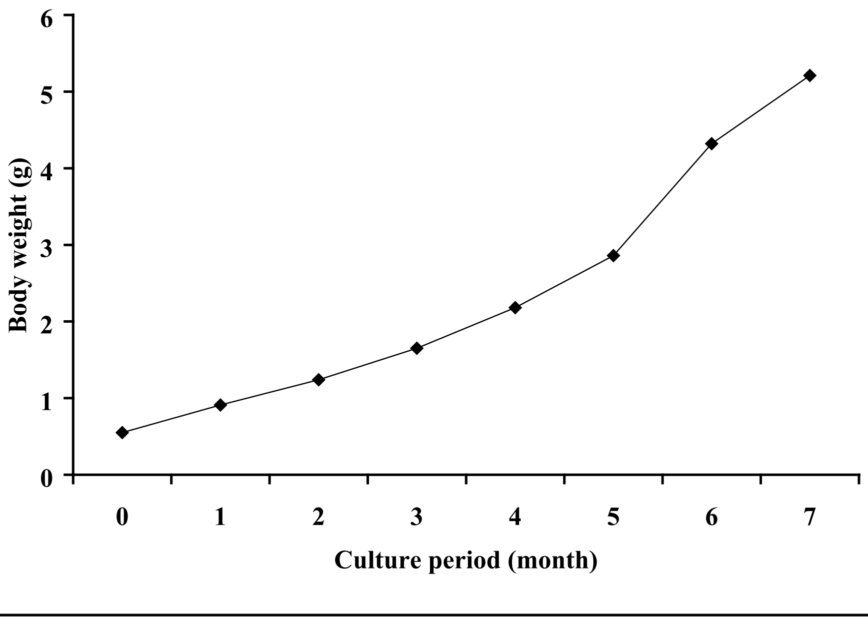
Growth

The average total yield of spotted Babylon was 10,525 kg/ha. Average growth rates over seven months were 0.67 g/month in body weight and 0.30 cm/month in shell length, respectively. At the end of the experiment, mean final body weight of snails was 5.22±0.63g with a mean shell length of 3.2±0.35cm, respectively. FCR over the course of the trials was 2.69 with 89.94% survival.

Salinity (ranging from 14-38ppt) and alkalinity (ranging from 30-88mg/L) were the water quality parameters that showed the greatest changes during the culture period. The range of other parameters was: Water temperature, 25-35°C; pH, 7.9 – 9.2; dissolved oxygen, 3.5 – 5.6 mg/L; nitrite 0 .0004 – 0.0125 mg/L; total ammonia 0.0329, nitrate, 0.2120 mg/L. Overall, the water quality within ponds showed a more gradual change than the local seawater, and we regard the parameters as suitable conditions for grow out of spotted Babylon.

Economic analysis

The parameters used for economic analysis of spotted Babylon monoculture are summarized in Table 1, based on a total farm area of 0.8ha. The farm data (total farm area, pond sizes, and total pond area), stocking data (average initial weight, stocking density) and harvest data (duration of grow-out, average weight at harvest, final survival, feed conversion ratio and yield) are based on the actual data from the pilot farm. Total investment requirement for construction was estimated to be $4,837. Construction of grow-out ponds and seawater reservoirs was the largest cost component of the farm (around 35% of the total investment cost), followed by building of canvass nursery ponds, land, seawater pumps and blowers. These five components of the farm represented 79.08% of total investment (Table 2). Ownership cost per production cycle was estimated to be $2,241. The major ownership cost items were depreciation, land and interest on investment (Table 3). Operating costs per production cycle was estimated to be $16,943. The four major operating cost items were purchase of juvenile spotted Babylon, feed, hired labor, interest on investment, electricity and fuel (Table 4). Total cost per production cycle for monoculture of spotted Babylon in a total farm area of 0.8 ha was $19,184. Ownership cost and operating cost accounted for 11.68% and 88.32% of total cost, respectively. The cost of producing spotted Babylon marketable sizes in this grow-out farm design was $5.69/kg (Table 5). The enterprise budgets of a total farm area of 0.8 ha for monoculture of spotted Babylon in earthen ponds are presented in Table 6. The enterprise budgets based on the price of spotted Babylon at farm gate in 2003



of $9.00/kg resulted in a gross return of $30,312, net return of $11,124, return to capital and management of $13,369 and return on investment of 2.76, respectively. The breakeven price and breakeven yield at this assumption was $5.69/kg and 2,131 kg per production cycle, respectively. Cash-flow budgets were developed to examine profitability in relation to the timing of expenditures and earning. Under the farm data, stocking data and harvest data used in this study, a farm gate price of $9.00/kg resulted in a positive cash flow by year two (Table 7).

The results of our study show that juvenile spotted Babylon can be successfully grown to marketable size in earthen ponds. The economic feasibility of this system bears further investigation. Although returns are small, production with 80% survival and a sale price of $9.00/kg is economically feasible under the assumptions employed. Profitability could be improved by targeting production for periods of peak market price and premium locations. With regard to production, profitability is most sensitive to changes in average final weights and survival. In general, snails are rendered unmarketable by stunting and deformities, characteristics that are presumably related to lower growth rates (i.e. final average weights) and survival. An economic analysis based on previous pilot production data of a 0.3 ha grow-out earthen pond production system for spotted Babylon suggested that the enterprise would be commercially feasible (at current market prices) with a final body weight of 6.6 g (150 snails/kg), and marginally feasible at 5.0 g (250 snails/kg). Decreasing the culture period to five months and reducing the cost of juveniles to $0.01 each would considerably improve the economic feasibility, profitability and allow production cycles per year.

This economic analysis is intended as a rough guide and must be modified to reflect individual situations. Application of these results to commercial levels of production should be preceded by careful examination of other parameters that might be important such as deterioration of water quality at high stocking densities. Further study should address improved pond design, management of seawater and pond bottom quality, feeding strategies, and competition for food and habitat due from other organisms naturally occurring in the ponds.

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Next issue:

Polyculture of Babylon snails...

...with Asian seabass!

Sampling of spotted Babylon in earthen ponds using baited traps.

Table 1. Parameters used for the economic analysis for monoculture of spotted Babylon in a total farm area of 0.8 ha of earthen ponds in Thailand.

Parameter	Value
A. Farm data	
Total farm area (ha)	0.8
Pond size (ha)	0.04
Total pond area (ha)	0.32
Total area of seawater reservoirs (ha)	0.4
B. Stocking data	
Average initial weight of spotted Babylon (g)	0.5
Stocking density of spotted Babylon (no./ m^2)	200
C. Harvest data	
Duration of grow-out (months)	7
Average number of crops per pond per year	1.4
Average final weight (g)	6.9
Average final survival (%)	84.94
Feed conversion ratio (FCR)	2.69
Yield per production cycle (kg/ha)	10,520
Sale price at farm gate ($/kg)	8.75 – 9.25

Table 2. Estimated investment requirements.

Item	Investment ($)	Percent of total cost
Land rent	500	10.34
Construction of eight 20.0 x 20.0 x 1.5 m earthen grow-out ponds and one 0.4 ha seawater reservoir	1,700	35.14
Construction of accommodation and storage house	250	5.17
Construction of four 3.0 x 5.0 x 0.7 m canvass nursery ponds and housing	625	12.92
Water pumps and housing	500	10.34
Blowers and housing	500	10.34
Traps for sampling and harvesting	100	2.06
Operating equipment (PVC pipes, plastic tanks, lighting, salinometer, thermometer, etc.)	162	3.35
Miscellaneous	500	10.34
Total investment	**4,837**	**100**

Table 3. Estimated ownership costs per production cycle.

Item	Investment ($)	% of total cost
Land	500	22.31
Depreciation on:		
- Earthen ponds and seawater reservoirs	340	15.17
- Accommodations and facilities	125	5.58
- Construction of canvass nursery ponds and housing	312	13.92
- Water pumps and housing	250	11.16
- Blowers and housing	250	11.16
- Traps for sampling and harvesting	1000	4.46
- Equipment (pvc pipes, plastic tanks, lighting etc.)	81	3.61
- Miscellaneous	250	11.16
Interest on fixed cost	33	1.47
Total ownership cost	**2,241**	**100**

Table 4. Estimated operating costs per production cycle.

Item	Investment ($)	Percent of total cost
Purchase of juvenile spotted Babylon	11,200	66.10
Fuel and lubricants	586	3.46
Electricity	378	2.23
Feed	1,358	8.02
Labor (2 full time)	1,750	10.33
Repairs and maintenance	375	2.21
Ice for feed storage	108	0.64
Interest on operating capital	1,188	7.01
Total operating cost	**16,943**	**100**

Table 5. Estimated total cost per production cycle.

Item	Investment ($)	Percent of cost
Ownership costs	2,241	11.68
Land	500	2.61
Depreciation	1,708	8.90
Interest on investment	33	0.17
Operating costs	16,943	88.32
Spotted Babylon juveniles	11,200	58.38
Fuel and lubricants	586	3.05
Electricity	378	1.97
Feed for spotted Babylon	1,358	7.08
Hired labour	1,750	9.12
Repairs and maintenance	375	1.95
Ice for storage of feed	108	0.56
Interests on investment	1,188	6.19
Total cost per production cycle	**19,184**	**100**

Table 6. Enterprise budgets for monoculture of spotted Babylon.

Parameter	Value
Production	
Spotted Babylon* (kg)	3,368
Costs per production cycle	
Initial investment requirements	4,837
Ownership costs ($)	2,241
Operating costs ($)	16,943
Total cost ($)	19,184
Returns	
Gross return ($)	30,312
Net returns ($)	11,124
Return to capital and management ($)	13,369
Return on investment	2.76

* *Total yield of spotted Babylon and sea bass per production cycle at 0.4 ha.*
Price at farm gate for spotted Babylon $9.00.

Table 7. Seven-year cash flow for monoculture of spotted Babylon using a total area of 0.4ha of earthen grow out ponds in Thailand, stocking density of 200 snails/m² and price at farm gate of $9.00/kg.

	Year 1 ($)	Year 2 ($)	Year 3 ($)	Year 4 ($)	Year 5 ($)	Year 6 ($)	Year 7 ($)
Investment	4,837	-	-	-	-	-	-
Ownership cost	2,241	2,241	2,241	2,241	2,241	2,241	2,241
Operating cost	16,943	16,943	16,943	16,943	16,943	16,943	16,943
Total cost	24,021	19,184	19,184	19,184	19,184	19,184	19,184
Gross return	30,312	30,312	30,312	30,312	30,312	30,312	30,312
Net return	11,124	11,124	11,124	11,124	11,124	11,124	11,124
Cumulative	-12,897	-1,773	9,351	20,475	31,599	42,723	53,847

Cage cum pond fish production using mixed sex nile tilapia in Nepal

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Nile tilapia (*Oreochromis niloticus)* was first introduced to Nepal from Thailand in 1985[1,2,3] and kept in Government fish farms for study[3], although no efforts were made to evaluate its performance or to make it available to farmers at that time[4]. Eventually, farmers introduced tilapia from neighboring countries by themselves and began growing it without technical guidance, particularly in the southeastern part of the country.

A preliminary study on tilapia culture carried out by the Nepal Agricultural Research Council (NARC) and Institute of Agriculture and Animal Science (IAAS) at Chitwan found positive results[5]. Nile tilapia grew 40 to 150 g in 108 days using fresh duckweed as feed[4]. Complete feeding or supplemental feeding with fertilization is necessary for large size tilapia production[6]. From a pond management prospective, a strategy for efficient production may be to apply fertilization early in the grow-out period to supply feed through natural pond productivity, with supplemental feed added once fish reach 100-150 g[7].

Tilapia cage culture has a relatively short history. In many cases caged fish, fed with protein-rich diets, directly or indirectly contribute to eutrophication of the surrounding waters, through release of nutrients to the environment. Lin *et al.*[8,15] developed methods to integrate intensive and semi-intensive aquaculture in ponds through practices for catfish-tilapia culture, and tilapia-tilapia culture is similarly well studied[9,10]. Intensive Nile tilapia cage culture within ponds can efficiently produce large fish from 100-150 g to 250-300 g, while smaller ones can be grown from 20-40 g to 125-150 g in a semi-intensive fashion in the open pond[11,12]. Such systems could allow small-scale farmers owning one pond to maximize fish production and profitability, increasing the economic viability of an otherwise limited operation. However, growth and production of Nile tilapia varies with season, especially between winter and summer in Nepal. Nile tilapia neither feed nor grow during mid December to mid February due to low water temperatures, which fall below 20ºC in Nepal's subtropical climate[11].

IAAS-NARC developed a model production system "cage cum pond fish culture for mixed sex Nile tilapia", based on two-production cycles a year. The model was trialed and developed at the IAAS station, and later field-tested by farmers in commercial operations.

Developing the model

Trials were conducted at Institute of Agriculture and Animal Science (IAAS), Rampur Campus, Chitwan, Nepal from 16 July to 16 December and from 12 February to 16 July. In the first culture cycle, larger sized mixed sex tilapia of mean weight 153.1 ± 3.2g were stocked at 30 fish/m^3 in cages and smaller fish of mean weight 30.8 ± 2.8 g stocked at 2 fish/m^2 in open ponds. Similarly, in cycle 2, larger fish of mean weight of 114.8 ± 2.5 g were stocked in cages and smaller fish of 60.5 ± 0.3 g in open ponds with the same stocking densities. The experiment was conducted in four cemented ponds, each of 72m^2 water area with cages of 2.5m^3 (1.5 x 1.5 x 1.1 m) used in each pond. Each cage bottom was 10 cm above the pond bottom and held approximately 2m^3 water volume.

Locally prepared pellet feed was prepared containing: Rice bran (59%), mustard oil cake (35%), tilapia fish meal (5%) and wheat flour (1%), and fed to caged fish at 2% body weight/day. The nutritional composition of feed was: 10.3 ± 0.4% moisture, 21.0 ± 0.2% crude protein (CP), 15.2 ± 0.2% ether extract (EE), 11.1 ± 0.7% crude fiber (CF), 10.8 ± 0.6% ash, and 41.9 ± 0.9% nitrogen free extract (NEF) on a dry matter basis. Ponds were fertilized with fresh pig manure (66.9 ± 0.5% moisture) at the rate of 2 kg/pond daily for the first week. Pond water level was maintained at 1m in depth and topped up weekly with tap water to compensate for evaporative losses.

Water quality in ponds was monitored weekly for temperature, specific conductivity (YSI Model 33), pH (Quick check model 106-ATC), dissolved oxygen (Winkler method[13]) at 0700-0800 hr, and Secchi disk visibility at 1000-1100 hrs. Caged fish were sampled fortnightly to record growth and feed adjustments made accordingly. Feed conversion ratio (FCR) was calculated based on feed consumed and net output yield from the system.

Based on the results obtained at IAAS, a verification trial was conducted at Kathar Village Development Committee (VDC)–1, Kusahana, Chitwan from 21 August to 21 December in cycle 1 and from 12 February to 19 July in cycle 2. Large size mixed sex tilapia of mean weight 81.3 ± 7.4 g sizes were stocked in cages and smaller fish of 14.6 ± 0.3 g in open ponds in cycle 1. In cycle 2, large fish with a mean weight of 108.8 ± 5.7 g sizes were stocked in cages and small fish of 6.3 ± 1.2 g sizes in open ponds. The stocking densities in cages and ponds were the same as used previously at IAAS. Three farmers, Gulabiya Chaudhary, Phul Kumari Chaudhary and Jhauri Mahato each had a 110m^2 size pond involved in cycle 1 and an additional four farmers including Hari Maya Chaudhary (owning 100m^2 pond) participated in cycle 2. A bamboo framed net cage of 3.7m^3 (2.0 x 1.7 x 1.1 m) was placed in each pond. Each cage bottom was 10 cm above the pond bottom and held approximately 3m^3 water volume (ie.

filled to 90cm). Caged fish were fed with locally prepared pellet feed as described above (FRD 2001). Ponds were also fertilized with fresh buffalo manure at the rate of 3 kg/pond daily for the first week. Pond water level was maintained at 1m depth with occasional topping of canal water to compensate for losses.

Water quality was monitored as in the station mentioned above. Column water samples were brought to IAAS laboratory and analysed for total alkalinity (methyl orange end point titration method[13]), total ammonium nitrogen (TAN) with an ammonia meter (Hanna Ammonia high range HI 97315), soluble reactive phosphorus (SRP) (ascorbic acid reduction method[13]) and chlorophyll-a (90% acetone extraction method[13]). Fish were sampled for growth records similar to the previous trials and feed adjustment was made accordingly.

Figure 1. Model for cage cum pond fish culture of mixed sex Nile tilapia in subtropical Nepal.

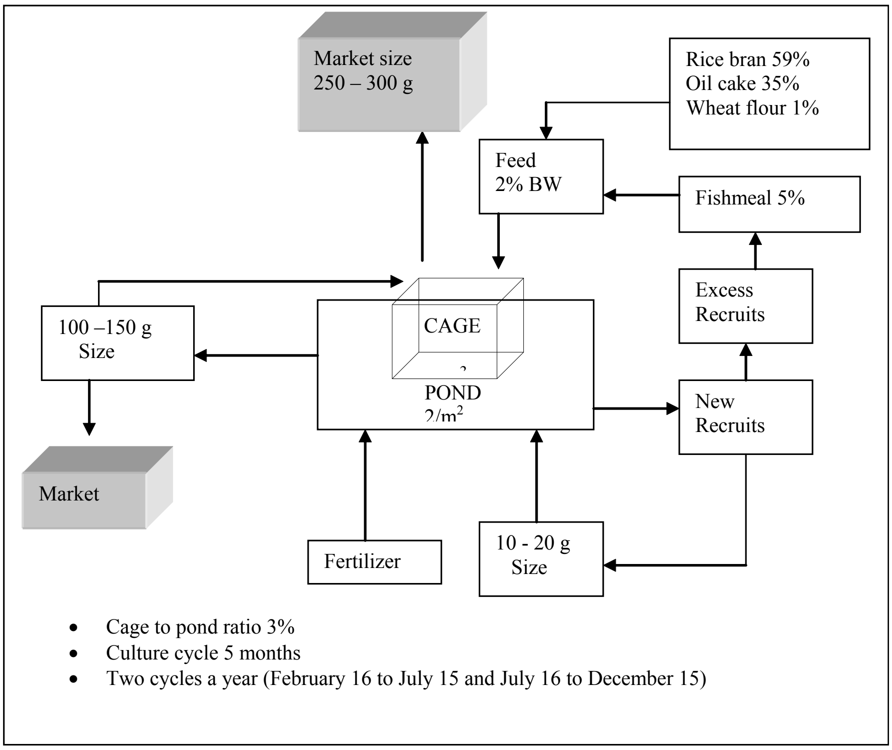
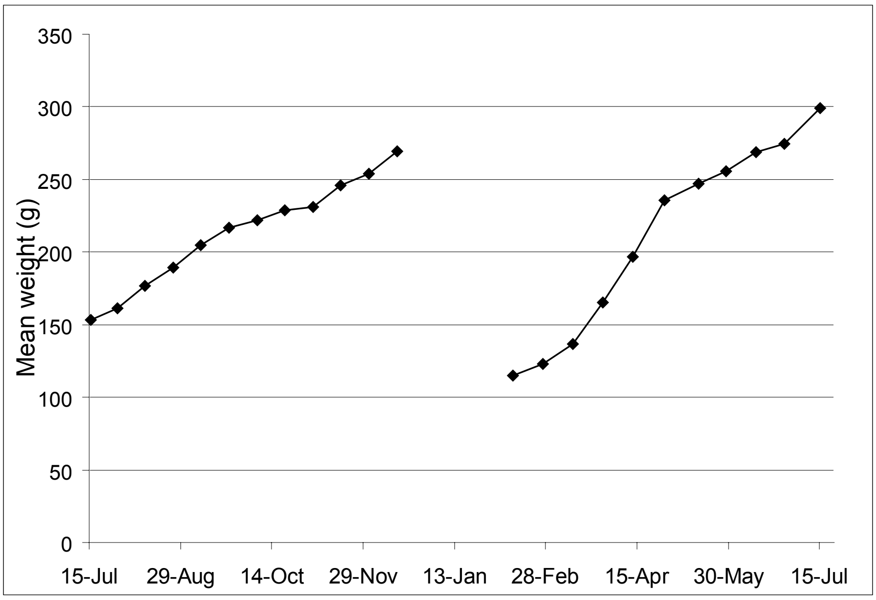


Figure 2. Fortnightly mean weight (g) of caged fish Nile tilapia during production cycle 1 and 2.



Outcomes

Fish growth and yield

In the IAAS trials, caged fish grew from 153.1 ± 3.2 g to 269.4 ± 7.3 g in the first five month production cycle and from 114.8 ± 2.5 g to 299.1 ± 3.9 g in the second cycle. Mean growth was 0.76 ± 0.03 g/day and 1.20 ± 0.02 g/day with 100% and 94% survival in production cycle 1 and cycle 2, respectively (Table 1). In open ponds, fish grew from 30.8 ± 2.8 to 121.4 ± 4.7 g and 60.5 ± 0.3 to 160.3 ± 17.1 g during production cycle 1 and cycle 2 respectively. Mean growth rate calculated was 0.60 ± 0.03 g/day and 0.65 ± 0.11 g/day, with a survival of 93 ± 1% and 98 ± 2% in production cycle 1 and 2, respectively (Table 1). The number of new tilapia recruits produced was 2,049 ± 372 individuals/pond with a mean weight 12.1 ± 1.0 g in cycle 1 and 4,434 ± 257 individual/pond with a mean weight 3.1 ± 0.3 g in cycle 2, respectively (Table 1).

In the farmer's ponds, fish grew from 81.3 ± 7.4 to 163.1 ± 12.1 g and 108.8 ± 5.7 to 176.7 ± 13.8 g in cages during cycle 1 and cycle 2, respectively. Mean growth calculated was 0.68 ± 0.0 g/day and 0.44 ± 0.1 g/day with 86 ± 8% and 90 ± 3 % survival in production cycle 1 and cycle 2, respectively. During cycle 1, the fish growth rate (0.68 ± 0.0 g/day) and harvest size (163.1 ± 12.1) obtained in cages in farmer's ponds was lower than that obtained at IAAS (0.76 ± 0.03 g/day and 269.4 ± 7.3 g)[5,14]. This might be due to smaller stocking size (81 g) and shorter culture period (four months) compared to IAAS where fish where stocked at 153 g and grown for five months. In cycle 2, the growth and harvest size of caged fish was very poor (0.44 ± 0.1 g/day and 176.7 ± 13.8 g) compared to that obtained at IAAS (1.20 ± 0.02 g/day and 299.1 ± 3.9 g)5,13. The mean weight of fish was measured every fortnight in cages (Fig. 2).

At IAAS, mean harvest yield from cages was 16.2 ± 0.7 kg and 16.9 ± 0.4 kg in production cycle 1 and cycle 2, respectively, with a total annual yield of 33.1 ± 1.1 kg. Similarly, mean harvest yield from pond stocking was 16.2 ± 0.5 kg and 22.6 ± 2.6 kg in cycle 1 and 2, respectively, with a total of 38.8 ± 2.3 kg. Some of the fish harvested from ponds were restocked in cages for further on growing in the next culture cycle. Thus, the net output from the system was 25.5 ± 0.9 kg and 31.4 ± 2.5 kg of fish from cycle 1 and cycle 2, respectively, a total annual net yield of 56.9 ± 2.7 kg per 72m^2 ponds, equivalent to 7.9 ± 0.4 t/ha/yr (Table 1).

In farmer's ponds, mean harvest yield from cages was 12.4 ± 0.3 kg and 14.2 ± 0.5 kg in production cycle 1 and cycle 2, respectively with a total annual yield of 26.6 kg (Table 1). Similarly, mean harvest yield from pond stocking was 14.8 ± 2.0 kg and 19.2 ± 2.0 kg in cycle 1 and cycle 2, respectively, with a total of 34 kg. Parts of the pond harvest fish for next culture cycle for respective ponds were restocked in cages. The net out put yield from the system resulted 17.7 ± 2.2 kg and 24.7 ± 1.3 kg of fish from cycle 1 and cycle 2, respectively, with a total annual net yield of 42.4 kg per 105m^2 ponds. The yield of cycle 1 was from four months of culture and is equivalent to 4.41 t/ha/yr (Table 1), somewhat less than the 7.9 t/ha/yr obtained at IAAS[5,14].

At IAAS, the system produced new recruits of 24.0 ± 2.6 kg and 13.8 ± 1.2 kg during production cycle 1 and cycle 2, respectively, with a total of 37.7 ± 1.7 kg and new recruits supplied fingerlings to restock in open pond. After restocking the ponds, an excess of recruits remained (24.7 ± 1.7 kg/pond/yr). Conversion of these fresh recruits yielded 3.7 kg dry fishmeal. Feed consumed during production cycle 1 and cycle 2 were 39.2 kg and 37.1 kg/pond, respectively, with a total annual consumption of 76.3 kg/pond. Feed used in this experiment contained 5% fishmeal, which required a total of 3.8 kg fishmeal. Based on the total net output yield from the system and feed consumed in ponds, FCR was calculated as 1.3 (Table 1).

In farmer's open ponds, fish grew from 14.6 ± 0.3 to 78.8 ± 6.8 g and 6.3 ± 1.2 to 97.6 ± 11.9 g during production cycle 1 and 2, respectively. Mean growth rate calculated was 0.53 ± 0.06 g/day and 0.60 ± 0.09 g/day, with a survival of 88 ± 3% and 94 ± 3% in production cycle 1 and 2, respectively (Table 1). In cycle 1, a total of 1,696 ± 893 tilapia recruits were produced per pond with a mean weight 4.1 ± 2.2 g. In cycle 2, a total of 984 ± 409 recruits per pond were produced with a mean weight of 26.6 ± 15.1 g. Fish growth in open ponds obtained in cycle 1 (0.53 ± 0.06 g/day) and cycle 2 (0.60 ± 0.09 g/day) was lower than that at IAAS (0.60 ± 0.03 g/day in cycle 1 and 0.65 ± 0.11 g/day in cycle 2). Lower growth in open ponds might have been due to less fertile and turbid conditions in the earthen ponds of farmers compared to highly green cement ponds in the farm of IAAS.

Conclusion

When tested under field conditions this cage cum pond integration system achieved double or more than the national average yield. However, the field trials did not achieve the same yield as that of trials at IAAS. Some of the problems in this trial were that the culture period and timing could not be followed as per the model system. Farmers were not trained in this culture system, feed adjustment was done on a monthly basis and there was a lack of proper handling of live fish during sampling of caged fish, causing stress and mortality. In future, it would be useful to develop a manual for farmers that intend to use this system, providing a daily or weekly feeding rate and schedule (without intermediate sampling), and guidelines on suitable stocking size, time of stocking and harvest, fertilization rates and schedule. Ideally, farmers wishing to practice this system should be provided with a short period of training. We suggest that a further trial should be conducted to develop and test the efficacy of the system with such a training/documentation package in place.

Tilapias are considered to be unique in their capacity to breed naturally in the cultured system without any artificial inducement. The free breeding capacity allows this species to be popular where supply of fish seed is a constraint for the development of fish culture. However, uncontrolled reproduction has been well recognized as a problem in tilapia culture. Uncontrolled reproduction resulting over population has led to the development of mono-sex culture systems for this species. Since there is no possibility of producing mono-sex fry in Nepal at present, we developed a model for mixed-sex culture in Nepal's subtropical regions.

The proposed model of cage cum pond integrated system produced 250 – 300 g size fish from cages and 110 – 150 g size fish from ponds in five month culture cycles. The systems produced a net output of 3.5 ± 0.1 t/ha and 4.4 ± 0.4 t/ha during culture cycle 1 and cycle 2 respectively, equivalent to a total annual net yield of 7.9 t/ha. Our model assumes a two-month over-wintering period (December 16 to February 15) without production. This system produces fish for stocking in ponds and cages along with enough fishmeal (from excess recruits) to supply feed manufacturing requirements for the next culture cycle. The feed conversion ratio calculated based on net output was 1.3, which is acceptable with this local feed. The yield of the system is more than two times higher than the national average. This model allows water quality to sustain fish production in a natural balance system. Moreover, system allows small-scale farmers to produce better fish yield for their nutrition and to supplement their incomes and livelihoods.

Acknowledgements

The authors are grateful to IAAS, Rampur Campus and women farmers of Kathar-1, Kusahana, Chitwan namely, Gulabiya Chaudhary, Phul Kumari Chaudhary, Jhauri Mahato and Hari Maya Chaudhary for providing facilities and participating in field trials. Authors acknowledge Mr. Chudamani Pandey M. Sc. (Aquaculture) student for field and laboratory work. We are also thankful to the lab and field staff of the Fisheries and Aquaculture Department, Rampur campus, for their assistance.

Table 1. Mean stocking wt., harvest yield, net yield, fishmeal yield, feed conversion ratio (FCR) data of mixed sex Nile tilapia in cage cum pond fish culture on farm and on station during cycle 1 and 2.

Particulars	Cycle 1 (Mean ± SE)		Cycle 2 (Mean ± SE)	
	IAAS	Farm	IAAS	Farm
Stocking in cage				
Cage size (m^3)	2	3	2	3
Stocked (number)	60	90	60	90
Total weight (kg)	9.2 ± 0.3	7.3±0.7	6.9 ± 0.1	9.8±0.5
Mean weight (g)	153.1 ± 3.2	81.3±7.4	114.8 ± 2.5	108.8±5.7
Stocking in ponds				
Pond size (m^2)	72	107±3.0	72	105±3
Stocked (number)	144	213±7.0	144	210±6
Total weight (kg)	4.4 ± 0.4	3.1±0.1	8.7 ± 0.1	1.3±0.2
Mean weight (g)	30.8 ± 2.8	14.6±0.3	60.5 ± 0.3	6.3±1.2
Harvest in cage				
Harvest (number)	60	77±7.0	57 ± 1	81±4
Total weight (kg)	16.2 ± 0.7	12.4±0.3	16.9 ± 0.4	14.2±0.5
Mean weight (g)	269.4 ± 7.3	163.1±12.1	299.1 ± 3.9	176.7±13.8
Mean growth (g/day)	0.76 ± 0.03	0.68±0.0	1.20 ± 0.02	0.44±0.07
Survival (%)	100	86±8.0	94 ± 2	90±4
Harvest in pond				
Harvest (number)	134 ± 2	187±11	141 ± 3	198±3
Total weight (kg)	16.2 ± 0.5	14.8±2.0	22.6 ± 2.6	19.2±2.0
Mean weight (g)	121.4 ± 4.7	78.8±6.8	160.3 ± 17.1	97.6±11.9
Mean growth (g/day)	0.60 ± 0.03	0.53±0.06	0.65 ± 0.11	0.60±0.09
Survival (%)	93 ± 1	88±3	98 ± 2	94±3
New recruits harvest in pond				
Harvest (number)	2049 ± 372	1696±893	4434 ± 257	984±409
Total weight (kg)	24.0 ± 2.6	3.8±1.7	13.8 ± 1.2	10.2±3.4
Mean weight (g)	12.1 ± 1.0	4.1±2.2	3.1 ± 0.3	26.6±15.1
Harvest yield from cage (kg)				
Harvest yield from pond (kg)	16.2 ± 0.7	12.4±0.3	16.9 ± 0.4	14.2±0.5
Total harvest yield from	16.2 ± 0.5	14.8±2.0	22.6 ± 2.6	19.2±2.0
cage+pond (kg)	32.4 ± 1.0	27.2±2.1	39.5 ± 2.5	33.5±2.3
Used in cage restocking for	6.9 ± 0.1*	9.8±0.5*	9.0*	8.7±1.1*
next cycle (kg)	25.5 ± 0.9	17.7±2.2	31.4 ± 2.5	24.7±1.3
Net output yield (kg)	3.5 ± 0.1	2.06	4.4 ± 0.4	2.35
Extrapolated yield (t/ha)				
New recruits yield (kg)				
Used in pond restocking for	24.0 ±2.6	3.8±1.7	13.8 ± 1.2	10.2±3.4
next cycle (kg)	8.7 ± 0.1*	1.3±0.2*	4.3*	2.3*
Net fish meal yield (kg)	15.3 ± 2.6	2.5	9.4 ± 1.2	7.9
Net dry fish meal yield (kg)	23	0.4	1.4	1.2
moisture= 85%	1.5	1.4	1.2	1.5
Feed conversion ratio (FCR)				

Table 2. Weekly pond water quality parameters measured during experimental period in cycle 1 and 2.

Parameters	Cycle 1		Cycle 2	
	IAAS	Farm	IAAS	Farm
	Range	Range	Range	Range
Water temperature (°C)	17.5 – 30.2	16.8-31.2	19.4 – 31.8	19.4-30.9
Dissolved oxygen (mg/L)	1.3 – 6.4	1.6-7.6	1.4 – 10.5	0.6-13.1
pH	6.7 – 8.4	7.4-8.4	7.4 – 9.3	7.1-8.5
Secchi disk visibility (cm)	29 - 53	19-50	23 – 51	15-50
Total alkalinity (mg/L $CaCO_3$)	80 – 132	66-177		84-140
TAN* (mg/L)		0.01-0.69		-2.86
SRP* (mg/L)		-0.12		-0.34
Specific conductivity (µmhos/cm)	184 –274	-	223 – 349	-

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VIBRIO 2005, 6-8 November, Het Pand, Ghent, Belgium

There have been tremendous developments in the study of the biology of vibrios over the last two decades. Nearly 80 species are now officially recognized today, some of which have well known ecological roles in nature. *V. cholerae* remains one of the main scourges of mankind, killing thousands of people yearly worldwide. Other vibrios e.g. *V. anguillarum*, *V. harveyi* and *V. salmonicida* are threats to reared marine animals. Vibrios are abundant in the marine environment and within the tissues/organs of several hosts e.g. fish and shellfish. More recently, certain vibrios have been associated with the mortality of corals and other cnidarians, worldwide. A wide range of biotechnological applications e.g. vaccine development, environmental monitoring and production of bioactive compounds are currently under way using vibrios. Seven species have their whole-genome sequences available or approaching completion allowing detailed genomic and post-genomics analyses. Clearly, it is timely to bring together researchers committed to the study of the biology of vibrios. The goal of this meeting is to have a forum of discussion of the present knowledge on vibrios as well as to identify the main research needs for future projects. Cutting-edge studies covering the four main streamlines of current research i.e. Biodiversity, Ecology & Applications, Genomics, and Disease & Epidemiology will be presented during Vibrio 2005. The meeting is targeted at bacterial taxonomists, microbial ecologists, genome researchers, health management workers and students.

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- Provide opportunity to hear experts in strategic fields and interact
- Develop strategies for bringing in awareness on environmental issues and socio-economic benefits for better technology transfer.
- Understand modern techniques of resource management.
- Encourage young scientists to undertake need based and resource specific research.
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